pandas: powerful Python data analysis toolkit

Release 0.21.0

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PDF Version

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Binary Installers: http://pypi.python.org/pypi/pandas

Source Repository: http://github.com/pandas-dev/pandas

Issues & Ideas: https://github.com/pandas-dev/pandas/issues

Q&A Support: http://stackoverflow.com/questions/tagged/pandas

Developer Mailing List: http://groups.google.com/group/pydata

pandas is a Python package providing fast, flexible, and expressive data structures designed to make working with "relational" or "labeled" data both easy and intuitive. It aims to be the fundamental high-level building block for doing practical, **real world** data analysis in Python. Additionally, it has the broader goal of becoming **the most powerful and flexible open source data analysis / manipulation tool available in any language**. It is already well on its way toward this goal.

pandas is well suited for many different kinds of data:

- Tabular data with heterogeneously-typed columns, as in an SQL table or Excel spreadsheet
- Ordered and unordered (not necessarily fixed-frequency) time series data.
- Arbitrary matrix data (homogeneously typed or heterogeneous) with row and column labels
- Any other form of observational / statistical data sets. The data actually need not be labeled at all to be placed into a pandas data structure

The two primary data structures of pandas, `Series` (1-dimensional) and `DataFrame` (2-dimensional), handle the vast majority of typical use cases in finance, statistics, social science, and many areas of engineering. For R users, `DataFrame` provides everything that R's `data.frame` provides and much more. pandas is built on top of NumPy and is intended to integrate well within a scientific computing environment with many other 3rd party libraries.

Here are just a few of the things that pandas does well:

- Easy handling of **missing data** (represented as NaN) in floating point as well as non-floating point data
- Size mutability: columns can be **inserted and deleted** from DataFrame and higher dimensional objects
- Automatic and explicit **data alignment**: objects can be explicitly aligned to a set of labels, or the user can simply ignore the labels and let *Series*, *DataFrame*, etc. automatically align the data for you in computations
- Powerful, flexible **group by** functionality to perform split-apply-combine operations on data sets, for both aggregating and transforming data
- Make it **easy to convert** ragged, differently-indexed data in other Python and NumPy data structures into DataFrame objects
- Intelligent label-based **slicing**, **fancy indexing**, and **subsetting** of large data sets
- Intuitive **merging** and **joining** data sets
- Flexible **reshaping** and pivoting of data sets
- **Hierarchical** labeling of axes (possible to have multiple labels per tick)
- Robust IO tools for loading data from **flat files** (CSV and delimited), Excel files, databases, and saving / loading data from the ultrafast **HDF5 format**
- **Time series**-specific functionality: date range generation and frequency conversion, moving window statistics, moving window linear regressions, date shifting and lagging, etc.

Many of these principles are here to address the shortcomings frequently experienced using other languages / scientific research environments. For data scientists, working with data is typically divided into multiple stages: munging and cleaning data, analyzing / modeling it, then organizing the results of the analysis into a form suitable for plotting or tabular display. pandas is the ideal tool for all of these tasks.

Some other notes

- pandas is **fast**. Many of the low-level algorithmic bits have been extensively tweaked in Cython code. However, as with anything else generalization usually sacrifices performance. So if you focus on one feature for your application you may be able to create a faster specialized tool.
- pandas is a dependency of statsmodels, making it an important part of the statistical computing ecosystem in Python.
- pandas has been used extensively in production in financial applications.

Note: This documentation assumes general familiarity with NumPy. If you haven't used NumPy much or at all, do invest some time in learning about NumPy first.

See the package overview for more detail about what's in the library.

CHAPTER

ONE

WHAT'S NEW

These are new features and improvements of note in each release.

1.1 v0.21.0 (October 27, 2017)

This is a major release from 0.20.3 and includes a number of API changes, deprecations, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Integration with Apache Parquet, including a new top-level `read_parquet()` function and `DataFrame.to_parquet()` method, see *here*.
- New user-facing `pandas.api.types.CategoricalDtype` for specifying categoricals independent of the data, see *here*.
- The behavior of `sum` and `prod` on all-NaN Series/DataFrames is now consistent and no longer depends on whether bottleneck is installed, see *here*.
- Compatibility fixes for pypy, see *here*.
- Additions to the `drop`, `reindex` and `rename` API to make them more consistent, see *here*.
- Addition of the new methods `DataFrame.infer_objects` (see *here*) and `GroupBy.pipe` (see *here*).
- Indexing with a list of labels, where one or more of the labels is missing, is deprecated and will raise a KeyError in a future version, see *here*.

Check the *API Changes* and *deprecations* before updating.

What's new in v0.21.0

1.1.1 New features

1.1.1.1 Integration with Apache Parquet file format

Integration with Apache Parquet, including a new top-level *`read_parquet()`* and *`DataFrame.to_parquet()`* method, see *here* (GH15838, GH17438).

Apache Parquet provides a cross-language, binary file format for reading and writing data frames efficiently. Parquet is designed to faithfully serialize and de-serialize `DataFrame` s, supporting all of the pandas dtypes, including extension dtypes such as datetime with timezones.

This functionality depends on either the pyarrow or fastparquet library. For more details, see see *the IO docs on Parquet*.

1.1.1.2 `infer_objects` type conversion

The *`DataFrame.infer_objects()`* and *`Series.infer_objects()`* methods have been added to perform dtype inference on object columns, replacing some of the functionality of the deprecated `convert_objects` method. See the documentation *here* for more details. (GH11221)

This method only performs soft conversions on object columns, converting Python objects to native types, but not any coercive conversions. For example:

```
In [1]: df = pd.DataFrame({'A': [1, 2, 3],
   ...:                    'B': np.array([1, 2, 3], dtype='object'),
   ...:                    'C': ['1', '2', '3']})
   ...:

In [2]: df.dtypes
Out[2]:
A     int64
B    object
C    object
dtype: object

In [3]: df.infer_objects().dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[3]:
A     int64
B     int64
C    object
dtype: object
```

Note that column `'C'` was not converted - only scalar numeric types will be converted to a new type. Other types of conversion should be accomplished using the *`to_numeric()`* function (or *`to_datetime()`*, *`to_timedelta()`*).

```
In [4]: df = df.infer_objects()

In [5]: df['C'] = pd.to_numeric(df['C'], errors='coerce')

In [6]: df.dtypes
Out[6]:
A    int64
B    int64
C    int64
dtype: object
```

1.1.1.3 Improved warnings when attempting to create columns

New users are often puzzled by the relationship between column operations and attribute access on `DataFrame` instances (GH7175). One specific instance of this confusion is attempting to create a new column by setting an attribute on the `DataFrame`:

```
In[1]: df = pd.DataFrame({'one': [1., 2., 3.]})
In[2]: df.two = [4, 5, 6]
```

This does not raise any obvious exceptions, but also does not create a new column:

```
In[3]: df
Out[3]:
    one
0   1.0
1   2.0
2   3.0
```

Setting a list-like data structure into a new attribute now raises a `UserWarning` about the potential for unexpected behavior. See *Attribute Access*.

1.1.1.4 `drop` now also accepts index/columns keywords

The *`drop()`* method has gained `index`/`columns` keywords as an alternative to specifying the `axis`. This is similar to the behavior of `reindex` (GH12392).

For example:

```
In [7]: df = pd.DataFrame(np.arange(8).reshape(2,4),
   ...:                   columns=['A', 'B', 'C', 'D'])
   ...:

In [8]: df
Out[8]:
   A  B  C  D
0  0  1  2  3
1  4  5  6  7

In [9]: df.drop(['B', 'C'], axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[9]:
   A  D
0  0  3
1  4  7

# the following is now equivalent
In [10]: df.drop(columns=['B', 'C'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[10]:␣
↪
   A  D
0  0  3
1  4  7
```

1.1.1.5 `rename`, `reindex` now also accept axis keyword

The *`DataFrame.rename()`* and *`DataFrame.reindex()`* methods have gained the `axis` keyword to specify the axis to target with the operation (GH12392).

Here's `rename`:

```
In [11]: df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})

In [12]: df.rename(str.lower, axis='columns')
Out[12]:
   a  b
0  1  4
1  2  5
2  3  6

In [13]: df.rename(id, axis='index')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[13]:
            A  B
4453153456  1  4
4453153488  2  5
4453153520  3  6
```

And `reindex`:

```
In [14]: df.reindex(['A', 'B', 'C'], axis='columns')
Out[14]:
   A  B   C
0  1  4 NaN
1  2  5 NaN
2  3  6 NaN

In [15]: df.reindex([0, 1, 3], axis='index')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[15]:
     A    B
0  1.0  4.0
1  2.0  5.0
3  NaN  NaN
```

The "index, columns" style continues to work as before.

```
In [16]: df.rename(index=id, columns=str.lower)
Out[16]:
            a  b
4453153456  1  4
4453153488  2  5
4453153520  3  6

In [17]: df.reindex(index=[0, 1, 3], columns=['A', 'B', 'C'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[17]:␣
↪
     A    B   C
0  1.0  4.0 NaN
1  2.0  5.0 NaN
3  NaN  NaN NaN
```

We *highly* encourage using named arguments to avoid confusion when using either style.

1.1.1.6 `CategoricalDtype` for specifying categoricals

`pandas.api.types.CategoricalDtype` has been added to the public API and expanded to include the `categories` and `ordered` attributes. A `CategoricalDtype` can be used to specify the set of categories and

orderedness of an array, independent of the data. This can be useful for example, when converting string data to a `Categorical` (GH14711, GH15078, GH16015, GH17643):

```
In [18]: from pandas.api.types import CategoricalDtype

In [19]: s = pd.Series(['a', 'b', 'c', 'a'])  # strings

In [20]: dtype = CategoricalDtype(categories=['a', 'b', 'c', 'd'], ordered=True)

In [21]: s.astype(dtype)
Out[21]:
0    a
1    b
2    c
3    a
dtype: category
Categories (4, object): [a < b < c < d]
```

One place that deserves special mention is in *read_csv()*. Previously, with `dtype={'col': 'category'}`, the returned values and categories would always be strings.

```
In [22]: data = 'A,B\na,1\nb,2\nc,3'

In [23]: pd.read_csv(StringIO(data), dtype={'B': 'category'}).B.cat.categories
Out[23]: Index(['1', '2', '3'], dtype='object')
```

Notice the "object" dtype.

With a `CategoricalDtype` of all numerics, datetimes, or timedeltas, we can automatically convert to the correct type

```
In [24]: dtype = {'B': CategoricalDtype([1, 2, 3])}

In [25]: pd.read_csv(StringIO(data), dtype=dtype).B.cat.categories
Out[25]: Int64Index([1, 2, 3], dtype='int64')
```

The values have been correctly interpreted as integers.

The `.dtype` property of a `Categorical`, `CategoricalIndex` or a `Series` with categorical type will now return an instance of `CategoricalDtype`. While the repr has changed, `str(CategoricalDtype())` is still the string `'category'`. We'll take this moment to remind users that the *preferred* way to detect categorical data is to use *pandas.api.types.is_categorical_dtype()*, and not `str(dtype) == 'category'`.

See the *CategoricalDtype docs* for more.

1.1.1.7 `GroupBy` objects now have a `pipe` method

`GroupBy` objects now have a `pipe` method, similar to the one on `DataFrame` and `Series`, that allow for functions that take a `GroupBy` to be composed in a clean, readable syntax. (GH17871)

For a concrete example on combining `.groupby` and `.pipe` , imagine having a DataFrame with columns for stores, products, revenue and sold quantity. We'd like to do a groupwise calculation of *prices* (i.e. revenue/quantity) per store and per product. We could do this in a multi-step operation, but expressing it in terms of piping can make the code more readable.

First we set the data:

```
In [26]: import numpy as np

In [27]: n = 1000

In [28]: df = pd.DataFrame({'Store': np.random.choice(['Store_1', 'Store_2'], n),
   ....:                    'Product': np.random.choice(['Product_1', 'Product_2',
↪'Product_3'], n),
   ....:                    'Revenue': (np.random.random(n)*50+10).round(2),
   ....:                    'Quantity': np.random.randint(1, 10, size=n)})
   ....:

In [29]: df.head(2)
Out[29]:
     Product  Quantity  Revenue    Store
0  Product_3         1    14.23  Store_2
1  Product_2         8    46.07  Store_1
```

Now, to find prices per store/product, we can simply do:

```
In [30]: (df.groupby(['Store', 'Product'])
   ....:    .pipe(lambda grp: grp.Revenue.sum()/grp.Quantity.sum())
   ....:    .unstack().round(2))
   ....:
Out[30]:
Product  Product_1  Product_2  Product_3
Store
Store_1       7.26       7.00       7.22
Store_2       7.10       6.35       7.45
```

See the *documentation* for more.

1.1.1.8 `Categorical.rename_categories` accepts a dict-like

`rename_categories()` now accepts a dict-like argument for `new_categories`. The previous categories are looked up in the dictionary's keys and replaced if found. The behavior of missing and extra keys is the same as in *`DataFrame.rename()`*.

```
In [31]: c = pd.Categorical(['a', 'a', 'b'])

In [32]: c.rename_categories({"a": "eh", "b": "bee"})
Out[32]:
[eh, eh, bee]
Categories (2, object): [eh, bee]
```

Warning: To assist with upgrading pandas, `rename_categories` treats `Series` as list-like. Typically, Series are considered to be dict-like (e.g. in `.rename`, `.map`). In a future version of pandas `rename_categories` will change to treat them as dict-like. Follow the warning message's recommendations for writing future-proof code.

```
In [33]: c.rename_categories(pd.Series([0, 1], index=['a', 'c']))
FutureWarning: Treating Series 'new_categories' as a list-like and using the values.
In a future version, 'rename_categories' will treat Series like a dictionary.
For dict-like, use 'new_categories.to_dict()'
For list-like, use 'new_categories.values'.
Out[33]:
[0, 0, 1]
Categories (2, int64): [0, 1]
```

1.1.1.9 Other Enhancements

New functions or methods

- *nearest()* is added to support nearest-neighbor upsampling (GH17496).
- *Index* has added support for a `to_frame` method (GH15230).

New keywords

- Added a `skipna` parameter to *infer_dtype()* to support type inference in the presence of missing values (GH17059).
- *Series.to_dict()* and *DataFrame.to_dict()* now support an `into` keyword which allows you to specify the `collections.Mapping` subclass that you would like returned. The default is `dict`, which is backwards compatible. (GH16122)
- *Series.set_axis()* and *DataFrame.set_axis()* now support the `inplace` parameter. (GH14636)
- *Series.to_pickle()* and *DataFrame.to_pickle()* have gained a `protocol` parameter (GH16252). By default, this parameter is set to HIGHEST_PROTOCOL
- *read_feather()* has gained the `nthreads` parameter for multi-threaded operations (GH16359)
- *DataFrame.clip()* and *Series.clip()* have gained an `inplace` argument. (GH15388)
- *crosstab()* has gained a `margins_name` parameter to define the name of the row / column that will contain the totals when `margins=True`. (GH15972)
- *read_json()* now accepts a `chunksize` parameter that can be used when `lines=True`. If `chunksize` is passed, read_json now returns an iterator which reads in `chunksize` lines with each iteration. (GH17048)
- *read_json()* and *to_json()* now accept a `compression` argument which allows them to transparently handle compressed files. (GH17798)

Various enhancements

- Improved the import time of pandas by about 2.25x. (GH16764)
- Support for PEP 519 – Adding a file system path protocol on most readers (e.g. *read_csv()*) and writers (e.g. *DataFrame.to_csv()*) (GH13823).
- Added a `__fspath__` method to `pd.HDFStore`, `pd.ExcelFile`, and `pd.ExcelWriter` to work properly with the file system path protocol (GH13823).
- The `validate` argument for *merge()* now checks whether a merge is one-to-one, one-to-many, many-to-one, or many-to-many. If a merge is found to not be an example of specified merge type, an exception of type `MergeError` will be raised. For more, see *here* (GH16270)
- Added support for PEP 518 (`pyproject.toml`) to the build system (GH16745)
- `RangeIndex.append()` now returns a `RangeIndex` object when possible (GH16212)
- *Series.rename_axis()* and *DataFrame.rename_axis()* with `inplace=True` now return `None` while renaming the axis inplace. (GH15704)

- `api.types.infer_dtype()` now infers decimals. (GH15690)
- `DataFrame.select_dtypes()` now accepts scalar values for include/exclude as well as list-like. (GH16855)
- `date_range()` now accepts 'YS' in addition to 'AS' as an alias for start of year. (GH9313)
- `date_range()` now accepts 'Y' in addition to 'A' as an alias for end of year. (GH9313)
- `DataFrame.add_prefix()` and `DataFrame.add_suffix()` now accept strings containing the '%' character. (GH17151)
- Read/write methods that infer compression (`read_csv()`, `read_table()`, `read_pickle()`, and `to_pickle()`) can now infer from path-like objects, such as `pathlib.Path`. (GH17206)
- `read_sas()` now recognizes much more of the most frequently used date (datetime) formats in SAS7BDAT files. (GH15871)
- `DataFrame.items()` and `Series.items()` are now present in both Python 2 and 3 and is lazy in all cases. (GH13918, GH17213)
- `pandas.io.formats.style.Styler.where()` has been implemented as a convenience for `pandas.io.formats.style.Styler.applymap()`. (GH17474)
- `MultiIndex.is_monotonic_decreasing()` has been implemented. Previously returned `False` in all cases. (GH16554)
- `read_excel()` raises `ImportError` with a better message if `xlrd` is not installed. (GH17613)
- `DataFrame.assign()` will preserve the original order of `**kwargs` for Python 3.6+ users instead of sorting the column names. (GH14207)
- `Series.reindex()`, `DataFrame.reindex()`, `Index.get_indexer()` now support list-like argument for `tolerance`. (GH17367)

1.1.2 Backwards incompatible API changes

1.1.2.1 Dependencies have increased minimum versions

We have updated our minimum supported versions of dependencies (GH15206, GH15543, GH15214). If installed, we now require:

Package	Minimum Version	Required
Numpy	1.9.0	X
Matplotlib	1.4.3	
Scipy	0.14.0	
Bottleneck	1.0.0	

Additionally, support has been dropped for Python 3.4 (GH15251).

1.1.2.2 Sum/Prod of all-NaN Series/DataFrames is now consistently NaN

The behavior of `sum` and `prod` on all-NaN Series/DataFrames no longer depends on whether bottleneck is installed. (GH9422, GH15507).

Calling `sum` or `prod` on an empty or all-`NaN` `Series`, or columns of a `DataFrame`, will result in `NaN`. See the *docs*.

```
In [33]: s = Series([np.nan])
```

Previously NO `bottleneck`

```
In [2]: s.sum()
Out[2]: np.nan
```

Previously WITH `bottleneck`

```
In [2]: s.sum()
Out[2]: 0.0
```

New Behavior, without regard to the bottleneck installation.

```
In [34]: s.sum()
Out[34]: nan
```

Note that this also changes the sum of an empty `Series`

Previously regardless of `bottlenck`

```
In [1]: pd.Series([]).sum()
Out[1]: 0
```

```
In [35]: pd.Series([]).sum()
Out[35]: nan
```

1.1.2.3 Indexing with a list with missing labels is Deprecated

Previously, selecting with a list of labels, where one or more labels were missing would always succeed, returning `NaN` for missing labels. This will now show a `FutureWarning`. In the future this will raise a `KeyError` (GH15747). This warning will trigger on a `DataFrame` or a `Series` for using `.loc[]` or `[[]]` when passing a list-of-labels with at least 1 missing label. See the *deprecation docs*.

```
In [36]: s = pd.Series([1, 2, 3])

In [37]: s
Out[37]:
0    1
1    2
2    3
dtype: int64
```

Previous Behavior

```
In [4]: s.loc[[1, 2, 3]]
Out[4]:
1    2.0
2    3.0
3    NaN
dtype: float64
```

Current Behavior

```
In [4]: s.loc[[1, 2, 3]]
Passing list-likes to .loc or [] with any missing label will raise
KeyError in the future, you can use .reindex() as an alternative.

See the documentation here:
```

```
http://pandas.pydata.org/pandas-docs/stable/indexing.html#deprecate-loc-reindex-
↪listlike

Out[4]:
1    2.0
2    3.0
3    NaN
dtype: float64
```

The idiomatic way to achieve selecting potentially not-found elements is via `.reindex()`

```
In [38]: s.reindex([1, 2, 3])
Out[38]:
1    2.0
2    3.0
3    NaN
dtype: float64
```

Selection with all keys found is unchanged.

```
In [39]: s.loc[[1, 2]]
Out[39]:
1    2
2    3
dtype: int64
```

1.1.2.4 NA naming Changes

In order to promote more consistency among the pandas API, we have added additional top-level functions *isna()* and *notna()* that are aliases for *isnull()* and *notnull()*. The naming scheme is now more consistent with methods like `.dropna()` and `.fillna()`. Furthermore in all cases where `.isnull()` and `.notnull()` methods are defined, these have additional methods named `.isna()` and `.notna()`, these are included for classes `Categorical`, `Index`, `Series`, and `DataFrame`. (GH15001).

The configuration option `pd.options.mode.use_inf_as_null` is deprecated, and `pd.options.mode.use_inf_as_na` is added as a replacement.

1.1.2.5 Iteration of Series/Index will now return Python scalars

Previously, when using certain iteration methods for a `Series` with dtype `int` or `float`, you would receive a `numpy` scalar, e.g. a `np.int64`, rather than a Python `int`. Issue (GH10904) corrected this for `Series.tolist()` and `list(Series)`. This change makes all iteration methods consistent, in particular, for `__iter__()` and `.map()`; note that this only affects int/float dtypes. (GH13236, GH13258, GH14216).

```
In [40]: s = pd.Series([1, 2, 3])

In [41]: s
Out[41]:
0    1
1    2
2    3
dtype: int64
```

Previously:

```
In [2]: type(list(s)[0])
Out[2]: numpy.int64
```

New Behaviour:

```
In [42]: type(list(s)[0])
Out[42]: int
```

Furthermore this will now correctly box the results of iteration for *DataFrame.to_dict()* as well.

```
In [43]: d = {'a':[1], 'b':['b']}

In [44]: df = pd.DataFrame(d)
```

Previously:

```
In [8]: type(df.to_dict()['a'][0])
Out[8]: numpy.int64
```

New Behaviour:

```
In [45]: type(df.to_dict()['a'][0])
Out[45]: int
```

1.1.2.6 Indexing with a Boolean Index

Previously when passing a boolean `Index` to `.loc`, if the index of the `Series/DataFrame` had `boolean` labels, you would get a label based selection, potentially duplicating result labels, rather than a boolean indexing selection (where `True` selects elements), this was inconsistent how a boolean numpy array indexed. The new behavior is to act like a boolean numpy array indexer. (GH17738)

Previous Behavior:

```
In [46]: s = pd.Series([1, 2, 3], index=[False, True, False])

In [47]: s
Out[47]:
False    1
True     2
False    3
dtype: int64
```

```
In [59]: s.loc[pd.Index([True, False, True])]
Out[59]:
True     2
False    1
False    3
True     2
dtype: int64
```

Current Behavior

```
In [48]: s.loc[pd.Index([True, False, True])]
Out[48]:
False    1
```

```
False    3
dtype: int64
```

Furthermore, previously if you had an index that was non-numeric (e.g. strings), then a boolean Index would raise a `KeyError`. This will now be treated as a boolean indexer.

Previously Behavior:

```
In [49]: s = pd.Series([1,2,3], index=['a', 'b', 'c'])

In [50]: s
Out[50]:
a    1
b    2
c    3
dtype: int64
```

```
In [39]: s.loc[pd.Index([True, False, True])]
KeyError: "None of [Index([True, False, True], dtype='object')] are in the [index]"
```

Current Behavior

```
In [51]: s.loc[pd.Index([True, False, True])]
Out[51]:
a    1
c    3
dtype: int64
```

1.1.2.7 `PeriodIndex` resampling

In previous versions of pandas, resampling a `Series/DataFrame` indexed by a `PeriodIndex` returned a `DatetimeIndex` in some cases (GH12884). Resampling to a multiplied frequency now returns a `PeriodIndex` (GH15944). As a minor enhancement, resampling a `PeriodIndex` can now handle `NaT` values (GH13224)

Previous Behavior:

```
In [1]: pi = pd.period_range('2017-01', periods=12, freq='M')

In [2]: s = pd.Series(np.arange(12), index=pi)

In [3]: resampled = s.resample('2Q').mean()

In [4]: resampled
Out[4]:
2017-03-31     1.0
2017-09-30     5.5
2018-03-31    10.0
Freq: 2Q-DEC, dtype: float64

In [5]: resampled.index
Out[5]: DatetimeIndex(['2017-03-31', '2017-09-30', '2018-03-31'], dtype=
↪'datetime64[ns]', freq='2Q-DEC')
```

New Behavior:

```
In [52]: pi = pd.period_range('2017-01', periods=12, freq='M')

In [53]: s = pd.Series(np.arange(12), index=pi)

In [54]: resampled = s.resample('2Q').mean()

In [55]: resampled
Out[55]:
2017Q1    2.5
2017Q3    8.5
Freq: 2Q-DEC, dtype: float64

In [56]: resampled.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[56]:␣
↪PeriodIndex(['2017Q1', '2017Q3'], dtype='period[2Q-DEC]', freq='2Q-DEC')
```

Upsampling and calling `.ohlc()` previously returned a `Series`, basically identical to calling `.asfreq()`. OHLC upsampling now returns a DataFrame with columns `open`, `high`, `low` and `close` (GH13083). This is consistent with downsampling and `DatetimeIndex` behavior.

Previous Behavior:

```
In [1]: pi = pd.PeriodIndex(start='2000-01-01', freq='D', periods=10)

In [2]: s = pd.Series(np.arange(10), index=pi)

In [3]: s.resample('H').ohlc()
Out[3]:
2000-01-01 00:00    0.0
                ...
2000-01-10 23:00    NaN
Freq: H, Length: 240, dtype: float64

In [4]: s.resample('M').ohlc()
Out[4]:
         open  high  low  close
2000-01     0     9    0      9
```

New Behavior:

```
In [57]: pi = pd.PeriodIndex(start='2000-01-01', freq='D', periods=10)

In [58]: s = pd.Series(np.arange(10), index=pi)

In [59]: s.resample('H').ohlc()
Out[59]:
                  open  high  low  close
2000-01-01 00:00   0.0   0.0  0.0    0.0
2000-01-01 01:00   NaN   NaN  NaN    NaN
2000-01-01 02:00   NaN   NaN  NaN    NaN
2000-01-01 03:00   NaN   NaN  NaN    NaN
2000-01-01 04:00   NaN   NaN  NaN    NaN
2000-01-01 05:00   NaN   NaN  NaN    NaN
2000-01-01 06:00   NaN   NaN  NaN    NaN
...                ...   ...  ...    ...
2000-01-10 17:00   NaN   NaN  NaN    NaN
2000-01-10 18:00   NaN   NaN  NaN    NaN
2000-01-10 19:00   NaN   NaN  NaN    NaN
```

```
2000-01-10 20:00   NaN   NaN  NaN    NaN
2000-01-10 21:00   NaN   NaN  NaN    NaN
2000-01-10 22:00   NaN   NaN  NaN    NaN
2000-01-10 23:00   NaN   NaN  NaN    NaN

[240 rows x 4 columns]

In [60]: s.resample('M').ohlc()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
         open  high  low  close
2000-01     0     9    0      9
```

1.1.2.8 Improved error handling during item assignment in pd.eval

`eval()` will now raise a `ValueError` when item assignment malfunctions, or inplace operations are specified, but there is no item assignment in the expression (GH16732)

```
In [61]: arr = np.array([1, 2, 3])
```

Previously, if you attempted the following expression, you would get a not very helpful error message:

```
In [3]: pd.eval("a = 1 + 2", target=arr, inplace=True)
...
IndexError: only integers, slices (`:`), ellipsis (`...`), numpy.newaxis (`None`)
and integer or boolean arrays are valid indices
```

This is a very long way of saying numpy arrays don't support string-item indexing. With this change, the error message is now this:

```
In [3]: pd.eval("a = 1 + 2", target=arr, inplace=True)
...
ValueError: Cannot assign expression output to target
```

It also used to be possible to evaluate expressions inplace, even if there was no item assignment:

```
In [4]: pd.eval("1 + 2", target=arr, inplace=True)
Out[4]: 3
```

However, this input does not make much sense because the output is not being assigned to the target. Now, a `ValueError` will be raised when such an input is passed in:

```
In [4]: pd.eval("1 + 2", target=arr, inplace=True)
...
ValueError: Cannot operate inplace if there is no assignment
```

1.1.2.9 Dtype Conversions

Previously assignments, `.where()` and `.fillna()` with a `bool` assignment, would coerce to same the type (e.g. int / float), or raise for datetimelikes. These will now preserve the bools with `object` dtypes. (GH16821).

```
In [62]: s = Series([1, 2, 3])
```

```
In [5]: s[1] = True

In [6]: s
Out[6]:
0    1
1    1
2    3
dtype: int64
```

New Behavior

```
In [63]: s[1] = True

In [64]: s
Out[64]:
0       1
1    True
2       3
dtype: object
```

Previously, as assignment to a datetimelike with a non-datetimelike would coerce the non-datetime-like item being assigned (GH14145).

```
In [65]: s = pd.Series([pd.Timestamp('2011-01-01'), pd.Timestamp('2012-01-01')])
```

```
In [1]: s[1] = 1

In [2]: s
Out[2]:
0   2011-01-01 00:00:00.000000000
1   1970-01-01 00:00:00.000000001
dtype: datetime64[ns]
```

These now coerce to `object` dtype.

```
In [66]: s[1] = 1

In [67]: s
Out[67]:
0    2011-01-01 00:00:00
1                      1
dtype: object
```

- Inconsistent behavior in `.where()` with datetimelikes which would raise rather than coerce to `object` (GH16402)
- Bug in assignment against `int64` data with `np.ndarray` with `float64` dtype may keep `int64` dtype (GH14001)

1.1.2.10 MultiIndex Constructor with a Single Level

The `MultiIndex` constructors no longer squeezes a MultiIndex with all length-one levels down to a regular `Index`. This affects all the `MultiIndex` constructors. (GH17178)

Previous behavior:

```
In [2]: pd.MultiIndex.from_tuples([('a',), ('b',)])
Out[2]: Index(['a', 'b'], dtype='object')
```

Length 1 levels are no longer special-cased. They behave exactly as if you had length 2+ levels, so a *MultiIndex* is always returned from all of the `MultiIndex` constructors:

```
In [68]: pd.MultiIndex.from_tuples([('a',), ('b',)])
Out[68]:
MultiIndex(levels=[['a', 'b']],
           labels=[[0, 1]])
```

1.1.2.11 UTC Localization with Series

Previously, *to_datetime()* did not localize datetime `Series` data when `utc=True` was passed. Now, *to_datetime()* will correctly localize `Series` with a `datetime64[ns, UTC]` dtype to be consistent with how list-like and `Index` data are handled. (GH6415).

Previous Behavior

```
In [69]: s = Series(['20130101 00:00:00'] * 3)
```

```
In [12]: pd.to_datetime(s, utc=True)
Out[12]:
0   2013-01-01
1   2013-01-01
2   2013-01-01
dtype: datetime64[ns]
```

New Behavior

```
In [70]: pd.to_datetime(s, utc=True)
Out[70]:
0   2013-01-01 00:00:00+00:00
1   2013-01-01 00:00:00+00:00
2   2013-01-01 00:00:00+00:00
dtype: datetime64[ns, UTC]
```

Additionally, DataFrames with datetime columns that were parsed by *read_sql_table()* and *read_sql_query()* will also be localized to UTC only if the original SQL columns were timezone aware datetime columns.

1.1.2.12 Consistency of Range Functions

In previous versions, there were some inconsistencies between the various range functions: *date_range()*, *bdate_range()*, *period_range()*, *timedelta_range()*, and *interval_range()*. (GH17471).

One of the inconsistent behaviors occurred when the `start`, `end` and `period` parameters were all specified, potentially leading to ambiguous ranges. When all three parameters were passed, `interval_range` ignored the `period` parameter, `period_range` ignored the `end` parameter, and the other range functions raised. To promote consistency among the range functions, and avoid potentially ambiguous ranges, `interval_range` and `period_range` will now raise when all three parameters are passed.

Previous Behavior:

```
In [2]: pd.interval_range(start=0, end=4, periods=6)
Out[2]:
IntervalIndex([(0, 1], (1, 2], (2, 3]]
              closed='right',
              dtype='interval[int64]')

In [3]: pd.period_range(start='2017Q1', end='2017Q4', periods=6, freq='Q')
Out[3]: PeriodIndex(['2017Q1', '2017Q2', '2017Q3', '2017Q4', '2018Q1', '2018Q2'],␣
↪dtype='period[Q-DEC]', freq='Q-DEC')
```

New Behavior:

```
In [2]: pd.interval_range(start=0, end=4, periods=6)
---------------------------------------------------------------------------
ValueError: Of the three parameters: start, end, and periods, exactly two must be␣
↪specified

In [3]: pd.period_range(start='2017Q1', end='2017Q4', periods=6, freq='Q')
---------------------------------------------------------------------------
ValueError: Of the three parameters: start, end, and periods, exactly two must be␣
↪specified
```

Additionally, the endpoint parameter `end` was not included in the intervals produced by `interval_range`. However, all other range functions include `end` in their output. To promote consistency among the range functions, `interval_range` will now include `end` as the right endpoint of the final interval, except if `freq` is specified in a way which skips `end`.

Previous Behavior:

```
In [4]: pd.interval_range(start=0, end=4)
Out[4]:
IntervalIndex([(0, 1], (1, 2], (2, 3]]
              closed='right',
              dtype='interval[int64]')
```

New Behavior:

```
In [71]: pd.interval_range(start=0, end=4)
Out[71]:
IntervalIndex([(0, 1], (1, 2], (2, 3], (3, 4]]
              closed='right',
              dtype='interval[int64]')
```

1.1.2.13 Other API Changes

- The Categorical constructor no longer accepts a scalar for the `categories` keyword. (GH16022)
- Accessing a non-existent attribute on a closed `HDFStore` will now raise an `AttributeError` rather than a `ClosedFileError` (GH16301)
- *`read_csv()`* now issues a `UserWarning` if the `names` parameter contains duplicates (GH17095)
- *`read_csv()`* now treats `'null'` and `'n/a'` strings as missing values by default (GH16471, GH16078)
- `pandas.HDFStore`'s string representation is now faster and less detailed. For the previous behavior, use `pandas.HDFStore.info()`. (GH16503).

- Compression defaults in HDF stores now follow pytables standards. Default is no compression and if `complib` is missing and `complevel` > 0 `zlib` is used (GH15943)
- `Index.get_indexer_non_unique()` now returns a ndarray indexer rather than an `Index`; this is consistent with `Index.get_indexer()` (GH16819)
- Removed the `@slow` decorator from `pandas.util.testing`, which caused issues for some downstream packages' test suites. Use `@pytest.mark.slow` instead, which achieves the same thing (GH16850)
- Moved definition of `MergeError` to the `pandas.errors` module.
- The signature of *`Series.set_axis()`* and *`DataFrame.set_axis()`* has been changed from `set_axis(axis, labels)` to `set_axis(labels, axis=0)`, for consistency with the rest of the API. The old signature is deprecated and will show a `FutureWarning` (GH14636)
- *`Series.argmin()`* and *`Series.argmax()`* will now raise a `TypeError` when used with `object` dtypes, instead of a `ValueError` (GH13595)
- *`Period`* is now immutable, and will now raise an `AttributeError` when a user tries to assign a new value to the `ordinal` or `freq` attributes (GH17116).
- *`to_datetime()`* when passed a tz-aware `origin=` kwarg will now raise a more informative `ValueError` rather than a `TypeError` (GH16842)
- *`to_datetime()`* now raises a `ValueError` when format includes `%W` or `%U` without also including day of the week and calendar year (GH16774)
- Renamed non-functional `index` to `index_col` in *`read_stata()`* to improve API consistency (GH16342)
- Bug in *`DataFrame.drop()`* caused boolean labels `False` and `True` to be treated as labels 0 and 1 respectively when dropping indices from a numeric index. This will now raise a ValueError (GH16877)
- Restricted DateOffset keyword arguments. Previously, `DateOffset` subclasses allowed arbitrary keyword arguments which could lead to unexpected behavior. Now, only valid arguments will be accepted. (GH17176).
- Pandas no longer registers matplotlib converters on import. The converters will be registered and used when the first plot is draw (GH17710)

1.1.3 Deprecations

- *`DataFrame.from_csv()`* and *`Series.from_csv()`* have been deprecated in favor of *`read_csv()`* (GH4191)
- *`read_excel()`* has deprecated `sheetname` in favor of `sheet_name` for consistency with `.to_excel()` (GH10559).
- *`read_excel()`* has deprecated `parse_cols` in favor of `usecols` for consistency with *`read_csv()`* (GH4988)
- *`read_csv()`* has deprecated the `tupleize_cols` argument. Column tuples will always be converted to a `MultiIndex` (GH17060)
- *`DataFrame.to_csv()`* has deprecated the `tupleize_cols` argument. Multi-index columns will be always written as rows in the CSV file (GH17060)
- The `convert` parameter has been deprecated in the `.take()` method, as it was not being respected (GH16948)
- `pd.options.html.border` has been deprecated in favor of `pd.options.display.html.border` (GH15793).
- `SeriesGroupBy.nth()` has deprecated `True` in favor of `'all'` for its kwarg `dropna` (GH11038).

- *DataFrame.as_blocks()* is deprecated, as this is exposing the internal implementation (GH17302)
- pd.TimeGrouper is deprecated in favor of *pandas.Grouper* (GH16747)
- cdate_range has been deprecated in favor of *bdate_range()*, which has gained weekmask and holidays parameters for building custom frequency date ranges. See the *documentation* for more details (GH17596)
- passing categories or ordered kwargs to *Series.astype()* is deprecated, in favor of passing a *CategoricalDtype* (GH17636)
- .get_value and .set_value on Series, DataFrame, Panel, SparseSeries, and SparseDataFrame are deprecated in favor of using .iat[] or .at[] accessors (GH15269)
- Passing a non-existent column in .to_excel(..., columns=) is deprecated and will raise a KeyError in the future (GH17295)
- raise_on_error parameter to *Series.where()*, *Series.mask()*, *DataFrame.where()*, *DataFrame.mask()* is deprecated, in favor of errors= (GH14968)
- Using *DataFrame.rename_axis()* and *Series.rename_axis()* to alter index or column *labels* is now deprecated in favor of using .rename. rename_axis may still be used to alter the name of the index or columns (GH17833).
- *reindex_axis()* has been deprecated in favor of *reindex()*. See *here* for more (GH17833).

1.1.3.1 Series.select and DataFrame.select

The *Series.select()* and *DataFrame.select()* methods are deprecated in favor of using df.loc[labels.map(crit)] (GH12401)

```
In [72]: df = DataFrame({'A': [1, 2, 3]}, index=['foo', 'bar', 'baz'])
```

```
In [3]: df.select(lambda x: x in ['bar', 'baz'])
FutureWarning: select is deprecated and will be removed in a future release. You can␣
↪use .loc[crit] as a replacement
Out[3]:
     A
bar  2
baz  3
```

```
In [73]: df.loc[df.index.map(lambda x: x in ['bar', 'baz'])]
Out[73]:
     A
bar  2
baz  3
```

1.1.3.2 Series.argmax and Series.argmin

The behavior of *Series.argmax()* and *Series.argmin()* have been deprecated in favor of *Series.idxmax()* and *Series.idxmin()*, respectively (GH16830).

For compatibility with NumPy arrays, pd.Series implements argmax and argmin. Since pandas 0.13.0, argmax has been an alias for *pandas.Series.idxmax()*, and argmin has been an alias for *pandas.Series.idxmin()*. They return the *label* of the maximum or minimum, rather than the *position*.

We've deprecated the current behavior of `Series.argmax` and `Series.argmin`. Using either of these will emit a `FutureWarning`. Use *`Series.idxmax()`* if you want the label of the maximum. Use `Series.values.argmax()` if you want the position of the maximum. Likewise for the minimum. In a future release `Series.argmax` and `Series.argmin` will return the position of the maximum or minimum.

1.1.4 Removal of prior version deprecations/changes

- *`read_excel()`* has dropped the `has_index_names` parameter (GH10967)
- The `pd.options.display.height` configuration has been dropped (GH3663)
- The `pd.options.display.line_width` configuration has been dropped (GH2881)
- The `pd.options.display.mpl_style` configuration has been dropped (GH12190)
- `Index` has dropped the `.sym_diff()` method in favor of `.symmetric_difference()` (GH12591)
- `Categorical` has dropped the `.order()` and `.sort()` methods in favor of `.sort_values()` (GH12882)
- *`eval()`* and *`DataFrame.eval()`* have changed the default of `inplace` from `None` to `False` (GH11149)
- The function `get_offset_name` has been dropped in favor of the `.freqstr` attribute for an offset (GH11834)
- pandas no longer tests for compatibility with hdf5-files created with pandas < 0.11 (GH17404).

1.1.5 Performance Improvements

- Improved performance of instantiating `SparseDataFrame` (GH16773)
- *`Series.dt`* no longer performs frequency inference, yielding a large speedup when accessing the attribute (GH17210)
- Improved performance of *`set_categories()`* by not materializing the values (GH17508)
- *`Timestamp.microsecond`* no longer re-computes on attribute access (GH17331)
- Improved performance of the *`CategoricalIndex`* for data that is already categorical dtype (GH17513)
- Improved performance of `RangeIndex.min()` and `RangeIndex.max()` by using `RangeIndex` properties to perform the computations (GH17607)

1.1.6 Documentation Changes

- Several `NaT` method docstrings (e.g. `NaT.ctime()`) were incorrect (GH17327)
- The documentation has had references to versions < v0.17 removed and cleaned up (GH17442, GH17442, GH17404 & GH17504)

1.1.7 Bug Fixes

1.1.7.1 Conversion

- Bug in assignment against datetime-like data with `int` may incorrectly convert to datetime-like (GH14145)
- Bug in assignment against `int64` data with `np.ndarray` with `float64` dtype may keep `int64` dtype (GH14001)

- Fixed the return type of `IntervalIndex.is_non_overlapping_monotonic` to be a Python `bool` for consistency with similar attributes/methods. Previously returned a `numpy.bool_`. (GH17237)
- Bug in `IntervalIndex.is_non_overlapping_monotonic` when intervals are closed on both sides and overlap at a point (GH16560)
- Bug in *`Series.fillna()`* returns frame when `inplace=True` and `value` is dict (GH16156)
- Bug in *`Timestamp.weekday_name`* returning a UTC-based weekday name when localized to a timezone (GH17354)
- Bug in `Timestamp.replace` when replacing `tzinfo` around DST changes (GH15683)
- Bug in `Timedelta` construction and arithmetic that would not propagate the `Overflow` exception (GH17367)
- Bug in *`astype()`* converting to object dtype when passed extension type classes (*DatetimeTZDtype*', `CategoricalDtype`) rather than instances. Now a `TypeError` is raised when a class is passed (GH17780).
- Bug in *`to_numeric()`* in which elements were not always being coerced to numeric when `errors='coerce'` (GH17007, GH17125)
- Bug in `DataFrame` and `Series` constructors where `range` objects are converted to `int32` dtype on Windows instead of `int64` (GH16804)

1.1.7.2 Indexing

- When called with a null slice (e.g. `df.iloc[:]`), the `.iloc` and `.loc` indexers return a shallow copy of the original object. Previously they returned the original object. (GH13873).
- When called on an unsorted `MultiIndex`, the `loc` indexer now will raise `UnsortedIndexError` only if proper slicing is used on non-sorted levels (GH16734).
- Fixes regression in 0.20.3 when indexing with a string on a `TimedeltaIndex` (GH16896).
- Fixed *`TimedeltaIndex.get_loc()`* handling of `np.timedelta64` inputs (GH16909).
- Fix `MultiIndex.sort_index()` ordering when `ascending` argument is a list, but not all levels are specified, or are in a different order (GH16934).
- Fixes bug where indexing with `np.inf` caused an `OverflowError` to be raised (GH16957)
- Bug in reindexing on an empty `CategoricalIndex` (GH16770)
- Fixes `DataFrame.loc` for setting with alignment and tz-aware `DatetimeIndex` (GH16889)
- Avoids `IndexError` when passing an Index or Series to `.iloc` with older numpy (GH17193)
- Allow unicode empty strings as placeholders in multilevel columns in Python 2 (GH17099)
- Bug in `.iloc` when used with inplace addition or assignment and an int indexer on a `MultiIndex` causing the wrong indexes to be read from and written to (GH17148)
- Bug in `.isin()` in which checking membership in empty `Series` objects raised an error (GH16991)
- Bug in `CategoricalIndex` reindexing in which specified indices containing duplicates were not being respected (GH17323)
- Bug in intersection of `RangeIndex` with negative step (GH17296)
- Bug in `IntervalIndex` where performing a scalar lookup fails for included right endpoints of non-overlapping monotonic decreasing indexes (GH16417, GH17271)
- Bug in *`DataFrame.first_valid_index()`* and *`DataFrame.last_valid_index()`* when no valid entry (GH17400)

- Bug in `Series.rename()` when called with a callable, incorrectly alters the name of the `Series`, rather than the name of the `Index`. (GH17407)
- Bug in `String.str_get()` raises `IndexError` instead of inserting NaNs when using a negative index. (GH17704)

1.1.7.3 I/O

- Bug in `read_hdf()` when reading a timezone aware index from `fixed` format HDFStore (GH17618)
- Bug in `read_csv()` in which columns were not being thoroughly de-duplicated (GH17060)
- Bug in `read_csv()` in which specified column names were not being thoroughly de-duplicated (GH17095)
- Bug in `read_csv()` in which non integer values for the header argument generated an unhelpful / unrelated error message (GH16338)
- Bug in `read_csv()` in which memory management issues in exception handling, under certain conditions, would cause the interpreter to segfault (GH14696, GH16798).
- Bug in `read_csv()` when called with `low_memory=False` in which a CSV with at least one column > 2GB in size would incorrectly raise a `MemoryError` (GH16798).
- Bug in `read_csv()` when called with a single-element list `header` would return a `DataFrame` of all NaN values (GH7757)
- Bug in `DataFrame.to_csv()` defaulting to 'ascii' encoding in Python 3, instead of 'utf-8' (GH17097)
- Bug in `read_stata()` where value labels could not be read when using an iterator (GH16923)
- Bug in `read_stata()` where the index was not set (GH16342)
- Bug in `read_html()` where import check fails when run in multiple threads (GH16928)
- Bug in `read_csv()` where automatic delimiter detection caused a `TypeError` to be thrown when a bad line was encountered rather than the correct error message (GH13374)
- Bug in `DataFrame.to_html()` with `notebook=True` where DataFrames with named indices or non-MultiIndex indices had undesired horizontal or vertical alignment for column or row labels, respectively (GH16792)
- Bug in `DataFrame.to_html()` in which there was no validation of the `justify` parameter (GH17527)
- Bug in `HDFStore.select()` when reading a contiguous mixed-data table featuring VLArray (GH17021)
- Bug in `to_json()` where several conditions (including objects with unprintable symbols, objects with deep recursion, overlong labels) caused segfaults instead of raising the appropriate exception (GH14256)

1.1.7.4 Plotting

- Bug in plotting methods using `secondary_y` and `fontsize` not setting secondary axis font size (GH12565)
- Bug when plotting `timedelta` and `datetime` dtypes on y-axis (GH16953)
- Line plots no longer assume monotonic x data when calculating xlims, they show the entire lines now even for unsorted x data. (GH11310, GH11471)
- With matplotlib 2.0.0 and above, calculation of x limits for line plots is left to matplotlib, so that its new default settings are applied. (GH15495)
- Bug in `Series.plot.bar` or `DataFrame.plot.bar` with `y` not respecting user-passed `color` (GH16822)

- Bug causing `plotting.parallel_coordinates` to reset the random seed when using random colors (GH17525)

1.1.7.5 Groupby/Resample/Rolling

- Bug in `DataFrame.resample(...).size()` where an empty `DataFrame` did not return a `Series` (GH14962)
- Bug in *`infer_freq()`* causing indices with 2-day gaps during the working week to be wrongly inferred as business daily (GH16624)
- Bug in `.rolling(...).quantile()` which incorrectly used different defaults than *`Series.quantile()`* and *`DataFrame.quantile()`* (GH9413, GH16211)
- Bug in `groupby.transform()` that would coerce boolean dtypes back to float (GH16875)
- Bug in `Series.resample(...).apply()` where an empty `Series` modified the source index and did not return the name of a `Series` (GH14313)
- Bug in `.rolling(...).apply(...)` with a `DataFrame` with a `DatetimeIndex`, a `window` of a timedelta-convertible and `min_periods >= 1` (GH15305)
- Bug in `DataFrame.groupby` where index and column keys were not recognized correctly when the number of keys equaled the number of elements on the groupby axis (GH16859)
- Bug in `groupby.nunique()` with `TimeGrouper` which cannot handle `NaT` correctly (GH17575)
- Bug in `DataFrame.groupby` where a single level selection from a `MultiIndex` unexpectedly sorts (GH17537)
- Bug in `DataFrame.groupby` where spurious warning is raised when `Grouper` object is used to override ambiguous column name (GH17383)
- Bug in `TimeGrouper` differs when passes as a list and as a scalar (GH17530)

1.1.7.6 Sparse

- Bug in `SparseSeries` raises `AttributeError` when a dictionary is passed in as data (GH16905)
- Bug in `SparseDataFrame.fillna()` not filling all NaNs when frame was instantiated from SciPy sparse matrix (GH16112)
- Bug in `SparseSeries.unstack()` and `SparseDataFrame.stack()` (GH16614, GH15045)
- Bug in `make_sparse()` treating two numeric/boolean data, which have same bits, as same when array `dtype` is `object` (GH17574)
- `SparseArray.all()` and `SparseArray.any()` are now implemented to handle `SparseArray`, these were used but not implemented (GH17570)

1.1.7.7 Reshaping

- Joining/Merging with a non unique `PeriodIndex` raised a `TypeError` (GH16871)
- Bug in *`crosstab()`* where non-aligned series of integers were casted to float (GH17005)
- Bug in merging with categorical dtypes with datetimelikes incorrectly raised a `TypeError` (GH16900)
- Bug when using `isin()` on a large object series and large comparison array (GH16012)

- Fixes regression from 0.20, `Series.aggregate()` and `DataFrame.aggregate()` allow dictionaries as return values again (GH16741)
- Fixes dtype of result with integer dtype input, from `pivot_table()` when called with `margins=True` (GH17013)
- Bug in `crosstab()` where passing two `Series` with the same name raised a `KeyError` (GH13279)
- `Series.argmin()`, `Series.argmax()`, and their counterparts on `DataFrame` and groupby objects work correctly with floating point data that contains infinite values (GH13595).
- Bug in `unique()` where checking a tuple of strings raised a `TypeError` (GH17108)
- Bug in `concat()` where order of result index was unpredictable if it contained non-comparable elements (GH17344)
- Fixes regression when sorting by multiple columns on a `datetime64` dtype `Series` with `NaT` values (GH16836)
- Bug in `pivot_table()` where the result's columns did not preserve the categorical dtype of `columns` when `dropna` was `False` (GH17842)
- Bug in `DataFrame.drop_duplicates` where dropping with non-unique column names raised a `ValueError` (GH17836)
- Bug in `unstack()` which, when called on a list of levels, would discard the `fillna` argument (GH13971)
- Bug in the alignment of `range` objects and other list-likes with `DataFrame` leading to operations being performed row-wise instead of column-wise (GH17901)

1.1.7.8 Numeric

- Bug in `.clip()` with `axis=1` and a list-like for `threshold` is passed; previously this raised `ValueError` (GH15390)
- `Series.clip()` and `DataFrame.clip()` now treat NA values for upper and lower arguments as `None` instead of raising `ValueError` (GH17276).

1.1.7.9 Categorical

- Bug in `Series.isin()` when called with a categorical (GH16639)
- Bug in the categorical constructor with empty values and categories causing the `.categories` to be an empty `Float64Index` rather than an empty `Index` with object dtype (GH17248)
- Bug in categorical operations with *Series.cat* not preserving the original Series' name (GH17509)
- Bug in `DataFrame.merge()` failing for categorical columns with boolean/int data types (GH17187)
- Bug in constructing a `Categorical`/`CategoricalDtype` when the specified `categories` are of categorical type (GH17884).

1.1.7.10 PyPy

- Compatibility with PyPy in `read_csv()` with `usecols=[<unsorted ints>]` and `read_json()` (GH17351)
- Split tests into cases for CPython and PyPy where needed, which highlights the fragility of index matching with `float('nan')`, `np.nan` and `NAT` (GH17351)

- Fix `DataFrame.memory_usage()` to support PyPy. Objects on PyPy do not have a fixed size, so an approximation is used instead (GH17228)

1.1.7.11 Other

- Bug where some inplace operators were not being wrapped and produced a copy when invoked (GH12962)
- Bug in `eval()` where the `inplace` parameter was being incorrectly handled (GH16732)

1.2 v0.20.3 (July 7, 2017)

This is a minor bug-fix release in the 0.20.x series and includes some small regression fixes and bug fixes. We recommend that all users upgrade to this version.

What's new in v0.20.3

1.2.1 Bug Fixes

- Fixed a bug in failing to compute rolling computations of a column-MultiIndexed `DataFrame` (GH16789, GH16825)
- Fixed a pytest marker failing downstream packages' tests suites (GH16680)

1.2.1.1 Conversion

- Bug in pickle compat prior to the v0.20.x series, when `UTC` is a timezone in a Series/DataFrame/Index (GH16608)
- Bug in `Series` construction when passing a `Series` with `dtype='category'` (GH16524).
- Bug in `DataFrame.astype()` when passing a `Series` as the `dtype` kwarg. (GH16717).

1.2.1.2 Indexing

- Bug in `Float64Index` causing an empty array instead of `None` to be returned from `.get(np.nan)` on a Series whose index did not contain any `NaN` s (GH8569)
- Bug in `MultiIndex.isin` causing an error when passing an empty iterable (GH16777)
- Fixed a bug in a slicing DataFrame/Series that have a `TimedeltaIndex` (GH16637)

1.2.1.3 I/O

- Bug in `read_csv()` in which files weren't opened as binary files by the C engine on Windows, causing EOF characters mid-field, which would fail (GH16039, GH16559, GH16675)
- Bug in `read_hdf()` in which reading a `Series` saved to an HDF file in 'fixed' format fails when an explicit `mode='r'` argument is supplied (GH16583)
- Bug in `DataFrame.to_latex()` where `bold_rows` was wrongly specified to be `True` by default, whereas in reality row labels remained non-bold whatever parameter provided. (GH16707)
- Fixed an issue with `DataFrame.style()` where generated element ids were not unique (GH16780)
- Fixed loading a `DataFrame` with a `PeriodIndex`, from a `format='fixed'` HDFStore, in Python 3, that was written in Python 2 (GH16781)

1.2.1.4 Plotting

- Fixed regression that prevented RGB and RGBA tuples from being used as color arguments (GH16233)
- Fixed an issue with `DataFrame.plot.scatter()` that incorrectly raised a `KeyError` when categorical data is used for plotting (GH16199)

1.2.1.5 Reshaping

- `PeriodIndex` / `TimedeltaIndex.join` was missing the `sort=` kwarg (GH16541)
- Bug in joining on a `MultiIndex` with a `category` dtype for a level (GH16627).
- Bug in `merge()` when merging/joining with multiple categorical columns (GH16767)

1.2.1.6 Categorical

- Bug in `DataFrame.sort_values` not respecting the `kind` parameter with categorical data (GH16793)

1.3 v0.20.2 (June 4, 2017)

This is a minor bug-fix release in the 0.20.x series and includes some small regression fixes, bug fixes and performance improvements. We recommend that all users upgrade to this version.

What's new in v0.20.2

- *Groupby/Resample/Rolling*
- *Sparse*
- *Reshaping*
- *Numeric*
- *Categorical*
- *Other*

1.3.1 Enhancements

- Unblocked access to additional compression types supported in pytables: 'blosc:blosclz, 'blosc:lz4', 'blosc:lz4hc', 'blosc:snappy', 'blosc:zlib', 'blosc:zstd' (GH14478)
- `Series` provides a `to_latex` method (GH16180)
- A new groupby method *`ngroup()`*, parallel to the existing *`cumcount()`*, has been added to return the group order (GH11642); see *here*.

1.3.2 Performance Improvements

- Performance regression fix when indexing with a list-like (GH16285)
- Performance regression fix for MultiIndexes (GH16319, GH16346)
- Improved performance of `.clip()` with scalar arguments (GH15400)
- Improved performance of groupby with categorical groupers (GH16413)
- Improved performance of `MultiIndex.remove_unused_levels()` (GH16556)

1.3.3 Bug Fixes

- Silenced a warning on some Windows environments about "tput: terminal attributes: No such device or address" when detecting the terminal size. This fix only applies to python 3 (GH16496)
- Bug in using `pathlib.Path` or `py.path.local` objects with io functions (GH16291)
- Bug in `Index.symmetric_difference()` on two equal MultiIndex's, results in a `TypeError` (:issue *13490*)
- Bug in `DataFrame.update()` with `overwrite=False` and `NaN values` (GH15593)
- Passing an invalid engine to *`read_csv()`* now raises an informative `ValueError` rather than `UnboundLocalError`. (GH16511)
- Bug in *`unique()`* on an array of tuples (GH16519)
- Bug in *`cut()`* when `labels` are set, resulting in incorrect label ordering (GH16459)
- Fixed a compatibility issue with IPython 6.0's tab completion showing deprecation warnings on `Categoricals` (GH16409)

1.3.3.1 Conversion

- Bug in *to_numeric()* in which empty data inputs were causing a segfault of the interpreter (GH16302)
- Silence numpy warnings when broadcasting `DataFrame` to `Series` with comparison ops (GH16378, GH16306)

1.3.3.2 Indexing

- Bug in `DataFrame.reset_index(level=)` with single level index (GH16263)
- Bug in partial string indexing with a monotonic, but not strictly-monotonic, index incorrectly reversing the slice bounds (GH16515)
- Bug in `MultiIndex.remove_unused_levels()` that would not return a `MultiIndex` equal to the original. (GH16556)

1.3.3.3 I/O

- Bug in *read_csv()* when `comment` is passed in a space delimited text file (GH16472)
- Bug in *read_csv()* not raising an exception with nonexistent columns in `usecols` when it had the correct length (GH14671)
- Bug that would force importing of the clipboard routines unnecessarily, potentially causing an import error on startup (GH16288)
- Bug that raised `IndexError` when HTML-rendering an empty `DataFrame` (GH15953)
- Bug in *read_csv()* in which tarfile object inputs were raising an error in Python 2.x for the C engine (GH16530)
- Bug where `DataFrame.to_html()` ignored the `index_names` parameter (GH16493)
- Bug where `pd.read_hdf()` returns numpy strings for index names (GH13492)
- Bug in `HDFStore.select_as_multiple()` where start/stop arguments were not respected (GH16209)

1.3.3.4 Plotting

- Bug in `DataFrame.plot` with a single column and a list-like `color` (GH3486)
- Bug in `plot` where `NaT` in `DatetimeIndex` results in `Timestamp.min` (:issue: *12405*)
- Bug in `DataFrame.boxplot` where `figsize` keyword was not respected for non-grouped boxplots (GH11959)

1.3.3.5 Groupby/Resample/Rolling

- Bug in creating a time-based rolling window on an empty `DataFrame` (GH15819)
- Bug in `rolling.cov()` with offset window (GH16058)
- Bug in `.resample()` and `.groupby()` when aggregating on integers (GH16361)

1.3.3.6 Sparse

- Bug in construction of `SparseDataFrame` from `scipy.sparse.dok_matrix` (GH16179)

1.3.3.7 Reshaping

- Bug in `DataFrame.stack` with unsorted levels in `MultiIndex` columns (GH16323)
- Bug in `pd.wide_to_long()` where no error was raised when `i` was not a unique identifier (GH16382)
- Bug in `Series.isin(..)` with a list of tuples (GH16394)
- Bug in construction of a `DataFrame` with mixed dtypes including an all-NaT column. (GH16395)
- Bug in `DataFrame.agg()` and `Series.agg()` with aggregating on non-callable attributes (GH16405)

1.3.3.8 Numeric

- Bug in `.interpolate()`, where `limit_direction` was not respected when `limit=None` (default) was passed (GH16282)

1.3.3.9 Categorical

- Fixed comparison operations considering the order of the categories when both categoricals are unordered (GH16014)

1.3.3.10 Other

- Bug in `DataFrame.drop()` with an empty-list with non-unique indices (GH16270)

1.4 v0.20.1 (May 5, 2017)

This is a major release from 0.19.2 and includes a number of API changes, deprecations, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- New `.agg()` API for Series/DataFrame similar to the groupby-rolling-resample API's, see *here*
- Integration with the `feather-format`, including a new top-level `pd.read_feather()` and `DataFrame.to_feather()` method, see *here*.
- The `.ix` indexer has been deprecated, see *here*
- `Panel` has been deprecated, see *here*
- Addition of an `IntervalIndex` and `Interval` scalar type, see *here*
- Improved user API when grouping by index levels in `.groupby()`, see *here*
- Improved support for `UInt64` dtypes, see *here*
- A new orient for JSON serialization, `orient='table'`, that uses the Table Schema spec and that gives the possibility for a more interactive repr in the Jupyter Notebook, see *here*

- Experimental support for exporting styled DataFrames (`DataFrame.style`) to Excel, see *here*
- Window binary corr/cov operations now return a MultiIndexed `DataFrame` rather than a `Panel`, as `Panel` is now deprecated, see *here*
- Support for S3 handling now uses `s3fs`, see *here*
- Google BigQuery support now uses the `pandas-gbq` library, see *here*

Warning: Pandas has changed the internal structure and layout of the codebase. This can affect imports that are not from the top-level `pandas.*` namespace, please see the changes *here*.

Check the *API Changes* and *deprecations* before updating.

Note: This is a combined release for 0.20.0 and and 0.20.1. Version 0.20.1 contains one additional change for backwards-compatibility with downstream projects using pandas' `utils` routines. (GH16250)

What's new in v0.20.0

1.4.1 New features

1.4.1.1 agg API for DataFrame/Series

Series & DataFrame have been enhanced to support the aggregation API. This is a familiar API from groupby, window operations, and resampling. This allows aggregation operations in a concise way by using `agg()` and `transform()`. The full documentation is *here* (GH1623).

Here is a sample

```
In [1]: df = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
   ...:                   index=pd.date_range('1/1/2000', periods=10))
   ...:

In [2]: df.iloc[3:7] = np.nan

In [3]: df
Out[3]:
                   A         B         C
2000-01-01  0.665719  0.234544 -0.497107
2000-01-02  0.603650  0.567011 -0.994009
2000-01-03 -2.230893 -1.635263  0.357573
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08  1.667624  1.619575 -0.948507
2000-01-09 -0.360596  1.412609 -0.398833
2000-01-10 -2.429301 -0.645124 -0.102111
```

One can operate using string function names, callables, lists, or dictionaries of these.

Using a single function is equivalent to `.apply`.

```
In [4]: df.agg('sum')
Out[4]:
A   -2.083797
B    1.553352
C   -2.582995
dtype: float64
```

Multiple aggregations with a list of functions.

```
In [5]: df.agg(['sum', 'min'])
Out[5]:
            A         B         C
sum -2.083797  1.553352 -2.582995
min -2.429301 -1.635263 -0.994009
```

Using a dict provides the ability to apply specific aggregations per column. You will get a matrix-like output of all of the aggregators. The output has one column per unique function. Those functions applied to a particular column will be `NaN`:

```
In [6]: df.agg({'A' : ['sum', 'min'], 'B' : ['min', 'max']})
Out[6]:
            A         B
max       NaN  1.619575
```

```
min -2.429301 -1.635263
sum -2.083797       NaN
```

The API also supports a `.transform()` function for broadcasting results.

```
In [7]: df.transform(['abs', lambda x: x - x.min()])
Out[7]:
                   A                   B                   C
                 abs  <lambda>       abs  <lambda>       abs  <lambda>
2000-01-01  0.665719  3.095020  0.234544  1.869807  0.497107  0.496902
2000-01-02  0.603650  3.032952  0.567011  2.202274  0.994009  0.000000
2000-01-03  2.230893  0.198409  1.635263  0.000000  0.357573  1.351583
2000-01-04       NaN       NaN       NaN       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN       NaN       NaN       NaN
2000-01-08  1.667624  4.096925  1.619575  3.254838  0.948507  0.045502
2000-01-09  0.360596  2.068705  1.412609  3.047871  0.398833  0.595176
2000-01-10  2.429301  0.000000  0.645124  0.990138  0.102111  0.891898
```

When presented with mixed dtypes that cannot be aggregated, `.agg()` will only take the valid aggregations. This is similiar to how groupby `.agg()` works. (GH15015)

```
In [8]: df = pd.DataFrame({'A': [1, 2, 3],
   ...:                    'B': [1., 2., 3.],
   ...:                    'C': ['foo', 'bar', 'baz'],
   ...:                    'D': pd.date_range('20130101', periods=3)})
   ...:

In [9]: df.dtypes
Out[9]:
A             int64
B           float64
C            object
D    datetime64[ns]
dtype: object
```

```
In [10]: df.agg(['min', 'sum'])
Out[10]:
     A    B          C          D
min  1  1.0        bar 2013-01-01
sum  6  6.0  foobarbaz        NaT
```

1.4.1.2 `dtype` keyword for data IO

The `'python'` engine for *read_csv()*, as well as the *read_fwf()* function for parsing fixed-width text files and *read_excel()* for parsing Excel files, now accept the `dtype` keyword argument for specifying the types of specific columns (GH14295). See the *io docs* for more information.

```
In [11]: data = "a  b\n1  2\n3  4"

In [12]: pd.read_fwf(StringIO(data)).dtypes
Out[12]:
a    int64
b    int64
dtype: object
```

```
In [13]: pd.read_fwf(StringIO(data), dtype={'a':'float64', 'b':'object'}).dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[13]:
a     float64
b      object
dtype: object
```

1.4.1.3 `.to_datetime()` has gained an `origin` parameter

`to_datetime()` has gained a new parameter, `origin`, to define a reference date from where to compute the resulting timestamps when parsing numerical values with a specific `unit` specified. (GH11276, GH11745)

For example, with 1960-01-01 as the starting date:

```
In [14]: pd.to_datetime([1, 2, 3], unit='D', origin=pd.Timestamp('1960-01-01'))
Out[14]: DatetimeIndex(['1960-01-02', '1960-01-03', '1960-01-04'], dtype=
↪'datetime64[ns]', freq=None)
```

The default is set at `origin='unix'`, which defaults to `1970-01-01 00:00:00`, which is commonly called 'unix epoch' or POSIX time. This was the previous default, so this is a backward compatible change.

```
In [15]: pd.to_datetime([1, 2, 3], unit='D')
Out[15]: DatetimeIndex(['1970-01-02', '1970-01-03', '1970-01-04'], dtype=
↪'datetime64[ns]', freq=None)
```

1.4.1.4 Groupby Enhancements

Strings passed to `DataFrame.groupby()` as the `by` parameter may now reference either column names or index level names. Previously, only column names could be referenced. This allows to easily group by a column and index level at the same time. (GH5677)

```
In [16]: arrays = [['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'],
   ....:           ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two']]
   ....:

In [17]: index = pd.MultiIndex.from_arrays(arrays, names=['first', 'second'])

In [18]: df = pd.DataFrame({'A': [1, 1, 1, 1, 2, 2, 3, 3],
   ....:                    'B': np.arange(8)},
   ....:                   index=index)
   ....:

In [19]: df
Out[19]:
              A  B
first second
bar   one     1  0
      two     1  1
baz   one     1  2
      two     1  3
foo   one     2  4
      two     2  5
qux   one     3  6
      two     3  7
```

```
In [20]: df.groupby(['second', 'A']).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          B
second A   
one    1  2
       2  4
       3  6
two    1  4
       2  5
       3  7
```

1.4.1.5 Better support for compressed URLs in `read_csv`

The compression code was refactored (GH12688). As a result, reading dataframes from URLs in *`read_csv()`* or *`read_table()`* now supports additional compression methods: `xz`, `bz2`, and `zip` (GH14570). Previously, only `gzip` compression was supported. By default, compression of URLs and paths are now inferred using their file extensions. Additionally, support for bz2 compression in the python 2 C-engine improved (GH14874).

```
In [21]: url = 'https://github.com/{repo}/raw/{branch}/{path}'.format(
   ....:     repo = 'pandas-dev/pandas',
   ....:     branch = 'master',
   ....:     path = 'pandas/tests/io/parser/data/salaries.csv.bz2',
   ....: )
   ....: 

In [22]: df = pd.read_table(url, compression='infer')  # default, infer compression

In [23]: df = pd.read_table(url, compression='bz2')  # explicitly specify compression

In [24]: df.head(2)
Out[24]: 
       S  X  E  M
0  13876  1  1  1
1  11608  1  3  0
```

1.4.1.6 Pickle file I/O now supports compression

`read_pickle()`, *`DataFrame.to_pickle()`* and *`Series.to_pickle()`* can now read from and write to compressed pickle files. Compression methods can be an explicit parameter or be inferred from the file extension. See *the docs here.*

```
In [25]: df = pd.DataFrame({
   ....:     'A': np.random.randn(1000),
   ....:     'B': 'foo',
   ....:     'C': pd.date_range('20130101', periods=1000, freq='s')})
   ....: 
```

Using an explicit compression type

```
In [26]: df.to_pickle("data.pkl.compress", compression="gzip")

In [27]: rt = pd.read_pickle("data.pkl.compress", compression="gzip")
```

```
In [28]: rt.head()
Out[28]:
          A    B                   C
0  0.804438  foo 2013-01-01 00:00:00
1 -0.000818  foo 2013-01-01 00:00:01
2 -1.084383  foo 2013-01-01 00:00:02
3  1.776343  foo 2013-01-01 00:00:03
4  0.884521  foo 2013-01-01 00:00:04
```

The default is to infer the compression type from the extension (`compression='infer'`):

```
In [29]: df.to_pickle("data.pkl.gz")

In [30]: rt = pd.read_pickle("data.pkl.gz")

In [31]: rt.head()
Out[31]:
          A    B                   C
0  0.804438  foo 2013-01-01 00:00:00
1 -0.000818  foo 2013-01-01 00:00:01
2 -1.084383  foo 2013-01-01 00:00:02
3  1.776343  foo 2013-01-01 00:00:03
4  0.884521  foo 2013-01-01 00:00:04

In [32]: df["A"].to_pickle("s1.pkl.bz2")

In [33]: rt = pd.read_pickle("s1.pkl.bz2")

In [34]: rt.head()
Out[34]:
0    0.804438
1   -0.000818
2   -1.084383
3    1.776343
4    0.884521
Name: A, dtype: float64
```

1.4.1.7 UInt64 Support Improved

Pandas has significantly improved support for operations involving unsigned, or purely non-negative, integers. Previously, handling these integers would result in improper rounding or data-type casting, leading to incorrect results. Notably, a new numerical index, `UInt64Index`, has been created (GH14937)

```
In [35]: idx = pd.UInt64Index([1, 2, 3])

In [36]: df = pd.DataFrame({'A': ['a', 'b', 'c']}, index=idx)

In [37]: df.index
Out[37]: UInt64Index([1, 2, 3], dtype='uint64')
```

- Bug in converting object elements of array-like objects to unsigned 64-bit integers (GH4471, GH14982)
- Bug in `Series.unique()` in which unsigned 64-bit integers were causing overflow (GH14721)
- Bug in `DataFrame` construction in which unsigned 64-bit integer elements were being converted to objects (GH14881)

- Bug in `pd.read_csv()` in which unsigned 64-bit integer elements were being improperly converted to the wrong data types (GH14983)
- Bug in `pd.unique()` in which unsigned 64-bit integers were causing overflow (GH14915)
- Bug in `pd.value_counts()` in which unsigned 64-bit integers were being erroneously truncated in the output (GH14934)

1.4.1.8 GroupBy on Categoricals

In previous versions, `.groupby(..., sort=False)` would fail with a `ValueError` when grouping on a categorical series with some categories not appearing in the data. (GH13179)

```
In [38]: chromosomes = np.r_[np.arange(1, 23).astype(str), ['X', 'Y']]

In [39]: df = pd.DataFrame({
   ....:     'A': np.random.randint(100),
   ....:     'B': np.random.randint(100),
   ....:     'C': np.random.randint(100),
   ....:     'chromosomes': pd.Categorical(np.random.choice(chromosomes, 100),
   ....:                                   categories=chromosomes,
   ....:                                   ordered=True)})
   ....:

In [40]: df
Out[40]:
     A   B   C chromosomes
0   61  79  43          17
1   61  79  43          11
2   61  79  43           8
3   61  79  43          17
4   61  79  43          14
5   61  79  43          14
6   61  79  43           X
..  ..  ..  ..         ...
93  61  79  43           1
94  61  79  43           1
95  61  79  43           6
96  61  79  43          11
97  61  79  43          13
98  61  79  43           3
99  61  79  43           8

[100 rows x 4 columns]
```

Previous Behavior:

```
In [3]: df[df.chromosomes != '1'].groupby('chromosomes', sort=False).sum()
---------------------------------------------------------------------------
ValueError: items in new_categories are not the same as in old categories
```

New Behavior:

```
In [41]: df[df.chromosomes != '1'].groupby('chromosomes', sort=False).sum()
Out[41]:
                 A      B      C
chromosomes
2            305.0  395.0  215.0
```

```
3              61.0   79.0   43.0
4             244.0  316.0  172.0
5             366.0  474.0  258.0
6             305.0  395.0  215.0
7             244.0  316.0  172.0
8             305.0  395.0  215.0
...             ...    ...    ...
19            305.0  395.0  215.0
20            122.0  158.0   86.0
22            366.0  474.0  258.0
X             244.0  316.0  172.0
Y             183.0  237.0  129.0
1               NaN    NaN    NaN
21              NaN    NaN    NaN

[24 rows x 3 columns]
```

1.4.1.9 Table Schema Output

The new orient `'table'` for *`DataFrame.to_json()`* will generate a Table Schema compatible string representation of the data.

```
In [42]: df = pd.DataFrame(
   ....:     {'A': [1, 2, 3],
   ....:      'B': ['a', 'b', 'c'],
   ....:      'C': pd.date_range('2016-01-01', freq='d', periods=3),
   ....:     }, index=pd.Index(range(3), name='idx'))
   ....:

In [43]: df
Out[43]:
     A  B          C
idx
0    1  a 2016-01-01
1    2  b 2016-01-02
2    3  c 2016-01-03

In [44]: df.to_json(orient='table')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪'{"schema": {"fields":[{"name":"idx","type":"integer"},{"name":"A","type":"integer"}
↪,{"name":"B","type":"string"},{"name":"C","type":"datetime"}],"primaryKey":["idx"],
↪"pandas_version":"0.20.0"}, "data": [{"idx":0,"A":1,"B":"a","C":"2016-01-
↪01T00:00:00.000Z"},{"idx":1,"A":2,"B":"b","C":"2016-01-02T00:00:00.000Z"},{"idx":2,
↪"A":3,"B":"c","C":"2016-01-03T00:00:00.000Z"}]}'
```

See *IO: Table Schema for more information*.

Additionally, the repr for `DataFrame` and `Series` can now publish this JSON Table schema representation of the Series or DataFrame if you are using IPython (or another frontend like nteract using the Jupyter messaging protocol). This gives frontends like the Jupyter notebook and nteract more flexiblity in how they display pandas objects, since they have more information about the data. You must enable this by setting the `display.html.table_schema` option to `True`.

1.4.1.10 SciPy sparse matrix from/to SparseDataFrame

Pandas now supports creating sparse dataframes directly from `scipy.sparse.spmatrix` instances. See the *documentation* for more information. (GH4343)

All sparse formats are supported, but matrices that are not in `COOrdinate` format will be converted, copying data as needed.

```
In [45]: from scipy.sparse import csr_matrix

In [46]: arr = np.random.random(size=(1000, 5))

In [47]: arr[arr < .9] = 0

In [48]: sp_arr = csr_matrix(arr)

In [49]: sp_arr
Out[49]:
<1000x5 sparse matrix of type '<class 'numpy.float64'>'
        with 521 stored elements in Compressed Sparse Row format>

In [50]: sdf = pd.SparseDataFrame(sp_arr)

In [51]: sdf
Out[51]:
            0         1         2         3         4
0         NaN       NaN       NaN       NaN       NaN
1         NaN       NaN       NaN  0.999681       NaN
2    0.989621       NaN       NaN       NaN       NaN
3         NaN  0.986495       NaN       NaN       NaN
4         NaN       NaN       NaN       NaN  0.990083
5         NaN       NaN  0.987794       NaN       NaN
6         NaN       NaN       NaN       NaN       NaN
..        ...       ...       ...       ...       ...
993  0.936109       NaN       NaN       NaN       NaN
994       NaN       NaN       NaN       NaN       NaN
995       NaN       NaN       NaN       NaN  0.981932
996       NaN  0.985932       NaN  0.967058       NaN
997       NaN       NaN       NaN       NaN       NaN
998       NaN       NaN       NaN       NaN       NaN
999       NaN       NaN       NaN       NaN       NaN

[1000 rows x 5 columns]
```

To convert a `SparseDataFrame` back to sparse SciPy matrix in COO format, you can use:

```
In [52]: sdf.to_coo()
Out[52]:
<1000x5 sparse matrix of type '<class 'numpy.float64'>'
        with 521 stored elements in COOrdinate format>
```

1.4.1.11 Excel output for styled DataFrames

Experimental support has been added to export `DataFrame.style` formats to Excel using the `openpyxl` engine. (GH15530)

For example, after running the following, `styled.xlsx` renders as below:

```
In [53]: np.random.seed(24)

In [54]: df = pd.DataFrame({'A': np.linspace(1, 10, 10)})

In [55]: df = pd.concat([df, pd.DataFrame(np.random.RandomState(24).randn(10, 4),
   ....:                                  columns=list('BCDE'))],
   ....:                 axis=1)
   ....:

In [56]: df.iloc[0, 2] = np.nan

In [57]: df
Out[57]:
      A         B         C         D         E
0   1.0  1.329212       NaN -0.316280 -0.990810
1   2.0 -1.070816 -1.438713  0.564417  0.295722
2   3.0 -1.626404  0.219565  0.678805  1.889273
3   4.0  0.961538  0.104011 -0.481165  0.850229
4   5.0  1.453425  1.057737  0.165562  0.515018
5   6.0 -1.336936  0.562861  1.392855 -0.063328
6   7.0  0.121668  1.207603 -0.002040  1.627796
7   8.0  0.354493  1.037528 -0.385684  0.519818
8   9.0  1.686583 -1.325963  1.428984 -2.089354
9  10.0 -0.129820  0.631523 -0.586538  0.290720

In [58]: styled = df.style.\
   ....:     applymap(lambda val: 'color: %s' % 'red' if val < 0 else 'black').\
   ....:     highlight_max()
   ....:

In [59]: styled.to_excel('styled.xlsx', engine='openpyxl')
```

	A	B	C	D	E	F
1		A	B	C	D	E
2	0	1	1.329212		-0.31628	-0.99081
3	1	2	-1.070816	-1.438713	0.564417	0.295722
4	2	3	-1.626404	0.219565	0.678805	1.889273
5	3	4	0.961538	0.104011	-0.481165	0.850229
6	4	5	1.453425	1.057737	0.165562	0.515018
7	5	6	-1.336936	0.562861	1.392855	-0.063328
8	6	7	0.121668	1.207603	-0.00204	1.627796
9	7	8	0.354493	1.037528	-0.385684	0.519818
10	8	9	1.686583	-1.325963	1.428984	-2.089354
11	9	10	-0.12982	0.631523	-0.586538	0.29072

See the *Style documentation* for more detail.

1.4.1.12 IntervalIndex

pandas has gained an `IntervalIndex` with its own dtype, `interval` as well as the `Interval` scalar type. These allow first-class support for interval notation, specifically as a return type for the categories in `cut()` and `qcut()`. The `IntervalIndex` allows some unique indexing, see the *docs*. (GH7640, GH8625)

> **Warning:** These indexing behaviors of the IntervalIndex are provisional and may change in a future version of pandas. Feedback on usage is welcome.

Previous behavior:

The returned categories were strings, representing Intervals

```
In [1]: c = pd.cut(range(4), bins=2)

In [2]: c
Out[2]:
[(-0.003, 1.5], (-0.003, 1.5], (1.5, 3], (1.5, 3]]
Categories (2, object): [(-0.003, 1.5] < (1.5, 3]]

In [3]: c.categories
Out[3]: Index(['(-0.003, 1.5]', '(1.5, 3]'], dtype='object')
```

New behavior:

```
In [60]: c = pd.cut(range(4), bins=2)

In [61]: c
Out[61]:
[(-0.003, 1.5], (-0.003, 1.5], (1.5, 3.0], (1.5, 3.0]]
Categories (2, interval[float64]): [(-0.003, 1.5] < (1.5, 3.0]]

In [62]: c.categories
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
IntervalIndex([(-0.003, 1.5], (1.5, 3.0]]
              closed='right',
              dtype='interval[float64]')
```

Furthermore, this allows one to bin *other* data with these same bins, with `NaN` representing a missing value similar to other dtypes.

```
In [63]: pd.cut([0, 3, 5, 1], bins=c.categories)
Out[63]:
[(-0.003, 1.5], (1.5, 3.0], NaN, (-0.003, 1.5]]
Categories (2, interval[float64]): [(-0.003, 1.5] < (1.5, 3.0]]
```

An `IntervalIndex` can also be used in `Series` and `DataFrame` as the index.

```
In [64]: df = pd.DataFrame({'A': range(4),
   ....:                    'B': pd.cut([0, 3, 1, 1], bins=c.categories)}
   ....:                   ).set_index('B')
   ....:

In [65]: df
Out[65]:
```

```
                A
B
(-0.003, 1.5]   0
(1.5, 3.0]      1
(-0.003, 1.5]   2
(-0.003, 1.5]   3
```

Selecting via a specific interval:

```
In [66]: df.loc[pd.Interval(1.5, 3.0)]
Out[66]:
A    1
Name: (1.5, 3.0], dtype: int64
```

Selecting via a scalar value that is contained *in* the intervals.

```
In [67]: df.loc[0]
Out[67]:
                A
B
(-0.003, 1.5]   0
(-0.003, 1.5]   2
(-0.003, 1.5]   3
```

1.4.1.13 Other Enhancements

- `DataFrame.rolling()` now accepts the parameter `closed='right'|'left'|'both'|'neither'` to choose the rolling window-endpoint closedness. See the *documentation* (GH13965)
- Integration with the `feather-format`, including a new top-level `pd.read_feather()` and `DataFrame.to_feather()` method, see *here*.
- `Series.str.replace()` now accepts a callable, as replacement, which is passed to `re.sub` (GH15055)
- `Series.str.replace()` now accepts a compiled regular expression as a pattern (GH15446)
- `Series.sort_index` accepts parameters `kind` and `na_position` (GH13589, GH14444)
- `DataFrame` and `DataFrame.groupby()` have gained a `nunique()` method to count the distinct values over an axis (GH14336, GH15197).
- `DataFrame` has gained a `melt()` method, equivalent to `pd.melt()`, for unpivoting from a wide to long format (GH12640).
- `pd.read_excel()` now preserves sheet order when using `sheetname=None` (GH9930)
- Multiple offset aliases with decimal points are now supported (e.g. `0.5min` is parsed as `30s`) (GH8419)
- `.isnull()` and `.notnull()` have been added to `Index` object to make them more consistent with the `Series` API (GH15300)
- New `UnsortedIndexError` (subclass of `KeyError`) raised when indexing/slicing into an unsorted MultiIndex (GH11897). This allows differentiation between errors due to lack of sorting or an incorrect key. See *here*
- `MultiIndex` has gained a `.to_frame()` method to convert to a `DataFrame` (GH12397)
- `pd.cut` and `pd.qcut` now support datetime64 and timedelta64 dtypes (GH14714, GH14798)
- `pd.qcut` has gained the `duplicates='raise'|'drop'` option to control whether to raise on duplicated edges (GH7751)

- `Series` provides a `to_excel` method to output Excel files (GH8825)
- The `usecols` argument in `pd.read_csv()` now accepts a callable function as a value (GH14154)
- The `skiprows` argument in `pd.read_csv()` now accepts a callable function as a value (GH10882)
- The `nrows` and `chunksize` arguments in `pd.read_csv()` are supported if both are passed (GH6774, GH15755)
- `DataFrame.plot` now prints a title above each subplot if `suplots=True` and `title` is a list of strings (GH14753)
- `DataFrame.plot` can pass the matplotlib 2.0 default color cycle as a single string as color parameter, see here. (GH15516)
- `Series.interpolate()` now supports timedelta as an index type with `method='time'` (GH6424)
- Addition of a `level` keyword to `DataFrame/Series.rename` to rename labels in the specified level of a MultiIndex (GH4160).
- `DataFrame.reset_index()` will now interpret a tuple `index.name` as a key spanning across levels of `columns`, if this is a `MultiIndex` (GH16164)
- `Timedelta.isoformat` method added for formatting Timedeltas as an ISO 8601 duration. See the *Timedelta docs* (GH15136)
- `.select_dtypes()` now allows the string `datetimetz` to generically select datetimes with tz (GH14910)
- The `.to_latex()` method will now accept `multicolumn` and `multirow` arguments to use the accompanying LaTeX enhancements
- `pd.merge_asof()` gained the option `direction='backward'|'forward'|'nearest'` (GH14887)
- `Series/DataFrame.asfreq()` have gained a `fill_value` parameter, to fill missing values (GH3715).
- `Series/DataFrame.resample.asfreq` have gained a `fill_value` parameter, to fill missing values during resampling (GH3715).
- `pandas.util.hash_pandas_object()` has gained the ability to hash a `MultiIndex` (GH15224)
- `Series/DataFrame.squeeze()` have gained the `axis` parameter. (GH15339)
- `DataFrame.to_excel()` has a new `freeze_panes` parameter to turn on Freeze Panes when exporting to Excel (GH15160)
- `pd.read_html()` will parse multiple header rows, creating a MutliIndex header. (GH13434).
- HTML table output skips `colspan` or `rowspan` attribute if equal to 1. (GH15403)
- *`pandas.io.formats.style.Styler`* template now has blocks for easier extension, *see the example notebook* (GH15649)
- *`Styler.render()`* now accepts `**kwargs` to allow user-defined variables in the template (GH15649)
- Compatibility with Jupyter notebook 5.0; MultiIndex column labels are left-aligned and MultiIndex row-labels are top-aligned (GH15379)
- `TimedeltaIndex` now has a custom date-tick formatter specifically designed for nanosecond level precision (GH8711)
- `pd.api.types.union_categoricals` gained the `ignore_ordered` argument to allow ignoring the ordered attribute of unioned categoricals (GH13410). See the *categorical union docs* for more information.
- `DataFrame.to_latex()` and `DataFrame.to_string()` now allow optional header aliases. (GH15536)

- Re-enable the `parse_dates` keyword of `pd.read_excel()` to parse string columns as dates (GH14326)
- Added `.empty` property to subclasses of `Index`. (GH15270)
- Enabled floor division for `Timedelta` and `TimedeltaIndex` (GH15828)
- `pandas.io.json.json_normalize()` gained the option `errors='ignore'|'raise'`; the default is `errors='raise'` which is backward compatible. (GH14583)
- `pandas.io.json.json_normalize()` with an empty `list` will return an empty `DataFrame` (GH15534)
- `pandas.io.json.json_normalize()` has gained a `sep` option that accepts `str` to separate joined fields; the default is ".", which is backward compatible. (GH14883)
- *`MultiIndex.remove_unused_levels()`* has been added to facilitate *removing unused levels*. (GH15694)
- `pd.read_csv()` will now raise a `ParserError` error whenever any parsing error occurs (GH15913, GH15925)
- `pd.read_csv()` now supports the `error_bad_lines` and `warn_bad_lines` arguments for the Python parser (GH15925)
- The `display.show_dimensions` option can now also be used to specify whether the length of a `Series` should be shown in its repr (GH7117).
- `parallel_coordinates()` has gained a `sort_labels` keyword argument that sorts class labels and the colors assigned to them (GH15908)
- Options added to allow one to turn on/off using `bottleneck` and `numexpr`, see *here* (GH16157)
- `DataFrame.style.bar()` now accepts two more options to further customize the bar chart. Bar alignment is set with `align='left'|'mid'|'zero'`, the default is "left", which is backward compatible; You can now pass a list of `color=[color_negative, color_positive]`. (GH14757)

1.4.2 Backwards incompatible API changes

1.4.2.1 Possible incompatibility for HDF5 formats created with pandas < 0.13.0

`pd.TimeSeries` was deprecated officially in 0.17.0, though has already been an alias since 0.13.0. It has been dropped in favor of `pd.Series`. (GH15098).

This *may* cause HDF5 files that were created in prior versions to become unreadable if `pd.TimeSeries` was used. This is most likely to be for pandas < 0.13.0. If you find yourself in this situation. You can use a recent prior version of pandas to read in your HDF5 files, then write them out again after applying the procedure below.

```
In [2]: s = pd.TimeSeries([1,2,3], index=pd.date_range('20130101', periods=3))

In [3]: s
Out[3]:
2013-01-01    1
2013-01-02    2
2013-01-03    3
Freq: D, dtype: int64

In [4]: type(s)
Out[4]: pandas.core.series.TimeSeries

In [5]: s = pd.Series(s)
```

```
In [6]: s
Out[6]:
2013-01-01    1
2013-01-02    2
2013-01-03    3
Freq: D, dtype: int64

In [7]: type(s)
Out[7]: pandas.core.series.Series
```

1.4.2.2 Map on Index types now return other Index types

`map` on an `Index` now returns an `Index`, not a numpy array (GH12766)

```
In [68]: idx = Index([1, 2])

In [69]: idx
Out[69]: Int64Index([1, 2], dtype='int64')

In [70]: mi = MultiIndex.from_tuples([(1, 2), (2, 4)])

In [71]: mi
Out[71]:
MultiIndex(levels=[[1, 2], [2, 4]],
           labels=[[0, 1], [0, 1]])
```

Previous Behavior:

```
In [5]: idx.map(lambda x: x * 2)
Out[5]: array([2, 4])

In [6]: idx.map(lambda x: (x, x * 2))
Out[6]: array([(1, 2), (2, 4)], dtype=object)

In [7]: mi.map(lambda x: x)
Out[7]: array([(1, 2), (2, 4)], dtype=object)

In [8]: mi.map(lambda x: x[0])
Out[8]: array([1, 2])
```

New Behavior:

```
In [72]: idx.map(lambda x: x * 2)
Out[72]: Int64Index([2, 4], dtype='int64')

In [73]: idx.map(lambda x: (x, x * 2))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[73]:
MultiIndex(levels=[[1, 2], [2, 4]],
           labels=[[0, 1], [0, 1]])

In [74]: mi.map(lambda x: x)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
MultiIndex(levels=[[1, 2], [2, 4]],
           labels=[[0, 1], [0, 1]])
```

```
In [75]: mi.map(lambda x: x[0])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Int64Index([1, 2], dtype='int64')
```

`map` on a `Series` with `datetime64` values may return `int64` dtypes rather than `int32`

```
In [76]: s = Series(date_range('2011-01-02T00:00', '2011-01-02T02:00', freq='H').tz_
↪localize('Asia/Tokyo'))

In [77]: s
Out[77]:
0   2011-01-02 00:00:00+09:00
1   2011-01-02 01:00:00+09:00
2   2011-01-02 02:00:00+09:00
dtype: datetime64[ns, Asia/Tokyo]
```

Previous Behavior:

```
In [9]: s.map(lambda x: x.hour)
Out[9]:
0    0
1    1
2    2
dtype: int32
```

New Behavior:

```
In [78]: s.map(lambda x: x.hour)
Out[78]:
0    0
1    1
2    2
dtype: int64
```

1.4.2.3 Accessing datetime fields of Index now return Index

The datetime-related attributes (see *here* for an overview) of `DatetimeIndex`, `PeriodIndex` and `TimedeltaIndex` previously returned numpy arrays. They will now return a new `Index` object, except in the case of a boolean field, where the result will still be a boolean ndarray. (GH15022)

Previous behaviour:

```
In [1]: idx = pd.date_range("2015-01-01", periods=5, freq='10H')

In [2]: idx.hour
Out[2]: array([ 0, 10, 20,  6, 16], dtype=int32)
```

New Behavior:

```
In [79]: idx = pd.date_range("2015-01-01", periods=5, freq='10H')

In [80]: idx.hour
Out[80]: Int64Index([0, 10, 20, 6, 16], dtype='int64')
```

This has the advantage that specific `Index` methods are still available on the result. On the other hand, this might have backward incompatibilities: e.g. compared to numpy arrays, `Index` objects are not mutable. To get the original ndarray, you can always convert explicitly using `np.asarray(idx.hour)`.

1.4.2.4 pd.unique will now be consistent with extension types

In prior versions, using *`Series.unique()`* and *`pandas.unique()`* on `Categorical` and tz-aware data-types would yield different return types. These are now made consistent. (GH15903)

- Datetime tz-aware

  Previous behaviour:

```
# Series
In [5]: pd.Series([pd.Timestamp('20160101', tz='US/Eastern'),
                   pd.Timestamp('20160101', tz='US/Eastern')]).unique()
Out[5]: array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')],␣
↪dtype=object)

In [6]: pd.unique(pd.Series([pd.Timestamp('20160101', tz='US/Eastern'),
                             pd.Timestamp('20160101', tz='US/Eastern')]))
Out[6]: array(['2016-01-01T05:00:00.000000000'], dtype='datetime64[ns]')

# Index
In [7]: pd.Index([pd.Timestamp('20160101', tz='US/Eastern'),
                  pd.Timestamp('20160101', tz='US/Eastern')]).unique()
Out[7]: DatetimeIndex(['2016-01-01 00:00:00-05:00'], dtype='datetime64[ns, US/
↪Eastern]', freq=None)

In [8]: pd.unique([pd.Timestamp('20160101', tz='US/Eastern'),
                   pd.Timestamp('20160101', tz='US/Eastern')])
Out[8]: array(['2016-01-01T05:00:00.000000000'], dtype='datetime64[ns]')
```

  New Behavior:

```
# Series, returns an array of Timestamp tz-aware
In [81]: pd.Series([pd.Timestamp('20160101', tz='US/Eastern'),
   ....:            pd.Timestamp('20160101', tz='US/Eastern')]).unique()
   ....:
Out[81]: array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')],␣
↪dtype=object)

In [82]: pd.unique(pd.Series([pd.Timestamp('20160101', tz='US/Eastern'),
   ....:                      pd.Timestamp('20160101', tz='US/Eastern')]))
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[82]:␣
↪array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')], dtype=object)

# Index, returns a DatetimeIndex
In [83]: pd.Index([pd.Timestamp('20160101', tz='US/Eastern'),
   ....:           pd.Timestamp('20160101', tz='US/Eastern')]).unique()
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪DatetimeIndex(['2016-01-01 00:00:00-05:00'], dtype='datetime64[ns, US/Eastern]',
↪ freq=None)

In [84]: pd.unique(pd.Index([pd.Timestamp('20160101', tz='US/Eastern'),
   ....:                     pd.Timestamp('20160101', tz='US/Eastern')]))
```

```
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪DatetimeIndex(['2016-01-01 00:00:00-05:00'], dtype='datetime64[ns, US/Eastern]',
↪ freq=None)
```

- Categoricals

  Previous behaviour:

```
In [1]: pd.Series(list('baabc'), dtype='category').unique()
Out[1]:
[b, a, c]
Categories (3, object): [b, a, c]

In [2]: pd.unique(pd.Series(list('baabc'), dtype='category'))
Out[2]: array(['b', 'a', 'c'], dtype=object)
```

  New Behavior:

```
# returns a Categorical
In [85]: pd.Series(list('baabc'), dtype='category').unique()
Out[85]:
[b, a, c]
Categories (3, object): [b, a, c]

In [86]: pd.unique(pd.Series(list('baabc'), dtype='category'))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[86]:
[b, a, c]
Categories (3, object): [b, a, c]
```

1.4.2.5 S3 File Handling

pandas now uses s3fs for handling S3 connections. This shouldn't break any code. However, since `s3fs` is not a required dependency, you will need to install it separately, like `boto` in prior versions of pandas. (GH11915).

1.4.2.6 Partial String Indexing Changes

DatetimeIndex Partial String Indexing now works as an exact match, provided that string resolution coincides with index resolution, including a case when both are seconds (GH14826). See *Slice vs. Exact Match* for details.

```
In [87]: df = DataFrame({'a': [1, 2, 3]}, DatetimeIndex(['2011-12-31 23:59:59',
   ....:                                                  '2012-01-01 00:00:00',
   ....:                                                  '2012-01-01 00:00:01']))
   ....:
```

Previous Behavior:

```
In [4]: df['2011-12-31 23:59:59']
Out[4]:
                       a
2011-12-31 23:59:59  1

In [5]: df['a']['2011-12-31 23:59:59']
Out[5]:
2011-12-31 23:59:59    1
Name: a, dtype: int64
```

New Behavior:

```
In [4]: df['2011-12-31 23:59:59']
KeyError: '2011-12-31 23:59:59'

In [5]: df['a']['2011-12-31 23:59:59']
Out[5]: 1
```

1.4.2.7 Concat of different float dtypes will not automatically upcast

Previously, `concat` of multiple objects with different `float` dtypes would automatically upcast results to a dtype of `float64`. Now the smallest acceptable dtype will be used (GH13247)

```
In [88]: df1 = pd.DataFrame(np.array([1.0], dtype=np.float32, ndmin=2))

In [89]: df1.dtypes
Out[89]:
0    float32
dtype: object

In [90]: df2 = pd.DataFrame(np.array([np.nan], dtype=np.float32, ndmin=2))

In [91]: df2.dtypes
Out[91]:
0    float32
dtype: object
```

Previous Behavior:

```
In [7]: pd.concat([df1, df2]).dtypes
Out[7]:
0    float64
dtype: object
```

New Behavior:

```
In [92]: pd.concat([df1, df2]).dtypes
Out[92]:
0    float32
dtype: object
```

1.4.2.8 Pandas Google BigQuery support has moved

pandas has split off Google BigQuery support into a separate package `pandas-gbq`. You can `conda install pandas-gbq -c conda-forge` or `pip install pandas-gbq` to get it. The functionality of *`read_gbq()`* and *`DataFrame.to_gbq()`* remain the same with the currently released version of `pandas-gbq=0.1.4`. Documentation is now hosted here (GH15347)

1.4.2.9 Memory Usage for Index is more Accurate

In previous versions, showing `.memory_usage()` on a pandas structure that has an index, would only include actual index values and not include structures that facilitated fast indexing. This will generally be different for `Index` and `MultiIndex` and less-so for other index types. (GH15237)

Previous Behavior:

```
In [8]: index = Index(['foo', 'bar', 'baz'])

In [9]: index.memory_usage(deep=True)
Out[9]: 180

In [10]: index.get_loc('foo')
Out[10]: 0

In [11]: index.memory_usage(deep=True)
Out[11]: 180
```

New Behavior:

```
In [8]: index = Index(['foo', 'bar', 'baz'])

In [9]: index.memory_usage(deep=True)
Out[9]: 180

In [10]: index.get_loc('foo')
Out[10]: 0

In [11]: index.memory_usage(deep=True)
Out[11]: 260
```

1.4.2.10 DataFrame.sort_index changes

In certain cases, calling `.sort_index()` on a MultiIndexed DataFrame would return the *same* DataFrame without seeming to sort. This would happen with a `lexsorted`, but non-monotonic levels. (GH15622, GH15687, GH14015, GH13431, GH15797)

This is *unchanged* from prior versions, but shown for illustration purposes:

```
In [93]: df = DataFrame(np.arange(6), columns=['value'], index=MultiIndex.from_
↪product([list('BA'), range(3)]))

In [94]: df
Out[94]:
     value
B 0      0
  1      1
  2      2
A 0      3
  1      4
  2      5
```

```
In [95]: df.index.is_lexsorted()
Out[95]: False

In [96]: df.index.is_monotonic
\\\\\\\\\\\\\\\Out[96]: False
```

Sorting works as expected

```
In [97]: df.sort_index()
Out[97]:
```

```
     value
A 0      3
  1      4
  2      5
B 0      0
  1      1
  2      2
```

```
In [98]: df.sort_index().index.is_lexsorted()
Out[98]: True

In [99]: df.sort_index().index.is_monotonic
\\\\\\\\\\\\\\Out[99]: True
```

However, this example, which has a non-monotonic 2nd level, doesn't behave as desired.

```
In [100]: df = pd.DataFrame(
   .....:         {'value': [1, 2, 3, 4]},
   .....:          index=pd.MultiIndex(levels=[['a', 'b'], ['bb', 'aa']],
   .....:                              labels=[[0, 0, 1, 1], [0, 1, 0, 1]]))
   .....:

In [101]: df
Out[101]:
      value
a bb      1
  aa      2
b bb      3
  aa      4
```

Previous Behavior:

```
In [11]: df.sort_index()
Out[11]:
      value
a bb      1
  aa      2
b bb      3
  aa      4

In [14]: df.sort_index().index.is_lexsorted()
Out[14]: True

In [15]: df.sort_index().index.is_monotonic
Out[15]: False
```

New Behavior:

```
In [102]: df.sort_index()
Out[102]:
      value
a aa      2
  bb      1
b aa      4
  bb      3

In [103]: df.sort_index().index.is_lexsorted()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[103]: True
```

```
In [104]: df.sort_index().index.is_monotonic
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[104]:␣
↪True
```

1.4.2.11 Groupby Describe Formatting

The output formatting of `groupby.describe()` now labels the `describe()` metrics in the columns instead of the index. This format is consistent with `groupby.agg()` when applying multiple functions at once. (GH4792)

Previous Behavior:

```
In [1]: df = pd.DataFrame({'A': [1, 1, 2, 2], 'B': [1, 2, 3, 4]})

In [2]: df.groupby('A').describe()
Out[2]:
                B
A
1 count  2.000000
  mean   1.500000
  std    0.707107
  min    1.000000
  25%    1.250000
  50%    1.500000
  75%    1.750000
  max    2.000000
2 count  2.000000
  mean   3.500000
  std    0.707107
  min    3.000000
  25%    3.250000
  50%    3.500000
  75%    3.750000
  max    4.000000

In [3]: df.groupby('A').agg([np.mean, np.std, np.min, np.max])
Out[3]:
     B
  mean       std amin amax
A
1  1.5  0.707107    1    2
2  3.5  0.707107    3    4
```

New Behavior:

```
In [105]: df = pd.DataFrame({'A': [1, 1, 2, 2], 'B': [1, 2, 3, 4]})

In [106]: df.groupby('A').describe()
Out[106]:
      B
  count mean       std  min   25%  50%   75%  max
A
1   2.0  1.5  0.707107  1.0  1.25  1.5  1.75  2.0
2   2.0  3.5  0.707107  3.0  3.25  3.5  3.75  4.0

In [107]: df.groupby('A').agg([np.mean, np.std, np.min, np.max])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
     B
  mean       std amin amax
A
1  1.5  0.707107    1    2
2  3.5  0.707107    3    4
```

1.4.2.12 Window Binary Corr/Cov operations return a MultiIndex DataFrame

A binary window operation, like `.corr()` or `.cov()`, when operating on a `.rolling(..)`, `.expanding(..)`, or `.ewm(..)` object, will now return a 2-level `MultiIndexed DataFrame` rather than a `Panel`, as `Panel` is now deprecated, see *here*. These are equivalent in function, but a MultiIndexed `DataFrame` enjoys more support in pandas. See the section on *Windowed Binary Operations* for more information. (GH15677)

```
In [108]: np.random.seed(1234)

In [109]: df = pd.DataFrame(np.random.rand(100, 2),
   .....:                   columns=pd.Index(['A', 'B'], name='bar'),
   .....:                   index=pd.date_range('20160101',
   .....:                                       periods=100, freq='D', name='foo'))
   .....:

In [110]: df.tail()
Out[110]:
bar                A         B
foo
2016-04-05  0.640880  0.126205
2016-04-06  0.171465  0.737086
2016-04-07  0.127029  0.369650
2016-04-08  0.604334  0.103104
2016-04-09  0.802374  0.945553
```

Previous Behavior:

```
In [2]: df.rolling(12).corr()
Out[2]:
<class 'pandas.core.panel.Panel'>
Dimensions: 100 (items) x 2 (major_axis) x 2 (minor_axis)
Items axis: 2016-01-01 00:00:00 to 2016-04-09 00:00:00
Major_axis axis: A to B
Minor_axis axis: A to B
```

New Behavior:

```
In [111]: res = df.rolling(12).corr()

In [112]: res.tail()
Out[112]:
bar                    A         B
foo        bar
2016-04-07 B   -0.132090  1.000000
2016-04-08 A    1.000000 -0.145775
           B   -0.145775  1.000000
2016-04-09 A    1.000000  0.119645
           B    0.119645  1.000000
```

Retrieving a correlation matrix for a cross-section

```
In [113]: df.rolling(12).corr().loc['2016-04-07']
Out[113]:
bar                   A        B
foo        bar
2016-04-07 A    1.00000 -0.13209
           B   -0.13209  1.00000
```

1.4.2.13 HDFStore where string comparison

In previous versions most types could be compared to string column in a `HDFStore` usually resulting in an invalid comparison, returning an empty result frame. These comparisons will now raise a `TypeError` (GH15492)

```
In [114]: df = pd.DataFrame({'unparsed_date': ['2014-01-01', '2014-01-01']})

In [115]: df.to_hdf('store.h5', 'key', format='table', data_columns=True)

In [116]: df.dtypes
Out[116]:
unparsed_date    object
dtype: object
```

Previous Behavior:

```
In [4]: pd.read_hdf('store.h5', 'key', where='unparsed_date > ts')
File "<string>", line 1
  (unparsed_date > 1970-01-01 00:00:01.388552400)
                           ^
SyntaxError: invalid token
```

New Behavior:

```
In [18]: ts = pd.Timestamp('2014-01-01')

In [19]: pd.read_hdf('store.h5', 'key', where='unparsed_date > ts')
TypeError: Cannot compare 2014-01-01 00:00:00 of
type <class 'pandas.tslib.Timestamp'> to string column
```

1.4.2.14 Index.intersection and inner join now preserve the order of the left Index

`Index.intersection()` now preserves the order of the calling `Index` (left) instead of the other `Index` (right) (GH15582). This affects inner joins, *`DataFrame.join()`* and *`merge()`*, and the `.align` method.

- `Index.intersection`

```
In [117]: left = pd.Index([2, 1, 0])

In [118]: left
Out[118]: Int64Index([2, 1, 0], dtype='int64')

In [119]: right = pd.Index([1, 2, 3])

In [120]: right
Out[120]: Int64Index([1, 2, 3], dtype='int64')
```

Previous Behavior:

```
In [4]: left.intersection(right)
Out[4]: Int64Index([1, 2], dtype='int64')
```

New Behavior:

```
In [121]: left.intersection(right)
Out[121]: Int64Index([2, 1], dtype='int64')
```

- `DataFrame.join` and `pd.merge`

```
In [122]: left = pd.DataFrame({'a': [20, 10, 0]}, index=[2, 1, 0])

In [123]: left
Out[123]:
    a
2  20
1  10
0   0

In [124]: right = pd.DataFrame({'b': [100, 200, 300]}, index=[1, 2, 3])

In [125]: right
Out[125]:
     b
1  100
2  200
3  300
```

Previous Behavior:

```
In [4]: left.join(right, how='inner')
Out[4]:
    a    b
1  10  100
2  20  200
```

New Behavior:

```
In [126]: left.join(right, how='inner')
Out[126]:
    a    b
2  20  200
1  10  100
```

1.4.2.15 Pivot Table always returns a DataFrame

The documentation for *`pivot_table()`* states that a `DataFrame` is *always* returned. Here a bug is fixed that allowed this to return a `Series` under certain circumstance. (GH4386)

```
In [127]: df = DataFrame({'col1': [3, 4, 5],
   .....:                 'col2': ['C', 'D', 'E'],
   .....:                 'col3': [1, 3, 9]})
   .....:

In [128]: df
Out[128]:
```

```
   col1 col2  col3
0     3    C     1
1     4    D     3
2     5    E     9
```

Previous Behavior:

```
In [2]: df.pivot_table('col1', index=['col3', 'col2'], aggfunc=np.sum)
Out[2]:
col3  col2
1     C       3
3     D       4
9     E       5
Name: col1, dtype: int64
```

New Behavior:

```
In [129]: df.pivot_table('col1', index=['col3', 'col2'], aggfunc=np.sum)
Out[129]:
           col1
col3 col2
1    C        3
3    D        4
9    E        5
```

1.4.2.16 Other API Changes

- `numexpr` version is now required to be >= 2.4.6 and it will not be used at all if this requisite is not fulfilled (GH15213).
- `CParserError` has been renamed to `ParserError` in `pd.read_csv()` and will be removed in the future (GH12665)
- `SparseArray.cumsum()` and `SparseSeries.cumsum()` will now always return `SparseArray` and `SparseSeries` respectively (GH12855)
- `DataFrame.applymap()` with an empty `DataFrame` will return a copy of the empty `DataFrame` instead of a `Series` (GH8222)
- `Series.map()` now respects default values of dictionary subclasses with a `__missing__` method, such as `collections.Counter` (GH15999)
- `.loc` has compat with `.ix` for accepting iterators, and NamedTuples (GH15120)
- `interpolate()` and `fillna()` will raise a `ValueError` if the `limit` keyword argument is not greater than 0. (GH9217)
- `pd.read_csv()` will now issue a `ParserWarning` whenever there are conflicting values provided by the `dialect` parameter and the user (GH14898)
- `pd.read_csv()` will now raise a `ValueError` for the C engine if the quote character is larger than than one byte (GH11592)
- `inplace` arguments now require a boolean value, else a `ValueError` is thrown (GH14189)
- `pandas.api.types.is_datetime64_ns_dtype` will now report `True` on a tz-aware dtype, similar to `pandas.api.types.is_datetime64_any_dtype`
- `DataFrame.asof()` will return a null filled `Series` instead the scalar `NaN` if a match is not found (GH15118)

- Specific support for `copy.copy()` and `copy.deepcopy()` functions on NDFrame objects (GH15444)
- `Series.sort_values()` accepts a one element list of bool for consistency with the behavior of `DataFrame.sort_values()` (GH15604)
- `.merge()` and `.join()` on `category` dtype columns will now preserve the category dtype when possible (GH10409)
- `SparseDataFrame.default_fill_value` will be 0, previously was `nan` in the return from `pd.get_dummies(..., sparse=True)` (GH15594)
- The default behaviour of `Series.str.match` has changed from extracting groups to matching the pattern. The extracting behaviour was deprecated since pandas version 0.13.0 and can be done with the `Series.str.extract` method (GH5224). As a consequence, the `as_indexer` keyword is ignored (no longer needed to specify the new behaviour) and is deprecated.
- `NaT` will now correctly report `False` for datetimelike boolean operations such as `is_month_start` (GH15781)
- `NaT` will now correctly return `np.nan` for `Timedelta` and `Period` accessors such as `days` and `quarter` (GH15782)
- `NaT` will now returns `NaT` for `tz_localize` and `tz_convert` methods (GH15830)
- `DataFrame` and `Panel` constructors with invalid input will now raise `ValueError` rather than `PandasError`, if called with scalar inputs and not axes (GH15541)
- `DataFrame` and `Panel` constructors with invalid input will now raise `ValueError` rather than `pandas.core.common.PandasError`, if called with scalar inputs and not axes; The exception `PandasError` is removed as well. (GH15541)
- The exception `pandas.core.common.AmbiguousIndexError` is removed as it is not referenced (GH15541)

1.4.3 Reorganization of the library: Privacy Changes

1.4.3.1 Modules Privacy Has Changed

Some formerly public python/c/c++/cython extension modules have been moved and/or renamed. These are all removed from the public API. Furthermore, the `pandas.core`, `pandas.compat`, and `pandas.util` top-level modules are now considered to be PRIVATE. If indicated, a deprecation warning will be issued if you reference theses modules. (GH12588)

Previous Location	New Location	Deprecated
pandas.lib	pandas._libs.lib	X
pandas.tslib	pandas._libs.tslib	X
pandas.computation	pandas.core.computation	X
pandas.msgpack	pandas.io.msgpack	
pandas.index	pandas._libs.index	
pandas.algos	pandas._libs.algos	
pandas.hashtable	pandas._libs.hashtable	
pandas.indexes	pandas.core.indexes	
pandas.json	pandas._libs.json / pandas.io.json	X
pandas.parser	pandas._libs.parsers	X
pandas.formats	pandas.io.formats	
pandas.sparse	pandas.core.sparse	
pandas.tools	pandas.core.reshape	X
pandas.types	pandas.core.dtypes	X
pandas.io.sas.saslib	pandas.io.sas._sas	
pandas._join	pandas._libs.join	
pandas._hash	pandas._libs.hashing	
pandas._period	pandas._libs.period	
pandas._sparse	pandas._libs.sparse	
pandas._testing	pandas._libs.testing	
pandas._window	pandas._libs.window	

Some new subpackages are created with public functionality that is not directly exposed in the top-level namespace: `pandas.errors`, `pandas.plotting` and `pandas.testing` (more details below). Together with `pandas.api.types` and certain functions in the `pandas.io` and `pandas.tseries` submodules, these are now the public subpackages.

Further changes:

- The function *`union_categoricals()`* is now importable from `pandas.api.types`, formerly from `pandas.types.concat` (GH15998)
- The type import `pandas.tslib.NaTType` is deprecated and can be replaced by using `type(pandas.NaT)` (GH16146)
- The public functions in `pandas.tools.hashing` deprecated from that locations, but are now importable from `pandas.util` (GH16223)
- The modules in `pandas.util`: `decorators`, `print_versions`, `doctools`, `validators`, `depr_module` are now private. Only the functions exposed in `pandas.util` itself are public (GH16223)

1.4.3.2 pandas.errors

We are adding a standard public module for all pandas exceptions & warnings `pandas.errors`. (GH14800). Previously these exceptions & warnings could be imported from `pandas.core.common` or `pandas.io.common`. These exceptions and warnings will be removed from the `*.common` locations in a future release. (GH15541)

The following are now part of this API:

```
['DtypeWarning',
 'EmptyDataError',
 'OutOfBoundsDatetime',
 'ParserError',
 'ParserWarning',
 'PerformanceWarning',
```

```
 'UnsortedIndexError',
 'UnsupportedFunctionCall']
```

1.4.3.3 pandas.testing

We are adding a standard module that exposes the public testing functions in `pandas.testing` (GH9895). Those functions can be used when writing tests for functionality using pandas objects.

The following testing functions are now part of this API:

- *testing.assert_frame_equal()*
- *testing.assert_series_equal()*
- *testing.assert_index_equal()*

1.4.3.4 pandas.plotting

A new public `pandas.plotting` module has been added that holds plotting functionality that was previously in either `pandas.tools.plotting` or in the top-level namespace. See the *deprecations sections* for more details.

1.4.3.5 Other Development Changes

- Building pandas for development now requires `cython >= 0.23` (GH14831)
- Require at least 0.23 version of cython to avoid problems with character encodings (GH14699)
- Switched the test framework to use pytest (GH13097)
- Reorganization of tests directory layout (GH14854, GH15707).

1.4.4 Deprecations

1.4.4.1 Deprecate .ix

The `.ix` indexer is deprecated, in favor of the more strict `.iloc` and `.loc` indexers. `.ix` offers a lot of magic on the inference of what the user wants to do. To wit, `.ix` can decide to index *positionally* OR via *labels*, depending on the data type of the index. This has caused quite a bit of user confusion over the years. The full indexing documentation is *here*. (GH14218)

The recommended methods of indexing are:

- `.loc` if you want to *label* index
- `.iloc` if you want to *positionally* index.

Using `.ix` will now show a `DeprecationWarning` with a link to some examples of how to convert code *here*.

```
In [130]: df = pd.DataFrame({'A': [1, 2, 3],
   .....:                    'B': [4, 5, 6]},
   .....:                   index=list('abc'))
   .....:

In [131]: df
Out[131]:
   A  B
```

```
a  1  4
b  2  5
c  3  6
```

Previous Behavior, where you wish to get the 0th and the 2nd elements from the index in the 'A' column.

```
In [3]: df.ix[[0, 2], 'A']
Out[3]:
a    1
c    3
Name: A, dtype: int64
```

Using `.loc`. Here we will select the appropriate indexes from the index, then use *label* indexing.

```
In [132]: df.loc[df.index[[0, 2]], 'A']
Out[132]:
a    1
c    3
Name: A, dtype: int64
```

Using `.iloc`. Here we will get the location of the 'A' column, then use *positional* indexing to select things.

```
In [133]: df.iloc[[0, 2], df.columns.get_loc('A')]
Out[133]:
a    1
c    3
Name: A, dtype: int64
```

1.4.4.2 Deprecate Panel

`Panel` is deprecated and will be removed in a future version. The recommended way to represent 3-D data are with a `MultiIndex` on a `DataFrame` via the *`to_frame()`* or with the xarray package. Pandas provides a *`to_xarray()`* method to automate this conversion. For more details see *Deprecate Panel* documentation. (GH13563).

```
In [134]: p = tm.makePanel()

In [135]: p
Out[135]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 3 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to D
```

Convert to a MultiIndex DataFrame

```
In [136]: p.to_frame()
Out[136]:
                     ItemA     ItemB     ItemC
major      minor
2000-01-03 A      0.628776 -1.409432  0.209395
           B      0.988138 -1.347533 -0.896581
           C     -0.938153  1.272395 -0.161137
           D     -0.223019 -0.591863 -1.051539
2000-01-04 A      0.186494  1.422986 -0.592886
```

```
           B     -0.072608  0.363565  1.104352
           C     -1.239072 -1.449567  0.889157
           D      2.123692 -0.414505 -0.319561
2000-01-05 A      0.952478 -2.147855 -1.473116
           B     -0.550603 -0.014752 -0.431550
           C      0.139683 -1.195524  0.288377
           D      0.122273 -1.425795 -0.619993
```

Convert to an xarray DataArray

```
In [137]: p.to_xarray()
Out[137]:
<xarray.DataArray (items: 3, major_axis: 3, minor_axis: 4)>
array([[[ 0.628776,  0.988138, -0.938153, -0.223019],
        [ 0.186494, -0.072608, -1.239072,  2.123692],
        [ 0.952478, -0.550603,  0.139683,  0.122273]],

       [[-1.409432, -1.347533,  1.272395, -0.591863],
        [ 1.422986,  0.363565, -1.449567, -0.414505],
        [-2.147855, -0.014752, -1.195524, -1.425795]],

       [[ 0.209395, -0.896581, -0.161137, -1.051539],
        [-0.592886,  1.104352,  0.889157, -0.319561],
        [-1.473116, -0.43155 ,  0.288377, -0.619993]]])
Coordinates:
  * items       (items) object 'ItemA' 'ItemB' 'ItemC'
  * major_axis  (major_axis) datetime64[ns] 2000-01-03 2000-01-04 2000-01-05
  * minor_axis  (minor_axis) object 'A' 'B' 'C' 'D'
```

1.4.4.3 Deprecate groupby.agg() with a dictionary when renaming

The `.groupby(..).agg(..)`, `.rolling(..).agg(..)`, and `.resample(..).agg(..)` syntax can accept a variable of inputs, including scalars, list, and a dict of column names to scalars or lists. This provides a useful syntax for constructing multiple (potentially different) aggregations.

However, `.agg(..)` can *also* accept a dict that allows 'renaming' of the result columns. This is a complicated and confusing syntax, as well as not consistent between `Series` and `DataFrame`. We are deprecating this 'renaming' functionaility.

- We are deprecating passing a dict to a grouped/rolled/resampled `Series`. This allowed one to `rename` the resulting aggregation, but this had a completely different meaning than passing a dictionary to a grouped `DataFrame`, which accepts column-to-aggregations.
- We are deprecating passing a dict-of-dicts to a grouped/rolled/resampled `DataFrame` in a similar manner.

This is an illustrative example:

```
In [138]: df = pd.DataFrame({'A': [1, 1, 1, 2, 2],
   .....:                    'B': range(5),
   .....:                    'C': range(5)})
   .....:

In [139]: df
Out[139]:
   A  B  C
0  1  0  0
1  1  1  1
```

```
2  1  2  2
3  2  3  3
4  2  4  4
```

Here is a typical useful syntax for computing different aggregations for different columns. This is a natural, and useful syntax. We aggregate from the dict-to-list by taking the specified columns and applying the list of functions. This returns a `MultiIndex` for the columns (this is *not* deprecated).

```
In [140]: df.groupby('A').agg({'B': 'sum', 'C': 'min'})
Out[140]:
   B  C
A
1  3  0
2  7  3
```

Here's an example of the first deprecation, passing a dict to a grouped `Series`. This is a combination aggregation & renaming:

```
In [6]: df.groupby('A').B.agg({'foo': 'count'})
FutureWarning: using a dict on a Series for aggregation
is deprecated and will be removed in a future version

Out[6]:
   foo
A
1    3
2    2
```

You can accomplish the same operation, more idiomatically by:

```
In [141]: df.groupby('A').B.agg(['count']).rename(columns={'count': 'foo'})
Out[141]:
   foo
A
1    3
2    2
```

Here's an example of the second deprecation, passing a dict-of-dict to a grouped `DataFrame`:

```
In [23]: (df.groupby('A')
            .agg({'B': {'foo': 'sum'}, 'C': {'bar': 'min'}})
         )
FutureWarning: using a dict with renaming is deprecated and
will be removed in a future version

Out[23]:
     B   C
   foo bar
A
1   3   0
2   7   3
```

You can accomplish nearly the same by:

```
In [142]: (df.groupby('A')
   .....:    .agg({'B': 'sum', 'C': 'min'})
   .....:    .rename(columns={'B': 'foo', 'C': 'bar'})
   .....: )
```

```
   .....:
Out[142]:
   foo  bar
A
1    3    0
2    7    3
```

1.4.4.4 Deprecate .plotting

The `pandas.tools.plotting` module has been deprecated, in favor of the top level `pandas.plotting` module. All the public plotting functions are now available from `pandas.plotting` (GH12548).

Furthermore, the top-level `pandas.scatter_matrix` and `pandas.plot_params` are deprecated. Users can import these from `pandas.plotting` as well.

Previous script:

```
pd.tools.plotting.scatter_matrix(df)
pd.scatter_matrix(df)
```

Should be changed to:

```
pd.plotting.scatter_matrix(df)
```

1.4.4.5 Other Deprecations

- `SparseArray.to_dense()` has deprecated the `fill` parameter, as that parameter was not being respected (GH14647)
- `SparseSeries.to_dense()` has deprecated the `sparse_only` parameter (GH14647)
- `Series.repeat()` has deprecated the `reps` parameter in favor of `repeats` (GH12662)
- The `Series` constructor and `.astype` method have deprecated accepting timestamp dtypes without a frequency (e.g. `np.datetime64`) for the `dtype` parameter (GH15524)
- `Index.repeat()` and `MultiIndex.repeat()` have deprecated the `n` parameter in favor of `repeats` (GH12662)
- `Categorical.searchsorted()` and `Series.searchsorted()` have deprecated the `v` parameter in favor of `value` (GH12662)
- `TimedeltaIndex.searchsorted()`, `DatetimeIndex.searchsorted()`, and `PeriodIndex.searchsorted()` have deprecated the `key` parameter in favor of `value` (GH12662)
- `DataFrame.astype()` has deprecated the `raise_on_error` parameter in favor of `errors` (GH14878)
- `Series.sortlevel` and `DataFrame.sortlevel` have been deprecated in favor of `Series.sort_index` and `DataFrame.sort_index` (GH15099)
- importing `concat` from `pandas.tools.merge` has been deprecated in favor of imports from the `pandas` namespace. This should only affect explict imports (GH15358)
- `Series/DataFrame/Panel.consolidate()` been deprecated as a public method. (GH15483)
- The `as_indexer` keyword of `Series.str.match()` has been deprecated (ignored keyword) (GH15257).
- The following top-level pandas functions have been deprecated and will be removed in a future version (GH13790, GH15940)

  - `pd.pnow()`, replaced by `Period.now()`
  - `pd.Term`, is removed, as it is not applicable to user code. Instead use in-line string expressions in the where clause when searching in HDFStore
  - `pd.Expr`, is removed, as it is not applicable to user code.
  - `pd.match()`, is removed.
  - `pd.groupby()`, replaced by using the `.groupby()` method directly on a `Series/DataFrame`
  - `pd.get_store()`, replaced by a direct call to `pd.HDFStore(...)`
- `is_any_int_dtype`, `is_floating_dtype`, and `is_sequence` are deprecated from `pandas.api.types` (GH16042)

1.4.5 Removal of prior version deprecations/changes

- The `pandas.rpy` module is removed. Similar functionality can be accessed through the rpy2 project. See the *R interfacing docs* for more details.
- The `pandas.io.ga` module with a `google-analytics` interface is removed (GH11308). Similar functionality can be found in the Google2Pandas package.
- `pd.to_datetime` and `pd.to_timedelta` have dropped the `coerce` parameter in favor of `errors` (GH13602)
- `pandas.stats.fama_macbeth`, `pandas.stats.ols`, `pandas.stats.plm` and `pandas.stats.var`, as well as the top-level `pandas.fama_macbeth` and `pandas.ols` routines are removed. Similar functionaility can be found in the statsmodels package. (GH11898)
- The `TimeSeries` and `SparseTimeSeries` classes, aliases of `Series` and `SparseSeries`, are removed (GH10890, GH15098).
- `Series.is_time_series` is dropped in favor of `Series.index.is_all_dates` (GH15098)
- The deprecated `irow`, `icol`, `iget` and `iget_value` methods are removed in favor of `iloc` and `iat` as explained *here* (GH10711).
- The deprecated `DataFrame.iterkv()` has been removed in favor of `DataFrame.iteritems()` (GH10711)
- The `Categorical` constructor has dropped the `name` parameter (GH10632)
- `Categorical` has dropped support for `NaN` categories (GH10748)
- The `take_last` parameter has been dropped from `duplicated()`, `drop_duplicates()`, `nlargest()`, and `nsmallest()` methods (GH10236, GH10792, GH10920)
- `Series`, `Index`, and `DataFrame` have dropped the `sort` and `order` methods (GH10726)
- Where clauses in `pytables` are only accepted as strings and expressions types and not other data-types (GH12027)
- `DataFrame` has dropped the `combineAdd` and `combineMult` methods in favor of `add` and `mul` respectively (GH10735)

1.4.6 Performance Improvements

- Improved performance of `pd.wide_to_long()` (GH14779)

- Improved performance of `pd.factorize()` by releasing the GIL with `object` dtype when inferred as strings (GH14859, GH16057)
- Improved performance of timeseries plotting with an irregular DatetimeIndex (or with `compat_x=True`) (GH15073).
- Improved performance of `groupby().cummin()` and `groupby().cummax()` (GH15048, GH15109, GH15561, GH15635)
- Improved performance and reduced memory when indexing with a `MultiIndex` (GH15245)
- When reading buffer object in `read_sas()` method without specified format, filepath string is inferred rather than buffer object. (GH14947)
- Improved performance of `.rank()` for categorical data (GH15498)
- Improved performance when using `.unstack()` (GH15503)
- Improved performance of merge/join on `category` columns (GH10409)
- Improved performance of `drop_duplicates()` on `bool` columns (GH12963)
- Improve performance of `pd.core.groupby.GroupBy.apply` when the applied function used the `.name` attribute of the group DataFrame (GH15062).
- Improved performance of `iloc` indexing with a list or array (GH15504).
- Improved performance of `Series.sort_index()` with a monotonic index (GH15694)
- Improved performance in `pd.read_csv()` on some platforms with buffered reads (GH16039)

1.4.7 Bug Fixes

1.4.7.1 Conversion

- Bug in `Timestamp.replace` now raises `TypeError` when incorrect argument names are given; previously this raised `ValueError` (GH15240)
- Bug in `Timestamp.replace` with compat for passing long integers (GH15030)
- Bug in `Timestamp` returning UTC based time/date attributes when a timezone was provided (GH13303, GH6538)
- Bug in `Timestamp` incorrectly localizing timezones during construction (GH11481, GH15777)
- Bug in `TimedeltaIndex` addition where overflow was being allowed without error (GH14816)
- Bug in `TimedeltaIndex` raising a `ValueError` when boolean indexing with `loc` (GH14946)
- Bug in catching an overflow in `Timestamp` + `Timedelta/Offset` operations (GH15126)
- Bug in `DatetimeIndex.round()` and `Timestamp.round()` floating point accuracy when rounding by milliseconds or less (GH14440, GH15578)
- Bug in `astype()` where `inf` values were incorrectly converted to integers. Now raises error now with `astype()` for Series and DataFrames (GH14265)
- Bug in `DataFrame(..).apply(to_numeric)` when values are of type decimal.Decimal. (GH14827)
- Bug in `describe()` when passing a numpy array which does not contain the median to the `percentiles` keyword argument (GH14908)
- Cleaned up `PeriodIndex` constructor, including raising on floats more consistently (GH13277)
- Bug in using `__deepcopy__` on empty NDFrame objects (GH15370)

- Bug in `.replace()` may result in incorrect dtypes. (GH12747, GH15765)
- Bug in `Series.replace` and `DataFrame.replace` which failed on empty replacement dicts (GH15289)
- Bug in `Series.replace` which replaced a numeric by string (GH15743)
- Bug in `Index` construction with `NaN` elements and integer dtype specified (GH15187)
- Bug in `Series` construction with a datetimetz (GH14928)
- Bug in `Series.dt.round()` inconsistent behaviour on `NaT` 's with different arguments (GH14940)
- Bug in `Series` constructor when both `copy=True` and `dtype` arguments are provided (GH15125)
- Incorrect dtyped `Series` was returned by comparison methods (e.g., `lt`, `gt`, ...) against a constant for an empty `DataFrame` (GH15077)
- Bug in `Series.ffill()` with mixed dtypes containing tz-aware datetimes. (GH14956)
- Bug in `DataFrame.fillna()` where the argument `downcast` was ignored when fillna value was of type `dict` (GH15277)
- Bug in `.asfreq()`, where frequency was not set for empty `Series` (GH14320)
- Bug in `DataFrame` construction with nulls and datetimes in a list-like (GH15869)
- Bug in `DataFrame.fillna()` with tz-aware datetimes (GH15855)
- Bug in `is_string_dtype`, `is_timedelta64_ns_dtype`, and `is_string_like_dtype` in which an error was raised when `None` was passed in (GH15941)
- Bug in the return type of `pd.unique` on a `Categorical`, which was returning an ndarray and not a `Categorical` (GH15903)
- Bug in `Index.to_series()` where the index was not copied (and so mutating later would change the original), (GH15949)
- Bug in indexing with partial string indexing with a len-1 DataFrame (GH16071)
- Bug in `Series` construction where passing invalid dtype didn't raise an error. (GH15520)

1.4.7.2 Indexing

- Bug in `Index` power operations with reversed operands (GH14973)
- Bug in `DataFrame.sort_values()` when sorting by multiple columns where one column is of type `int64` and contains `NaT` (GH14922)
- Bug in `DataFrame.reindex()` in which `method` was ignored when passing `columns` (GH14992)
- Bug in `DataFrame.loc` with indexing a `MultiIndex` with a `Series` indexer (GH14730, GH15424)
- Bug in `DataFrame.loc` with indexing a `MultiIndex` with a numpy array (GH15434)
- Bug in `Series.asof` which raised if the series contained all `np.nan` (GH15713)
- Bug in `.at` when selecting from a tz-aware column (GH15822)
- Bug in `Series.where()` and `DataFrame.where()` where array-like conditionals were being rejected (GH15414)
- Bug in `Series.where()` where TZ-aware data was converted to float representation (GH15701)
- Bug in `.loc` that would not return the correct dtype for scalar access for a DataFrame (GH11617)
- Bug in output formatting of a `MultiIndex` when names are integers (GH12223, GH15262)

- Bug in `Categorical.searchsorted()` where alphabetical instead of the provided categorical order was used (GH14522)
- Bug in `Series.iloc` where a `Categorical` object for list-like indexes input was returned, where a `Series` was expected. (GH14580)
- Bug in `DataFrame.isin` comparing datetimelike to empty frame (GH15473)
- Bug in `.reset_index()` when an all `NaN` level of a `MultiIndex` would fail (GH6322)
- Bug in `.reset_index()` when raising error for index name already present in `MultiIndex` columns (GH16120)
- Bug in creating a `MultiIndex` with tuples and not passing a list of names; this will now raise `ValueError` (GH15110)
- Bug in the HTML display with with a `MultiIndex` and truncation (GH14882)
- Bug in the display of `.info()` where a qualifier (+) would always be displayed with a `MultiIndex` that contains only non-strings (GH15245)
- Bug in `pd.concat()` where the names of `MultiIndex` of resulting `DataFrame` are not handled correctly when `None` is presented in the names of `MultiIndex` of input `DataFrame` (GH15787)
- Bug in `DataFrame.sort_index()` and `Series.sort_index()` where `na_position` doesn't work with a `MultiIndex` (GH14784, GH16604)
- Bug in in `pd.concat()` when combining objects with a `CategoricalIndex` (GH16111)
- Bug in indexing with a scalar and a `CategoricalIndex` (GH16123)

1.4.7.3 I/O

- Bug in `pd.to_numeric()` in which float and unsigned integer elements were being improperly casted (GH14941, GH15005)
- Bug in `pd.read_fwf()` where the skiprows parameter was not being respected during column width inference (GH11256)
- Bug in `pd.read_csv()` in which the `dialect` parameter was not being verified before processing (GH14898)
- Bug in `pd.read_csv()` in which missing data was being improperly handled with `usecols` (GH6710)
- Bug in `pd.read_csv()` in which a file containing a row with many columns followed by rows with fewer columns would cause a crash (GH14125)
- Bug in `pd.read_csv()` for the C engine where `usecols` were being indexed incorrectly with `parse_dates` (GH14792)
- Bug in `pd.read_csv()` with `parse_dates` when multiline headers are specified (GH15376)
- Bug in `pd.read_csv()` with `float_precision='round_trip'` which caused a segfault when a text entry is parsed (GH15140)
- Bug in `pd.read_csv()` when an index was specified and no values were specified as null values (GH15835)
- Bug in `pd.read_csv()` in which certain invalid file objects caused the Python interpreter to crash (GH15337)
- Bug in `pd.read_csv()` in which invalid values for `nrows` and `chunksize` were allowed (GH15767)
- Bug in `pd.read_csv()` for the Python engine in which unhelpful error messages were being raised when parsing errors occurred (GH15910)
- Bug in `pd.read_csv()` in which the `skipfooter` parameter was not being properly validated (GH15925)

- Bug in `pd.to_csv()` in which there was numeric overflow when a timestamp index was being written (GH15982)
- Bug in `pd.util.hashing.hash_pandas_object()` in which hashing of categoricals depended on the ordering of categories, instead of just their values. (GH15143)
- Bug in `.to_json()` where `lines=True` and contents (keys or values) contain escaped characters (GH15096)
- Bug in `.to_json()` causing single byte ascii characters to be expanded to four byte unicode (GH15344)
- Bug in `.to_json()` for the C engine where rollover was not correctly handled for case where frac is odd and diff is exactly 0.5 (GH15716, GH15864)
- Bug in `pd.read_json()` for Python 2 where `lines=True` and contents contain non-ascii unicode characters (GH15132)
- Bug in `pd.read_msgpack()` in which `Series` categoricals were being improperly processed (GH14901)
- Bug in `pd.read_msgpack()` which did not allow loading of a dataframe with an index of type `CategoricalIndex` (GH15487)
- Bug in `pd.read_msgpack()` when deserializing a `CategoricalIndex` (GH15487)
- Bug in `DataFrame.to_records()` with converting a `DatetimeIndex` with a timezone (GH13937)
- Bug in `DataFrame.to_records()` which failed with unicode characters in column names (GH11879)
- Bug in `.to_sql()` when writing a DataFrame with numeric index names (GH15404).
- Bug in `DataFrame.to_html()` with `index=False` and `max_rows` raising in `IndexError` (GH14998)
- Bug in `pd.read_hdf()` passing a `Timestamp` to the `where` parameter with a non date column (GH15492)
- Bug in `DataFrame.to_stata()` and `StataWriter` which produces incorrectly formatted files to be produced for some locales (GH13856)
- Bug in `StataReader` and `StataWriter` which allows invalid encodings (GH15723)
- Bug in the `Series` repr not showing the length when the output was truncated (GH15962).

1.4.7.4 Plotting

- Bug in `DataFrame.hist` where `plt.tight_layout` caused an `AttributeError` (use `matplotlib >= 2.0.1`) (GH9351)
- Bug in `DataFrame.boxplot` where `fontsize` was not applied to the tick labels on both axes (GH15108)
- Bug in the date and time converters pandas registers with matplotlib not handling multiple dimensions (GH16026)
- Bug in `pd.scatter_matrix()` could accept either `color` or `c`, but not both (GH14855)

1.4.7.5 Groupby/Resample/Rolling

- Bug in `.groupby(..).resample()` when passed the `on=` kwarg. (GH15021)
- Properly set `__name__` and `__qualname__` for `Groupby.*` functions (GH14620)
- Bug in `GroupBy.get_group()` failing with a categorical grouper (GH15155)
- Bug in `.groupby(...).rolling(...)` when `on` is specified and using a `DatetimeIndex` (GH15130, GH13966)

- Bug in groupby operations with `timedelta64` when passing `numeric_only=False` (GH5724)
- Bug in `groupby.apply()` coercing `object` dtypes to numeric types, when not all values were numeric (GH14423, GH15421, GH15670)
- Bug in `resample`, where a non-string `loffset` argument would not be applied when resampling a timeseries (GH13218)
- Bug in `DataFrame.groupby().describe()` when grouping on `Index` containing tuples (GH14848)
- Bug in `groupby().nunique()` with a datetimelike-grouper where bins counts were incorrect (GH13453)
- Bug in `groupby.transform()` that would coerce the resultant dtypes back to the original (GH10972, GH11444)
- Bug in `groupby.agg()` incorrectly localizing timezone on `datetime` (GH15426, GH10668, GH13046)
- Bug in `.rolling/expanding()` functions where `count()` was not counting `np.Inf`, nor handling `object` dtypes (GH12541)
- Bug in `.rolling()` where `pd.Timedelta` or `datetime.timedelta` was not accepted as a `window` argument (GH15440)
- Bug in `Rolling.quantile` function that caused a segmentation fault when called with a quantile value outside of the range [0, 1] (GH15463)
- Bug in `DataFrame.resample().median()` if duplicate column names are present (GH14233)

1.4.7.6 Sparse

- Bug in `SparseSeries.reindex` on single level with list of length 1 (GH15447)
- Bug in repr-formatting a `SparseDataFrame` after a value was set on (a copy of) one of its series (GH15488)
- Bug in `SparseDataFrame` construction with lists not coercing to dtype (GH15682)
- Bug in sparse array indexing in which indices were not being validated (GH15863)

1.4.7.7 Reshaping

- Bug in `pd.merge_asof()` where `left_index` or `right_index` caused a failure when multiple `by` was specified (GH15676)
- Bug in `pd.merge_asof()` where `left_index/right_index` together caused a failure when `tolerance` was specified (GH15135)
- Bug in `DataFrame.pivot_table()` where `dropna=True` would not drop all-NaN columns when the columns was a `category` dtype (GH15193)
- Bug in `pd.melt()` where passing a tuple value for `value_vars` caused a `TypeError` (GH15348)
- Bug in `pd.pivot_table()` where no error was raised when values argument was not in the columns (GH14938)
- Bug in `pd.concat()` in which concatenating with an empty dataframe with `join='inner'` was being improperly handled (GH15328)
- Bug with `sort=True` in `DataFrame.join` and `pd.merge` when joining on indexes (GH15582)
- Bug in `DataFrame.nsmallest` and `DataFrame.nlargest` where identical values resulted in duplicated rows (GH15297)

- Bug in *pandas.pivot_table()* incorrectly raising `UnicodeError` when passing unicode input for `margins keyword (GH13292)

1.4.7.8 Numeric

- Bug in `.rank()` which incorrectly ranks ordered categories (GH15420)
- Bug in `.corr()` and `.cov()` where the column and index were the same object (GH14617)
- Bug in `.mode()` where `mode` was not returned if was only a single value (GH15714)
- Bug in `pd.cut()` with a single bin on an all 0s array (GH15428)
- Bug in `pd.qcut()` with a single quantile and an array with identical values (GH15431)
- Bug in `pandas.tools.utils.cartesian_product()` with large input can cause overflow on windows (GH15265)
- Bug in `.eval()` which caused multiline evals to fail with local variables not on the first line (GH15342)

1.4.7.9 Other

- Compat with SciPy 0.19.0 for testing on `.interpolate()` (GH15662)
- Compat for 32-bit platforms for `.qcut/cut`; bins will now be `int64` dtype (GH14866)
- Bug in interactions with `Qt` when a `QtApplication` already exists (GH14372)
- Avoid use of `np.finfo()` during `import pandas` removed to mitigate deadlock on Python GIL misuse (GH14641)

1.5 v0.19.2 (December 24, 2016)

This is a minor bug-fix release in the 0.19.x series and includes some small regression fixes, bug fixes and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

- Compatibility with Python 3.6
- Added a Pandas Cheat Sheet. (GH13202).

What's new in v0.19.2

- *Enhancements*
- *Performance Improvements*
- *Bug Fixes*

1.5.1 Enhancements

The `pd.merge_asof()`, added in 0.19.0, gained some improvements:

- `pd.merge_asof()` gained `left_index/right_index` and `left_by/right_by` arguments (GH14253)

- `pd.merge_asof()` can take multiple columns in `by` parameter and has specialized dtypes for better performace (GH13936)

1.5.2 Performance Improvements

- Performance regression with `PeriodIndex` (GH14822)
- Performance regression in indexing with getitem (GH14930)
- Improved performance of `.replace()` (GH12745)
- Improved performance `Series` creation with a datetime index and dictionary data (GH14894)

1.5.3 Bug Fixes

- Compat with python 3.6 for pickling of some offsets (GH14685)
- Compat with python 3.6 for some indexing exception types (GH14684, GH14689)
- Compat with python 3.6 for deprecation warnings in the test suite (GH14681)
- Compat with python 3.6 for Timestamp pickles (GH14689)
- Compat with `dateutil==2.6.0`; segfault reported in the testing suite (GH14621)
- Allow `nanoseconds` in `Timestamp.replace` as a kwarg (GH14621)
- Bug in `pd.read_csv` in which aliasing was being done for `na_values` when passed in as a dictionary (GH14203)
- Bug in `pd.read_csv` in which column indices for a dict-like `na_values` were not being respected (GH14203)
- Bug in `pd.read_csv` where reading files fails, if the number of headers is equal to the number of lines in the file (GH14515)
- Bug in `pd.read_csv` for the Python engine in which an unhelpful error message was being raised when multi-char delimiters were not being respected with quotes (GH14582)
- Fix bugs (GH14734, GH13654) in `pd.read_sas` and `pandas.io.sas.sas7bdat.SAS7BDATReader` that caused problems when reading a SAS file incrementally.
- Bug in `pd.read_csv` for the Python engine in which an unhelpful error message was being raised when `skipfooter` was not being respected by Python's CSV library (GH13879)
- Bug in `.fillna()` in which timezone aware datetime64 values were incorrectly rounded (GH14872)
- Bug in `.groupby(..., sort=True)` of a non-lexsorted MultiIndex when grouping with multiple levels (GH14776)
- Bug in `pd.cut` with negative values and a single bin (GH14652)
- Bug in `pd.to_numeric` where a 0 was not unsigned on a `downcast='unsigned'` argument (GH14401)
- Bug in plotting regular and irregular timeseries using shared axes (`sharex=True` or `ax.twinx()`) (GH13341, GH14322).
- Bug in not propogating exceptions in parsing invalid datetimes, noted in python 3.6 (GH14561)
- Bug in resampling a `DatetimeIndex` in local TZ, covering a DST change, which would raise `AmbiguousTimeError` (GH14682)
- Bug in indexing that transformed `RecursionError` into `KeyError` or `IndexingError` (GH14554)

- Bug in `HDFStore` when writing a `MultiIndex` when using `data_columns=True` (GH14435)
- Bug in `HDFStore.append()` when writing a `Series` and passing a `min_itemsize` argument containing a value for the `index` (GH11412)
- Bug when writing to a `HDFStore` in `table` format with a `min_itemsize` value for the `index` and without asking to append (GH10381)
- Bug in `Series.groupby.nunique()` raising an `IndexError` for an empty `Series` (GH12553)
- Bug in `DataFrame.nlargest` and `DataFrame.nsmallest` when the index had duplicate values (GH13412)
- Bug in clipboard functions on linux with python2 with unicode and separators (GH13747)
- Bug in clipboard functions on Windows 10 and python 3 (GH14362, GH12807)
- Bug in `.to_clipboard()` and Excel compat (GH12529)
- Bug in `DataFrame.combine_first()` for integer columns (GH14687).
- Bug in `pd.read_csv()` in which the `dtype` parameter was not being respected for empty data (GH14712)
- Bug in `pd.read_csv()` in which the `nrows` parameter was not being respected for large input when using the C engine for parsing (GH7626)
- Bug in `pd.merge_asof()` could not handle timezone-aware DatetimeIndex when a tolerance was specified (GH14844)
- Explicit check in `to_stata` and `StataWriter` for out-of-range values when writing doubles (GH14618)
- Bug in `.plot(kind='kde')` which did not drop missing values to generate the KDE Plot, instead generating an empty plot. (GH14821)
- Bug in `unstack()` if called with a list of column(s) as an argument, regardless of the dtypes of all columns, they get coerced to `object` (GH11847)

1.6 v0.19.1 (November 3, 2016)

This is a minor bug-fix release from 0.19.0 and includes some small regression fixes, bug fixes and performance improvements. We recommend that all users upgrade to this version.

What's new in v0.19.1

- *Performance Improvements*
- *Bug Fixes*

1.6.1 Performance Improvements

- Fixed performance regression in factorization of `Period` data (GH14338)
- Fixed performance regression in `Series.asof(where)` when `where` is a scalar (GH14461)
- Improved performance in `DataFrame.asof(where)` when `where` is a scalar (GH14461)
- Improved performance in `.to_json()` when `lines=True` (GH14408)
- Improved performance in certain types of *loc* indexing with a MultiIndex (GH14551).

1.6.2 Bug Fixes

- Source installs from PyPI will now again work without `cython` installed, as in previous versions (GH14204)
- Compat with Cython 0.25 for building (GH14496)
- Fixed regression where user-provided file handles were closed in `read_csv` (c engine) (GH14418).
- Fixed regression in `DataFrame.quantile` when missing values where present in some columns (GH14357).
- Fixed regression in `Index.difference` where the `freq` of a `DatetimeIndex` was incorrectly set (GH14323)
- Added back `pandas.core.common.array_equivalent` with a deprecation warning (GH14555).
- Bug in `pd.read_csv` for the C engine in which quotation marks were improperly parsed in skipped rows (GH14459)
- Bug in `pd.read_csv` for Python 2.x in which Unicode quote characters were no longer being respected (GH14477)
- Fixed regression in `Index.append` when categorical indices were appended (GH14545).
- Fixed regression in `pd.DataFrame` where constructor fails when given dict with `None` value (GH14381)
- Fixed regression in `DatetimeIndex._maybe_cast_slice_bound` when index is empty (GH14354).
- Bug in localizing an ambiguous timezone when a boolean is passed (GH14402)
- Bug in `TimedeltaIndex` addition with a Datetime-like object where addition overflow in the negative direction was not being caught (GH14068, GH14453)
- Bug in string indexing against data with `object Index` may raise `AttributeError` (GH14424)
- Corrrecly raise `ValueError` on empty input to `pd.eval()` and `df.query()` (GH13139)
- Bug in `RangeIndex.intersection` when result is a empty set (GH14364).
- Bug in groupby-transform broadcasting that could cause incorrect dtype coercion (GH14457)
- Bug in `Series.__setitem__` which allowed mutating read-only arrays (GH14359).
- Bug in `DataFrame.insert` where multiple calls with duplicate columns can fail (GH14291)
- `pd.merge()` will raise `ValueError` with non-boolean parameters in passed boolean type arguments (GH14434)
- Bug in `Timestamp` where dates very near the minimum (1677-09) could underflow on creation (GH14415)
- Bug in `pd.concat` where names of the `keys` were not propagated to the resulting `MultiIndex` (GH14252)
- Bug in `pd.concat` where `axis` cannot take string parameters `'rows'` or `'columns'` (GH14369)
- Bug in `pd.concat` with dataframes heterogeneous in length and tuple `keys` (GH14438)
- Bug in `MultiIndex.set_levels` where illegal level values were still set after raising an error (GH13754)
- Bug in `DataFrame.to_json` where `lines=True` and a value contained a `}` character (GH14391)
- Bug in `df.groupby` causing an `AttributeError` when grouping a single index frame by a column and the index level (:issue‘14327‘)
- Bug in `df.groupby` where `TypeError` raised when `pd.Grouper(key=...)` is passed in a list (GH14334)
- Bug in `pd.pivot_table` may raise `TypeError` or `ValueError` when `index` or `columns` is not scalar and `values` is not specified (GH14380)

1.7 v0.19.0 (October 2, 2016)

This is a major release from 0.18.1 and includes number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- `merge_asof()` for asof-style time-series joining, see *here*
- `.rolling()` is now time-series aware, see *here*
- `read_csv()` now supports parsing `Categorical` data, see *here*
- A function `union_categorical()` has been added for combining categoricals, see *here*
- `PeriodIndex` now has its own `period` dtype, and changed to be more consistent with other `Index` classes. See *here*
- Sparse data structures gained enhanced support of `int` and `bool` dtypes, see *here*
- Comparison operations with `Series` no longer ignores the index, see *here* for an overview of the API changes.
- Introduction of a pandas development API for utility functions, see *here*.
- Deprecation of `Panel4D` and `PanelND`. We recommend to represent these types of n-dimensional data with the xarray package.
- Removal of the previously deprecated modules `pandas.io.data`, `pandas.io.wb`, `pandas.tools.rplot`.

Warning: pandas >= 0.19.0 will no longer silence numpy ufunc warnings upon import, see *here*.

What's new in v0.19.0

1.7.1 New features

1.7.1.1 `merge_asof` for asof-style time-series joining

A long-time requested feature has been added through the `merge_asof()` function, to support asof style joining of time-series (GH1870, GH13695, GH13709, GH13902). Full documentation is *here*.

The *merge_asof()* performs an asof merge, which is similar to a left-join except that we match on nearest key rather than equal keys.

```
In [1]: left = pd.DataFrame({'a': [1, 5, 10],
   ...:                      'left_val': ['a', 'b', 'c']})
   ...:

In [2]: right = pd.DataFrame({'a': [1, 2, 3, 6, 7],
   ...:                      'right_val': [1, 2, 3, 6, 7]})
   ...:

In [3]: left
Out[3]:
    a left_val
0   1        a
1   5        b
2  10        c

In [4]: right
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[4]:
   a  right_val
0  1          1
1  2          2
2  3          3
3  6          6
4  7          7
```

We typically want to match exactly when possible, and use the most recent value otherwise.

```
In [5]: pd.merge_asof(left, right, on='a')
Out[5]:
    a left_val  right_val
0   1        a          1
1   5        b          3
2  10        c          7
```

We can also match rows ONLY with prior data, and not an exact match.

```
In [6]: pd.merge_asof(left, right, on='a', allow_exact_matches=False)
Out[6]:
    a left_val  right_val
0   1        a        NaN
1   5        b        3.0
2  10        c        7.0
```

In a typical time-series example, we have `trades` and `quotes` and we want to `asof-join` them. This also illustrates using the `by` parameter to group data before merging.

```
In [7]: trades = pd.DataFrame({
   ...:     'time': pd.to_datetime(['20160525 13:30:00.023',
   ...:                             '20160525 13:30:00.038',
   ...:                             '20160525 13:30:00.048',
   ...:                             '20160525 13:30:00.048',
   ...:                             '20160525 13:30:00.048']),
   ...:     'ticker': ['MSFT', 'MSFT',
   ...:                'GOOG', 'GOOG', 'AAPL'],
   ...:     'price': [51.95, 51.95,
   ...:               720.77, 720.92, 98.00],
```

```
   ...:     'quantity': [75, 155,
   ...:                  100, 100, 100]},
   ...:     columns=['time', 'ticker', 'price', 'quantity'])
   ...:

In [8]: quotes = pd.DataFrame({
   ...:     'time': pd.to_datetime(['20160525 13:30:00.023',
   ...:                             '20160525 13:30:00.023',
   ...:                             '20160525 13:30:00.030',
   ...:                             '20160525 13:30:00.041',
   ...:                             '20160525 13:30:00.048',
   ...:                             '20160525 13:30:00.049',
   ...:                             '20160525 13:30:00.072',
   ...:                             '20160525 13:30:00.075']),
   ...:     'ticker': ['GOOG', 'MSFT', 'MSFT',
   ...:                'MSFT', 'GOOG', 'AAPL', 'GOOG',
   ...:                'MSFT'],
   ...:     'bid': [720.50, 51.95, 51.97, 51.99,
   ...:             720.50, 97.99, 720.50, 52.01],
   ...:     'ask': [720.93, 51.96, 51.98, 52.00,
   ...:             720.93, 98.01, 720.88, 52.03]},
   ...:     columns=['time', 'ticker', 'bid', 'ask'])
   ...:
```

```
In [9]: trades
Out[9]:
                     time ticker   price  quantity
0 2016-05-25 13:30:00.023   MSFT   51.95        75
1 2016-05-25 13:30:00.038   MSFT   51.95       155
2 2016-05-25 13:30:00.048   GOOG  720.77       100
3 2016-05-25 13:30:00.048   GOOG  720.92       100
4 2016-05-25 13:30:00.048   AAPL   98.00       100

In [10]: quotes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                     time ticker     bid     ask
0 2016-05-25 13:30:00.023   GOOG  720.50  720.93
1 2016-05-25 13:30:00.023   MSFT   51.95   51.96
2 2016-05-25 13:30:00.030   MSFT   51.97   51.98
3 2016-05-25 13:30:00.041   MSFT   51.99   52.00
4 2016-05-25 13:30:00.048   GOOG  720.50  720.93
5 2016-05-25 13:30:00.049   AAPL   97.99   98.01
6 2016-05-25 13:30:00.072   GOOG  720.50  720.88
7 2016-05-25 13:30:00.075   MSFT   52.01   52.03
```

An asof merge joins on the `on`, typically a datetimelike field, which is ordered, and in this case we are using a grouper in the `by` field. This is like a left-outer join, except that forward filling happens automatically taking the most recent non-NaN value.

```
In [11]: pd.merge_asof(trades, quotes,
   ....:               on='time',
   ....:               by='ticker')
   ....:
Out[11]:
                     time ticker   price  quantity     bid     ask
0 2016-05-25 13:30:00.023   MSFT   51.95        75   51.95   51.96
```

```
1 2016-05-25 13:30:00.038   MSFT   51.95        155   51.97   51.98
2 2016-05-25 13:30:00.048   GOOG  720.77        100  720.50  720.93
3 2016-05-25 13:30:00.048   GOOG  720.92        100  720.50  720.93
4 2016-05-25 13:30:00.048   AAPL   98.00        100     NaN     NaN
```

This returns a merged DataFrame with the entries in the same order as the original left passed DataFrame (`trades` in this case), with the fields of the `quotes` merged.

1.7.1.2 `.rolling()` is now time-series aware

`.rolling()` objects are now time-series aware and can accept a time-series offset (or convertible) for the `window` argument (GH13327, GH12995). See the full documentation *here*.

```
In [12]: dft = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]},
   ....:                    index=pd.date_range('20130101 09:00:00', periods=5, freq=
↪'s'))
   ....:

In [13]: dft
Out[13]:
                       B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:01  1.0
2013-01-01 09:00:02  2.0
2013-01-01 09:00:03  NaN
2013-01-01 09:00:04  4.0
```

This is a regular frequency index. Using an integer window parameter works to roll along the window frequency.

```
In [14]: dft.rolling(2).sum()
Out[14]:
                       B
2013-01-01 09:00:00  NaN
2013-01-01 09:00:01  1.0
2013-01-01 09:00:02  3.0
2013-01-01 09:00:03  NaN
2013-01-01 09:00:04  NaN

In [15]: dft.rolling(2, min_periods=1).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                       B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:01  1.0
2013-01-01 09:00:02  3.0
2013-01-01 09:00:03  2.0
2013-01-01 09:00:04  4.0
```

Specifying an offset allows a more intuitive specification of the rolling frequency.

```
In [16]: dft.rolling('2s').sum()
Out[16]:
                       B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:01  1.0
2013-01-01 09:00:02  3.0
```

```
2013-01-01 09:00:03  2.0
2013-01-01 09:00:04  4.0
```

Using a non-regular, but still monotonic index, rolling with an integer window does not impart any special calculation.

```
In [17]: dft = DataFrame({'B': [0, 1, 2, np.nan, 4]},
   ....:                 index = pd.Index([pd.Timestamp('20130101 09:00:00'),
   ....:                                   pd.Timestamp('20130101 09:00:02'),
   ....:                                   pd.Timestamp('20130101 09:00:03'),
   ....:                                   pd.Timestamp('20130101 09:00:05'),
   ....:                                   pd.Timestamp('20130101 09:00:06')],
   ....:                                  name='foo'))
   ....:

In [18]: dft
Out[18]:
                       B
foo
2013-01-01 09:00:00  0.0
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  2.0
2013-01-01 09:00:05  NaN
2013-01-01 09:00:06  4.0

In [19]: dft.rolling(2).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                       B
foo
2013-01-01 09:00:00  NaN
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  3.0
2013-01-01 09:00:05  NaN
2013-01-01 09:00:06  NaN
```

Using the time-specification generates variable windows for this sparse data.

```
In [20]: dft.rolling('2s').sum()
Out[20]:
                       B
foo
2013-01-01 09:00:00  0.0
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  3.0
2013-01-01 09:00:05  NaN
2013-01-01 09:00:06  4.0
```

Furthermore, we now allow an optional `on` parameter to specify a column (rather than the default of the index) in a DataFrame.

```
In [21]: dft = dft.reset_index()

In [22]: dft
Out[22]:
                  foo    B
0 2013-01-01 09:00:00  0.0
1 2013-01-01 09:00:02  1.0
2 2013-01-01 09:00:03  2.0
```

```
3 2013-01-01 09:00:05  NaN
4 2013-01-01 09:00:06  4.0

In [23]: dft.rolling('2s', on='foo').sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                  foo    B
0 2013-01-01 09:00:00  0.0
1 2013-01-01 09:00:02  1.0
2 2013-01-01 09:00:03  3.0
3 2013-01-01 09:00:05  NaN
4 2013-01-01 09:00:06  4.0
```

1.7.1.3 `read_csv` has improved support for duplicate column names

Duplicate column names are now supported in *`read_csv()`* whether they are in the file or passed in as the `names` parameter (GH7160, GH9424)

```
In [24]: data = '0,1,2\n3,4,5'

In [25]: names = ['a', 'b', 'a']
```

Previous behavior:

```
In [2]: pd.read_csv(StringIO(data), names=names)
Out[2]:
   a  b  a
0  2  1  2
1  5  4  5
```

The first `a` column contained the same data as the second `a` column, when it should have contained the values `[0, 3]`.

New behavior:

```
In [26]: pd.read_csv(StringIO(data), names=names)
Out[26]:
   a  b  a.1
0  0  1    2
1  3  4    5
```

1.7.1.4 `read_csv` supports parsing `Categorical` directly

The *`read_csv()`* function now supports parsing a `Categorical` column when specified as a dtype (GH10153). Depending on the structure of the data, this can result in a faster parse time and lower memory usage compared to converting to `Categorical` after parsing. See the io *docs here*.

```
In [27]: data = 'col1,col2,col3\na,b,1\na,b,2\nc,d,3'

In [28]: pd.read_csv(StringIO(data))
Out[28]:
  col1 col2  col3
0    a    b     1
1    a    b     2
2    c    d     3
```

```
In [29]: pd.read_csv(StringIO(data)).dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[29]:␣
↪
col1    object
col2    object
col3     int64
dtype: object

In [30]: pd.read_csv(StringIO(data), dtype='category').dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
col1    category
col2    category
col3    category
dtype: object
```

Individual columns can be parsed as a `Categorical` using a dict specification

```
In [31]: pd.read_csv(StringIO(data), dtype={'col1': 'category'}).dtypes
Out[31]:
col1    category
col2      object
col3       int64
dtype: object
```

Note: The resulting categories will always be parsed as strings (object dtype). If the categories are numeric they can be converted using the *`to_numeric()`* function, or as appropriate, another converter such as *`to_datetime()`*.

```
In [32]: df = pd.read_csv(StringIO(data), dtype='category')

In [33]: df.dtypes
Out[33]:
col1    category
col2    category
col3    category
dtype: object

In [34]: df['col3']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[34]:
0    1
1    2
2    3
Name: col3, dtype: category
Categories (3, object): [1, 2, 3]

In [35]: df['col3'].cat.categories = pd.to_numeric(df['col3'].cat.categories)

In [36]: df['col3']
Out[36]:
0    1
1    2
2    3
Name: col3, dtype: category
Categories (3, int64): [1, 2, 3]
```

1.7.1.5 Categorical Concatenation

- A function `union_categoricals()` has been added for combining categoricals, see *Unioning Categoricals* (GH13361, GH:13763, issue:*13846*, GH14173)

```
In [37]: from pandas.api.types import union_categoricals

In [38]: a = pd.Categorical(["b", "c"])

In [39]: b = pd.Categorical(["a", "b"])

In [40]: union_categoricals([a, b])
Out[40]:
[b, c, a, b]
Categories (3, object): [b, c, a]
```

- `concat` and `append` now can concat `category` dtypes with different `categories` as `object` dtype (GH13524)

```
In [41]: s1 = pd.Series(['a', 'b'], dtype='category')

In [42]: s2 = pd.Series(['b', 'c'], dtype='category')
```

Previous behavior:

```
In [1]: pd.concat([s1, s2])
ValueError: incompatible categories in categorical concat
```

New behavior:

```
In [43]: pd.concat([s1, s2])
Out[43]:
0    a
1    b
0    b
1    c
dtype: object
```

1.7.1.6 Semi-Month Offsets

Pandas has gained new frequency offsets, `SemiMonthEnd` ('SM') and `SemiMonthBegin` ('SMS'). These provide date offsets anchored (by default) to the 15th and end of month, and 15th and 1st of month respectively. (GH1543)

```
In [44]: from pandas.tseries.offsets import SemiMonthEnd, SemiMonthBegin
```

SemiMonthEnd:

```
In [45]: Timestamp('2016-01-01') + SemiMonthEnd()
Out[45]: Timestamp('2016-01-15 00:00:00')

In [46]: pd.date_range('2015-01-01', freq='SM', periods=4)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[46]: DatetimeIndex(['2015-01-15', '2015-
↪01-31', '2015-02-15', '2015-02-28'], dtype='datetime64[ns]', freq='SM-15')
```

SemiMonthBegin:

```
In [47]: Timestamp('2016-01-01') + SemiMonthBegin()
Out[47]: Timestamp('2016-01-15 00:00:00')

In [48]: pd.date_range('2015-01-01', freq='SMS', periods=4)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[48]: DatetimeIndex(['2015-01-01', '2015-
↪01-15', '2015-02-01', '2015-02-15'], dtype='datetime64[ns]', freq='SMS-15')
```

Using the anchoring suffix, you can also specify the day of month to use instead of the 15th.

```
In [49]: pd.date_range('2015-01-01', freq='SMS-16', periods=4)
Out[49]: DatetimeIndex(['2015-01-01', '2015-01-16', '2015-02-01', '2015-02-16'],␣
↪dtype='datetime64[ns]', freq='SMS-16')

In [50]: pd.date_range('2015-01-01', freq='SM-14', periods=4)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪DatetimeIndex(['2015-01-14', '2015-01-31', '2015-02-14', '2015-02-28'], dtype=
↪'datetime64[ns]', freq='SM-14')
```

1.7.1.7 New Index methods

The following methods and options are added to `Index`, to be more consistent with the `Series` and `DataFrame` API.

`Index` now supports the `.where()` function for same shape indexing (GH13170)

```
In [51]: idx = pd.Index(['a', 'b', 'c'])

In [52]: idx.where([True, False, True])
Out[52]: Index(['a', nan, 'c'], dtype='object')
```

`Index` now supports `.dropna()` to exclude missing values (GH6194)

```
In [53]: idx = pd.Index([1, 2, np.nan, 4])

In [54]: idx.dropna()
Out[54]: Float64Index([1.0, 2.0, 4.0], dtype='float64')
```

For `MultiIndex`, values are dropped if any level is missing by default. Specifying `how='all'` only drops values where all levels are missing.

```
In [55]: midx = pd.MultiIndex.from_arrays([[1, 2, np.nan, 4],
   ....:                                   [1, 2, np.nan, np.nan]])
   ....:

In [56]: midx
Out[56]:
MultiIndex(levels=[[1, 2, 4], [1, 2]],
           labels=[[0, 1, -1, 2], [0, 1, -1, -1]])

In [57]: midx.dropna()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
MultiIndex(levels=[[1, 2, 4], [1, 2]],
           labels=[[0, 1], [0, 1]])

In [58]: midx.dropna(how='all')
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
MultiIndex(levels=[[1, 2, 4], [1, 2]],
           labels=[[0, 1, 2], [0, 1, -1]])
```

`Index` now supports `.str.extractall()` which returns a `DataFrame`, see the *docs here* (GH10008, GH13156)

```
In [59]: idx = pd.Index(["a1a2", "b1", "c1"])

In [60]: idx.str.extractall("[ab](?P<digit>\d)")
Out[60]: 
        digit
  match      
0 0         1
  1         2
1 0         1
```

`Index.astype()` now accepts an optional boolean argument `copy`, which allows optional copying if the requirements on dtype are satisfied (GH13209)

1.7.1.8 Google BigQuery Enhancements

- The *`read_gbq()`* method has gained the `dialect` argument to allow users to specify whether to use BigQuery's legacy SQL or BigQuery's standard SQL. See the docs for more details (GH13615).
- The *`to_gbq()`* method now allows the DataFrame column order to differ from the destination table schema (GH11359).

1.7.1.9 Fine-grained numpy errstate

Previous versions of pandas would permanently silence numpy's ufunc error handling when `pandas` was imported. Pandas did this in order to silence the warnings that would arise from using numpy ufuncs on missing data, which are usually represented as `NaN` s. Unfortunately, this silenced legitimate warnings arising in non-pandas code in the application. Starting with 0.19.0, pandas will use the `numpy.errstate` context manager to silence these warnings in a more fine-grained manner, only around where these operations are actually used in the pandas codebase. (GH13109, GH13145)

After upgrading pandas, you may see *new* `RuntimeWarnings` being issued from your code. These are likely legitimate, and the underlying cause likely existed in the code when using previous versions of pandas that simply silenced the warning. Use numpy.errstate around the source of the `RuntimeWarning` to control how these conditions are handled.

1.7.1.10 `get_dummies` now returns integer dtypes

The `pd.get_dummies` function now returns dummy-encoded columns as small integers, rather than floats (GH8725). This should provide an improved memory footprint.

Previous behavior:

```
In [1]: pd.get_dummies(['a', 'b', 'a', 'c']).dtypes

Out[1]:
a    float64
b    float64
```

```
c    float64
dtype: object
```

New behavior:

```
In [61]: pd.get_dummies(['a', 'b', 'a', 'c']).dtypes
Out[61]:
a    uint8
b    uint8
c    uint8
dtype: object
```

1.7.1.11 Downcast values to smallest possible dtype in `to_numeric`

`pd.to_numeric()` now accepts a `downcast` parameter, which will downcast the data if possible to smallest specified numerical dtype (GH13352)

```
In [62]: s = ['1', 2, 3]

In [63]: pd.to_numeric(s, downcast='unsigned')
Out[63]: array([1, 2, 3], dtype=uint8)

In [64]: pd.to_numeric(s, downcast='integer')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[64]: array([1, 2, 3], dtype=int8)
```

1.7.1.12 pandas development API

As part of making pandas API more uniform and accessible in the future, we have created a standard sub-package of pandas, `pandas.api` to hold public API's. We are starting by exposing type introspection functions in `pandas.api.types`. More sub-packages and officially sanctioned API's will be published in future versions of pandas (GH13147, GH13634)

The following are now part of this API:

```
In [65]: import pprint

In [66]: from pandas.api import types

In [67]: funcs = [ f for f in dir(types) if not f.startswith('_') ]

In [68]: pprint.pprint(funcs)
['CategoricalDtype',
 'DatetimeTZDtype',
 'IntervalDtype',
 'PeriodDtype',
 'infer_dtype',
 'is_any_int_dtype',
 'is_bool',
 'is_bool_dtype',
 'is_categorical',
 'is_categorical_dtype',
 'is_complex',
 'is_complex_dtype',
 'is_datetime64_any_dtype',
 'is_datetime64_dtype',
```

```
 'is_datetime64_ns_dtype',
 'is_datetime64tz_dtype',
 'is_datetimetz',
 'is_dict_like',
 'is_dtype_equal',
 'is_extension_type',
 'is_file_like',
 'is_float',
 'is_float_dtype',
 'is_floating_dtype',
 'is_hashable',
 'is_int64_dtype',
 'is_integer',
 'is_integer_dtype',
 'is_interval',
 'is_interval_dtype',
 'is_iterator',
 'is_list_like',
 'is_named_tuple',
 'is_number',
 'is_numeric_dtype',
 'is_object_dtype',
 'is_period',
 'is_period_dtype',
 'is_re',
 'is_re_compilable',
 'is_scalar',
 'is_sequence',
 'is_signed_integer_dtype',
 'is_sparse',
 'is_string_dtype',
 'is_timedelta64_dtype',
 'is_timedelta64_ns_dtype',
 'is_unsigned_integer_dtype',
 'pandas_dtype',
 'union_categoricals']
```

Note: Calling these functions from the internal module `pandas.core.common` will now show a `DeprecationWarning` (GH13990)

1.7.1.13 Other enhancements

- `Timestamp` can now accept positional and keyword parameters similar to `datetime.datetime()` (GH10758, GH11630)

```
In [69]: pd.Timestamp(2012, 1, 1)
Out[69]: Timestamp('2012-01-01 00:00:00')

In [70]: pd.Timestamp(year=2012, month=1, day=1, hour=8, minute=30)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[70]: Timestamp('2012-01-01 08:30:00
↪')
```

- The `.resample()` function now accepts a `on=` or `level=` parameter for resampling on a datetimelike column or `MultiIndex` level (GH13500)

```
In [71]: df = pd.DataFrame({'date': pd.date_range('2015-01-01', freq='W',␣
↪periods=5),
   ....:                          'a': np.arange(5)},
   ....:                         index=pd.MultiIndex.from_arrays([
   ....:                                  [1,2,3,4,5],
   ....:                                  pd.date_range('2015-01-01', freq='W',␣
↪periods=5)],
   ....:                              names=['v','d']))
   ....:

In [72]: df
Out[72]:
              a       date
v d
1 2015-01-04  0 2015-01-04
2 2015-01-11  1 2015-01-11
3 2015-01-18  2 2015-01-18
4 2015-01-25  3 2015-01-25
5 2015-02-01  4 2015-02-01

In [73]: df.resample('M', on='date').sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
            a
date
2015-01-31  6
2015-02-28  4

In [74]: df.resample('M', level='d').sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
            a
d
2015-01-31  6
2015-02-28  4
```

- The `.get_credentials()` method of `GbqConnector` can now first try to fetch the application default credentials. See the docs for more details (GH13577).
- The `.tz_localize()` method of `DatetimeIndex` and `Timestamp` has gained the `errors` keyword, so you can potentially coerce nonexistent timestamps to `NaT`. The default behavior remains to raising a `NonExistentTimeError` (GH13057)
- `.to_hdf/read_hdf()` now accept path objects (e.g. `pathlib.Path`, `py.path.local`) for the file path (GH11773)
- The `pd.read_csv()` with `engine='python'` has gained support for the `decimal` (GH12933), `na_filter` (GH13321) and the `memory_map` option (GH13381).
- Consistent with the Python API, `pd.read_csv()` will now interpret `+inf` as positive infinity (GH13274)
- The `pd.read_html()` has gained support for the `na_values`, `converters`, `keep_default_na` options (GH13461)
- `Categorical.astype()` now accepts an optional boolean argument `copy`, effective when dtype is categorical (GH13209)
- `DataFrame` has gained the `.asof()` method to return the last non-NaN values according to the selected subset (GH13358)

- The `DataFrame` constructor will now respect key ordering if a list of `OrderedDict` objects are passed in (GH13304)
- `pd.read_html()` has gained support for the `decimal` option (GH12907)
- `Series` has gained the properties `.is_monotonic`, `.is_monotonic_increasing`, `.is_monotonic_decreasing`, similar to `Index` (GH13336)
- `DataFrame.to_sql()` now allows a single value as the SQL type for all columns (GH11886).
- `Series.append` now supports the `ignore_index` option (GH13677)
- `.to_stata()` and `StataWriter` can now write variable labels to Stata dta files using a dictionary to make column names to labels (GH13535, GH13536)
- `.to_stata()` and `StataWriter` will automatically convert `datetime64[ns]` columns to Stata format `%tc`, rather than raising a `ValueError` (GH12259)
- `read_stata()` and `StataReader` raise with a more explicit error message when reading Stata files with repeated value labels when `convert_categoricals=True` (GH13923)
- `DataFrame.style` will now render sparsified MultiIndexes (GH11655)
- `DataFrame.style` will now show column level names (e.g. `DataFrame.columns.names`) (GH13775)
- `DataFrame` has gained support to re-order the columns based on the values in a row using `df.sort_values(by='...', axis=1)` (GH10806)

```
In [75]: df = pd.DataFrame({'A': [2, 7], 'B': [3, 5], 'C': [4, 8]},
   ....:                   index=['row1', 'row2'])
   ....:

In [76]: df
Out[76]:
      A  B  C
row1  2  3  4
row2  7  5  8

In [77]: df.sort_values(by='row2', axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[77]:
      B  A  C
row1  3  2  4
row2  5  7  8
```

- Added documentation to *I/O* regarding the perils of reading in columns with mixed dtypes and how to handle it (GH13746)
- *`to_html()`* now has a `border` argument to control the value in the opening `<table>` tag. The default is the value of the `html.border` option, which defaults to 1. This also affects the notebook HTML repr, but since Jupyter's CSS includes a border-width attribute, the visual effect is the same. (GH11563).
- Raise `ImportError` in the sql functions when `sqlalchemy` is not installed and a connection string is used (GH11920).
- Compatibility with matplotlib 2.0. Older versions of pandas should also work with matplotlib 2.0 (GH13333)
- `Timestamp`, `Period`, `DatetimeIndex`, `PeriodIndex` and `.dt` accessor have gained a `.is_leap_year` property to check whether the date belongs to a leap year. (GH13727)
- `astype()` will now accept a dict of column name to data types mapping as the `dtype` argument. (GH12086)
- The `pd.read_json` and `DataFrame.to_json` has gained support for reading and writing json lines with `lines` option see *Line delimited json* (GH9180)

- *read_excel()* now supports the true_values and false_values keyword arguments (GH13347)
- groupby() will now accept a scalar and a single-element list for specifying level on a non-MultiIndex grouper. (GH13907)
- Non-convertible dates in an excel date column will be returned without conversion and the column will be object dtype, rather than raising an exception (GH10001).
- pd.Timedelta(None) is now accepted and will return NaT, mirroring pd.Timestamp (GH13687)
- pd.read_stata() can now handle some format 111 files, which are produced by SAS when generating Stata dta files (GH11526)
- Series and Index now support divmod which will return a tuple of series or indices. This behaves like a standard binary operator with regards to broadcasting rules (GH14208).

1.7.2 API changes

1.7.2.1 Series.tolist() will now return Python types

Series.tolist() will now return Python types in the output, mimicking NumPy .tolist() behavior (GH10904)

```
In [78]: s = pd.Series([1,2,3])
```

Previous behavior:

```
In [7]: type(s.tolist()[0])
Out[7]:
 <class 'numpy.int64'>
```

New behavior:

```
In [79]: type(s.tolist()[0])
Out[79]: int
```

1.7.2.2 Series operators for different indexes

Following Series operators have been changed to make all operators consistent, including DataFrame (GH1134, GH4581, GH13538)

- Series comparison operators now raise ValueError when index are different.
- Series logical operators align both index of left and right hand side.

> **Warning:** Until 0.18.1, comparing Series with the same length, would succeed even if the .index are different (the result ignores .index). As of 0.19.0, this will raises ValueError to be more strict. This section also describes how to keep previous behavior or align different indexes, using the flexible comparison methods like .eq.

As a result, Series and DataFrame operators behave as below:

Arithmetic operators

Arithmetic operators align both `index` (no changes).

```
In [80]: s1 = pd.Series([1, 2, 3], index=list('ABC'))

In [81]: s2 = pd.Series([2, 2, 2], index=list('ABD'))

In [82]: s1 + s2
Out[82]:
A    3.0
B    4.0
C    NaN
D    NaN
dtype: float64

In [83]: df1 = pd.DataFrame([1, 2, 3], index=list('ABC'))

In [84]: df2 = pd.DataFrame([2, 2, 2], index=list('ABD'))

In [85]: df1 + df2
Out[85]:
     0
A  3.0
B  4.0
C  NaN
D  NaN
```

Comparison operators

Comparison operators raise `ValueError` when `.index` are different.

Previous Behavior (`Series`):

`Series` compared values ignoring the `.index` as long as both had the same length:

```
In [1]: s1 == s2
Out[1]:
A    False
B     True
C    False
dtype: bool
```

New behavior (`Series`):

```
In [2]: s1 == s2
Out[2]:
ValueError: Can only compare identically-labeled Series objects
```

Note: To achieve the same result as previous versions (compare values based on locations ignoring `.index`), compare both `.values`.

```
In [86]: s1.values == s2.values
Out[86]: array([False,  True, False], dtype=bool)
```

If you want to compare `Series` aligning its `.index`, see flexible comparison methods section below:

```
In [87]: s1.eq(s2)
Out[87]:
A    False
B     True
C    False
D    False
dtype: bool
```

Current Behavior (`DataFrame`, no change):

```
In [3]: df1 == df2
Out[3]:
ValueError: Can only compare identically-labeled DataFrame objects
```

Logical operators

Logical operators align both `.index` of left and right hand side.

Previous behavior (`Series`), only left hand side `index` was kept:

```
In [4]: s1 = pd.Series([True, False, True], index=list('ABC'))
In [5]: s2 = pd.Series([True, True, True], index=list('ABD'))
In [6]: s1 & s2
Out[6]:
A     True
B    False
C    False
dtype: bool
```

New behavior (`Series`):

```
In [88]: s1 = pd.Series([True, False, True], index=list('ABC'))

In [89]: s2 = pd.Series([True, True, True], index=list('ABD'))

In [90]: s1 & s2
Out[90]:
A     True
B    False
C    False
D    False
dtype: bool
```

Note: `Series` logical operators fill a `NaN` result with `False`.

Note: To achieve the same result as previous versions (compare values based on only left hand side index), you can use `reindex_like`:

```
In [91]: s1 & s2.reindex_like(s1)
Out[91]:
A     True
B    False
```

```
C    False
dtype: bool
```

Current Behavior (`DataFrame`, no change):

```
In [92]: df1 = pd.DataFrame([True, False, True], index=list('ABC'))

In [93]: df2 = pd.DataFrame([True, True, True], index=list('ABD'))

In [94]: df1 & df2
Out[94]:
       0
A   True
B  False
C    NaN
D    NaN
```

Flexible comparison methods

`Series` flexible comparison methods like `eq`, `ne`, `le`, `lt`, `ge` and `gt` now align both `index`. Use these operators if you want to compare two `Series` which has the different `index`.

```
In [95]: s1 = pd.Series([1, 2, 3], index=['a', 'b', 'c'])

In [96]: s2 = pd.Series([2, 2, 2], index=['b', 'c', 'd'])

In [97]: s1.eq(s2)
Out[97]:
a    False
b     True
c    False
d    False
dtype: bool

In [98]: s1.ge(s2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[98]:
a    False
b     True
c     True
d    False
dtype: bool
```

Previously, this worked the same as comparison operators (see above).

1.7.2.3 `Series` type promotion on assignment

A `Series` will now correctly promote its dtype for assignment with incompat values to the current dtype (GH13234)

```
In [99]: s = pd.Series()
```

Previous behavior:

```
In [2]: s["a"] = pd.Timestamp("2016-01-01")
```

```
In [3]: s["b"] = 3.0
TypeError: invalid type promotion
```

New behavior:

```
In [100]: s["a"] = pd.Timestamp("2016-01-01")

In [101]: s["b"] = 3.0

In [102]: s
Out[102]:
a    2016-01-01 00:00:00
b                      3
dtype: object

In [103]: s.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[103]:␣
↪dtype('O')
```

1.7.2.4 `.to_datetime()` changes

Previously if `.to_datetime()` encountered mixed integers/floats and strings, but no datetimes with `errors='coerce'` it would convert all to `NaT`.

Previous behavior:

```
In [2]: pd.to_datetime([1, 'foo'], errors='coerce')
Out[2]: DatetimeIndex(['NaT', 'NaT'], dtype='datetime64[ns]', freq=None)
```

Current behavior:

This will now convert integers/floats with the default unit of `ns`.

```
In [104]: pd.to_datetime([1, 'foo'], errors='coerce')
Out[104]: DatetimeIndex(['1970-01-01 00:00:00.000000001', 'NaT'], dtype=
↪'datetime64[ns]', freq=None)
```

Bug fixes related to `.to_datetime()`:

- Bug in `pd.to_datetime()` when passing integers or floats, and no `unit` and `errors='coerce'` (GH13180).
- Bug in `pd.to_datetime()` when passing invalid datatypes (e.g. bool); will now respect the `errors` keyword (GH13176)
- Bug in `pd.to_datetime()` which overflowed on `int8`, and `int16` dtypes (GH13451)
- Bug in `pd.to_datetime()` raise `AttributeError` with `NaN` and the other string is not valid when `errors='ignore'` (GH12424)
- Bug in `pd.to_datetime()` did not cast floats correctly when `unit` was specified, resulting in truncated datetime (GH13834)

1.7.2.5 Merging changes

Merging will now preserve the dtype of the join keys (GH8596)

```
In [105]: df1 = pd.DataFrame({'key': [1], 'v1': [10]})

In [106]: df1
Out[106]:
   key  v1
0    1  10

In [107]: df2 = pd.DataFrame({'key': [1, 2], 'v1': [20, 30]})

In [108]: df2
Out[108]:
   key  v1
0    1  20
1    2  30
```

Previous behavior:

```
In [5]: pd.merge(df1, df2, how='outer')
Out[5]:
   key    v1
0  1.0  10.0
1  1.0  20.0
2  2.0  30.0

In [6]: pd.merge(df1, df2, how='outer').dtypes
Out[6]:
key     float64
v1      float64
dtype: object
```

New behavior:

We are able to preserve the join keys

```
In [109]: pd.merge(df1, df2, how='outer')
Out[109]:
   key  v1
0    1  10
1    1  20
2    2  30

In [110]: pd.merge(df1, df2, how='outer').dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[110]:
key     int64
v1      int64
dtype: object
```

Of course if you have missing values that are introduced, then the resulting dtype will be upcast, which is unchanged from previous.

```
In [111]: pd.merge(df1, df2, how='outer', on='key')
Out[111]:
   key  v1_x  v1_y
0    1  10.0    20
1    2   NaN    30

In [112]: pd.merge(df1, df2, how='outer', on='key').dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[112]:
```

```
key       int64
v1_x    float64
v1_y      int64
dtype: object
```

1.7.2.6 .describe() changes

Percentile identifiers in the index of a .describe() output will now be rounded to the least precision that keeps them distinct (GH13104)

```
In [113]: s = pd.Series([0, 1, 2, 3, 4])

In [114]: df = pd.DataFrame([0, 1, 2, 3, 4])
```

Previous behavior:

The percentiles were rounded to at most one decimal place, which could raise ValueError for a data frame if the percentiles were duplicated.

```
In [3]: s.describe(percentiles=[0.0001, 0.0005, 0.001, 0.999, 0.9995, 0.9999])
Out[3]:
count     5.000000
mean      2.000000
std       1.581139
min       0.000000
0.0%      0.000400
0.1%      0.002000
0.1%      0.004000
50%       2.000000
99.9%     3.996000
100.0%    3.998000
100.0%    3.999600
max       4.000000
dtype: float64

In [4]: df.describe(percentiles=[0.0001, 0.0005, 0.001, 0.999, 0.9995, 0.9999])
Out[4]:
...
ValueError: cannot reindex from a duplicate axis
```

New behavior:

```
In [115]: s.describe(percentiles=[0.0001, 0.0005, 0.001, 0.999, 0.9995, 0.9999])
Out[115]:
count     5.000000
mean      2.000000
std       1.581139
min       0.000000
0.01%     0.000400
0.05%     0.002000
0.1%      0.004000
50%       2.000000
99.9%     3.996000
99.95%    3.998000
99.99%    3.999600
max       4.000000
dtype: float64
```

```
In [116]: df.describe(percentiles=[0.0001, 0.0005, 0.001, 0.999, 0.9995, 0.9999])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
               0
count   5.000000
mean    2.000000
std     1.581139
min     0.000000
0.01%   0.000400
0.05%   0.002000
0.1%    0.004000
50%     2.000000
99.9%   3.996000
99.95%  3.998000
99.99%  3.999600
max     4.000000
```

Furthermore:

- Passing duplicated `percentiles` will now raise a `ValueError`.
- Bug in `.describe()` on a DataFrame with a mixed-dtype column index, which would previously raise a `TypeError` (GH13288)

1.7.2.7 `Period` changes

`PeriodIndex` now has `period` dtype

`PeriodIndex` now has its own `period` dtype. The `period` dtype is a pandas extension dtype like `category` or the *timezone aware dtype* (`datetime64[ns, tz]`) (GH13941). As a consequence of this change, `PeriodIndex` no longer has an integer dtype:

Previous behavior:

```
In [1]: pi = pd.PeriodIndex(['2016-08-01'], freq='D')

In [2]: pi
Out[2]: PeriodIndex(['2016-08-01'], dtype='int64', freq='D')

In [3]: pd.api.types.is_integer_dtype(pi)
Out[3]: True

In [4]: pi.dtype
Out[4]: dtype('int64')
```

New behavior:

```
In [117]: pi = pd.PeriodIndex(['2016-08-01'], freq='D')

In [118]: pi
Out[118]: PeriodIndex(['2016-08-01'], dtype='period[D]', freq='D')

In [119]: pd.api.types.is_integer_dtype(pi)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[119]: False

In [120]: pd.api.types.is_period_dtype(pi)
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[120]:␣
↪True

In [121]: pi.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out
↪period[D]

In [122]: type(pi.dtype)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪pandas.core.dtypes.dtypes.PeriodDtype
```

`Period('NaT')` now returns `pd.NaT`

Previously, `Period` has its own `Period('NaT')` representation different from `pd.NaT`. Now `Period('NaT')` has been changed to return `pd.NaT`. (GH12759, GH13582)

Previous behavior:

```
In [5]: pd.Period('NaT', freq='D')
Out[5]: Period('NaT', 'D')
```

New behavior:

These result in `pd.NaT` without providing `freq` option.

```
In [123]: pd.Period('NaT')
Out[123]: NaT

In [124]: pd.Period(None)
\\\\\\\\\\\\\\Out[124]: NaT
```

To be compatible with `Period` addition and subtraction, `pd.NaT` now supports addition and subtraction with `int`. Previously it raised `ValueError`.

Previous behavior:

```
In [5]: pd.NaT + 1
...
ValueError: Cannot add integral value to Timestamp without freq.
```

New behavior:

```
In [125]: pd.NaT + 1
Out[125]: NaT

In [126]: pd.NaT - 1
\\\\\\\\\\\\\\Out[126]: NaT
```

`PeriodIndex.values` now returns array of `Period` object

`.values` is changed to return an array of `Period` objects, rather than an array of integers (GH13988).

Previous behavior:

```
In [6]: pi = pd.PeriodIndex(['2011-01', '2011-02'], freq='M')
In [7]: pi.values
array([492, 493])
```

New behavior:

```
In [127]: pi = pd.PeriodIndex(['2011-01', '2011-02'], freq='M')

In [128]: pi.values
Out[128]: array([Period('2011-01', 'M'), Period('2011-02', 'M')], dtype=object)
```

1.7.2.8 Index + / – no longer used for set operations

Addition and subtraction of the base Index type and of DatetimeIndex (not the numeric index types) previously performed set operations (set union and difference). This behavior was already deprecated since 0.15.0 (in favor using the specific `.union()` and `.difference()` methods), and is now disabled. When possible, + and – are now used for element-wise operations, for example for concatenating strings or subtracting datetimes (GH8227, GH14127).

Previous behavior:

```
In [1]: pd.Index(['a', 'b']) + pd.Index(['a', 'c'])
FutureWarning: using '+' to provide set union with Indexes is deprecated, use '|' or .
↪union()
Out[1]: Index(['a', 'b', 'c'], dtype='object')
```

New behavior: the same operation will now perform element-wise addition:

```
In [129]: pd.Index(['a', 'b']) + pd.Index(['a', 'c'])
Out[129]: Index(['aa', 'bc'], dtype='object')
```

Note that numeric Index objects already performed element-wise operations. For example, the behavior of adding two integer Indexes is unchanged. The base `Index` is now made consistent with this behavior.

```
In [130]: pd.Index([1, 2, 3]) + pd.Index([2, 3, 4])
Out[130]: Int64Index([3, 5, 7], dtype='int64')
```

Further, because of this change, it is now possible to subtract two DatetimeIndex objects resulting in a TimedeltaIndex:

Previous behavior:

```
In [1]: pd.DatetimeIndex(['2016-01-01', '2016-01-02']) - pd.DatetimeIndex(['2016-01-02
↪', '2016-01-03'])
FutureWarning: using '-' to provide set differences with datetimelike Indexes is␣
↪deprecated, use .difference()
Out[1]: DatetimeIndex(['2016-01-01'], dtype='datetime64[ns]', freq=None)
```

New behavior:

```
In [131]: pd.DatetimeIndex(['2016-01-01', '2016-01-02']) - pd.DatetimeIndex(['2016-01-
↪02', '2016-01-03'])
Out[131]: TimedeltaIndex(['-1 days', '-1 days'], dtype='timedelta64[ns]', freq=None)
```

1.7.2.9 `Index.difference` and `.symmetric_difference` changes

`Index.difference` and `Index.symmetric_difference` will now, more consistently, treat `NaN` values as any other values. (GH13514)

```
In [132]: idx1 = pd.Index([1, 2, 3, np.nan])

In [133]: idx2 = pd.Index([0, 1, np.nan])
```

Previous behavior:

```
In [3]: idx1.difference(idx2)
Out[3]: Float64Index([nan, 2.0, 3.0], dtype='float64')

In [4]: idx1.symmetric_difference(idx2)
Out[4]: Float64Index([0.0, nan, 2.0, 3.0], dtype='float64')
```

New behavior:

```
In [134]: idx1.difference(idx2)
Out[134]: Float64Index([2.0, 3.0], dtype='float64')

In [135]: idx1.symmetric_difference(idx2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[135]: Float64Index([0.0, 2.0,␣
↪3.0], dtype='float64')
```

1.7.2.10 `Index.unique` consistently returns `Index`

`Index.unique()` now returns unique values as an `Index` of the appropriate `dtype`. (GH13395). Previously, most `Index` classes returned `np.ndarray`, and `DatetimeIndex`, `TimedeltaIndex` and `PeriodIndex` returned `Index` to keep metadata like timezone.

Previous behavior:

```
In [1]: pd.Index([1, 2, 3]).unique()
Out[1]: array([1, 2, 3])

In [2]: pd.DatetimeIndex(['2011-01-01', '2011-01-02', '2011-01-03'], tz='Asia/Tokyo').
↪unique()
Out[2]:
DatetimeIndex(['2011-01-01 00:00:00+09:00', '2011-01-02 00:00:00+09:00',
               '2011-01-03 00:00:00+09:00'],
              dtype='datetime64[ns, Asia/Tokyo]', freq=None)
```

New behavior:

```
In [136]: pd.Index([1, 2, 3]).unique()
Out[136]: Int64Index([1, 2, 3], dtype='int64')

In [137]: pd.DatetimeIndex(['2011-01-01', '2011-01-02', '2011-01-03'], tz='Asia/Tokyo
↪').unique()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[137]:
DatetimeIndex(['2011-01-01 00:00:00+09:00', '2011-01-02 00:00:00+09:00',
               '2011-01-03 00:00:00+09:00'],
              dtype='datetime64[ns, Asia/Tokyo]', freq=None)
```

1.7.2.11 `MultiIndex` constructors, `groupby` and `set_index` preserve categorical dtypes

`MultiIndex.from_arrays` and `MultiIndex.from_product` will now preserve categorical dtype in `MultiIndex` levels (GH13743, GH13854).

```
In [138]: cat = pd.Categorical(['a', 'b'], categories=list("bac"))

In [139]: lvl1 = ['foo', 'bar']

In [140]: midx = pd.MultiIndex.from_arrays([cat, lvl1])

In [141]: midx
Out[141]: 
MultiIndex(levels=[['b', 'a', 'c'], ['bar', 'foo']],
           labels=[[1, 0], [1, 0]])
```

Previous behavior:

```
In [4]: midx.levels[0]
Out[4]: Index(['b', 'a', 'c'], dtype='object')

In [5]: midx.get_level_values[0]
Out[5]: Index(['a', 'b'], dtype='object')
```

New behavior: the single level is now a `CategoricalIndex`:

```
In [142]: midx.levels[0]
Out[142]: CategoricalIndex(['b', 'a', 'c'], categories=['b', 'a', 'c'], ordered=False,
↪ dtype='category')

In [143]: midx.get_level_values(0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪CategoricalIndex(['a', 'b'], categories=['b', 'a', 'c'], ordered=False, dtype=
↪'category')
```

An analogous change has been made to `MultiIndex.from_product`. As a consequence, `groupby` and `set_index` also preserve categorical dtypes in indexes

```
In [144]: df = pd.DataFrame({'A': [0, 1], 'B': [10, 11], 'C': cat})

In [145]: df_grouped = df.groupby(by=['A', 'C']).first()

In [146]: df_set_idx = df.set_index(['A', 'C'])
```

Previous behavior:

```
In [11]: df_grouped.index.levels[1]
Out[11]: Index(['b', 'a', 'c'], dtype='object', name='C')
In [12]: df_grouped.reset_index().dtypes
Out[12]:
A      int64
C     object
B    float64
dtype: object

In [13]: df_set_idx.index.levels[1]
Out[13]: Index(['b', 'a', 'c'], dtype='object', name='C')
In [14]: df_set_idx.reset_index().dtypes
Out[14]:
A      int64
C     object
B      int64
dtype: object
```

New behavior:

```
In [147]: df_grouped.index.levels[1]
Out[147]: CategoricalIndex(['b', 'a', 'c'], categories=['b', 'a', 'c'], ordered=False,
↪ name='C', dtype='category')

In [148]: df_grouped.reset_index().dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A       int64
C    category
B     float64
dtype: object

In [149]: df_set_idx.index.levels[1]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪CategoricalIndex(['b', 'a', 'c'], categories=['b', 'a', 'c'], ordered=False, name='C
↪', dtype='category')

In [150]: df_set_idx.reset_index().dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A       int64
C    category
B       int64
dtype: object
```

1.7.2.12 `read_csv` will progressively enumerate chunks

When *read_csv()* is called with `chunksize=n` and without specifying an index, each chunk used to have an independently generated index from `0` to `n-1`. They are now given instead a progressive index, starting from `0` for the first chunk, from `n` for the second, and so on, so that, when concatenated, they are identical to the result of calling *read_csv()* without the `chunksize=` argument (GH12185).

```
In [151]: data = 'A,B\n0,1\n2,3\n4,5\n6,7'
```

Previous behavior:

```
In [2]: pd.concat(pd.read_csv(StringIO(data), chunksize=2))
Out[2]:
   A  B
0  0  1
1  2  3
0  4  5
1  6  7
```

New behavior:

```
In [152]: pd.concat(pd.read_csv(StringIO(data), chunksize=2))
Out[152]:
   A  B
0  0  1
1  2  3
2  4  5
3  6  7
```

1.7.2.13 Sparse Changes

These changes allow pandas to handle sparse data with more dtypes, and for work to make a smoother experience with data handling.

`int64` and `bool` support enhancements

Sparse data structures now gained enhanced support of `int64` and `bool` `dtype` (GH667, GH13849).

Previously, sparse data were `float64` dtype by default, even if all inputs were of `int` or `bool` dtype. You had to specify `dtype` explicitly to create sparse data with `int64` dtype. Also, `fill_value` had to be specified explicitly because the default was `np.nan` which doesn't appear in `int64` or `bool` data.

```
In [1]: pd.SparseArray([1, 2, 0, 0])
Out[1]:
[1.0, 2.0, 0.0, 0.0]
Fill: nan
IntIndex
Indices: array([0, 1, 2, 3], dtype=int32)

# specifying int64 dtype, but all values are stored in sp_values because
# fill_value default is np.nan
In [2]: pd.SparseArray([1, 2, 0, 0], dtype=np.int64)
Out[2]:
[1, 2, 0, 0]
Fill: nan
IntIndex
Indices: array([0, 1, 2, 3], dtype=int32)

In [3]: pd.SparseArray([1, 2, 0, 0], dtype=np.int64, fill_value=0)
Out[3]:
[1, 2, 0, 0]
Fill: 0
IntIndex
Indices: array([0, 1], dtype=int32)
```

As of v0.19.0, sparse data keeps the input dtype, and uses more appropriate `fill_value` defaults (`0` for `int64` dtype, `False` for `bool` dtype).

```
In [153]: pd.SparseArray([1, 2, 0, 0], dtype=np.int64)
Out[153]:
[1, 2, 0, 0]
Fill: 0
IntIndex
Indices: array([0, 1], dtype=int32)

In [154]: pd.SparseArray([True, False, False, False])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[154]:␣
↪
[True, False, False, False]
Fill: False
IntIndex
Indices: array([0], dtype=int32)
```

See the *docs* for more details.

Operators now preserve dtypes

- Sparse data structure now can preserve `dtype` after arithmetic ops (GH13848)

```
In [155]: s = pd.SparseSeries([0, 2, 0, 1], fill_value=0, dtype=np.int64)

In [156]: s.dtype
Out[156]: dtype('int64')

In [157]: s + 1
\\\\\\\\\\\\\\\\\\\\\\\\\Out[157]:
0    1
1    3
2    1
3    2
dtype: int64
BlockIndex
Block locations: array([1, 3], dtype=int32)
Block lengths: array([1, 1], dtype=int32)
```

- Sparse data structure now support `astype` to convert internal `dtype` (GH13900)

```
In [158]: s = pd.SparseSeries([1., 0., 2., 0.], fill_value=0)

In [159]: s
Out[159]:
0    1.0
1    0.0
2    2.0
3    0.0
dtype: float64
BlockIndex
Block locations: array([0, 2], dtype=int32)
Block lengths: array([1, 1], dtype=int32)

In [160]: s.astype(np.int64)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    0
2    2
3    0
dtype: int64
BlockIndex
Block locations: array([0, 2], dtype=int32)
Block lengths: array([1, 1], dtype=int32)
```

`astype` fails if data contains values which cannot be converted to specified `dtype`. Note that the limitation is applied to `fill_value` which default is `np.nan`.

```
In [7]: pd.SparseSeries([1., np.nan, 2., np.nan], fill_value=np.nan).astype(np.
↪int64)
Out[7]:
ValueError: unable to coerce current fill_value nan to int64 dtype
```

Other sparse fixes

- Subclassed `SparseDataFrame` and `SparseSeries` now preserve class types when slicing or transposing. (GH13787)
- `SparseArray` with `bool` dtype now supports logical (bool) operators (GH14000)
- Bug in `SparseSeries` with `MultiIndex []` indexing may raise `IndexError` (GH13144)
- Bug in `SparseSeries` with `MultiIndex []` indexing result may have normal `Index` (GH13144)
- Bug in `SparseDataFrame` in which `axis=None` did not default to `axis=0` (GH13048)
- Bug in `SparseSeries` and `SparseDataFrame` creation with `object` dtype may raise `TypeError` (GH11633)
- Bug in `SparseDataFrame` doesn't respect passed `SparseArray` or `SparseSeries` 's dtype and `fill_value` (GH13866)
- Bug in `SparseArray` and `SparseSeries` don't apply ufunc to `fill_value` (GH13853)
- Bug in `SparseSeries.abs` incorrectly keeps negative `fill_value` (GH13853)
- Bug in single row slicing on multi-type `SparseDataFrame` s, types were previously forced to float (GH13917)
- Bug in `SparseSeries` slicing changes integer dtype to float (GH8292)
- Bug in `SparseDataFarme` comparison ops may raise `TypeError` (GH13001)
- Bug in `SparseDataFarme.isnull` raises `ValueError` (GH8276)
- Bug in `SparseSeries` representation with `bool` dtype may raise `IndexError` (GH13110)
- Bug in `SparseSeries` and `SparseDataFrame` of `bool` or `int64` dtype may display its values like `float64` dtype (GH13110)
- Bug in sparse indexing using `SparseArray` with `bool` dtype may return incorrect result (GH13985)
- Bug in `SparseArray` created from `SparseSeries` may lose `dtype` (GH13999)
- Bug in `SparseSeries` comparison with dense returns normal `Series` rather than `SparseSeries` (GH13999)

1.7.2.14 Indexer dtype changes

Note: This change only affects 64 bit python running on Windows, and only affects relatively advanced indexing operations

Methods such as `Index.get_indexer` that return an indexer array, coerce that array to a "platform int", so that it can be directly used in 3rd party library operations like `numpy.take`. Previously, a platform int was defined as `np.int_` which corresponds to a C integer, but the correct type, and what is being used now, is `np.intp`, which corresponds to the C integer size that can hold a pointer (GH3033, GH13972).

These types are the same on many platform, but for 64 bit python on Windows, `np.int_` is 32 bits, and `np.intp` is 64 bits. Changing this behavior improves performance for many operations on that platform.

Previous behavior:

```
In [1]: i = pd.Index(['a', 'b', 'c'])

In [2]: i.get_indexer(['b', 'b', 'c']).dtype
Out[2]: dtype('int32')
```

New behavior:

```
In [1]: i = pd.Index(['a', 'b', 'c'])

In [2]: i.get_indexer(['b', 'b', 'c']).dtype
Out[2]: dtype('int64')
```

1.7.2.15 Other API Changes

- `Timestamp.to_pydatetime` will issue a `UserWarning` when `warn=True`, and the instance has a non-zero number of nanoseconds, previously this would print a message to stdout (GH14101).
- `Series.unique()` with datetime and timezone now returns return array of `Timestamp` with timezone (GH13565).
- `Panel.to_sparse()` will raise a `NotImplementedError` exception when called (GH13778).
- `Index.reshape()` will raise a `NotImplementedError` exception when called (GH12882).
- `.filter()` enforces mutual exclusion of the keyword arguments (GH12399).
- `eval`'s upcasting rules for `float32` types have been updated to be more consistent with NumPy's rules. New behavior will not upcast to `float64` if you multiply a pandas `float32` object by a scalar float64 (GH12388).
- An `UnsupportedFunctionCall` error is now raised if NumPy ufuncs like `np.mean` are called on groupby or resample objects (GH12811).
- `__setitem__` will no longer apply a callable rhs as a function instead of storing it. Call `where` directly to get the previous behavior (GH13299).
- Calls to `.sample()` will respect the random seed set via `numpy.random.seed(n)` (GH13161)
- `Styler.apply` is now more strict about the outputs your function must return. For `axis=0` or `axis=1`, the output shape must be identical. For `axis=None`, the output must be a DataFrame with identical columns and index labels (GH13222).
- `Float64Index.astype(int)` will now raise `ValueError` if `Float64Index` contains `NaN` values (GH13149)
- `TimedeltaIndex.astype(int)` and `DatetimeIndex.astype(int)` will now return `Int64Index` instead of `np.array` (GH13209)
- Passing `Period` with multiple frequencies to normal `Index` now returns `Index` with `object` dtype (GH13664)
- `PeriodIndex.fillna` with `Period` has different freq now coerces to `object` dtype (GH13664)
- Faceted boxplots from `DataFrame.boxplot(by=col)` now return a `Series` when `return_type` is not None. Previously these returned an `OrderedDict`. Note that when `return_type=None`, the default, these still return a 2-D NumPy array (GH12216, GH7096).
- `pd.read_hdf` will now raise a `ValueError` instead of `KeyError`, if a mode other than `r`, `r+` and `a` is supplied. (GH13623)

- `pd.read_csv()`, `pd.read_table()`, and `pd.read_hdf()` raise the builtin `FileNotFoundError` exception for Python 3.x when called on a nonexistent file; this is back-ported as `IOError` in Python 2.x (GH14086)
- More informative exceptions are passed through the csv parser. The exception type would now be the original exception type instead of `CParserError` (GH13652).
- `pd.read_csv()` in the C engine will now issue a `ParserWarning` or raise a `ValueError` when `sep` encoded is more than one character long (GH14065)
- `DataFrame.values` will now return `float64` with a `DataFrame` of mixed `int64` and `uint64` dtypes, conforming to `np.find_common_type` (GH10364, GH13917)
- `.groupby.groups` will now return a dictionary of `Index` objects, rather than a dictionary of `np.ndarray` or `lists` (GH14293)

1.7.3 Deprecations

- `Series.reshape` and `Categorical.reshape` have been deprecated and will be removed in a subsequent release (GH12882, GH12882)
- `PeriodIndex.to_datetime` has been deprecated in favor of `PeriodIndex.to_timestamp` (GH8254)
- `Timestamp.to_datetime` has been deprecated in favor of `Timestamp.to_pydatetime` (GH8254)
- `Index.to_datetime` and `DatetimeIndex.to_datetime` have been deprecated in favor of `pd.to_datetime` (GH8254)
- `pandas.core.datetools` module has been deprecated and will be removed in a subsequent release (GH14094)
- `SparseList` has been deprecated and will be removed in a future version (GH13784)
- `DataFrame.to_html()` and `DataFrame.to_latex()` have dropped the `colSpace` parameter in favor of `col_space` (GH13857)
- `DataFrame.to_sql()` has deprecated the `flavor` parameter, as it is superfluous when SQLAlchemy is not installed (GH13611)
- Deprecated `read_csv` keywords:
  - `compact_ints` and `use_unsigned` have been deprecated and will be removed in a future version (GH13320)
  - `buffer_lines` has been deprecated and will be removed in a future version (GH13360)
  - `as_recarray` has been deprecated and will be removed in a future version (GH13373)
  - `skip_footer` has been deprecated in favor of `skipfooter` and will be removed in a future version (GH13349)
- top-level `pd.ordered_merge()` has been renamed to `pd.merge_ordered()` and the original name will be removed in a future version (GH13358)
- `Timestamp.offset` property (and named arg in the constructor), has been deprecated in favor of `freq` (GH12160)
- `pd.tseries.util.pivot_annual` is deprecated. Use `pivot_table` as alternative, an example is *here* (GH736)
- `pd.tseries.util.isleapyear` has been deprecated and will be removed in a subsequent release. Datetime-likes now have a `.is_leap_year` property (GH13727)

- `Panel4D` and `PanelND` constructors are deprecated and will be removed in a future version. The recommended way to represent these types of n-dimensional data are with the xarray package. Pandas provides a `to_xarray()` method to automate this conversion (GH13564).
- `pandas.tseries.frequencies.get_standard_freq` is deprecated. Use `pandas.tseries.frequencies.to_offset(freq).rule_code` instead (GH13874)
- `pandas.tseries.frequencies.to_offset`'s `freqstr` keyword is deprecated in favor of `freq` (GH13874)
- `Categorical.from_array` has been deprecated and will be removed in a future version (GH13854)

1.7.4 Removal of prior version deprecations/changes

- The `SparsePanel` class has been removed (GH13778)
- The `pd.sandbox` module has been removed in favor of the external library `pandas-qt` (GH13670)
- The `pandas.io.data` and `pandas.io.wb` modules are removed in favor of the pandas-datareader package (GH13724).
- The `pandas.tools.rplot` module has been removed in favor of the seaborn package (GH13855)
- `DataFrame.to_csv()` has dropped the `engine` parameter, as was deprecated in 0.17.1 (GH11274, GH13419)
- `DataFrame.to_dict()` has dropped the `outtype` parameter in favor of `orient` (GH13627, GH8486)
- `pd.Categorical` has dropped setting of the `ordered` attribute directly in favor of the `set_ordered` method (GH13671)
- `pd.Categorical` has dropped the `levels` attribute in favor of `categories` (GH8376)
- `DataFrame.to_sql()` has dropped the `mysql` option for the `flavor` parameter (GH13611)
- `Panel.shift()` has dropped the `lags` parameter in favor of `periods` (GH14041)
- `pd.Index` has dropped the `diff` method in favor of `difference` (GH13669)
- `pd.DataFrame` has dropped the `to_wide` method in favor of `to_panel` (GH14039)
- `Series.to_csv` has dropped the `nanRep` parameter in favor of `na_rep` (GH13804)
- `Series.xs`, `DataFrame.xs`, `Panel.xs`, `Panel.major_xs`, and `Panel.minor_xs` have dropped the `copy` parameter (GH13781)
- `str.split` has dropped the `return_type` parameter in favor of `expand` (GH13701)
- Removal of the legacy time rules (offset aliases), deprecated since 0.17.0 (this has been alias since 0.8.0) (GH13590, GH13868). Now legacy time rules raises `ValueError`. For the list of currently supported offsets, see *here*.
- The default value for the `return_type` parameter for `DataFrame.plot.box` and `DataFrame.boxplot` changed from `None` to `"axes"`. These methods will now return a matplotlib axes by default instead of a dictionary of artists. See *here* (GH6581).
- The `tquery` and `uquery` functions in the `pandas.io.sql` module are removed (GH5950).

1.7.5 Performance Improvements

- Improved performance of sparse `IntIndex.intersect` (GH13082)

- Improved performance of sparse arithmetic with `BlockIndex` when the number of blocks are large, though recommended to use `IntIndex` in such cases (GH13082)
- Improved performance of `DataFrame.quantile()` as it now operates per-block (GH11623)
- Improved performance of float64 hash table operations, fixing some very slow indexing and groupby operations in python 3 (GH13166, GH13334)
- Improved performance of `DataFrameGroupBy.transform` (GH12737)
- Improved performance of `Index` and `Series .duplicated` (GH10235)
- Improved performance of `Index.difference` (GH12044)
- Improved performance of `RangeIndex.is_monotonic_increasing` and `is_monotonic_decreasing` (GH13749)
- Improved performance of datetime string parsing in `DatetimeIndex` (GH13692)
- Improved performance of hashing `Period` (GH12817)
- Improved performance of `factorize` of datetime with timezone (GH13750)
- Improved performance of by lazily creating indexing hashtables on larger Indexes (GH14266)
- Improved performance of `groupby.groups` (GH14293)
- Unecessary materializing of a MultiIndex when introspecting for memory usage (GH14308)

1.7.6 Bug Fixes

- Bug in `groupby().shift()`, which could cause a segfault or corruption in rare circumstances when grouping by columns with missing values (GH13813)
- Bug in `groupby().cumsum()` calculating `cumprod` when `axis=1`. (GH13994)
- Bug in `pd.to_timedelta()` in which the `errors` parameter was not being respected (GH13613)
- Bug in `io.json.json_normalize()`, where non-ascii keys raised an exception (GH13213)
- Bug when passing a not-default-indexed `Series` as `xerr` or `yerr` in `.plot()` (GH11858)
- Bug in area plot draws legend incorrectly if subplot is enabled or legend is moved after plot (matplotlib 1.5.0 is required to draw area plot legend properly) (GH9161, GH13544)
- Bug in `DataFrame` assignment with an object-dtyped `Index` where the resultant column is mutable to the original object. (GH13522)
- Bug in matplotlib `AutoDataFormatter`; this restores the second scaled formatting and re-adds micro-second scaled formatting (GH13131)
- Bug in selection from a `HDFStore` with a fixed format and `start` and/or `stop` specified will now return the selected range (GH8287)
- Bug in `Categorical.from_codes()` where an unhelpful error was raised when an invalid `ordered` parameter was passed in (GH14058)
- Bug in `Series` construction from a tuple of integers on windows not returning default dtype (int64) (GH13646)
- Bug in `TimedeltaIndex` addition with a Datetime-like object where addition overflow was not being caught (GH14068)
- Bug in `.groupby(..).resample(..)` when the same object is called multiple times (GH13174)
- Bug in `.to_records()` when index name is a unicode string (GH13172)

- Bug in calling `.memory_usage()` on object which doesn't implement (GH12924)
- Regression in `Series.quantile` with nans (also shows up in `.median()` and `.describe()`); furthermore now names the `Series` with the quantile (GH13098, GH13146)
- Bug in `SeriesGroupBy.transform` with datetime values and missing groups (GH13191)
- Bug where empty `Series` were incorrectly coerced in datetime-like numeric operations (GH13844)
- Bug in `Categorical` constructor when passed a `Categorical` containing datetimes with timezones (GH14190)
- Bug in `Series.str.extractall()` with `str` index raises `ValueError` (GH13156)
- Bug in `Series.str.extractall()` with single group and quantifier (GH13382)
- Bug in `DatetimeIndex` and `Period` subtraction raises `ValueError` or `AttributeError` rather than `TypeError` (GH13078)
- Bug in `Index` and `Series` created with `NaN` and `NaT` mixed data may not have `datetime64` dtype (GH13324)
- Bug in `Index` and `Series` may ignore `np.datetime64('nat')` and `np.timdelta64('nat')` to infer dtype (GH13324)
- Bug in `PeriodIndex` and `Period` subtraction raises `AttributeError` (GH13071)
- Bug in `PeriodIndex` construction returning a `float64` index in some circumstances (GH13067)
- Bug in `.resample(..)` with a `PeriodIndex` not changing its `freq` appropriately when empty (GH13067)
- Bug in `.resample(..)` with a `PeriodIndex` not retaining its type or name with an empty `DataFrame` appropriately when empty (GH13212)
- Bug in `groupby(..).apply(..)` when the passed function returns scalar values per group (GH13468).
- Bug in `groupby(..).resample(..)` where passing some keywords would raise an exception (GH13235)
- Bug in `.tz_convert` on a tz-aware `DateTimeIndex` that relied on index being sorted for correct results (GH13306)
- Bug in `.tz_localize` with `dateutil.tz.tzlocal` may return incorrect result (GH13583)
- Bug in `DatetimeTZDtype` dtype with `dateutil.tz.tzlocal` cannot be regarded as valid dtype (GH13583)
- Bug in `pd.read_hdf()` where attempting to load an HDF file with a single dataset, that had one or more categorical columns, failed unless the key argument was set to the name of the dataset. (GH13231)
- Bug in `.rolling()` that allowed a negative integer window in contruction of the `Rolling()` object, but would later fail on aggregation (GH13383)
- Bug in `Series` indexing with tuple-valued data and a numeric index (GH13509)
- Bug in printing `pd.DataFrame` where unusual elements with the `object` dtype were causing segfaults (GH13717)
- Bug in ranking `Series` which could result in segfaults (GH13445)
- Bug in various index types, which did not propagate the name of passed index (GH12309)
- Bug in `DatetimeIndex`, which did not honour the `copy=True` (GH13205)
- Bug in `DatetimeIndex.is_normalized` returns incorrectly for normalized date_range in case of local timezones (GH13459)

- Bug in `pd.concat` and `.append` may coerces `datetime64` and `timedelta` to `object` dtype containing python built-in `datetime` or `timedelta` rather than `Timestamp` or `Timedelta` (GH13626)
- Bug in `PeriodIndex.append` may raises `AttributeError` when the result is `object` dtype (GH13221)
- Bug in `CategoricalIndex.append` may accept normal `list` (GH13626)
- Bug in `pd.concat` and `.append` with the same timezone get reset to UTC (GH7795)
- Bug in `Series` and `DataFrame` `.append` raises `AmbiguousTimeError` if data contains datetime near DST boundary (GH13626)
- Bug in `DataFrame.to_csv()` in which float values were being quoted even though quotations were specified for non-numeric values only (GH12922, GH13259)
- Bug in `DataFrame.describe()` raising `ValueError` with only boolean columns (GH13898)
- Bug in `MultiIndex` slicing where extra elements were returned when level is non-unique (GH12896)
- Bug in `.str.replace` does not raise `TypeError` for invalid replacement (GH13438)
- Bug in `MultiIndex.from_arrays` which didn't check for input array lengths matching (GH13599)
- Bug in `cartesian_product` and `MultiIndex.from_product` which may raise with empty input arrays (GH12258)
- Bug in `pd.read_csv()` which may cause a segfault or corruption when iterating in large chunks over a stream/file under rare circumstances (GH13703)
- Bug in `pd.read_csv()` which caused errors to be raised when a dictionary containing scalars is passed in for `na_values` (GH12224)
- Bug in `pd.read_csv()` which caused BOM files to be incorrectly parsed by not ignoring the BOM (GH4793)
- Bug in `pd.read_csv()` with `engine='python'` which raised errors when a numpy array was passed in for `usecols` (GH12546)
- Bug in `pd.read_csv()` where the index columns were being incorrectly parsed when parsed as dates with a `thousands` parameter (GH14066)
- Bug in `pd.read_csv()` with `engine='python'` in which `NaN` values weren't being detected after data was converted to numeric values (GH13314)
- Bug in `pd.read_csv()` in which the `nrows` argument was not properly validated for both engines (GH10476)
- Bug in `pd.read_csv()` with `engine='python'` in which infinities of mixed-case forms were not being interpreted properly (GH13274)
- Bug in `pd.read_csv()` with `engine='python'` in which trailing `NaN` values were not being parsed (GH13320)
- Bug in `pd.read_csv()` with `engine='python'` when reading from a `tempfile.TemporaryFile` on Windows with Python 3 (GH13398)
- Bug in `pd.read_csv()` that prevents `usecols` kwarg from accepting single-byte unicode strings (GH13219)
- Bug in `pd.read_csv()` that prevents `usecols` from being an empty set (GH13402)
- Bug in `pd.read_csv()` in the C engine where the NULL character was not being parsed as NULL (GH14012)
- Bug in `pd.read_csv()` with `engine='c'` in which NULL `quotechar` was not accepted even though `quoting` was specified as `None` (GH13411)

- Bug in `pd.read_csv()` with `engine='c'` in which fields were not properly cast to float when quoting was specified as non-numeric (GH13411)
- Bug in `pd.read_csv()` in Python 2.x with non-UTF8 encoded, multi-character separated data (GH3404)
- Bug in `pd.read_csv()`, where aliases for utf-xx (e.g. UTF-xx, UTF_xx, utf_xx) raised UnicodeDecodeError (GH13549)
- Bug in `pd.read_csv`, `pd.read_table`, `pd.read_fwf`, `pd.read_stata` and `pd.read_sas` where files were opened by parsers but not closed if both `chunksize` and `iterator` were `None`. (GH13940)
- Bug in `StataReader`, `StataWriter`, `XportReader` and `SAS7BDATReader` where a file was not properly closed when an error was raised. (GH13940)
- Bug in `pd.pivot_table()` where `margins_name` is ignored when `aggfunc` is a list (GH13354)
- Bug in `pd.Series.str.zfill`, `center`, `ljust`, `rjust`, and `pad` when passing non-integers, did not raise `TypeError` (GH13598)
- Bug in checking for any null objects in a `TimedeltaIndex`, which always returned `True` (GH13603)
- Bug in `Series` arithmetic raises `TypeError` if it contains datetime-like as `object` dtype (GH13043)
- Bug `Series.isnull()` and `Series.notnull()` ignore `Period('NaT')` (GH13737)
- Bug `Series.fillna()` and `Series.dropna()` don't affect to `Period('NaT')` (GH13737
- Bug in `.fillna(value=np.nan)` incorrectly raises `KeyError` on a `category` dtyped `Series` (GH14021)
- Bug in extension dtype creation where the created types were not is/identical (GH13285)
- Bug in `.resample(..)` where incorrect warnings were triggered by IPython introspection (GH13618)
- Bug in `NaT - Period` raises `AttributeError` (GH13071)
- Bug in `Series` comparison may output incorrect result if rhs contains `NaT` (GH9005)
- Bug in `Series` and `Index` comparison may output incorrect result if it contains `NaT` with `object` dtype (GH13592)
- Bug in `Period` addition raises `TypeError` if `Period` is on right hand side (GH13069)
- Bug in `Peirod` and `Series` or `Index` comparison raises `TypeError` (GH13200)
- Bug in `pd.set_eng_float_format()` that would prevent NaN and Inf from formatting (GH11981)
- Bug in `.unstack` with `Categorical` dtype resets `.ordered` to `True` (GH13249)
- Clean some compile time warnings in datetime parsing (GH13607)
- Bug in `factorize` raises `AmbiguousTimeError` if data contains datetime near DST boundary (GH13750)
- Bug in `.set_index` raises `AmbiguousTimeError` if new index contains DST boundary and multi levels (GH12920)
- Bug in `.shift` raises `AmbiguousTimeError` if data contains datetime near DST boundary (GH13926)
- Bug in `pd.read_hdf()` returns incorrect result when a `DataFrame` with a `categorical` column and a query which doesn't match any values (GH13792)
- Bug in `.iloc` when indexing with a non lex-sorted MultiIndex (GH13797)
- Bug in `.loc` when indexing with date strings in a reverse sorted `DatetimeIndex` (GH14316)
- Bug in `Series` comparison operators when dealing with zero dim NumPy arrays (GH13006)
- Bug in `.combine_first` may return incorrect `dtype` (GH7630, GH10567)

- Bug in `groupby` where `apply` returns different result depending on whether first result is `None` or not (GH12824)
- Bug in `groupby(..).nth()` where the group key is included inconsistently if called after `.head()/.tail()` (GH12839)
- Bug in `.to_html`, `.to_latex` and `.to_string` silently ignore custom datetime formatter passed through the `formatters` key word (GH10690)
- Bug in `DataFrame.iterrows()`, not yielding a `Series` subclasse if defined (GH13977)
- Bug in `pd.to_numeric` when `errors='coerce'` and input contains non-hashable objects (GH13324)
- Bug in invalid `Timedelta` arithmetic and comparison may raise `ValueError` rather than `TypeError` (GH13624)
- Bug in invalid datetime parsing in `to_datetime` and `DatetimeIndex` may raise `TypeError` rather than `ValueError` (GH11169, GH11287)
- Bug in `Index` created with tz-aware `Timestamp` and mismatched `tz` option incorrectly coerces timezone (GH13692)
- Bug in `DatetimeIndex` with nanosecond frequency does not include timestamp specified with `end` (GH13672)
- Bug in `` `Series` `` when setting a slice with a `` `np.timedelta64` `` (GH14155)
- Bug in `Index` raises `OutOfBoundsDatetime` if `datetime` exceeds `datetime64[ns]` bounds, rather than coercing to `object` dtype (GH13663)
- Bug in `Index` may ignore specified `datetime64` or `timedelta64` passed as `dtype` (GH13981)
- Bug in `RangeIndex` can be created without no arguments rather than raises `TypeError` (GH13793)
- Bug in `.value_counts()` raises `OutOfBoundsDatetime` if data exceeds `datetime64[ns]` bounds (GH13663)
- Bug in `DatetimeIndex` may raise `OutOfBoundsDatetime` if input `np.datetime64` has other unit than `ns` (GH9114)
- Bug in `Series` creation with `np.datetime64` which has other unit than `ns` as `object` dtype results in incorrect values (GH13876)
- Bug in `resample` with timedelta data where data was casted to float (GH13119).
- Bug in `pd.isnull()` `pd.notnull()` raise `TypeError` if input datetime-like has other unit than `ns` (GH13389)
- Bug in `pd.merge()` may raise `TypeError` if input datetime-like has other unit than `ns` (GH13389)
- Bug in `HDFStore`/`read_hdf()` discarded `DatetimeIndex.name` if `tz` was set (GH13884)
- Bug in `Categorical.remove_unused_categories()` changes `.codes` dtype to platform int (GH13261)
- Bug in `groupby` with `as_index=False` returns all NaN's when grouping on multiple columns including a categorical one (GH13204)
- Bug in `df.groupby(...)[...]` where getitem with `Int64Index` raised an error (GH13731)
- Bug in the CSS classes assigned to `DataFrame.style` for index names. Previously they were assigned `"col_heading level<n> col<c>"` where `n` was the number of levels + 1. Now they are assigned `"index_name level<n>"`, where `n` is the correct level for that MultiIndex.
- Bug where `pd.read_gbq()` could throw `ImportError: No module named discovery` as a result of a naming conflict with another python package called apiclient (GH13454)

- Bug in `Index.union` returns an incorrect result with a named empty index (GH13432)
- Bugs in `Index.difference` and `DataFrame.join` raise in Python3 when using mixed-integer indexes (GH13432, GH12814)
- Bug in subtract tz-aware `datetime.datetime` from tz-aware `datetime64` series (GH14088)
- Bug in `.to_excel()` when DataFrame contains a MultiIndex which contains a label with a NaN value (GH13511)
- Bug in invalid frequency offset string like "D1", "-2-3H" may not raise `ValueError` (GH13930)
- Bug in `concat` and `groupby` for hierarchical frames with `RangeIndex` levels (GH13542).
- Bug in `Series.str.contains()` for Series containing only `NaN` values of `object` dtype (GH14171)
- Bug in `agg()` function on groupby dataframe changes dtype of `datetime64[ns]` column to `float64` (GH12821)
- Bug in using NumPy ufunc with `PeriodIndex` to add or subtract integer raise `IncompatibleFrequency`. Note that using standard operator like + or − is recommended, because standard operators use more efficient path (GH13980)
- Bug in operations on `NaT` returning `float` instead of `datetime64[ns]` (GH12941)
- Bug in `Series` flexible arithmetic methods (like `.add()`) raises `ValueError` when `axis=None` (GH13894)
- Bug in `DataFrame.to_csv()` with `MultiIndex` columns in which a stray empty line was added (GH6618)
- Bug in `DatetimeIndex`, `TimedeltaIndex` and `PeriodIndex.equals()` may return `True` when input isn't `Index` but contains the same values (GH13107)
- Bug in assignment against datetime with timezone may not work if it contains datetime near DST boundary (GH14146)
- Bug in `pd.eval()` and `HDFStore` query truncating long float literals with python 2 (GH14241)
- Bug in `Index` raises `KeyError` displaying incorrect column when column is not in the df and columns contains duplicate values (GH13822)
- Bug in `Period` and `PeriodIndex` creating wrong dates when frequency has combined offset aliases (GH13874)
- Bug in `.to_string()` when called with an integer `line_width` and `index=False` raises an UnboundLocalError exception because `idx` referenced before assignment.
- Bug in `eval()` where the `resolvers` argument would not accept a list (GH14095)
- Bugs in `stack`, `get_dummies`, `make_axis_dummies` which don't preserve categorical dtypes in (multi)indexes (GH13854)
- `PeriodIndex` can now accept `list` and `array` which contains `pd.NaT` (GH13430)
- Bug in `df.groupby` where `.median()` returns arbitrary values if grouped dataframe contains empty bins (GH13629)
- Bug in `Index.copy()` where `name` parameter was ignored (GH14302)

1.8 v0.18.1 (May 3, 2016)

This is a minor bug-fix release from 0.18.0 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

- `.groupby(...)` has been enhanced to provide convenient syntax when working with `.rolling(..)`, `.expanding(..)` and `.resample(..)` per group, see *here*
- `pd.to_datetime()` has gained the ability to assemble dates from a `DataFrame`, see *here*
- Method chaining improvements, see *here*.
- Custom business hour offset, see *here*.
- Many bug fixes in the handling of `sparse`, see *here*
- Expanded the *Tutorials section* with a feature on modern pandas, courtesy of @TomAugsburger. (GH13045).

What's new in v0.18.1

1.8.1 New features

1.8.1.1 Custom Business Hour

The `CustomBusinessHour` is a mixture of `BusinessHour` and `CustomBusinessDay` which allows you to specify arbitrary holidays. For details, see *Custom Business Hour* (GH11514)

```
In [1]: from pandas.tseries.offsets import CustomBusinessHour

In [2]: from pandas.tseries.holiday import USFederalHolidayCalendar

In [3]: bhour_us = CustomBusinessHour(calendar=USFederalHolidayCalendar())
```

Friday before MLK Day

```
In [4]: dt = datetime(2014, 1, 17, 15)

In [5]: dt + bhour_us
Out[5]: Timestamp('2014-01-17 16:00:00')
```

Tuesday after MLK Day (Monday is skipped because it's a holiday)

```
In [6]: dt + bhour_us * 2
Out[6]: Timestamp('2014-01-20 09:00:00')
```

1.8.1.2 `.groupby(..)` syntax with window and resample operations

`.groupby(...)` has been enhanced to provide convenient syntax when working with `.rolling(..)`, `.expanding(..)` and `.resample(..)` per group, see (GH12486, GH12738).

You can now use `.rolling(..)` and `.expanding(..)` as methods on groupbys. These return another deferred object (similar to what `.rolling()` and `.expanding()` do on ungrouped pandas objects). You can then operate on these `RollingGroupby` objects in a similar manner.

Previously you would have to do this to get a rolling window mean per-group:

```
In [7]: df = pd.DataFrame({'A': [1] * 20 + [2] * 12 + [3] * 8,
   ...:                    'B': np.arange(40)})
   ...:

In [8]: df
Out[8]:
    A   B
0   1   0
1   1   1
2   1   2
3   1   3
4   1   4
5   1   5
6   1   6
..  ..  ..
33  3  33
34  3  34
35  3  35
36  3  36
37  3  37
38  3  38
```

```
39  3  39

[40 rows x 2 columns]
```

```
In [9]: df.groupby('A').apply(lambda x: x.rolling(4).B.mean())
Out[9]:
A
1  0      NaN
   1      NaN
   2      NaN
   3      1.5
   4      2.5
   5      3.5
   6      4.5
         ...
3  33     NaN
   34     NaN
   35    33.5
   36    34.5
   37    35.5
   38    36.5
   39    37.5
Name: B, Length: 40, dtype: float64
```

Now you can do:

```
In [10]: df.groupby('A').rolling(4).B.mean()
Out[10]:
A
1  0      NaN
   1      NaN
   2      NaN
   3      1.5
   4      2.5
   5      3.5
   6      4.5
         ...
3  33     NaN
   34     NaN
   35    33.5
   36    34.5
   37    35.5
   38    36.5
   39    37.5
Name: B, Length: 40, dtype: float64
```

For `.resample(..)` type of operations, previously you would have to:

```
In [11]: df = pd.DataFrame({'date': pd.date_range(start='2016-01-01',
   ....:                                          periods=4,
   ....:                                          freq='W'),
   ....:                    'group': [1, 1, 2, 2],
   ....:                    'val': [5, 6, 7, 8]}).set_index('date')
   ....:

In [12]: df
Out[12]:
            group  val
```

```
date
2016-01-03      1    5
2016-01-10      1    6
2016-01-17      2    7
2016-01-24      2    8
```

```
In [13]: df.groupby('group').apply(lambda x: x.resample('1D').ffill())
Out[13]:
                   group  val
group date
1     2016-01-03      1    5
      2016-01-04      1    5
      2016-01-05      1    5
      2016-01-06      1    5
      2016-01-07      1    5
      2016-01-08      1    5
      2016-01-09      1    5
...                 ...  ...
2     2016-01-18      2    7
      2016-01-19      2    7
      2016-01-20      2    7
      2016-01-21      2    7
      2016-01-22      2    7
      2016-01-23      2    7
      2016-01-24      2    8

[16 rows x 2 columns]
```

Now you can do:

```
In [14]: df.groupby('group').resample('1D').ffill()
Out[14]:
                   group  val
group date
1     2016-01-03      1    5
      2016-01-04      1    5
      2016-01-05      1    5
      2016-01-06      1    5
      2016-01-07      1    5
      2016-01-08      1    5
      2016-01-09      1    5
...                 ...  ...
2     2016-01-18      2    7
      2016-01-19      2    7
      2016-01-20      2    7
      2016-01-21      2    7
      2016-01-22      2    7
      2016-01-23      2    7
      2016-01-24      2    8

[16 rows x 2 columns]
```

1.8.1.3 Method chaininng improvements

The following methods / indexers now accept a `callable`. It is intended to make these more useful in method chains, see the *documentation*. (GH11485, GH12533)

- `.where()` and `.mask()`
- `.loc[]`, `iloc[]` and `.ix[]`
- `[]` indexing

`.where()` and `.mask()`

These can accept a callable for the condition and `other` arguments.

```
In [15]: df = pd.DataFrame({'A': [1, 2, 3],
   ....:                    'B': [4, 5, 6],
   ....:                    'C': [7, 8, 9]})
   ....:

In [16]: df.where(lambda x: x > 4, lambda x: x + 10)
Out[16]:
    A   B  C
0  11  14  7
1  12   5  8
2  13   6  9
```

`.loc[]`, `.iloc[]`, `.ix[]`

These can accept a callable, and a tuple of callable as a slicer. The callable can return a valid boolean indexer or anything which is valid for these indexer's input.

```
# callable returns bool indexer
In [17]: df.loc[lambda x: x.A >= 2, lambda x: x.sum() > 10]
Out[17]:
   B  C
1  5  8
2  6  9

# callable returns list of labels
In [18]: df.loc[lambda x: [1, 2], lambda x: ['A', 'B']]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[18]:
   A  B
1  2  5
2  3  6
```

`[]` indexing

Finally, you can use a callable in `[]` indexing of Series, DataFrame and Panel. The callable must return a valid input for `[]` indexing depending on its class and index type.

```
In [19]: df[lambda x: 'A']
Out[19]:
0    1
1    2
2    3
Name: A, dtype: int64
```

Using these methods / indexers, you can chain data selection operations without using temporary variable.

```
In [20]: bb = pd.read_csv('data/baseball.csv', index_col='id')

In [21]: (bb.groupby(['year', 'team'])
   ....:     .sum()
   ....:     .loc[lambda df: df.r > 100]
   ....: )
   ....:
Out[21]:
           stint    g    ab    r    h  X2b  X3b  hr    rbi    sb   cs   bb  \
year team
2007 CIN       6  379   745  101  203   35    2  36  125.0  10.0  1.0  105
     DET       5  301  1062  162  283   54    4  37  144.0  24.0  7.0   97
     HOU       4  311   926  109  218   47    6  14   77.0  10.0  4.0   60
     LAN      11  413  1021  153  293   61    3  36  154.0   7.0  5.0  114
     NYN      13  622  1854  240  509  101    3  61  243.0  22.0  4.0  174
     SFN       5  482  1305  198  337   67    6  40  171.0  26.0  7.0  235
     TEX       2  198   729  115  200   40    4  28  115.0  21.0  4.0   73
     TOR       4  459  1408  187  378   96    2  58  223.0   4.0  2.0  190

               so   ibb   hbp    sh    sf  gidp
year team
2007 CIN   127.0  14.0   1.0   1.0  15.0  18.0
     DET   176.0   3.0  10.0   4.0   8.0  28.0
     HOU   212.0   3.0   9.0  16.0   6.0  17.0
     LAN   141.0   8.0   9.0   3.0   8.0  29.0
     NYN   310.0  24.0  23.0  18.0  15.0  48.0
     SFN   188.0  51.0   8.0  16.0   6.0  41.0
     TEX   140.0   4.0   5.0   2.0   8.0  16.0
     TOR   265.0  16.0  12.0   4.0  16.0  38.0
```

1.8.1.4 Partial string indexing on `DateTimeIndex` when part of a `MultiIndex`

Partial string indexing now matches on `DateTimeIndex` when part of a `MultiIndex` (GH10331)

```
In [22]: dft2 = pd.DataFrame(np.random.randn(20, 1),
   ....:                     columns=['A'],
   ....:                     index=pd.MultiIndex.from_product([pd.date_range('20130101
↪',
   ....:                                                                              ␣
↪periods=10,
   ....:                                                                               freq='12H
↪'),
   ....:                                                          ['a', 'b']]))
   ....:

In [23]: dft2
Out[23]:
                            A
2013-01-01 00:00:00 a  0.156998
                    b -0.571455
2013-01-01 12:00:00 a  1.057633
                    b -0.791489
2013-01-02 00:00:00 a -0.524627
                    b  0.071878
2013-01-02 12:00:00 a  1.910759
...                         ...
2013-01-04 00:00:00 b  1.015405
```

```
2013-01-04 12:00:00 a  0.749185
                    b -0.675521
2013-01-05 00:00:00 a  0.440266
                    b  0.688972
2013-01-05 12:00:00 a -0.276646
                    b  1.924533

[20 rows x 1 columns]

In [24]: dft2.loc['2013-01-05']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                              A
2013-01-05 00:00:00 a  0.440266
                    b  0.688972
2013-01-05 12:00:00 a -0.276646
                    b  1.924533
```

On other levels

```
In [25]: idx = pd.IndexSlice

In [26]: dft2 = dft2.swaplevel(0, 1).sort_index()

In [27]: dft2
Out[27]:
                              A
a 2013-01-01 00:00:00  0.156998
  2013-01-01 12:00:00  1.057633
  2013-01-02 00:00:00 -0.524627
  2013-01-02 12:00:00  1.910759
  2013-01-03 00:00:00  0.513082
  2013-01-03 12:00:00  1.043945
  2013-01-04 00:00:00  1.459927
...                         ...
b 2013-01-02 12:00:00  0.787965
  2013-01-03 00:00:00 -0.546416
  2013-01-03 12:00:00  2.107785
  2013-01-04 00:00:00  1.015405
  2013-01-04 12:00:00 -0.675521
  2013-01-05 00:00:00  0.688972
  2013-01-05 12:00:00  1.924533

[20 rows x 1 columns]

In [28]: dft2.loc[idx[:, '2013-01-05'], :]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                              A
a 2013-01-05 00:00:00  0.440266
  2013-01-05 12:00:00 -0.276646
b 2013-01-05 00:00:00  0.688972
  2013-01-05 12:00:00  1.924533
```

1.8.1.5 Assembling Datetimes

`pd.to_datetime()` has gained the ability to assemble datetimes from a passed in `DataFrame` or a dict.

(GH8158).

```
In [29]: df = pd.DataFrame({'year': [2015, 2016],
   ....:                    'month': [2, 3],
   ....:                    'day': [4, 5],
   ....:                    'hour': [2, 3]})
   ....:

In [30]: df
Out[30]:
   day  hour  month  year
0    4     2      2  2015
1    5     3      3  2016
```

Assembling using the passed frame.

```
In [31]: pd.to_datetime(df)
Out[31]:
0   2015-02-04 02:00:00
1   2016-03-05 03:00:00
dtype: datetime64[ns]
```

You can pass only the columns that you need to assemble.

```
In [32]: pd.to_datetime(df[['year', 'month', 'day']])
Out[32]:
0   2015-02-04
1   2016-03-05
dtype: datetime64[ns]
```

1.8.1.6 Other Enhancements

- `pd.read_csv()` now supports `delim_whitespace=True` for the Python engine (GH12958)
- `pd.read_csv()` now supports opening ZIP files that contains a single CSV, via extension inference or explict `compression='zip'` (GH12175)
- `pd.read_csv()` now supports opening files using xz compression, via extension inference or explicit `compression='xz'` is specified; `xz` compressions is also supported by `DataFrame.to_csv` in the same way (GH11852)
- `pd.read_msgpack()` now always gives writeable ndarrays even when compression is used (GH12359).
- `pd.read_msgpack()` now supports serializing and de-serializing categoricals with msgpack (GH12573)
- `.to_json()` now supports `NDFrames` that contain categorical and sparse data (GH10778)
- `interpolate()` now supports `method='akima'` (GH7588).
- `pd.read_excel()` now accepts path objects (e.g. `pathlib.Path`, `py.path.local`) for the file path, in line with other `read_*` functions (GH12655)
- Added `.weekday_name` property as a component to `DatetimeIndex` and the `.dt` accessor. (GH11128)
- `Index.take` now handles `allow_fill` and `fill_value` consistently (GH12631)

```
In [33]: idx = pd.Index([1., 2., 3., 4.], dtype='float')

# default, allow_fill=True, fill_value=None
In [34]: idx.take([2, -1])
```

```
Out[34]: Float64Index([3.0, 4.0], dtype='float64')

In [35]: idx.take([2, -1], fill_value=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[35]: Float64Index([3.0,␣
↪nan], dtype='float64')
```

- `Index` now supports `.str.get_dummies()` which returns `MultiIndex`, see *Creating Indicator Variables* (GH10008, GH10103)

```
In [36]: idx = pd.Index(['a|b', 'a|c', 'b|c'])

In [37]: idx.str.get_dummies('|')
Out[37]:
MultiIndex(levels=[[0, 1], [0, 1], [0, 1]],
           labels=[[1, 1, 0], [1, 0, 1], [0, 1, 1]],
           names=['a', 'b', 'c'])
```

- `pd.crosstab()` has gained a `normalize` argument for normalizing frequency tables (GH12569). Examples in the updated docs *here*.
- `.resample(..).interpolate()` is now supported (GH12925)
- `.isin()` now accepts passed `sets` (GH12988)

1.8.2 Sparse changes

These changes conform sparse handling to return the correct types and work to make a smoother experience with indexing.

`SparseArray.take` now returns a scalar for scalar input, `SparseArray` for others. Furthermore, it handles a negative indexer with the same rule as `Index` (GH10560, GH12796)

```
In [38]: s = pd.SparseArray([np.nan, np.nan, 1, 2, 3, np.nan, 4, 5, np.nan, 6])

In [39]: s.take(0)
Out[39]: nan

In [40]: s.take([1, 2, 3])
\\\\\\\\\\\\\Out[40]:
[nan, 1.0, 2.0]
Fill: nan
IntIndex
Indices: array([1, 2], dtype=int32)
```

- Bug in `SparseSeries[]` indexing with `Ellipsis` raises `KeyError` (GH9467)
- Bug in `SparseArray[]` indexing with tuples are not handled properly (GH12966)
- Bug in `SparseSeries.loc[]` with list-like input raises `TypeError` (GH10560)
- Bug in `SparseSeries.iloc[]` with scalar input may raise `IndexError` (GH10560)
- Bug in `SparseSeries.loc[]`, `.iloc[]` with `slice` returns `SparseArray`, rather than `SparseSeries` (GH10560)
- Bug in `SparseDataFrame.loc[]`, `.iloc[]` may results in dense `Series`, rather than `SparseSeries` (GH12787)
- Bug in `SparseArray` addition ignores `fill_value` of right hand side (GH12910)

- Bug in `SparseArray` mod raises `AttributeError` (GH12910)
- Bug in `SparseArray` pow calculates `1 ** np.nan` as `np.nan` which must be 1 (GH12910)
- Bug in `SparseArray` comparison output may incorrect result or raise `ValueError` (GH12971)
- Bug in `SparseSeries.__repr__` raises `TypeError` when it is longer than `max_rows` (GH10560)
- Bug in `SparseSeries.shape` ignores `fill_value` (GH10452)
- Bug in `SparseSeries` and `SparseArray` may have different `dtype` from its dense values (GH12908)
- Bug in `SparseSeries.reindex` incorrectly handle `fill_value` (GH12797)
- Bug in `SparseArray.to_frame()` results in `DataFrame`, rather than `SparseDataFrame` (GH9850)
- Bug in `SparseSeries.value_counts()` does not count `fill_value` (GH6749)
- Bug in `SparseArray.to_dense()` does not preserve `dtype` (GH10648)
- Bug in `SparseArray.to_dense()` incorrectly handle `fill_value` (GH12797)
- Bug in `pd.concat()` of `SparseSeries` results in dense (GH10536)
- Bug in `pd.concat()` of `SparseDataFrame` incorrectly handle `fill_value` (GH9765)
- Bug in `pd.concat()` of `SparseDataFrame` may raise `AttributeError` (GH12174)
- Bug in `SparseArray.shift()` may raise `NameError` or `TypeError` (GH12908)

1.8.3 API changes

1.8.3.1 `.groupby(..).nth()` changes

The index in `.groupby(..).nth()` output is now more consistent when the `as_index` argument is passed (GH11039):

```
In [41]: df = DataFrame({'A' : ['a', 'b', 'a'],
   ....:                 'B' : [1, 2, 3]})
   ....:

In [42]: df
Out[42]:
   A  B
0  a  1
1  b  2
2  a  3
```

Previous Behavior:

```
In [3]: df.groupby('A', as_index=True)['B'].nth(0)
Out[3]:
0    1
1    2
Name: B, dtype: int64

In [4]: df.groupby('A', as_index=False)['B'].nth(0)
Out[4]:
0    1
1    2
Name: B, dtype: int64
```

New Behavior:

```
In [43]: df.groupby('A', as_index=True)['B'].nth(0)
Out[43]:
A
a    1
b    2
Name: B, dtype: int64

In [44]: df.groupby('A', as_index=False)['B'].nth(0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[44]:
0    1
1    2
Name: B, dtype: int64
```

Furthermore, previously, a `.groupby` would always sort, regardless if `sort=False` was passed with `.nth()`.

```
In [45]: np.random.seed(1234)

In [46]: df = pd.DataFrame(np.random.randn(100, 2), columns=['a', 'b'])

In [47]: df['c'] = np.random.randint(0, 4, 100)
```

Previous Behavior:

```
In [4]: df.groupby('c', sort=True).nth(1)
Out[4]:
          a         b
c
0 -0.334077  0.002118
1  0.036142 -2.074978
2 -0.720589  0.887163
3  0.859588 -0.636524

In [5]: df.groupby('c', sort=False).nth(1)
Out[5]:
          a         b
c
0 -0.334077  0.002118
1  0.036142 -2.074978
2 -0.720589  0.887163
3  0.859588 -0.636524
```

New Behavior:

```
In [48]: df.groupby('c', sort=True).nth(1)
Out[48]:
          a         b
c
0 -0.334077  0.002118
1  0.036142 -2.074978
2 -0.720589  0.887163
3  0.859588 -0.636524

In [49]: df.groupby('c', sort=False).nth(1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          a         b
c
```

```
2 -0.720589  0.887163
3  0.859588 -0.636524
0 -0.334077  0.002118
1  0.036142 -2.074978
```

1.8.3.2 numpy function compatibility

Compatibility between pandas array-like methods (e.g. `sum` and `take`) and their `numpy` counterparts has been greatly increased by augmenting the signatures of the `pandas` methods so as to accept arguments that can be passed in from `numpy`, even if they are not necessarily used in the `pandas` implementation (GH12644, GH12638, GH12687)

- `.searchsorted()` for `Index` and `TimedeltaIndex` now accept a `sorter` argument to maintain compatibility with numpy's `searchsorted` function (GH12238)
- Bug in numpy compatibility of `np.round()` on a `Series` (GH12600)

An example of this signature augmentation is illustrated below:

```
In [50]: sp = pd.SparseDataFrame([1, 2, 3])

In [51]: sp
Out[51]:
   0
0  1
1  2
2  3
```

Previous behaviour:

```
In [2]: np.cumsum(sp, axis=0)
...
TypeError: cumsum() takes at most 2 arguments (4 given)
```

New behaviour:

```
In [52]: np.cumsum(sp, axis=0)
Out[52]:
   0
0  1
1  3
2  6
```

1.8.3.3 Using `.apply` on groupby resampling

Using `apply` on resampling groupby operations (using a `pd.TimeGrouper`) now has the same output types as similar `apply` calls on other groupby operations. (GH11742).

```
In [53]: df = pd.DataFrame({'date': pd.to_datetime(['10/10/2000', '11/10/2000']),
   ....:                    'value': [10, 13]})
   ....:

In [54]: df
Out[54]:
        date  value
0 2000-10-10     10
1 2000-11-10     13
```

Previous behavior:

```
In [1]: df.groupby(pd.TimeGrouper(key='date', freq='M')).apply(lambda x: x.value.
↪sum())
Out[1]:
...
TypeError: cannot concatenate a non-NDFrame object

# Output is a Series
In [2]: df.groupby(pd.TimeGrouper(key='date', freq='M')).apply(lambda x: x[['value']].
↪sum())
Out[2]:
date
2000-10-31  value    10
2000-11-30  value    13
dtype: int64
```

New Behavior:

```
# Output is a Series
In [55]: df.groupby(pd.TimeGrouper(key='date', freq='M')).apply(lambda x: x.value.
↪sum())
Out[55]:
date
2000-10-31    10
2000-11-30    13
Freq: M, dtype: int64

# Output is a DataFrame
In [56]: df.groupby(pd.TimeGrouper(key='date', freq='M')).apply(lambda x: x[['value
↪']].sum())
Out[56]:
            value
date
2000-10-31     10
2000-11-30     13
```

1.8.3.4 Changes in `read_csv` exceptions

In order to standardize the `read_csv` API for both the `c` and `python` engines, both will now raise an `EmptyDataError`, a subclass of `ValueError`, in response to empty columns or header (GH12493, GH12506)

Previous behaviour:

```
In [1]: df = pd.read_csv(StringIO(''), engine='c')
...
ValueError: No columns to parse from file

In [2]: df = pd.read_csv(StringIO(''), engine='python')
...
StopIteration
```

New behaviour:

```
In [1]: df = pd.read_csv(StringIO(''), engine='c')
...
pandas.io.common.EmptyDataError: No columns to parse from file
```

```
In [2]: df = pd.read_csv(StringIO(''), engine='python')
...
pandas.io.common.EmptyDataError: No columns to parse from file
```

In addition to this error change, several others have been made as well:

- `CParserError` now sub-classes `ValueError` instead of just a `Exception` (GH12551)
- A `CParserError` is now raised instead of a generic `Exception` in `read_csv` when the `c` engine cannot parse a column (GH12506)
- A `ValueError` is now raised instead of a generic `Exception` in `read_csv` when the `c` engine encounters a `NaN` value in an integer column (GH12506)
- A `ValueError` is now raised instead of a generic `Exception` in `read_csv` when `true_values` is specified, and the `c` engine encounters an element in a column containing unencodable bytes (GH12506)
- `pandas.parser.OverflowError` exception has been removed and has been replaced with Python's built-in `OverflowError` exception (GH12506)
- `pd.read_csv()` no longer allows a combination of strings and integers for the `usecols` parameter (GH12678)

1.8.3.5 `to_datetime` error changes

Bugs in `pd.to_datetime()` when passing a `unit` with convertible entries and `errors='coerce'` or non-convertible with `errors='ignore'`. Furthermore, an `OutOfBoundsDateime` exception will be raised when an out-of-range value is encountered for that unit when `errors='raise'`. (GH11758, GH13052, GH13059)

Previous behaviour:

```
In [27]: pd.to_datetime(1420043460, unit='s', errors='coerce')
Out[27]: NaT

In [28]: pd.to_datetime(11111111, unit='D', errors='ignore')
OverflowError: Python int too large to convert to C long

In [29]: pd.to_datetime(11111111, unit='D', errors='raise')
OverflowError: Python int too large to convert to C long
```

New behaviour:

```
In [2]: pd.to_datetime(1420043460, unit='s', errors='coerce')
Out[2]: Timestamp('2014-12-31 16:31:00')

In [3]: pd.to_datetime(11111111, unit='D', errors='ignore')
Out[3]: 11111111

In [4]: pd.to_datetime(11111111, unit='D', errors='raise')
OutOfBoundsDatetime: cannot convert input with unit 'D'
```

1.8.3.6 Other API changes

- `.swaplevel()` for `Series`, `DataFrame`, `Panel`, and `MultiIndex` now features defaults for its first two parameters `i` and `j` that swap the two innermost levels of the index. (GH12934)

- `.searchsorted()` for `Index` and `TimedeltaIndex` now accept a `sorter` argument to maintain compatibility with numpy's `searchsorted` function (GH12238)
- `Period` and `PeriodIndex` now raises `IncompatibleFrequency` error which inherits `ValueError` rather than raw `ValueError` (GH12615)
- `Series.apply` for category dtype now applies the passed function to each of the `.categories` (and not the `.codes`), and returns a `category` dtype if possible (GH12473)
- `read_csv` will now raise a `TypeError` if `parse_dates` is neither a boolean, list, or dictionary (matches the doc-string) (GH5636)
- The default for `.query()/.eval()` is now `engine=None`, which will use `numexpr` if it's installed; otherwise it will fallback to the `python` engine. This mimics the pre-0.18.1 behavior if `numexpr` is installed (and which, previously, if numexpr was not installed, `.query()/.eval()` would raise). (GH12749)
- `pd.show_versions()` now includes `pandas_datareader` version (GH12740)
- Provide a proper `__name__` and `__qualname__` attributes for generic functions (GH12021)
- `pd.concat(ignore_index=True)` now uses `RangeIndex` as default (GH12695)
- `pd.merge()` and `DataFrame.join()` will show a `UserWarning` when merging/joining a single- with a multi-leveled dataframe (GH9455, GH12219)
- Compat with `scipy` > 0.17 for deprecated `piecewise_polynomial` interpolation method; support for the replacement `from_derivatives` method (GH12887)

1.8.3.7 Deprecations

- The method name `Index.sym_diff()` is deprecated and can be replaced by `Index.symmetric_difference()` (GH12591)
- The method name `Categorical.sort()` is deprecated in favor of `Categorical.sort_values()` (GH12882)

1.8.4 Performance Improvements

- Improved speed of SAS reader (GH12656, GH12961)
- Performance improvements in `.groupby(..).cumcount()` (GH11039)
- Improved memory usage in `pd.read_csv()` when using `skiprows=an_integer` (GH13005)
- Improved performance of `DataFrame.to_sql` when checking case sensitivity for tables. Now only checks if table has been created correctly when table name is not lower case. (GH12876)
- Improved performance of `Period` construction and time series plotting (GH12903, GH11831).
- Improved performance of `.str.encode()` and `.str.decode()` methods (GH13008)
- Improved performance of `to_numeric` if input is numeric dtype (GH12777)
- Improved performance of sparse arithmetic with `IntIndex` (GH13036)

1.8.5 Bug Fixes

- `usecols` parameter in `pd.read_csv` is now respected even when the lines of a CSV file are not even (GH12203)

- Bug in `groupby.transform(..)` when `axis=1` is specified with a non-monotonic ordered index (GH12713)
- Bug in `Period` and `PeriodIndex` creation raises `KeyError` if `freq="Minute"` is specified. Note that "Minute" freq is deprecated in v0.17.0, and recommended to use `freq="T"` instead (GH11854)
- Bug in `.resample(...).count()` with a `PeriodIndex` always raising a `TypeError` (GH12774)
- Bug in `.resample(...)` with a `PeriodIndex` casting to a `DatetimeIndex` when empty (GH12868)
- Bug in `.resample(...)` with a `PeriodIndex` when resampling to an existing frequency (GH12770)
- Bug in printing data which contains `Period` with different `freq` raises `ValueError` (GH12615)
- Bug in `Series` construction with `Categorical` and `dtype='category'` is specified (GH12574)
- Bugs in concatenation with a coercable dtype was too aggressive, resulting in different dtypes in outputformatting when an object was longer than `display.max_rows` (GH12411, GH12045, GH11594, GH10571, GH12211)
- Bug in `float_format` option with option not being validated as a callable. (GH12706)
- Bug in `GroupBy.filter` when `dropna=False` and no groups fulfilled the criteria (GH12768)
- Bug in `__name__` of `.cum*` functions (GH12021)
- Bug in `.astype()` of a `Float64Inde/Int64Index` to an `Int64Index` (GH12881)
- Bug in roundtripping an integer based index in `.to_json()/.read_json()` when `orient='index'` (the default) (GH12866)
- Bug in plotting `Categorical` dtypes cause error when attempting stacked bar plot (GH13019)
- Compat with >= `numpy` 1.11 for `NaT` comparions (GH12969)
- Bug in `.drop()` with a non-unique `MultiIndex`. (GH12701)
- Bug in `.concat` of datetime tz-aware and naive DataFrames (GH12467)
- Bug in correctly raising a `ValueError` in `.resample(..).fillna(..)` when passing a non-string (GH12952)
- Bug fixes in various encoding and header processing issues in `pd.read_sas()` (GH12659, GH12654, GH12647, GH12809)
- Bug in `pd.crosstab()` where would silently ignore `aggfunc` if `values=None` (GH12569).
- Potential segfault in `DataFrame.to_json` when serialising `datetime.time` (GH11473).
- Potential segfault in `DataFrame.to_json` when attempting to serialise 0d array (GH11299).
- Segfault in `to_json` when attempting to serialise a `DataFrame` or `Series` with non-ndarray values; now supports serialization of `category`, `sparse`, and `datetime64[ns, tz]` dtypes (GH10778).
- Bug in `DataFrame.to_json` with unsupported dtype not passed to default handler (GH12554).
- Bug in `.align` not returning the sub-class (GH12983)
- Bug in aligning a `Series` with a `DataFrame` (GH13037)
- Bug in `ABCPanel` in which `Panel4D` was not being considered as a valid instance of this generic type (GH12810)
- Bug in consistency of `.name` on `.groupby(..).apply(..)` cases (GH12363)
- Bug in `Timestamp.__repr__` that caused `pprint` to fail in nested structures (GH12622)

- Bug in `Timedelta.min` and `Timedelta.max`, the properties now report the true minimum/maximum `timedeltas` as recognized by pandas. See the *documentation*. (GH12727)
- Bug in `.quantile()` with interpolation may coerce to `float` unexpectedly (GH12772)
- Bug in `.quantile()` with empty `Series` may return scalar rather than empty `Series` (GH12772)
- Bug in `.loc` with out-of-bounds in a large indexer would raise `IndexError` rather than `KeyError` (GH12527)
- Bug in resampling when using a `TimedeltaIndex` and `.asfreq()`, would previously not include the final fencepost (GH12926)
- Bug in equality testing with a `Categorical` in a `DataFrame` (GH12564)
- Bug in `GroupBy.first()`, `.last()` returns incorrect row when `TimeGrouper` is used (GH7453)
- Bug in `pd.read_csv()` with the `c` engine when specifying `skiprows` with newlines in quoted items (GH10911, GH12775)
- Bug in `DataFrame` timezone lost when assigning tz-aware datetime `Series` with alignment (GH12981)
- Bug in `.value_counts()` when `normalize=True` and `dropna=True` where nulls still contributed to the normalized count (GH12558)
- Bug in `Series.value_counts()` loses name if its dtype is `category` (GH12835)
- Bug in `Series.value_counts()` loses timezone info (GH12835)
- Bug in `Series.value_counts(normalize=True)` with `Categorical` raises `UnboundLocalError` (GH12835)
- Bug in `Panel.fillna()` ignoring `inplace=True` (GH12633)
- Bug in `pd.read_csv()` when specifying `names`, `usecols`, and `parse_dates` simultaneously with the `c` engine (GH9755)
- Bug in `pd.read_csv()` when specifying `delim_whitespace=True` and `lineterminator` simultaneously with the `c` engine (GH12912)
- Bug in `Series.rename`, `DataFrame.rename` and `DataFrame.rename_axis` not treating `Series` as mappings to relabel (GH12623).
- Clean in `.rolling.min` and `.rolling.max` to enhance dtype handling (GH12373)
- Bug in `groupby` where complex types are coerced to float (GH12902)
- Bug in `Series.map` raises `TypeError` if its dtype is `category` or tz-aware `datetime` (GH12473)
- Bugs on 32bit platforms for some test comparisons (GH12972)
- Bug in index coercion when falling back from `RangeIndex` construction (GH12893)
- Better error message in window functions when invalid argument (e.g. a float window) is passed (GH12669)
- Bug in slicing subclassed `DataFrame` defined to return subclassed `Series` may return normal `Series` (GH11559)
- Bug in `.str` accessor methods may raise `ValueError` if input has `name` and the result is `DataFrame` or `MultiIndex` (GH12617)
- Bug in `DataFrame.last_valid_index()` and `DataFrame.first_valid_index()` on empty frames (GH12800)
- Bug in `CategoricalIndex.get_loc` returns different result from regular `Index` (GH12531)
- Bug in `PeriodIndex.resample` where name not propagated (GH12769)

- Bug in `date_range` `closed` keyword and timezones (GH12684).
- Bug in `pd.concat` raises `AttributeError` when input data contains tz-aware datetime and timedelta (GH12620)
- Bug in `pd.concat` did not handle empty `Series` properly (GH11082)
- Bug in `.plot.bar` alginment when `width` is specified with `int` (GH12979)
- Bug in `fill_value` is ignored if the argument to a binary operator is a constant (GH12723)
- Bug in `pd.read_html()` when using bs4 flavor and parsing table with a header and only one column (GH9178)
- Bug in `.pivot_table` when `margins=True` and `dropna=True` where nulls still contributed to margin count (GH12577)
- Bug in `.pivot_table` when `dropna=False` where table index/column names disappear (GH12133)
- Bug in `pd.crosstab()` when `margins=True` and `dropna=False` which raised (GH12642)
- Bug in `Series.name` when `name` attribute can be a hashable type (GH12610)
- Bug in `.describe()` resets categorical columns information (GH11558)
- Bug where `loffset` argument was not applied when calling `resample().count()` on a timeseries (GH12725)
- `pd.read_excel()` now accepts column names associated with keyword argument `names` (GH12870)
- Bug in `pd.to_numeric()` with `Index` returns `np.ndarray`, rather than `Index` (GH12777)
- Bug in `pd.to_numeric()` with datetime-like may raise `TypeError` (GH12777)
- Bug in `pd.to_numeric()` with scalar raises `ValueError` (GH12777)

1.9 v0.18.0 (March 13, 2016)

This is a major release from 0.17.1 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

> **Warning:** pandas >= 0.18.0 no longer supports compatibility with Python version 2.6 and 3.3 (GH7718, GH11273)

> **Warning:** `numexpr` version 2.4.4 will now show a warning and not be used as a computation back-end for pandas because of some buggy behavior. This does not affect other versions (>= 2.1 and >= 2.4.6). (GH12489)

Highlights include:

- Moving and expanding window functions are now methods on Series and DataFrame, similar to `.groupby`, see *here*.
- Adding support for a `RangeIndex` as a specialized form of the `Int64Index` for memory savings, see *here*.
- API breaking change to the `.resample` method to make it more `.groupby` like, see *here*.
- Removal of support for positional indexing with floats, which was deprecated since 0.14.0. This will now raise a `TypeError`, see *here*.

- The `.to_xarray()` function has been added for compatibility with the xarray package, see *here*.
- The `read_sas` function has been enhanced to read `sas7bdat` files, see *here*.
- Addition of the *.str.extractall() method*, and API changes to the *.str.extract() method* and *.str.cat() method*.
- `pd.test()` top-level nose test runner is available (GH4327).

Check the *API Changes* and *deprecations* before updating.

What's new in v0.18.0

- *Bug Fixes*

1.9.1 New features

1.9.1.1 Window functions are now methods

Window functions have been refactored to be methods on `Series/DataFrame` objects, rather than top-level functions, which are now deprecated. This allows these window-type functions, to have a similar API to that of `.groupby`. See the full documentation *here* (GH11603, GH12373)

```
In [1]: np.random.seed(1234)

In [2]: df = pd.DataFrame({'A' : range(10), 'B' : np.random.randn(10)})

In [3]: df
Out[3]:
   A         B
0  0  0.471435
1  1 -1.190976
2  2  1.432707
3  3 -0.312652
4  4 -0.720589
5  5  0.887163
6  6  0.859588
7  7 -0.636524
8  8  0.015696
9  9 -2.242685
```

Previous Behavior:

```
In [8]: pd.rolling_mean(df,window=3)
        FutureWarning: pd.rolling_mean is deprecated for DataFrame and will be␣
↪removed in a future version, replace with
                      DataFrame.rolling(window=3,center=False).mean()
Out[8]:
    A         B
0 NaN       NaN
1 NaN       NaN
2   1  0.237722
3   2 -0.023640
4   3  0.133155
5   4 -0.048693
6   5  0.342054
7   6  0.370076
8   7  0.079587
9   8 -0.954504
```

New Behavior:

```
In [4]: r = df.rolling(window=3)
```

These show a descriptive repr

```
In [5]: r
Out[5]: Rolling [window=3,center=False,axis=0]
```

with tab-completion of available methods and properties.

```
In [9]: r.
r.A            r.agg          r.apply        r.count        r.exclusions   r.max          r.
↪median        r.name         r.skew         r.sum
r.B            r.aggregate    r.corr         r.cov          r.kurt         r.mean         r.
↪min           r.quantile     r.std          r.var
```

The methods operate on the `Rolling` object itself

```
In [6]: r.mean()
Out[6]:
     A         B
0  NaN       NaN
1  NaN       NaN
2  1.0  0.237722
3  2.0 -0.023640
4  3.0  0.133155
5  4.0 -0.048693
6  5.0  0.342054
7  6.0  0.370076
8  7.0  0.079587
9  8.0 -0.954504
```

They provide getitem accessors

```
In [7]: r['A'].mean()
Out[7]:
0    NaN
1    NaN
2    1.0
3    2.0
4    3.0
5    4.0
6    5.0
7    6.0
8    7.0
9    8.0
Name: A, dtype: float64
```

And multiple aggregations

```
In [8]: r.agg({'A' : ['mean','std'],
   ...:        'B' : ['mean','std']})
   ...:
Out[8]:
     A              B
  mean  std      mean       std
0  NaN  NaN       NaN       NaN
1  NaN  NaN       NaN       NaN
2  1.0  1.0  0.237722  1.327364
3  2.0  1.0 -0.023640  1.335505
4  3.0  1.0  0.133155  1.143778
5  4.0  1.0 -0.048693  0.835747
6  5.0  1.0  0.342054  0.920379
7  6.0  1.0  0.370076  0.871850
8  7.0  1.0  0.079587  0.750099
9  8.0  1.0 -0.954504  1.162285
```

1.9.1.2 Changes to rename

`Series.rename` and `NDFrame.rename_axis` can now take a scalar or list-like argument for altering the Series or axis *name*, in addition to their old behaviors of altering labels. (GH9494, GH11965)

```
In [9]: s = pd.Series(np.random.randn(5))

In [10]: s.rename('newname')
Out[10]:
0    1.150036
1    0.991946
2    0.953324
3   -2.021255
4   -0.334077
Name: newname, dtype: float64
```

```
In [11]: df = pd.DataFrame(np.random.randn(5, 2))

In [12]: (df.rename_axis("indexname")
   ....:    .rename_axis("columns_name", axis="columns"))
   ....:
Out[12]:
columns_name         0         1
indexname
0             0.002118  0.405453
1             0.289092  1.321158
2            -1.546906 -0.202646
3            -0.655969  0.193421
4             0.553439  1.318152
```

The new functionality works well in method chains. Previously these methods only accepted functions or dicts mapping a *label* to a new label. This continues to work as before for function or dict-like values.

1.9.1.3 Range Index

A `RangeIndex` has been added to the `Int64Index` sub-classes to support a memory saving alternative for common use cases. This has a similar implementation to the python `range` object (`xrange` in python 2), in that it only stores the start, stop, and step values for the index. It will transparently interact with the user API, converting to `Int64Index` if needed.

This will now be the default constructed index for `NDFrame` objects, rather than previous an `Int64Index`. (GH939, GH12070, GH12071, GH12109, GH12888)

Previous Behavior:

```
In [3]: s = pd.Series(range(1000))

In [4]: s.index
Out[4]:
Int64Index([  0,   1,   2,   3,   4,   5,   6,   7,   8,   9,
            ...
            990, 991, 992, 993, 994, 995, 996, 997, 998, 999], dtype='int64',␣
↪length=1000)

In [6]: s.index.nbytes
Out[6]: 8000
```

New Behavior:

```
In [13]: s = pd.Series(range(1000))

In [14]: s.index
Out[14]: RangeIndex(start=0, stop=1000, step=1)

In [15]: s.index.nbytes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[15]: 80
```

1.9.1.4 Changes to str.extract

The *.str.extract* method takes a regular expression with capture groups, finds the first match in each subject string, and returns the contents of the capture groups (GH11386).

In v0.18.0, the `expand` argument was added to `extract`.

- `expand=False`: it returns a `Series`, `Index`, or `DataFrame`, depending on the subject and regular expression pattern (same behavior as pre-0.18.0).
- `expand=True`: it always returns a `DataFrame`, which is more consistent and less confusing from the perspective of a user.

Currently the default is `expand=None` which gives a `FutureWarning` and uses `expand=False`. To avoid this warning, please explicitly specify `expand`.

```
In [1]: pd.Series(['a1', 'b2', 'c3']).str.extract('[ab](\d)', expand=None)
FutureWarning: currently extract(expand=None) means expand=False (return Index/Series/
↪DataFrame)
but in a future version of pandas this will be changed to expand=True (return␣
↪DataFrame)

Out[1]:
0      1
1      2
2    NaN
dtype: object
```

Extracting a regular expression with one group returns a Series if `expand=False`.

```
In [16]: pd.Series(['a1', 'b2', 'c3']).str.extract('[ab](\d)', expand=False)
Out[16]:
0      1
1      2
2    NaN
dtype: object
```

It returns a `DataFrame` with one column if `expand=True`.

```
In [17]: pd.Series(['a1', 'b2', 'c3']).str.extract('[ab](\d)', expand=True)
Out[17]:
     0
0    1
1    2
2  NaN
```

Calling on an `Index` with a regex with exactly one capture group returns an `Index` if `expand=False`.

```
In [18]: s = pd.Series(["a1", "b2", "c3"], ["A11", "B22", "C33"])

In [19]: s.index
Out[19]: Index(['A11', 'B22', 'C33'], dtype='object')

In [20]: s.index.str.extract("(?P<letter>[a-zA-Z])", expand=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[20]: Index(['A', 'B', 'C'],␣
↪dtype='object', name='letter')
```

It returns a `DataFrame` with one column if `expand=True`.

```
In [21]: s.index.str.extract("(?P<letter>[a-zA-Z])", expand=True)
Out[21]:
  letter
0      A
1      B
2      C
```

Calling on an `Index` with a regex with more than one capture group raises `ValueError` if `expand=False`.

```
>>> s.index.str.extract("(?P<letter>[a-zA-Z])([0-9]+)", expand=False)
ValueError: only one regex group is supported with Index
```

It returns a `DataFrame` if `expand=True`.

```
In [22]: s.index.str.extract("(?P<letter>[a-zA-Z])([0-9]+)", expand=True)
Out[22]:
  letter   1
0      A  11
1      B  22
2      C  33
```

In summary, `extract(expand=True)` always returns a `DataFrame` with a row for every subject string, and a column for every capture group.

1.9.1.5 Addition of str.extractall

The *.str.extractall* method was added (GH11386). Unlike `extract`, which returns only the first match.

```
In [23]: s = pd.Series(["a1a2", "b1", "c1"], ["A", "B", "C"])

In [24]: s
Out[24]:
A    a1a2
B      b1
C      c1
dtype: object

In [25]: s.str.extract("(?P<letter>[ab])(?P<digit>\d)", expand=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[25]:
  letter digit
A      a     1
B      b     1
C    NaN   NaN
```

The `extractall` method returns all matches.

```
In [26]: s.str.extractall("(?P<letter>[ab])(?P<digit>\d)")
Out[26]: 
        letter digit
  match             
A 0          a     1
  1          a     2
B 0          b     1
```

1.9.1.6 Changes to str.cat

The method `.str.cat()` concatenates the members of a `Series`. Before, if `NaN` values were present in the Series, calling `.str.cat()` on it would return `NaN`, unlike the rest of the `Series.str.*` API. This behavior has been amended to ignore `NaN` values by default. (GH11435).

A new, friendlier `ValueError` is added to protect against the mistake of supplying the `sep` as an arg, rather than as a kwarg. (GH11334).

```
In [27]: pd.Series(['a','b',np.nan,'c']).str.cat(sep=' ')
Out[27]: 'a b c'

In [28]: pd.Series(['a','b',np.nan,'c']).str.cat(sep=' ', na_rep='?')
\\\\\\\\\\\\\\\\\Out[28]: 'a b ? c'
```

```
In [2]: pd.Series(['a','b',np.nan,'c']).str.cat(' ')
ValueError: Did you mean to supply a `sep` keyword?
```

1.9.1.7 Datetimelike rounding

`DatetimeIndex`, `Timestamp`, `TimedeltaIndex`, `Timedelta` have gained the `.round()`, `.floor()` and `.ceil()` method for datetimelike rounding, flooring and ceiling. (GH4314, GH11963)

Naive datetimes

```
In [29]: dr = pd.date_range('20130101 09:12:56.1234', periods=3)

In [30]: dr
Out[30]: 
DatetimeIndex(['2013-01-01 09:12:56.123400', '2013-01-02 09:12:56.123400',
               '2013-01-03 09:12:56.123400'],
              dtype='datetime64[ns]', freq='D')

In [31]: dr.round('s')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2013-01-01 09:12:56', '2013-01-02 09:12:56',
               '2013-01-03 09:12:56'],
              dtype='datetime64[ns]', freq=None)

# Timestamp scalar
In [32]: dr[0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2013-01-01 09:12:56.123400', freq='D')

In [33]: dr[0].round('10s')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2013-01-01 09:13:00')
```

Tz-aware are rounded, floored and ceiled in local times

```
In [34]: dr = dr.tz_localize('US/Eastern')

In [35]: dr
Out[35]:
DatetimeIndex(['2013-01-01 09:12:56.123400-05:00',
               '2013-01-02 09:12:56.123400-05:00',
               '2013-01-03 09:12:56.123400-05:00'],
              dtype='datetime64[ns, US/Eastern]', freq='D')

In [36]: dr.round('s')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2013-01-01 09:12:56-05:00', '2013-01-02 09:12:56-05:00',
               '2013-01-03 09:12:56-05:00'],
              dtype='datetime64[ns, US/Eastern]', freq=None)
```

Timedeltas

```
In [37]: t = timedelta_range('1 days 2 hr 13 min 45 us',periods=3,freq='d')

In [38]: t
Out[38]:
TimedeltaIndex(['1 days 02:13:00.000045', '2 days 02:13:00.000045',
                '3 days 02:13:00.000045'],
               dtype='timedelta64[ns]', freq='D')

In [39]: t.round('10min')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪TimedeltaIndex(['1 days 02:10:00', '2 days 02:10:00', '3 days 02:10:00'], dtype=
↪'timedelta64[ns]', freq=None)

# Timedelta scalar
In [40]: t[0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('1 days 02:13:00.000045')

In [41]: t[0].round('2h')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('1 days 02:00:00')
```

In addition, `.round()`, `.floor()` and `.ceil()` will be available thru the `.dt` accessor of `Series`.

```
In [42]: s = pd.Series(dr)

In [43]: s
Out[43]:
0   2013-01-01 09:12:56.123400-05:00
1   2013-01-02 09:12:56.123400-05:00
2   2013-01-03 09:12:56.123400-05:00
dtype: datetime64[ns, US/Eastern]

In [44]: s.dt.round('D')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2013-01-01 00:00:00-05:00
```

```
1   2013-01-02 00:00:00-05:00
2   2013-01-03 00:00:00-05:00
dtype: datetime64[ns, US/Eastern]
```

1.9.1.8 Formatting of Integers in FloatIndex

Integers in `FloatIndex`, e.g. 1., are now formatted with a decimal point and a `0` digit, e.g. `1.0` (GH11713) This change not only affects the display to the console, but also the output of IO methods like `.to_csv` or `.to_html`.

Previous Behavior:

```
In [2]: s = pd.Series([1,2,3], index=np.arange(3.))

In [3]: s
Out[3]:
0    1
1    2
2    3
dtype: int64

In [4]: s.index
Out[4]: Float64Index([0.0, 1.0, 2.0], dtype='float64')

In [5]: print(s.to_csv(path=None))
0,1
1,2
2,3
```

New Behavior:

```
In [45]: s = pd.Series([1,2,3], index=np.arange(3.))

In [46]: s
Out[46]:
0.0    1
1.0    2
2.0    3
dtype: int64

In [47]: s.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[47]: Float64Index([0.0, 1.0, 2.
↪0], dtype='float64')

In [48]: print(s.to_csv(path=None))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪0,1
1.0,2
2.0,3
```

1.9.1.9 Changes to dtype assignment behaviors

When a DataFrame's slice is updated with a new slice of the same dtype, the dtype of the DataFrame will now remain the same. (GH10503)

Previous Behavior:

```
In [5]: df = pd.DataFrame({'a': [0, 1, 1],
                           'b': pd.Series([100, 200, 300], dtype='uint32')})

In [7]: df.dtypes
Out[7]:
a     int64
b    uint32
dtype: object

In [8]: ix = df['a'] == 1

In [9]: df.loc[ix, 'b'] = df.loc[ix, 'b']

In [11]: df.dtypes
Out[11]:
a    int64
b    int64
dtype: object
```

New Behavior:

```
In [49]: df = pd.DataFrame({'a': [0, 1, 1],
   ....:                    'b': pd.Series([100, 200, 300], dtype='uint32')})
   ....:

In [50]: df.dtypes
Out[50]:
a     int64
b    uint32
dtype: object

In [51]: ix = df['a'] == 1

In [52]: df.loc[ix, 'b'] = df.loc[ix, 'b']

In [53]: df.dtypes
Out[53]:
a     int64
b    uint32
dtype: object
```

When a DataFrame's integer slice is partially updated with a new slice of floats that could potentially be downcasted to integer without losing precision, the dtype of the slice will be set to float instead of integer.

Previous Behavior:

```
In [4]: df = pd.DataFrame(np.array(range(1,10)).reshape(3,3),
                          columns=list('abc'),
                          index=[[4,4,8], [8,10,12]])

In [5]: df
Out[5]:
      a  b  c
4 8   1  2  3
  10  4  5  6
8 12  7  8  9

In [7]: df.ix[4, 'c'] = np.array([0., 1.])
```

```
In [8]: df
Out[8]:
      a  b  c
4 8   1  2  0
  10  4  5  1
8 12  7  8  9
```

New Behavior:

```
In [54]: df = pd.DataFrame(np.array(range(1,10)).reshape(3,3),
   ....:                   columns=list('abc'),
   ....:                   index=[[4,4,8], [8,10,12]])
   ....:

In [55]: df
Out[55]:
      a  b  c
4 8   1  2  3
  10  4  5  6
8 12  7  8  9

In [56]: df.loc[4, 'c'] = np.array([0., 1.])

In [57]: df
Out[57]:
      a  b    c
4 8   1  2  0.0
  10  4  5  1.0
8 12  7  8  9.0
```

1.9.1.10 to_xarray

In a future version of pandas, we will be deprecating `Panel` and other > 2 ndim objects. In order to provide for continuity, all `NDFrame` objects have gained the `.to_xarray()` method in order to convert to `xarray` objects, which has a pandas-like interface for > 2 ndim. (GH11972)

See the xarray full-documentation here.

```
In [1]: p = Panel(np.arange(2*3*4).reshape(2,3,4))

In [2]: p.to_xarray()
Out[2]:
<xarray.DataArray (items: 2, major_axis: 3, minor_axis: 4)>
array([[[ 0,  1,  2,  3],
        [ 4,  5,  6,  7],
        [ 8,  9, 10, 11]],

       [[12, 13, 14, 15],
        [16, 17, 18, 19],
        [20, 21, 22, 23]]])
Coordinates:
  * items       (items) int64 0 1
  * major_axis  (major_axis) int64 0 1 2
  * minor_axis  (minor_axis) int64 0 1 2 3
```

1.9.1.11 Latex Representation

`DataFrame` has gained a `._repr_latex_()` method in order to allow for conversion to latex in a ipython/jupyter notebook using nbconvert. (GH11778)

Note that this must be activated by setting the option `pd.display.latex.repr=True` (GH12182)

For example, if you have a jupyter notebook you plan to convert to latex using nbconvert, place the statement `pd.display.latex.repr=True` in the first cell to have the contained DataFrame output also stored as latex.

The options `display.latex.escape` and `display.latex.longtable` have also been added to the configuration and are used automatically by the `to_latex` method. See the *available options docs* for more info.

1.9.1.12 `pd.read_sas()` changes

`read_sas` has gained the ability to read SAS7BDAT files, including compressed files. The files can be read in entirety, or incrementally. For full details see *here*. (GH4052)

1.9.1.13 Other enhancements

- Handle truncated floats in SAS xport files (GH11713)
- Added option to hide index in `Series.to_string` (GH11729)
- `read_excel` now supports s3 urls of the format `s3://bucketname/filename` (GH11447)
- add support for `AWS_S3_HOST` env variable when reading from s3 (GH12198)
- A simple version of `Panel.round()` is now implemented (GH11763)
- For Python 3.x, `round(DataFrame)`, `round(Series)`, `round(Panel)` will work (GH11763)
- `sys.getsizeof(obj)` returns the memory usage of a pandas object, including the values it contains (GH11597)
- `Series` gained an `is_unique` attribute (GH11946)
- `DataFrame.quantile` and `Series.quantile` now accept `interpolation` keyword (GH10174).
- Added `DataFrame.style.format` for more flexible formatting of cell values (GH11692)
- `DataFrame.select_dtypes` now allows the `np.float16` typecode (GH11990)
- `pivot_table()` now accepts most iterables for the `values` parameter (GH12017)
- Added Google `BigQuery` service account authentication support, which enables authentication on remote servers. (GH11881, GH12572). For further details see here
- `HDFStore` is now iterable: `for k in store` is equivalent to `for k in store.keys()` (GH12221).
- Add missing methods/fields to `.dt` for `Period` (GH8848)
- The entire codebase has been `PEP`-ified (GH12096)

1.9.2 Backwards incompatible API changes

- the leading whitespaces have been removed from the output of `.to_string(index=False)` method (GH11833)
- the `out` parameter has been removed from the `Series.round()` method. (GH11763)
- `DataFrame.round()` leaves non-numeric columns unchanged in its return, rather than raises. (GH11885)

- `DataFrame.head(0)` and `DataFrame.tail(0)` return empty frames, rather than `self`. (GH11937)
- `Series.head(0)` and `Series.tail(0)` return empty series, rather than `self`. (GH11937)
- `to_msgpack` and `read_msgpack` encoding now defaults to `'utf-8'`. (GH12170)
- the order of keyword arguments to text file parsing functions (`.read_csv()`, `.read_table()`, `.read_fwf()`) changed to group related arguments. (GH11555)
- `NaTType.isoformat` now returns the string `'NaT` to allow the result to be passed to the constructor of `Timestamp`. (GH12300)

1.9.2.1 NaT and Timedelta operations

`NaT` and `Timedelta` have expanded arithmetic operations, which are extended to `Series` arithmetic where applicable. Operations defined for `datetime64[ns]` or `timedelta64[ns]` are now also defined for `NaT` (GH11564).

`NaT` now supports arithmetic operations with integers and floats.

```
In [58]: pd.NaT * 1
Out[58]: NaT

In [59]: pd.NaT * 1.5
\\\\\\\\\\\\Out[59]: NaT

In [60]: pd.NaT / 2
\\\\\\\\\\\\\\\\\\\\\\\\Out[60]: NaT

In [61]: pd.NaT * np.nan
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[61]: NaT
```

`NaT` defines more arithmetic operations with `datetime64[ns]` and `timedelta64[ns]`.

```
In [62]: pd.NaT / pd.NaT
Out[62]: nan

In [63]: pd.Timedelta('1s') / pd.NaT
\\\\\\\\\\\\Out[63]: nan
```

`NaT` may represent either a `datetime64[ns]` null or a `timedelta64[ns]` null. Given the ambiguity, it is treated as a `timedelta64[ns]`, which allows more operations to succeed.

```
In [64]: pd.NaT + pd.NaT
Out[64]: NaT

# same as
In [65]: pd.Timedelta('1s') + pd.Timedelta('1s')
\\\\\\\\\\\\Out[65]: Timedelta('0 days 00:00:02')
```

as opposed to

```
In [3]: pd.Timestamp('19900315') + pd.Timestamp('19900315')
TypeError: unsupported operand type(s) for +: 'Timestamp' and 'Timestamp'
```

However, when wrapped in a `Series` whose `dtype` is `datetime64[ns]` or `timedelta64[ns]`, the `dtype` information is respected.

```
In [1]: pd.Series([pd.NaT], dtype='<M8[ns]') + pd.Series([pd.NaT], dtype='<M8[ns]')
TypeError: can only operate on a datetimes for subtraction,
           but the operator [__add__] was passed
```

```
In [66]: pd.Series([pd.NaT], dtype='<m8[ns]') + pd.Series([pd.NaT], dtype='<m8[ns]')
Out[66]:
0    NaT
dtype: timedelta64[ns]
```

`Timedelta` division by `floats` now works.

```
In [67]: pd.Timedelta('1s') / 2.0
Out[67]: Timedelta('0 days 00:00:00.500000')
```

Subtraction by `Timedelta` in a `Series` by a `Timestamp` works (GH11925)

```
In [68]: ser = pd.Series(pd.timedelta_range('1 day', periods=3))

In [69]: ser
Out[69]:
0    1 days
1    2 days
2    3 days
dtype: timedelta64[ns]

In [70]: pd.Timestamp('2012-01-01') - ser
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[70]:
0    2011-12-31
1    2011-12-30
2    2011-12-29
dtype: datetime64[ns]
```

`NaT.isoformat()` now returns `'NaT'`. This change allows allows `pd.Timestamp` to rehydrate any timestamp like object from its isoformat (GH12300).

1.9.2.2 Changes to msgpack

Forward incompatible changes in `msgpack` writing format were made over 0.17.0 and 0.18.0; older versions of pandas cannot read files packed by newer versions (GH12129, GH10527)

Bugs in `to_msgpack` and `read_msgpack` introduced in 0.17.0 and fixed in 0.18.0, caused files packed in Python 2 unreadable by Python 3 (GH12142). The following table describes the backward and forward compat of msgpacks.

Warning:

Packed with	Can be unpacked with
pre-0.17 / Python 2	any
pre-0.17 / Python 3	any
0.17 / Python 2	• ==0.17 / Python 2 • >=0.18 / any Python
0.17 / Python 3	>=0.18 / any Python
0.18	>= 0.18

0.18.0 is backward-compatible for reading files packed by older versions, except for files packed with 0.17 in Python 2, in which case only they can only be unpacked in Python 2.

1.9.2.3 Signature change for .rank

`Series.rank` and `DataFrame.rank` now have the same signature (GH11759)

Previous signature

```
In [3]: pd.Series([0,1]).rank(method='average', na_option='keep',
                              ascending=True, pct=False)
Out[3]:
0    1
1    2
dtype: float64

In [4]: pd.DataFrame([0,1]).rank(axis=0, numeric_only=None,
                                 method='average', na_option='keep',
                                 ascending=True, pct=False)
Out[4]:
   0
0  1
1  2
```

New signature

```
In [71]: pd.Series([0,1]).rank(axis=0, method='average', numeric_only=None,
   ....:                       na_option='keep', ascending=True, pct=False)
   ....:
Out[71]:
0    1.0
1    2.0
dtype: float64

In [72]: pd.DataFrame([0,1]).rank(axis=0, method='average', numeric_only=None,
   ....:                          na_option='keep', ascending=True, pct=False)
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[72]:
     0
0  1.0
1  2.0
```

1.9.2.4 Bug in QuarterBegin with n=0

In previous versions, the behavior of the QuarterBegin offset was inconsistent depending on the date when the `n` parameter was 0. (GH11406)

The general semantics of anchored offsets for `n=0` is to not move the date when it is an anchor point (e.g., a quarter start date), and otherwise roll forward to the next anchor point.

```
In [73]: d = pd.Timestamp('2014-02-01')

In [74]: d
Out[74]: Timestamp('2014-02-01 00:00:00')

In [75]: d + pd.offsets.QuarterBegin(n=0, startingMonth=2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[75]: Timestamp('2014-02-01 00:00:00')

In [76]: d + pd.offsets.QuarterBegin(n=0, startingMonth=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[76]:␣
↪Timestamp('2014-04-01 00:00:00')
```

For the `QuarterBegin` offset in previous versions, the date would be rolled *backwards* if date was in the same month as the quarter start date.

```
In [3]: d = pd.Timestamp('2014-02-15')

In [4]: d + pd.offsets.QuarterBegin(n=0, startingMonth=2)
Out[4]: Timestamp('2014-02-01 00:00:00')
```

This behavior has been corrected in version 0.18.0, which is consistent with other anchored offsets like `MonthBegin` and `YearBegin`.

```
In [77]: d = pd.Timestamp('2014-02-15')

In [78]: d + pd.offsets.QuarterBegin(n=0, startingMonth=2)
Out[78]: Timestamp('2014-05-01 00:00:00')
```

1.9.2.5 Resample API

Like the change in the window functions API *above*, `.resample(...)` is changing to have a more groupby-like API. (GH11732, GH12702, GH12202, GH12332, GH12334, GH12348, GH12448).

```
In [79]: np.random.seed(1234)

In [80]: df = pd.DataFrame(np.random.rand(10,4),
   ....:                   columns=list('ABCD'),
   ....:                   index=pd.date_range('2010-01-01 09:00:00', periods=10,␣
↪freq='s'))
   ....:

In [81]: df
Out[81]:
                            A         B         C         D
2010-01-01 09:00:00  0.191519  0.622109  0.437728  0.785359
2010-01-01 09:00:01  0.779976  0.272593  0.276464  0.801872
2010-01-01 09:00:02  0.958139  0.875933  0.357817  0.500995
2010-01-01 09:00:03  0.683463  0.712702  0.370251  0.561196
2010-01-01 09:00:04  0.503083  0.013768  0.772827  0.882641
2010-01-01 09:00:05  0.364886  0.615396  0.075381  0.368824
2010-01-01 09:00:06  0.933140  0.651378  0.397203  0.788730
2010-01-01 09:00:07  0.316836  0.568099  0.869127  0.436173
2010-01-01 09:00:08  0.802148  0.143767  0.704261  0.704581
2010-01-01 09:00:09  0.218792  0.924868  0.442141  0.909316
```

Previous API:

You would write a resampling operation that immediately evaluates. If a `how` parameter was not provided, it would default to `how='mean'`.

```
In [6]: df.resample('2s')
Out[6]:
                         A         B         C         D
2010-01-01 09:00:00  0.485748  0.447351  0.357096  0.793615
2010-01-01 09:00:02  0.820801  0.794317  0.364034  0.531096
2010-01-01 09:00:04  0.433985  0.314582  0.424104  0.625733
2010-01-01 09:00:06  0.624988  0.609738  0.633165  0.612452
2010-01-01 09:00:08  0.510470  0.534317  0.573201  0.806949
```

You could also specify a `how` directly

```
In [7]: df.resample('2s', how='sum')
Out[7]:
                          A         B         C         D
2010-01-01 09:00:00  0.971495  0.894701  0.714192  1.587231
2010-01-01 09:00:02  1.641602  1.588635  0.728068  1.062191
2010-01-01 09:00:04  0.867969  0.629165  0.848208  1.251465
2010-01-01 09:00:06  1.249976  1.219477  1.266330  1.224904
2010-01-01 09:00:08  1.020940  1.068634  1.146402  1.613897
```

New API:

Now, you can write `.resample(..)` as a 2-stage operation like `.groupby(...)`, which yields a `Resampler`.

```
In [82]: r = df.resample('2s')

In [83]: r
Out[83]: DatetimeIndexResampler [freq=<2 * Seconds>, axis=0, closed=left, label=left,␣
↪convention=start, base=0]
```

Downsampling

You can then use this object to perform operations. These are downsampling operations (going from a higher frequency to a lower one).

```
In [84]: r.mean()
Out[84]:
                           A         B         C         D
2010-01-01 09:00:00  0.485748  0.447351  0.357096  0.793615
2010-01-01 09:00:02  0.820801  0.794317  0.364034  0.531096
2010-01-01 09:00:04  0.433985  0.314582  0.424104  0.625733
2010-01-01 09:00:06  0.624988  0.609738  0.633165  0.612452
2010-01-01 09:00:08  0.510470  0.534317  0.573201  0.806949
```

```
In [85]: r.sum()
Out[85]:
                           A         B         C         D
2010-01-01 09:00:00  0.971495  0.894701  0.714192  1.587231
2010-01-01 09:00:02  1.641602  1.588635  0.728068  1.062191
2010-01-01 09:00:04  0.867969  0.629165  0.848208  1.251465
2010-01-01 09:00:06  1.249976  1.219477  1.266330  1.224904
2010-01-01 09:00:08  1.020940  1.068634  1.146402  1.613897
```

Furthermore, resample now supports `getitem` operations to perform the resample on specific columns.

```
In [86]: r[['A','C']].mean()
Out[86]:
                           A         C
2010-01-01 09:00:00  0.485748  0.357096
2010-01-01 09:00:02  0.820801  0.364034
2010-01-01 09:00:04  0.433985  0.424104
2010-01-01 09:00:06  0.624988  0.633165
2010-01-01 09:00:08  0.510470  0.573201
```

and `.aggregate` type operations.

```
In [87]: r.agg({'A' : 'mean', 'B' : 'sum'})
Out[87]:
                           A         B
2010-01-01 09:00:00  0.485748  0.894701
2010-01-01 09:00:02  0.820801  1.588635
2010-01-01 09:00:04  0.433985  0.629165
2010-01-01 09:00:06  0.624988  1.219477
2010-01-01 09:00:08  0.510470  1.068634
```

These accessors can of course, be combined

```
In [88]: r[['A','B']].agg(['mean','sum'])
Out[88]:
                           A                   B
                        mean       sum      mean       sum
2010-01-01 09:00:00  0.485748  0.971495  0.447351  0.894701
2010-01-01 09:00:02  0.820801  1.641602  0.794317  1.588635
2010-01-01 09:00:04  0.433985  0.867969  0.314582  0.629165
2010-01-01 09:00:06  0.624988  1.249976  0.609738  1.219477
2010-01-01 09:00:08  0.510470  1.020940  0.534317  1.068634
```

Upsampling

Upsampling operations take you from a lower frequency to a higher frequency. These are now performed with the `Resampler` objects with `backfill()`, `ffill()`, `fillna()` and `asfreq()` methods.

```
In [89]: s = pd.Series(np.arange(5,dtype='int64'),
   ....:               index=date_range('2010-01-01', periods=5, freq='Q'))
   ....:

In [90]: s
Out[90]:
2010-03-31    0
2010-06-30    1
2010-09-30    2
2010-12-31    3
2011-03-31    4
Freq: Q-DEC, dtype: int64
```

Previously

```
In [6]: s.resample('M', fill_method='ffill')
Out[6]:
2010-03-31    0
2010-04-30    0
2010-05-31    0
2010-06-30    1
2010-07-31    1
2010-08-31    1
2010-09-30    2
2010-10-31    2
2010-11-30    2
2010-12-31    3
2011-01-31    3
2011-02-28    3
```

```
2011-03-31    4
Freq: M, dtype: int64
```

New API

```
In [91]: s.resample('M').ffill()
Out[91]:
2010-03-31    0
2010-04-30    0
2010-05-31    0
2010-06-30    1
2010-07-31    1
2010-08-31    1
2010-09-30    2
2010-10-31    2
2010-11-30    2
2010-12-31    3
2011-01-31    3
2011-02-28    3
2011-03-31    4
Freq: M, dtype: int64
```

Note: In the new API, you can either downsample OR upsample. The prior implementation would allow you to pass an aggregator function (like `mean`) even though you were upsampling, providing a bit of confusion.

Previous API will work but with deprecations

Warning: This new API for resample includes some internal changes for the prior-to-0.18.0 API, to work with a deprecation warning in most cases, as the resample operation returns a deferred object. We can intercept operations and just do what the (pre 0.18.0) API did (with a warning). Here is a typical use case:

```
In [4]: r = df.resample('2s')

In [6]: r*10
pandas/tseries/resample.py:80: FutureWarning: .resample() is now a deferred␣
↪operation
use .resample(...).mean() instead of .resample(...)

Out[6]:
                      A         B         C         D
2010-01-01 09:00:00  4.857476  4.473507  3.570960  7.936154
2010-01-01 09:00:02  8.208011  7.943173  3.640340  5.310957
2010-01-01 09:00:04  4.339846  3.145823  4.241039  6.257326
2010-01-01 09:00:06  6.249881  6.097384  6.331650  6.124518
2010-01-01 09:00:08  5.104699  5.343172  5.732009  8.069486
```

However, getting and assignment operations directly on a `Resampler` will raise a `ValueError`:

```
In [7]: r.iloc[0] = 5
ValueError: .resample() is now a deferred operation
use .resample(...).mean() instead of .resample(...)
```

There is a situation where the new API can not perform all the operations when using original code. This code is

intending to resample every 2s, take the `mean` AND then take the `min` of those results.

```
In [4]: df.resample('2s').min()
Out[4]:
A    0.433985
B    0.314582
C    0.357096
D    0.531096
dtype: float64
```

The new API will:

```
In [92]: df.resample('2s').min()
Out[92]:
                              A         B         C         D
2010-01-01 09:00:00  0.191519  0.272593  0.276464  0.785359
2010-01-01 09:00:02  0.683463  0.712702  0.357817  0.500995
2010-01-01 09:00:04  0.364886  0.013768  0.075381  0.368824
2010-01-01 09:00:06  0.316836  0.568099  0.397203  0.436173
2010-01-01 09:00:08  0.218792  0.143767  0.442141  0.704581
```

The good news is the return dimensions will differ between the new API and the old API, so this should loudly raise an exception.

To replicate the original operation

```
In [93]: df.resample('2s').mean().min()
Out[93]:
A    0.433985
B    0.314582
C    0.357096
D    0.531096
dtype: float64
```

1.9.2.6 Changes to eval

In prior versions, new columns assignments in an `eval` expression resulted in an inplace change to the `DataFrame`. (GH9297, GH8664, GH10486)

```
In [94]: df = pd.DataFrame({'a': np.linspace(0, 10, 5), 'b': range(5)})

In [95]: df
Out[95]:
      a  b
0   0.0  0
1   2.5  1
2   5.0  2
3   7.5  3
4  10.0  4
```

```
In [12]: df.eval('c = a + b')
FutureWarning: eval expressions containing an assignment currentlydefault to␣
↪operating inplace.
This will change in a future version of pandas, use inplace=True to avoid this␣
↪warning.

In [13]: df
```

```
Out[13]:
      a  b     c
0   0.0  0   0.0
1   2.5  1   3.5
2   5.0  2   7.0
3   7.5  3  10.5
4  10.0  4  14.0
```

In version 0.18.0, a new `inplace` keyword was added to choose whether the assignment should be done inplace or return a copy.

```
In [96]: df
Out[96]:
      a  b     c
0   0.0  0   0.0
1   2.5  1   3.5
2   5.0  2   7.0
3   7.5  3  10.5
4  10.0  4  14.0

In [97]: df.eval('d = c - b', inplace=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      a  b     c     d
0   0.0  0   0.0   0.0
1   2.5  1   3.5   2.5
2   5.0  2   7.0   5.0
3   7.5  3  10.5   7.5
4  10.0  4  14.0  10.0

In [98]: df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      a  b     c
0   0.0  0   0.0
1   2.5  1   3.5
2   5.0  2   7.0
3   7.5  3  10.5
4  10.0  4  14.0

In [99]: df.eval('d = c - b', inplace=True)

In [100]: df
Out[100]:
      a  b     c     d
0   0.0  0   0.0   0.0
1   2.5  1   3.5   2.5
2   5.0  2   7.0   5.0
3   7.5  3  10.5   7.5
4  10.0  4  14.0  10.0
```

Warning: For backwards compatability, `inplace` defaults to `True` if not specified. This will change in a future version of pandas. If your code depends on an inplace assignment you should update to explicitly set `inplace=True`

The `inplace` keyword parameter was also added the `query` method.

```
In [101]: df.query('a > 5')
Out[101]:
      a  b     c     d
3   7.5  3  10.5   7.5
4  10.0  4  14.0  10.0

In [102]: df.query('a > 5', inplace=True)

In [103]: df
Out[103]:
      a  b     c     d
3   7.5  3  10.5   7.5
4  10.0  4  14.0  10.0
```

Warning: Note that the default value for `inplace` in a `query` is `False`, which is consistent with prior versions.

`eval` has also been updated to allow multi-line expressions for multiple assignments. These expressions will be evaluated one at a time in order. Only assignments are valid for multi-line expressions.

```
In [104]: df
Out[104]:
      a  b     c     d
3   7.5  3  10.5   7.5
4  10.0  4  14.0  10.0

In [105]: df.eval("""
   .....: e = d + a
   .....: f = e - 22
   .....: g = f / 2.0""", inplace=True)
   .....:

In [106]: df
Out[106]:
      a  b     c     d     e    f    g
3   7.5  3  10.5   7.5  15.0 -7.0 -3.5
4  10.0  4  14.0  10.0  20.0 -2.0 -1.0
```

1.9.2.7 Other API Changes

- `DataFrame.between_time` and `Series.between_time` now only parse a fixed set of time strings. Parsing of date strings is no longer supported and raises a `ValueError`. (GH11818)

```
In [107]: s = pd.Series(range(10), pd.date_range('2015-01-01', freq='H',␣
↪periods=10))

In [108]: s.between_time("7:00am", "9:00am")
Out[108]:
2015-01-01 07:00:00    7
2015-01-01 08:00:00    8
2015-01-01 09:00:00    9
Freq: H, dtype: int64
```

This will now raise.

```
In [2]: s.between_time('20150101 07:00:00','20150101 09:00:00')
ValueError: Cannot convert arg ['20150101 07:00:00'] to a time.
```

- `.memory_usage()` now includes values in the index, as does memory_usage in `.info()` (GH11597)
- `DataFrame.to_latex()` now supports non-ascii encodings (eg `utf-8`) in Python 2 with the parameter `encoding` (GH7061)
- `pandas.merge()` and `DataFrame.merge()` will show a specific error message when trying to merge with an object that is not of type `DataFrame` or a subclass (GH12081)
- `DataFrame.unstack` and `Series.unstack` now take `fill_value` keyword to allow direct replacement of missing values when an unstack results in missing values in the resulting `DataFrame`. As an added benefit, specifying `fill_value` will preserve the data type of the original stacked data. (GH9746)
- As part of the new API for *window functions* and *resampling*, aggregation functions have been clarified, raising more informative error messages on invalid aggregations. (GH9052). A full set of examples are presented in *groupby*.
- Statistical functions for `NDFrame` objects (like `sum(), mean(), min()`) will now raise if non-numpy-compatible arguments are passed in for `**kwargs` (GH12301)
- `.to_latex` and `.to_html` gain a `decimal` parameter like `.to_csv`; the default is `'.'` (GH12031)
- More helpful error message when constructing a `DataFrame` with empty data but with indices (GH8020)
- `.describe()` will now properly handle bool dtype as a categorical (GH6625)
- More helpful error message with an invalid `.transform` with user defined input (GH10165)
- Exponentially weighted functions now allow specifying alpha directly (GH10789) and raise `ValueError` if parameters violate `0 < alpha <= 1` (GH12492)

1.9.2.8 Deprecations

- The functions `pd.rolling_*`, `pd.expanding_*`, and `pd.ewm*` are deprecated and replaced by the corresponding method call. Note that the new suggested syntax includes all of the arguments (even if default) (GH11603)

```
In [1]: s = pd.Series(range(3))

In [2]: pd.rolling_mean(s,window=2,min_periods=1)
        FutureWarning: pd.rolling_mean is deprecated for Series and
             will be removed in a future version, replace with
             Series.rolling(min_periods=1,window=2,center=False).mean()
Out[2]:
        0    0.0
        1    0.5
        2    1.5
        dtype: float64

In [3]: pd.rolling_cov(s, s, window=2)
        FutureWarning: pd.rolling_cov is deprecated for Series and
             will be removed in a future version, replace with
             Series.rolling(window=2).cov(other=<Series>)
Out[3]:
        0    NaN
        1    0.5
        2    0.5
        dtype: float64
```

- The the `freq` and `how` arguments to the `.rolling`, `.expanding`, and `.ewm` (new) functions are deprecated, and will be removed in a future version. You can simply resample the input prior to creating a window function. (GH11603).

  For example, instead of `s.rolling(window=5,freq='D').max()` to get the max value on a rolling 5 Day window, one could use `s.resample('D').mean().rolling(window=5).max()`, which first resamples the data to daily data, then provides a rolling 5 day window.

- `pd.tseries.frequencies.get_offset_name` function is deprecated. Use offset's `.freqstr` property as alternative (GH11192)
- `pandas.stats.fama_macbeth` routines are deprecated and will be removed in a future version (GH6077)
- `pandas.stats.ols`, `pandas.stats.plm` and `pandas.stats.var` routines are deprecated and will be removed in a future version (GH6077)
- show a `FutureWarning` rather than a `DeprecationWarning` on using long-time deprecated syntax in `HDFStore.select`, where the `where` clause is not a string-like (GH12027)
- The `pandas.options.display.mpl_style` configuration has been deprecated and will be removed in a future version of pandas. This functionality is better handled by matplotlib's style sheets (GH11783).

1.9.2.9 Removal of deprecated float indexers

In GH4892 indexing with floating point numbers on a non-`Float64Index` was deprecated (in version 0.14.0). In 0.18.0, this deprecation warning is removed and these will now raise a `TypeError`. (GH12165, GH12333)

```
In [109]: s = pd.Series([1, 2, 3], index=[4, 5, 6])

In [110]: s
Out[110]:
4    1
5    2
6    3
dtype: int64

In [111]: s2 = pd.Series([1, 2, 3], index=list('abc'))

In [112]: s2
Out[112]:
a    1
b    2
c    3
dtype: int64
```

Previous Behavior:

```
# this is label indexing
In [2]: s[5.0]
FutureWarning: scalar indexers for index type Int64Index should be integers and not␣
↪floating point
Out[2]: 2

# this is positional indexing
In [3]: s.iloc[1.0]
FutureWarning: scalar indexers for index type Int64Index should be integers and not␣
↪floating point
```

```
Out[3]: 2

# this is label indexing
In [4]: s.loc[5.0]
FutureWarning: scalar indexers for index type Int64Index should be integers and not␣
↪floating point
Out[4]: 2

# .ix would coerce 1.0 to the positional 1, and index
In [5]: s2.ix[1.0] = 10
FutureWarning: scalar indexers for index type Index should be integers and not␣
↪floating point

In [6]: s2
Out[6]:
a     1
b    10
c     3
dtype: int64
```

New Behavior:

For iloc, getting & setting via a float scalar will always raise.

```
In [3]: s.iloc[2.0]
TypeError: cannot do label indexing on <class 'pandas.indexes.numeric.Int64Index'>␣
↪with these indexers [2.0] of <type 'float'>
```

Other indexers will coerce to a like integer for both getting and setting. The `FutureWarning` has been dropped for `.loc`, `.ix` and `[]`.

```
In [113]: s[5.0]
Out[113]: 2

In [114]: s.loc[5.0]
\\\\\\\\\\\\Out[114]: 2
```

and setting

```
In [115]: s_copy = s.copy()

In [116]: s_copy[5.0] = 10

In [117]: s_copy
Out[117]:
4     1
5    10
6     3
dtype: int64

In [118]: s_copy = s.copy()

In [119]: s_copy.loc[5.0] = 10

In [120]: s_copy
Out[120]:
4     1
5    10
```

```
6     3
dtype: int64
```

Positional setting with `.ix` and a float indexer will ADD this value to the index, rather than previously setting the value by position.

```
In [3]: s2.ix[1.0] = 10
In [4]: s2
Out[4]:
a       1
b       2
c       3
1.0    10
dtype: int64
```

Slicing will also coerce integer-like floats to integers for a non-`Float64Index`.

```
In [121]: s.loc[5.0:6]
Out[121]:
5    2
6    3
dtype: int64
```

Note that for floats that are NOT coercible to ints, the label based bounds will be excluded

```
In [122]: s.loc[5.1:6]
Out[122]:
6    3
dtype: int64
```

Float indexing on a `Float64Index` is unchanged.

```
In [123]: s = pd.Series([1, 2, 3], index=np.arange(3.))

In [124]: s[1.0]
Out[124]: 2

In [125]: s[1.0:2.5]
\\\\\\\\\\\Out[125]:
1.0    2
2.0    3
dtype: int64
```

1.9.2.10 Removal of prior version deprecations/changes

- Removal of `rolling_corr_pairwise` in favor of `.rolling().corr(pairwise=True)` (GH4950)
- Removal of `expanding_corr_pairwise` in favor of `.expanding().corr(pairwise=True)` (GH4950)
- Removal of `DataMatrix` module. This was not imported into the pandas namespace in any event (GH12111)
- Removal of `cols` keyword in favor of `subset` in `DataFrame.duplicated()` and `DataFrame.drop_duplicates()` (GH6680)
- Removal of the `read_frame` and `frame_query` (both aliases for `pd.read_sql`) and `write_frame` (alias of `to_sql`) functions in the `pd.io.sql` namespace, deprecated since 0.14.0 (GH6292).

- Removal of the `order` keyword from `.factorize()` (GH6930)

1.9.3 Performance Improvements

- Improved performance of `andrews_curves` (GH11534)
- Improved huge `DatetimeIndex`, `PeriodIndex` and `TimedeltaIndex`'s ops performance including `NaT` (GH10277)
- Improved performance of `pandas.concat` (GH11958)
- Improved performance of `StataReader` (GH11591)
- Improved performance in construction of `Categoricals` with `Series` of datetimes containing `NaT` (GH12077)
- Improved performance of ISO 8601 date parsing for dates without separators (GH11899), leading zeros (GH11871) and with whitespace preceding the time zone (GH9714)

1.9.4 Bug Fixes

- Bug in `GroupBy.size` when data-frame is empty. (GH11699)
- Bug in `Period.end_time` when a multiple of time period is requested (GH11738)
- Regression in `.clip` with tz-aware datetimes (GH11838)
- Bug in `date_range` when the boundaries fell on the frequency (GH11804, GH12409)
- Bug in consistency of passing nested dicts to `.groupby(...).agg(...)` (GH9052)
- Accept unicode in `Timedelta` constructor (GH11995)
- Bug in value label reading for `StataReader` when reading incrementally (GH12014)
- Bug in vectorized `DateOffset` when `n` parameter is `0` (GH11370)
- Compat for numpy 1.11 w.r.t. `NaT` comparison changes (GH12049)
- Bug in `read_csv` when reading from a `StringIO` in threads (GH11790)
- Bug in not treating `NaT` as a missing value in datetimelikes when factorizing & with `Categoricals` (GH12077)
- Bug in getitem when the values of a `Series` were tz-aware (GH12089)
- Bug in `Series.str.get_dummies` when one of the variables was 'name' (GH12180)
- Bug in `pd.concat` while concatenating tz-aware NaT series. (GH11693, GH11755, GH12217)
- Bug in `pd.read_stata` with version <= 108 files (GH12232)
- Bug in `Series.resample` using a frequency of `Nano` when the index is a `DatetimeIndex` and contains non-zero nanosecond parts (GH12037)
- Bug in resampling with `.nunique` and a sparse index (GH12352)
- Removed some compiler warnings (GH12471)
- Work around compat issues with `boto` in python 3.5 (GH11915)
- Bug in `NaT` subtraction from `Timestamp` or `DatetimeIndex` with timezones (GH11718)
- Bug in subtraction of `Series` of a single tz-aware `Timestamp` (GH12290)

- Use compat iterators in PY2 to support `.next()` (GH12299)
- Bug in `Timedelta.round` with negative values (GH11690)
- Bug in `.loc` against `CategoricalIndex` may result in normal `Index` (GH11586)
- Bug in `DataFrame.info` when duplicated column names exist (GH11761)
- Bug in `.copy` of datetime tz-aware objects (GH11794)
- Bug in `Series.apply` and `Series.map` where `timedelta64` was not boxed (GH11349)
- Bug in `DataFrame.set_index()` with tz-aware `Series` (GH12358)
- Bug in subclasses of `DataFrame` where `AttributeError` did not propagate (GH11808)
- Bug groupby on tz-aware data where selection not returning `Timestamp` (GH11616)
- Bug in `pd.read_clipboard` and `pd.to_clipboard` functions not supporting Unicode; upgrade included `pyperclip` to v1.5.15 (GH9263)
- Bug in `DataFrame.query` containing an assignment (GH8664)
- Bug in `from_msgpack` where `__contains__()` fails for columns of the unpacked `DataFrame`, if the `DataFrame` has object columns. (GH11880)
- Bug in `.resample` on categorical data with `TimedeltaIndex` (GH12169)
- Bug in timezone info lost when broadcasting scalar datetime to `DataFrame` (GH11682)
- Bug in `Index` creation from `Timestamp` with mixed tz coerces to UTC (GH11488)
- Bug in `to_numeric` where it does not raise if input is more than one dimension (GH11776)
- Bug in parsing timezone offset strings with non-zero minutes (GH11708)
- Bug in `df.plot` using incorrect colors for bar plots under matplotlib 1.5+ (GH11614)
- Bug in the `groupby` `plot` method when using keyword arguments (GH11805).
- Bug in `DataFrame.duplicated` and `drop_duplicates` causing spurious matches when setting `keep=False` (GH11864)
- Bug in `.loc` result with duplicated key may have `Index` with incorrect dtype (GH11497)
- Bug in `pd.rolling_median` where memory allocation failed even with sufficient memory (GH11696)
- Bug in `DataFrame.style` with spurious zeros (GH12134)
- Bug in `DataFrame.style` with integer columns not starting at 0 (GH12125)
- Bug in `.style.bar` may not rendered properly using specific browser (GH11678)
- Bug in rich comparison of `Timedelta` with a `numpy.array` of `Timedelta` that caused an infinite recursion (GH11835)
- Bug in `DataFrame.round` dropping column index name (GH11986)
- Bug in `df.replace` while replacing value in mixed dtype `Dataframe` (GH11698)
- Bug in `Index` prevents copying name of passed `Index`, when a new name is not provided (GH11193)
- Bug in `read_excel` failing to read any non-empty sheets when empty sheets exist and `sheetname=None` (GH11711)
- Bug in `read_excel` failing to raise `NotImplemented` error when keywords `parse_dates` and `date_parser` are provided (GH11544)
- Bug in `read_sql` with `pymysql` connections failing to return chunked data (GH11522)

- Bug in `.to_csv` ignoring formatting parameters `decimal`, `na_rep`, `float_format` for float indexes (GH11553)
- Bug in `Int64Index` and `Float64Index` preventing the use of the modulo operator (GH9244)
- Bug in `MultiIndex.drop` for not lexsorted multi-indexes (GH12078)
- Bug in `DataFrame` when masking an empty `DataFrame` (GH11859)
- Bug in `.plot` potentially modifying the `colors` input when the number of columns didn't match the number of series provided (GH12039).
- Bug in `Series.plot` failing when index has a `CustomBusinessDay` frequency (GH7222).
- Bug in `.to_sql` for `datetime.time` values with sqlite fallback (GH8341)
- Bug in `read_excel` failing to read data with one column when `squeeze=True` (GH12157)
- Bug in `read_excel` failing to read one empty column (GH12292, GH9002)
- Bug in `.groupby` where a `KeyError` was not raised for a wrong column if there was only one row in the dataframe (GH11741)
- Bug in `.read_csv` with dtype specified on empty data producing an error (GH12048)
- Bug in `.read_csv` where strings like `'2E'` are treated as valid floats (GH12237)
- Bug in building *pandas* with debugging symbols (GH12123)
- Removed `millisecond` property of `DatetimeIndex`. This would always raise a `ValueError` (GH12019).
- Bug in `Series` constructor with read-only data (GH11502)
- Removed `pandas.util.testing.choice()`. Should use `np.random.choice()`, instead. (GH12386)
- Bug in `.loc` setitem indexer preventing the use of a TZ-aware DatetimeIndex (GH12050)
- Bug in `.style` indexes and multi-indexes not appearing (GH11655)
- Bug in `to_msgpack` and `from_msgpack` which did not correctly serialize or deserialize `NaT` (GH12307).
- Bug in `.skew` and `.kurt` due to roundoff error for highly similar values (GH11974)
- Bug in `Timestamp` constructor where microsecond resolution was lost if HHMMSS were not separated with ':' (GH10041)
- Bug in `buffer_rd_bytes` src->buffer could be freed more than once if reading failed, causing a segfault (GH12098)
- Bug in `crosstab` where arguments with non-overlapping indexes would return a `KeyError` (GH10291)
- Bug in `DataFrame.apply` in which reduction was not being prevented for cases in which `dtype` was not a numpy dtype (GH12244)
- Bug when initializing categorical series with a scalar value. (GH12336)
- Bug when specifying a UTC `DatetimeIndex` by setting `utc=True` in `.to_datetime` (GH11934)
- Bug when increasing the buffer size of CSV reader in `read_csv` (GH12494)
- Bug when setting columns of a `DataFrame` with duplicate column names (GH12344)

1.10 v0.17.1 (November 21, 2015)

Note: We are proud to announce that *pandas* has become a sponsored project of the (NUMFocus organization). This will help ensure the success of development of *pandas* as a world-class open-source project.

This is a minor bug-fix release from 0.17.0 and includes a large number of bug fixes along several new features, enhancements, and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

- Support for Conditional HTML Formatting, see *here*
- Releasing the GIL on the csv reader & other ops, see *here*
- Fixed regression in `DataFrame.drop_duplicates` from 0.16.2, causing incorrect results on integer values (GH11376)

What's new in v0.17.1

1.10.1 New features

1.10.1.1 Conditional HTML Formatting

Warning: This is a new feature and is under active development. We'll be adding features an possibly making breaking changes in future releases. Feedback is welcome.

We've added *experimental* support for conditional HTML formatting: the visual styling of a DataFrame based on the data. The styling is accomplished with HTML and CSS. Acesses the styler class with the *`pandas.DataFrame.style`*, attribute, an instance of `Styler` with your data attached.

Here's a quick example:

```
In [1]: np.random.seed(123)

In [2]: df = DataFrame(np.random.randn(10, 5), columns=list('abcde'))

In [3]: html = df.style.background_gradient(cmap='viridis', low=.5)
```

We can render the HTML to get the following table.

`Styler` interacts nicely with the Jupyter Notebook. See the *documentation* for more.

1.10.2 Enhancements

- `DatetimeIndex` now supports conversion to strings with `astype(str)` (GH10442)
- Support for `compression` (gzip/bz2) in *`pandas.DataFrame.to_csv()`* (GH7615)
- `pd.read_*` functions can now also accept `pathlib.Path`, or `py._path.local.LocalPath` objects for the `filepath_or_buffer` argument. (GH11033) - The `DataFrame` and `Series` functions `.to_csv()`, `.to_html()` and `.to_latex()` can now handle paths beginning with tildes (e.g. `~/Documents/`) (GH11438)
- `DataFrame` now uses the fields of a `namedtuple` as columns, if columns are not supplied (GH11181)
- `DataFrame.itertuples()` now returns `namedtuple` objects, when possible. (GH11269, GH11625)
- Added `axvlines_kwds` to parallel coordinates plot (GH10709)
- Option to `.info()` and `.memory_usage()` to provide for deep introspection of memory consumption. Note that this can be expensive to compute and therefore is an optional parameter. (GH11595)

```
In [4]: df = DataFrame({'A' : ['foo']*1000})

In [5]: df['B'] = df['A'].astype('category')

# shows the '+' as we have object dtypes
In [6]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 2 columns):
A    1000 non-null object
B    1000 non-null category
dtypes: category(1), object(1)
memory usage: 9.0+ KB

# we have an accurate memory assessment (but can be expensive to compute this)
In [7]: df.info(memory_usage='deep')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 2 columns):
A    1000 non-null object
B    1000 non-null category
dtypes: category(1), object(1)
memory usage: 75.4 KB
```

- `Index` now has a `fillna` method (GH10089)

```
In [8]: pd.Index([1, np.nan, 3]).fillna(2)
Out[8]: Float64Index([1.0, 2.0, 3.0], dtype='float64')
```

- Series of type `category` now make `.str.<...>` and `.dt.<...>` accessor methods / properties available, if the categories are of that type. (GH10661)

```
In [9]: s = pd.Series(list('aabb')).astype('category')

In [10]: s
Out[10]:
```

```
0    a
1    a
2    b
3    b
dtype: category
Categories (2, object): [a, b]

In [11]: s.str.contains("a")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[11]:␣
↪
0     True
1     True
2    False
3    False
dtype: bool

In [12]: date = pd.Series(pd.date_range('1/1/2015', periods=5)).astype('category')

In [13]: date
Out[13]:
0   2015-01-01
1   2015-01-02
2   2015-01-03
3   2015-01-04
4   2015-01-05
dtype: category
Categories (5, datetime64[ns]): [2015-01-01, 2015-01-02, 2015-01-03, 2015-01-04,␣
↪2015-01-05]

In [14]: date.dt.day
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    2
2    3
3    4
4    5
dtype: int64
```

- `pivot_table` now has a `margins_name` argument so you can use something other than the default of 'All' (GH3335)
- Implement export of `datetime64[ns, tz]` dtypes with a fixed HDF5 store (GH11411)
- Pretty printing sets (e.g. in DataFrame cells) now uses set literal syntax (`{x, y}`) instead of Legacy Python syntax (`set([x, y])`) (GH11215)
- Improve the error message in `pandas.io.gbq.to_gbq()` when a streaming insert fails (GH11285) and when the DataFrame does not match the schema of the destination table (GH11359)

1.10.3 API changes

- raise `NotImplementedError` in `Index.shift` for non-supported index types (GH8038)
- `min` and `max` reductions on `datetime64` and `timedelta64` dtyped series now result in `NaT` and not `nan` (GH11245).
- Indexing with a null key will raise a `TypeError`, instead of a `ValueError` (GH11356)

- `Series.ptp` will now ignore missing values by default (GH11163)

1.10.3.1 Deprecations

- The `pandas.io.ga` module which implements `google-analytics` support is deprecated and will be removed in a future version (GH11308)
- Deprecate the `engine` keyword in `.to_csv()`, which will be removed in a future version (GH11274)

1.10.4 Performance Improvements

- Checking monotonic-ness before sorting on an index (GH11080)
- `Series.dropna` performance improvement when its dtype can't contain `NaN` (GH11159)
- Release the GIL on most datetime field operations (e.g. `DatetimeIndex.year`, `Series.dt.year`), normalization, and conversion to and from `Period`, `DatetimeIndex.to_period` and `PeriodIndex.to_timestamp` (GH11263)
- Release the GIL on some rolling algos: `rolling_median`, `rolling_mean`, `rolling_max`, `rolling_min`, `rolling_var`, `rolling_kurt`, `rolling_skew` (GH11450)
- Release the GIL when reading and parsing text files in `read_csv`, `read_table` (GH11272)
- Improved performance of `rolling_median` (GH11450)
- Improved performance of `to_excel` (GH11352)
- Performance bug in repr of `Categorical` categories, which was rendering the strings before chopping them for display (GH11305)
- Performance improvement in `Categorical.remove_unused_categories`, (GH11643).
- Improved performance of `Series` constructor with no data and `DatetimeIndex` (GH11433)
- Improved performance of `shift`, `cumprod`, and `cumsum` with groupby (GH4095)

1.10.5 Bug Fixes

- `SparseArray.__iter__()` now does not cause `PendingDeprecationWarning` in Python 3.5 (GH11622)
- Regression from 0.16.2 for output formatting of long floats/nan, restored in (GH11302)
- `Series.sort_index()` now correctly handles the `inplace` option (GH11402)
- Incorrectly distributed .c file in the build on `PyPi` when reading a csv of floats and passing `na_values=<a scalar>` would show an exception (GH11374)
- Bug in `.to_latex()` output broken when the index has a name (GH10660)
- Bug in `HDFStore.append` with strings whose encoded length exceded the max unencoded length (GH11234)
- Bug in merging `datetime64[ns, tz]` dtypes (GH11405)
- Bug in `HDFStore.select` when comparing with a numpy scalar in a where clause (GH11283)
- Bug in using `DataFrame.ix` with a multi-index indexer (GH11372)
- Bug in `date_range` with ambigous endpoints (GH11626)

- Prevent adding new attributes to the accessors `.str`, `.dt` and `.cat`. Retrieving such a value was not possible, so error out on setting it. (GH10673)
- Bug in tz-conversions with an ambiguous time and `.dt` accessors (GH11295)
- Bug in output formatting when using an index of ambiguous times (GH11619)
- Bug in comparisons of Series vs list-likes (GH11339)
- Bug in `DataFrame.replace` with a `datetime64[ns, tz]` and a non-compat to_replace (GH11326, GH11153)
- Bug in `isnull` where `numpy.datetime64('NaT')` in a `numpy.array` was not determined to be null(GH11206)
- Bug in list-like indexing with a mixed-integer Index (GH11320)
- Bug in `pivot_table` with `margins=True` when indexes are of `Categorical` dtype (GH10993)
- Bug in `DataFrame.plot` cannot use hex strings colors (GH10299)
- Regression in `DataFrame.drop_duplicates` from 0.16.2, causing incorrect results on integer values (GH11376)
- Bug in `pd.eval` where unary ops in a list error (GH11235)
- Bug in `squeeze()` with zero length arrays (GH11230, GH8999)
- Bug in `describe()` dropping column names for hierarchical indexes (GH11517)
- Bug in `DataFrame.pct_change()` not propagating `axis` keyword on `.fillna` method (GH11150)
- Bug in `.to_csv()` when a mix of integer and string column names are passed as the `columns` parameter (GH11637)
- Bug in indexing with a `range`, (GH11652)
- Bug in inference of numpy scalars and preserving dtype when setting columns (GH11638)
- Bug in `to_sql` using unicode column names giving UnicodeEncodeError with (GH11431).
- Fix regression in setting of `xticks` in `plot` (GH11529).
- Bug in `holiday.dates` where observance rules could not be applied to holiday and doc enhancement (GH11477, GH11533)
- Fix plotting issues when having plain `Axes` instances instead of `SubplotAxes` (GH11520, GH11556).
- Bug in `DataFrame.to_latex()` produces an extra rule when `header=False` (GH7124)
- Bug in `df.groupby(...).apply(func)` when a func returns a `Series` containing a new datetimelike column (GH11324)
- Bug in `pandas.json` when file to load is big (GH11344)
- Bugs in `to_excel` with duplicate columns (GH11007, GH10982, GH10970)
- Fixed a bug that prevented the construction of an empty series of dtype `datetime64[ns, tz]` (GH11245).
- Bug in `read_excel` with multi-index containing integers (GH11317)
- Bug in `to_excel` with openpyxl 2.2+ and merging (GH11408)
- Bug in `DataFrame.to_dict()` produces a `np.datetime64` object instead of `Timestamp` when only datetime is present in data (GH11327)
- Bug in `DataFrame.corr()` raises exception when computes Kendall correlation for DataFrames with boolean and not boolean columns (GH11560)

- Bug in the link-time error caused by C `inline` functions on FreeBSD 10+ (with `clang`) (GH10510)
- Bug in `DataFrame.to_csv` in passing through arguments for formatting `MultiIndexes`, including `date_format` (GH7791)
- Bug in `DataFrame.join()` with `how='right'` producing a `TypeError` (GH11519)
- Bug in `Series.quantile` with empty list results has `Index` with `object` dtype (GH11588)
- Bug in `pd.merge` results in empty `Int64Index` rather than `Index(dtype=object)` when the merge result is empty (GH11588)
- Bug in `Categorical.remove_unused_categories` when having `NaN` values (GH11599)
- Bug in `DataFrame.to_sparse()` loses column names for MultiIndexes (GH11600)
- Bug in `DataFrame.round()` with non-unique column index producing a Fatal Python error (GH11611)
- Bug in `DataFrame.round()` with `decimals` being a non-unique indexed Series producing extra columns (GH11618)

1.11 v0.17.0 (October 9, 2015)

This is a major release from 0.16.2 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

> **Warning:** pandas >= 0.17.0 will no longer support compatibility with Python version 3.2 (GH9118)

> **Warning:** The `pandas.io.data` package is deprecated and will be replaced by the pandas-datareader package. This will allow the data modules to be independently updated to your pandas installation. The API for `pandas-datareader v0.1.1` is exactly the same as in `pandas v0.17.0` (GH8961, GH10861).
>
> After installing pandas-datareader, you can easily change your imports:
>
> ```
> from pandas.io import data, wb
> ```
>
> becomes
>
> ```
> from pandas_datareader import data, wb
> ```

Highlights include:

- Release the Global Interpreter Lock (GIL) on some cython operations, see *here*
- Plotting methods are now available as attributes of the `.plot` accessor, see *here*
- The sorting API has been revamped to remove some long-time inconsistencies, see *here*
- Support for a `datetime64[ns]` with timezones as a first-class dtype, see *here*
- The default for `to_datetime` will now be to `raise` when presented with unparseable formats, previously this would return the original input. Also, date parse functions now return consistent results. See *here*
- The default for `dropna` in `HDFStore` has changed to `False`, to store by default all rows even if they are all `NaN`, see *here*

- Datetime accessor (`dt`) now supports `Series.dt.strftime` to generate formatted strings for datetime-likes, and `Series.dt.total_seconds` to generate each duration of the timedelta in seconds. See *here*
- `Period` and `PeriodIndex` can handle multiplied freq like `3D`, which corresponding to 3 days span. See *here*
- Development installed versions of pandas will now have `PEP440` compliant version strings (GH9518)
- Development support for benchmarking with the Air Speed Velocity library (GH8361)
- Support for reading SAS xport files, see *here*
- Documentation comparing SAS to *pandas*, see *here*
- Removal of the automatic TimeSeries broadcasting, deprecated since 0.8.0, see *here*
- Display format with plain text can optionally align with Unicode East Asian Width, see *here*
- Compatibility with Python 3.5 (GH11097)
- Compatibility with matplotlib 1.5.0 (GH11111)

Check the *API Changes* and *deprecations* before updating.

What's new in v0.17.0

1.11.1 New features

1.11.1.1 Datetime with TZ

We are adding an implementation that natively supports datetime with timezones. A `Series` or a `DataFrame` column previously *could* be assigned a datetime with timezones, and would work as an `object` dtype. This had performance issues with a large number rows. See the *docs* for more details. (GH8260, GH10763, GH11034).

The new implementation allows for having a single-timezone across all rows, with operations in a performant manner.

```
In [1]: df = DataFrame({'A' : date_range('20130101',periods=3),
   ...:                 'B' : date_range('20130101',periods=3,tz='US/Eastern'),
   ...:                 'C' : date_range('20130101',periods=3,tz='CET')})
   ...:

In [2]: df
Out[2]:
           A                         B                         C
0 2013-01-01 2013-01-01 00:00:00-05:00 2013-01-01 00:00:00+01:00
1 2013-01-02 2013-01-02 00:00:00-05:00 2013-01-02 00:00:00+01:00
2 2013-01-03 2013-01-03 00:00:00-05:00 2013-01-03 00:00:00+01:00

In [3]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A                 datetime64[ns]
B    datetime64[ns, US/Eastern]
C           datetime64[ns, CET]
dtype: object
```

```
In [4]: df.B
Out[4]:
0   2013-01-01 00:00:00-05:00
1   2013-01-02 00:00:00-05:00
2   2013-01-03 00:00:00-05:00
Name: B, dtype: datetime64[ns, US/Eastern]

In [5]: df.B.dt.tz_localize(None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2013-01-01
1   2013-01-02
```

```
2   2013-01-03
Name: B, dtype: datetime64[ns]
```

This uses a new-dtype representation as well, that is very similar in look-and-feel to its numpy cousin `datetime64[ns]`

```
In [6]: df['B'].dtype
Out[6]: datetime64[ns, US/Eastern]

In [7]: type(df['B'].dtype)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[7]: pandas.core.dtypes.dtypes.DatetimeTZDtype
```

Note: There is a slightly different string repr for the underlying `DatetimeIndex` as a result of the dtype changes, but functionally these are the same.

Previous Behavior:

```
In [1]: pd.date_range('20130101',periods=3,tz='US/Eastern')
Out[1]: DatetimeIndex(['2013-01-01 00:00:00-05:00', '2013-01-02 00:00:00-05:00',
                       '2013-01-03 00:00:00-05:00'],
                      dtype='datetime64[ns]', freq='D', tz='US/Eastern')

In [2]: pd.date_range('20130101',periods=3,tz='US/Eastern').dtype
Out[2]: dtype('<M8[ns]')
```

New Behavior:

```
In [8]: pd.date_range('20130101',periods=3,tz='US/Eastern')
Out[8]: 
DatetimeIndex(['2013-01-01 00:00:00-05:00', '2013-01-02 00:00:00-05:00',
               '2013-01-03 00:00:00-05:00'],
              dtype='datetime64[ns, US/Eastern]', freq='D')

In [9]: pd.date_range('20130101',periods=3,tz='US/Eastern').dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪datetime64[ns, US/Eastern]
```

1.11.1.2 Releasing the GIL

We are releasing the global-interpreter-lock (GIL) on some cython operations. This will allow other threads to run simultaneously during computation, potentially allowing performance improvements from multi-threading. Notably `groupby`, `nsmallest`, `value_counts` and some indexing operations benefit from this. (GH8882)

For example the groupby expression in the following code will have the GIL released during the factorization step, e.g. `df.groupby('key')` as well as the `.sum()` operation.

```
N = 1000000
ngroups = 10
df = DataFrame({'key' : np.random.randint(0,ngroups,size=N),
                'data' : np.random.randn(N) })
df.groupby('key')['data'].sum()
```

Releasing of the GIL could benefit an application that uses threads for user interactions (e.g. QT), or performing multi-threaded computations. A nice example of a library that can handle these types of computation-in-parallel is the dask library.

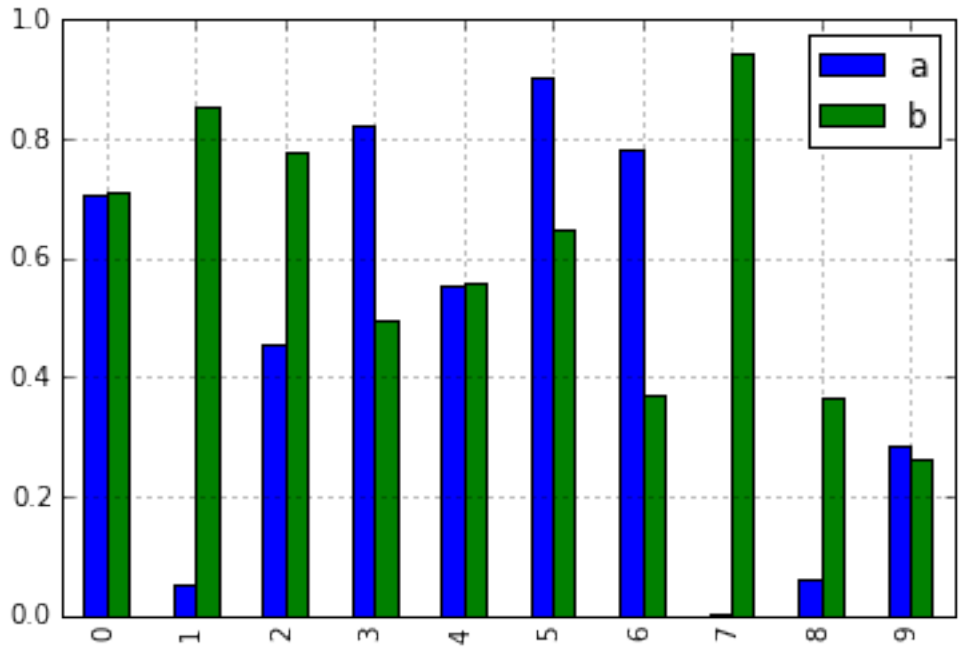
1.11.1.3 Plot submethods

The Series and DataFrame `.plot()` method allows for customizing *plot types* by supplying the `kind` keyword arguments. Unfortunately, many of these kinds of plots use different required and optional keyword arguments, which makes it difficult to discover what any given plot kind uses out of the dozens of possible arguments.

To alleviate this issue, we have added a new, optional plotting interface, which exposes each kind of plot as a method of the `.plot` attribute. Instead of writing `series.plot(kind=<kind>, ...)`, you can now also use `series.plot.<kind>(...)`:

```
In [10]: df = pd.DataFrame(np.random.rand(10, 2), columns=['a', 'b'])

In [11]: df.plot.bar()
```



As a result of this change, these methods are now all discoverable via tab-completion:

```
In [12]: df.plot.<TAB>
df.plot.area     df.plot.barh     df.plot.density  df.plot.hist     df.plot.line
↪df.plot.scatter
df.plot.bar      df.plot.box      df.plot.hexbin   df.plot.kde      df.plot.pie
```

Each method signature only includes relevant arguments. Currently, these are limited to required arguments, but in the future these will include optional arguments, as well. For an overview, see the new *Plotting* API documentation.

1.11.1.4 Additional methods for `dt` accessor

strftime

We are now supporting a `Series.dt.strftime` method for datetime-likes to generate a formatted string (GH10110). Examples:

```
# DatetimeIndex
In [13]: s = pd.Series(pd.date_range('20130101', periods=4))
```

```
In [14]: s
Out[14]:
0   2013-01-01
1   2013-01-02
2   2013-01-03
3   2013-01-04
dtype: datetime64[ns]

In [15]: s.dt.strftime('%Y/%m/%d')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[15]:␣
↪
0    2013/01/01
1    2013/01/02
2    2013/01/03
3    2013/01/04
dtype: object
```

```
# PeriodIndex
In [16]: s = pd.Series(pd.period_range('20130101', periods=4))

In [17]: s
Out[17]:
0   2013-01-01
1   2013-01-02
2   2013-01-03
3   2013-01-04
dtype: object

In [18]: s.dt.strftime('%Y/%m/%d')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[18]:␣
↪
0    2013/01/01
1    2013/01/02
2    2013/01/03
3    2013/01/04
dtype: object
```

The string format is as the python standard library and details can be found here

total_seconds

`pd.Series` of type `timedelta64` has new method `.dt.total_seconds()` returning the duration of the timedelta in seconds (GH10817)

```
# TimedeltaIndex
In [19]: s = pd.Series(pd.timedelta_range('1 minutes', periods=4))

In [20]: s
Out[20]:
0   0 days 00:01:00
1   1 days 00:01:00
2   2 days 00:01:00
3   3 days 00:01:00
dtype: timedelta64[ns]
```

```
In [21]: s.dt.total_seconds()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0        60.0
1     86460.0
2    172860.0
3    259260.0
dtype: float64
```

1.11.1.5 Period Frequency Enhancement

`Period`, `PeriodIndex` and `period_range` can now accept multiplied freq. Also, `Period.freq` and `PeriodIndex.freq` are now stored as a `DateOffset` instance like `DatetimeIndex`, and not as `str` (GH7811)

A multiplied freq represents a span of corresponding length. The example below creates a period of 3 days. Addition and subtraction will shift the period by its span.

```
In [22]: p = pd.Period('2015-08-01', freq='3D')

In [23]: p
Out[23]: Period('2015-08-01', '3D')

In [24]: p + 1
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[24]: Period('2015-08-04', '3D')

In [25]: p - 2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[25]:␣
↪Period('2015-07-26', '3D')

In [26]: p.to_timestamp()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2015-08-01 00:00:00')

In [27]: p.to_timestamp(how='E')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2015-08-03 00:00:00')
```

You can use the multiplied freq in `PeriodIndex` and `period_range`.

```
In [28]: idx = pd.period_range('2015-08-01', periods=4, freq='2D')

In [29]: idx
Out[29]: PeriodIndex(['2015-08-01', '2015-08-03', '2015-08-05', '2015-08-07'], dtype=
↪'period[2D]', freq='2D')

In [30]: idx + 1
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪PeriodIndex(['2015-08-03', '2015-08-05', '2015-08-07', '2015-08-09'], dtype=
↪'period[2D]', freq='2D')
```

1.11.1.6 Support for SAS XPORT files

`read_sas()` provides support for reading *SAS XPORT* format files. (GH4052).

```
df = pd.read_sas('sas_xport.xpt')
```

It is also possible to obtain an iterator and read an XPORT file incrementally.

```
for df in pd.read_sas('sas_xport.xpt', chunksize=10000)
    do_something(df)
```

See the *docs* for more details.

1.11.1.7 Support for Math Functions in .eval()

`eval()` now supports calling math functions (GH4893)

```
df = pd.DataFrame({'a': np.random.randn(10)})
df.eval("b = sin(a)")
```

The support math functions are *sin*, *cos*, *exp*, *log*, *expm1*, *log1p*, *sqrt*, *sinh*, *cosh*, *tanh*, *arcsin*, *arccos*, *arctan*, *arccosh*, *arcsinh*, *arctanh*, *abs* and *arctan2*.

These functions map to the intrinsics for the `NumExpr` engine. For the Python engine, they are mapped to `NumPy` calls.

1.11.1.8 Changes to Excel with `MultiIndex`

In version 0.16.2 a `DataFrame` with `MultiIndex` columns could not be written to Excel via `to_excel`. That functionality has been added (GH10564), along with updating `read_excel` so that the data can be read back with, no loss of information, by specifying which columns/rows make up the `MultiIndex` in the `header` and `index_col` parameters (GH4679)

See the *documentation* for more details.

```
In [31]: df = pd.DataFrame([[1,2,3,4], [5,6,7,8]],
   ....:                   columns = pd.MultiIndex.from_product([['foo','bar'],['a','b
↪']],
   ....:                                                        names = ['col1', 'col2
↪']),
   ....:                   index = pd.MultiIndex.from_product([['j'], ['l', 'k']],
   ....:                                                      names = ['i1', 'i2']))
   ....:

In [32]: df
Out[32]:
col1  foo    bar
col2    a  b   a  b
i1 i2
j  l    1  2   3  4
   k    5  6   7  8

In [33]: df.to_excel('test.xlsx')

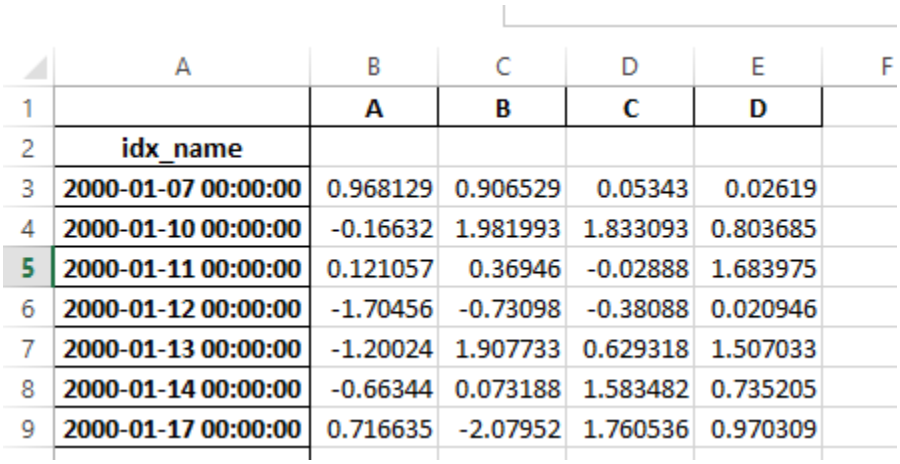
In [34]: df = pd.read_excel('test.xlsx', header=[0,1], index_col=[0,1])

In [35]: df
Out[35]:
col1  foo    bar
col2    a  b   a  b
```

```
i1 i2
j  l     1  2   3  4
   k     5  6   7  8
```

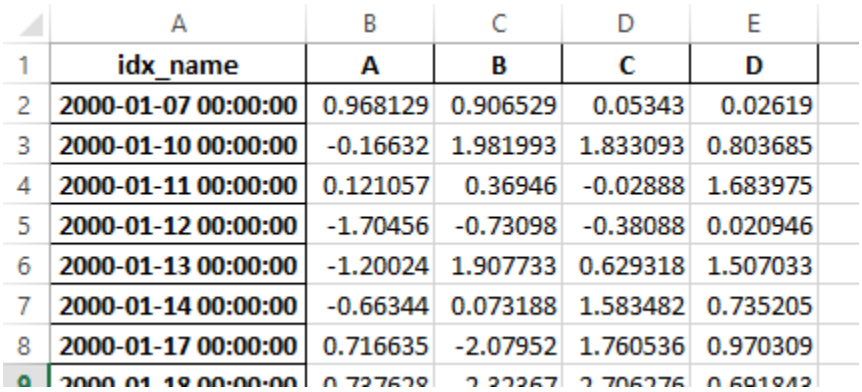
Previously, it was necessary to specify the `has_index_names` argument in `read_excel`, if the serialized data had index names. For version 0.17.0 the ouptput format of `to_excel` has been changed to make this keyword unnecessary - the change is shown below.

Old



	A	B	C	D	E
1		A	B	C	D
2	idx_name				
3	2000-01-07 00:00:00	0.968129	0.906529	0.05343	0.02619
4	2000-01-10 00:00:00	-0.16632	1.981993	1.833093	0.803685
5	2000-01-11 00:00:00	0.121057	0.36946	-0.02888	1.683975
6	2000-01-12 00:00:00	-1.70456	-0.73098	-0.38088	0.020946
7	2000-01-13 00:00:00	-1.20024	1.907733	0.629318	1.507033
8	2000-01-14 00:00:00	-0.66344	0.073188	1.583482	0.735205
9	2000-01-17 00:00:00	0.716635	-2.07952	1.760536	0.970309

New



	A	B	C	D	E
1	idx_name	A	B	C	D
2	2000-01-07 00:00:00	0.968129	0.906529	0.05343	0.02619
3	2000-01-10 00:00:00	-0.16632	1.981993	1.833093	0.803685
4	2000-01-11 00:00:00	0.121057	0.36946	-0.02888	1.683975
5	2000-01-12 00:00:00	-1.70456	-0.73098	-0.38088	0.020946
6	2000-01-13 00:00:00	-1.20024	1.907733	0.629318	1.507033
7	2000-01-14 00:00:00	-0.66344	0.073188	1.583482	0.735205
8	2000-01-17 00:00:00	0.716635	-2.07952	1.760536	0.970309
9	2000-01-18 00:00:00	0.737628	2.32367	2.706276	0.691843

Warning: Excel files saved in version 0.16.2 or prior that had index names will still able to be read in, but the `has_index_names` argument must specified to `True`.

1.11.1.9 Google BigQuery Enhancements

- Added ability to automatically create a table/dataset using the `pandas.io.gbq.to_gbq()` function if the destination table/dataset does not exist. (GH8325, GH11121).
- Added ability to replace an existing table and schema when calling the `pandas.io.gbq.to_gbq()` function via the `if_exists` argument. See the docs for more details (GH8325).
- `InvalidColumnOrder` and `InvalidPageToken` in the gbq module will raise `ValueError` instead of `IOError`.

- The `generate_bq_schema()` function is now deprecated and will be removed in a future version (GH11121)
- The gbq module will now support Python 3 (GH11094).

1.11.1.10 Display Alignment with Unicode East Asian Width

> **Warning:** Enabling this option will affect the performance for printing of `DataFrame` and `Series` (about 2 times slower). Use only when it is actually required.

Some East Asian countries use Unicode characters its width is corresponding to 2 alphabets. If a `DataFrame` or `Series` contains these characters, the default output cannot be aligned properly. The following options are added to enable precise handling for these characters.

- `display.unicode.east_asian_width`: Whether to use the Unicode East Asian Width to calculate the display text width. (GH2612)
- `display.unicode.ambiguous_as_wide`: Whether to handle Unicode characters belong to Ambiguous as Wide. (GH11102)

```
In [36]: df = pd.DataFrame({u'': ['UK', u''], u'': ['Alice', u'']})

In [37]: df;
```

```
>>> df = pd.DataFrame({u'国籍': ['UK', u'日本'], u'名前': ['Alice', u'しのぶ']})
>>> df
      名前  国籍
0  Alice  UK
1    しのぶ  日本
```

```
In [38]: pd.set_option('display.unicode.east_asian_width', True)

In [39]: df;
```

```
>>> pd.set_option('display.unicode.east_asian_width', True)
>>> df
     名前  国籍
0   Alice   UK
1  しのぶ  日本
```

For further details, see *here*

1.11.1.11 Other enhancements

- Support for `openpyxl` >= 2.2. The API for style support is now stable (GH10125)
- `merge` now accepts the argument `indicator` which adds a Categorical-type column (by default called `_merge`) to the output object that takes on the values (GH8790)

Observation Origin	`_merge` value
Merge key only in `'left'` frame	`left_only`
Merge key only in `'right'` frame	`right_only`
Merge key in both frames	`both`

```
In [40]: df1 = pd.DataFrame({'col1':[0,1], 'col_left':['a','b']})

In [41]: df2 = pd.DataFrame({'col1':[1,2,2],'col_right':[2,2,2]})

In [42]: pd.merge(df1, df2, on='col1', how='outer', indicator=True)
Out[42]:
   col1 col_left  col_right      _merge
0     0        a        NaN   left_only
1     1        b        2.0        both
2     2      NaN        2.0  right_only
3     2      NaN        2.0  right_only
```

For more, see the *updated docs*

- `pd.to_numeric` is a new function to coerce strings to numbers (possibly with coercion) (GH11133)
- `pd.merge` will now allow duplicate column names if they are not merged upon (GH10639).
- `pd.pivot` will now allow passing index as `None` (GH3962).
- `pd.concat` will now use existing Series names if provided (GH10698).

```
In [43]: foo = pd.Series([1,2], name='foo')

In [44]: bar = pd.Series([1,2])

In [45]: baz = pd.Series([4,5])
```

Previous Behavior:

```
In [1] pd.concat([foo, bar, baz], 1)
Out[1]:
      0  1  2
   0  1  1  4
   1  2  2  5
```

New Behavior:

```
In [46]: pd.concat([foo, bar, baz], 1)
Out[46]:
   foo  0  1
0    1  1  4
1    2  2  5
```

- `DataFrame` has gained the `nlargest` and `nsmallest` methods (GH10393)
- Add a `limit_direction` keyword argument that works with `limit` to enable `interpolate` to fill `NaN` values forward, backward, or both (GH9218, GH10420, GH11115)

```
In [47]: ser = pd.Series([np.nan, np.nan, 5, np.nan, np.nan, np.nan, 13])

In [48]: ser.interpolate(limit=1, limit_direction='both')
Out[48]:
0     NaN
1     5.0
2     5.0
3     7.0
4     NaN
5    11.0
```

```
6    13.0
dtype: float64
```

- Added a `DataFrame.round` method to round the values to a variable number of decimal places (GH10568).

```
In [49]: df = pd.DataFrame(np.random.random([3, 3]), columns=['A', 'B', 'C'],
   ....: index=['first', 'second', 'third'])
   ....:

In [50]: df
Out[50]:
               A         B         C
first   0.342764  0.304121  0.417022
second  0.681301  0.875457  0.510422
third   0.669314  0.585937  0.624904

In [51]: df.round(2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
           A     B     C
first   0.34  0.30  0.42
second  0.68  0.88  0.51
third   0.67  0.59  0.62

In [52]: df.round({'A': 0, 'C': 2})
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B     C
first   0.0  0.304121  0.42
second  1.0  0.875457  0.51
third   1.0  0.585937  0.62
```

- `drop_duplicates` and `duplicated` now accept a `keep` keyword to target first, last, and all duplicates. The `take_last` keyword is deprecated, see *here* (GH6511, GH8505)

```
In [53]: s = pd.Series(['A', 'B', 'C', 'A', 'B', 'D'])

In [54]: s.drop_duplicates()
Out[54]:
0    A
1    B
2    C
5    D
dtype: object

In [55]: s.drop_duplicates(keep='last')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[55]:
2    C
3    A
4    B
5    D
dtype: object

In [56]: s.drop_duplicates(keep=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2    C
5    D
```

```
dtype: object
```

- Reindex now has a `tolerance` argument that allows for finer control of *Limits on filling while reindexing* (GH10411):

```
In [57]: df = pd.DataFrame({'x': range(5),
   ....:                    't': pd.date_range('2000-01-01', periods=5)})
   ....:

In [58]: df.reindex([0.1, 1.9, 3.5],
   ....:            method='nearest',
   ....:            tolerance=0.2)
   ....:
Out[58]:
             t    x
0.1 2000-01-01  0.0
1.9 2000-01-03  2.0
3.5        NaT  NaN
```

When used on a `DatetimeIndex`, `TimedeltaIndex` or `PeriodIndex`, `tolerance` will coerced into a `Timedelta` if possible. This allows you to specify tolerance with a string:

```
In [59]: df = df.set_index('t')

In [60]: df.reindex(pd.to_datetime(['1999-12-31']),
   ....:            method='nearest',
   ....:            tolerance='1 day')
   ....:
Out[60]:
            x
1999-12-31  0
```

`tolerance` is also exposed by the lower level `Index.get_indexer` and `Index.get_loc` methods.

- Added functionality to use the `base` argument when resampling a `TimeDeltaIndex` (GH10530)
- `DatetimeIndex` can be instantiated using strings contains `NaT` (GH7599)
- `to_datetime` can now accept the `yearfirst` keyword (GH7599)
- `pandas.tseries.offsets` larger than the `Day` offset can now be used with a `Series` for addition/subtraction (GH10699). See the *docs* for more details.
- `pd.Timedelta.total_seconds()` now returns Timedelta duration to ns precision (previously microsecond precision) (GH10939)
- `PeriodIndex` now supports arithmetic with `np.ndarray` (GH10638)
- Support pickling of `Period` objects (GH10439)
- `.as_blocks` will now take a `copy` optional argument to return a copy of the data, default is to copy (no change in behavior from prior versions), (GH9607)
- `regex` argument to `DataFrame.filter` now handles numeric column names instead of raising `ValueError` (GH10384).
- Enable reading gzip compressed files via URL, either by explicitly setting the compression parameter or by inferring from the presence of the HTTP Content-Encoding header in the response (GH8685)
- Enable writing Excel files in *memory* using StringIO/BytesIO (GH7074)
- Enable serialization of lists and dicts to strings in `ExcelWriter` (GH8188)

- SQL io functions now accept a SQLAlchemy connectable. (GH7877)
- `pd.read_sql` and `to_sql` can accept database URI as `con` parameter (GH10214)
- `read_sql_table` will now allow reading from views (GH10750).
- Enable writing complex values to `HDFStores` when using the `table` format (GH10447)
- Enable `pd.read_hdf` to be used without specifying a key when the HDF file contains a single dataset (GH10443)
- `pd.read_stata` will now read Stata 118 type files. (GH9882)
- `msgpack` submodule has been updated to 0.4.6 with backward compatibility (GH10581)
- `DataFrame.to_dict` now accepts `orient='index'` keyword argument (GH10844).
- `DataFrame.apply` will return a Series of dicts if the passed function returns a dict and `reduce=True` (GH8735).
- Allow passing *kwargs* to the interpolation methods (GH10378).
- Improved error message when concatenating an empty iterable of `Dataframe` objects (GH9157)
- `pd.read_csv` can now read bz2-compressed files incrementally, and the C parser can read bz2-compressed files from AWS S3 (GH11070, GH11072).
- In `pd.read_csv`, recognize `s3n://` and `s3a://` URLs as designating S3 file storage (GH11070, GH11071).
- Read CSV files from AWS S3 incrementally, instead of first downloading the entire file. (Full file download still required for compressed files in Python 2.) (GH11070, GH11073)
- `pd.read_csv` is now able to infer compression type for files read from AWS S3 storage (GH11070, GH11074).

1.11.2 Backwards incompatible API changes

1.11.2.1 Changes to sorting API

The sorting API has had some longtime inconsistencies. (GH9816, GH8239).

Here is a summary of the API **PRIOR** to 0.17.0:

- `Series.sort` is **INPLACE** while `DataFrame.sort` returns a new object.
- `Series.order` returns a new object
- It was possible to use `Series/DataFrame.sort_index` to sort by **values** by passing the `by` keyword.
- `Series/DataFrame.sortlevel` worked only on a `MultiIndex` for sorting by index.

To address these issues, we have revamped the API:

- We have introduced a new method, `DataFrame.sort_values()`, which is the merger of `DataFrame.sort()`, `Series.sort()`, and `Series.order()`, to handle sorting of **values**.
- The existing methods `Series.sort()`, `Series.order()`, and `DataFrame.sort()` have been deprecated and will be removed in a future version.
- The `by` argument of `DataFrame.sort_index()` has been deprecated and will be removed in a future version.
- The existing method `.sort_index()` will gain the `level` keyword to enable level sorting.

We now have two distinct and non-overlapping methods of sorting. A * marks items that will show a `FutureWarning`.

To sort by the **values**:

Previous	Replacement
* `Series.order()`	`Series.sort_values()`
* `Series.sort()`	`Series.sort_values(inplace=True)`
* `DataFrame.sort(columns=...)`	`DataFrame.sort_values(by=...)`

To sort by the **index**:

Previous	Replacement
`Series.sort_index()`	`Series.sort_index()`
`Series.sortlevel(level=...)`	`Series.sort_index(level=...)`
`DataFrame.sort_index()`	`DataFrame.sort_index()`
`DataFrame.sortlevel(level=...)`	`DataFrame.sort_index(level=...)`
* `DataFrame.sort()`	`DataFrame.sort_index()`

We have also deprecated and changed similar methods in two Series-like classes, `Index` and `Categorical`.

Previous	Replacement
* `Index.order()`	`Index.sort_values()`
* `Categorical.order()`	`Categorical.sort_values()`

1.11.2.2 Changes to to_datetime and to_timedelta

Error handling

The default for `pd.to_datetime` error handling has changed to `errors='raise'`. In prior versions it was `errors='ignore'`. Furthermore, the `coerce` argument has been deprecated in favor of `errors='coerce'`. This means that invalid parsing will raise rather that return the original input as in previous versions. (GH10636)

Previous Behavior:

```
In [2]: pd.to_datetime(['2009-07-31', 'asd'])
Out[2]: array(['2009-07-31', 'asd'], dtype=object)
```

New Behavior:

```
In [3]: pd.to_datetime(['2009-07-31', 'asd'])
ValueError: Unknown string format
```

Of course you can coerce this as well.

```
In [61]: to_datetime(['2009-07-31', 'asd'], errors='coerce')
Out[61]: DatetimeIndex(['2009-07-31', 'NaT'], dtype='datetime64[ns]', freq=None)
```

To keep the previous behavior, you can use `errors='ignore'`:

```
In [62]: to_datetime(['2009-07-31', 'asd'], errors='ignore')
Out[62]: array(['2009-07-31', 'asd'], dtype=object)
```

Furthermore, `pd.to_timedelta` has gained a similar API, of `errors='raise'|'ignore'|'coerce'`, and the `coerce` keyword has been deprecated in favor of `errors='coerce'`.

Consistent Parsing

The string parsing of `to_datetime`, `Timestamp` and `DatetimeIndex` has been made consistent. (GH7599)

Prior to v0.17.0, `Timestamp` and `to_datetime` may parse year-only datetime-string incorrectly using today's date, otherwise `DatetimeIndex` uses the beginning of the year. `Timestamp` and `to_datetime` may raise `ValueError` in some types of datetime-string which `DatetimeIndex` can parse, such as a quarterly string.

Previous Behavior:

```
In [1]: Timestamp('2012Q2')
Traceback
   ...
ValueError: Unable to parse 2012Q2

# Results in today's date.
In [2]: Timestamp('2014')
Out [2]: 2014-08-12 00:00:00
```

v0.17.0 can parse them as below. It works on `DatetimeIndex` also.

New Behavior:

```
In [63]: Timestamp('2012Q2')
Out[63]: Timestamp('2012-04-01 00:00:00')

In [64]: Timestamp('2014')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[64]: Timestamp('2014-01-01 00:00:00')

In [65]: DatetimeIndex(['2012Q2', '2014'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[65]:␣
↪DatetimeIndex(['2012-04-01', '2014-01-01'], dtype='datetime64[ns]', freq=None)
```

Note: If you want to perform calculations based on today's date, use `Timestamp.now()` and `pandas.tseries.offsets`.

```
In [66]: import pandas.tseries.offsets as offsets

In [67]: Timestamp.now()
Out[67]: Timestamp('2017-10-27 10:37:30.766906')

In [68]: Timestamp.now() + offsets.DateOffset(years=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[68]: Timestamp('2018-10-27␣
↪10:37:30.768416')
```

1.11.2.3 Changes to Index Comparisons

Operator equal on `Index` should behavior similarly to `Series` (GH9947, GH10637)

Starting in v0.17.0, comparing `Index` objects of different lengths will raise a `ValueError`. This is to be consistent with the behavior of `Series`.

Previous Behavior:

```
In [2]: pd.Index([1, 2, 3]) == pd.Index([1, 4, 5])
Out[2]: array([ True, False, False], dtype=bool)
```

```
In [3]: pd.Index([1, 2, 3]) == pd.Index([2])
Out[3]: array([False,  True, False], dtype=bool)

In [4]: pd.Index([1, 2, 3]) == pd.Index([1, 2])
Out[4]: False
```

New Behavior:

```
In [8]: pd.Index([1, 2, 3]) == pd.Index([1, 4, 5])
Out[8]: array([ True, False, False], dtype=bool)

In [9]: pd.Index([1, 2, 3]) == pd.Index([2])
ValueError: Lengths must match to compare

In [10]: pd.Index([1, 2, 3]) == pd.Index([1, 2])
ValueError: Lengths must match to compare
```

Note that this is different from the `numpy` behavior where a comparison can be broadcast:

```
In [69]: np.array([1, 2, 3]) == np.array([1])
Out[69]: array([ True, False, False], dtype=bool)
```

or it can return False if broadcasting can not be done:

```
In [70]: np.array([1, 2, 3]) == np.array([1, 2])
Out[70]: False
```

1.11.2.4 Changes to Boolean Comparisons vs. None

Boolean comparisons of a `Series` vs `None` will now be equivalent to comparing with `np.nan`, rather than raise `TypeError`. (GH1079).

```
In [71]: s = Series(range(3))

In [72]: s.iloc[1] = None

In [73]: s
Out[73]:
0    0.0
1    NaN
2    2.0
dtype: float64
```

Previous Behavior:

```
In [5]: s==None
TypeError: Could not compare <type 'NoneType'> type with Series
```

New Behavior:

```
In [74]: s==None
Out[74]:
0    False
1    False
```

```
2    False
dtype: bool
```

Usually you simply want to know which values are null.

```
In [75]: s.isnull()
Out[75]:
0    False
1     True
2    False
dtype: bool
```

Warning: You generally will want to use `isnull/notnull` for these types of comparisons, as `isnull/notnull` tells you which elements are null. One has to be mindful that `nan's` don't compare equal, but `None's` do. Note that Pandas/numpy uses the fact that `np.nan != np.nan`, and treats `None` like `np.nan`.

```
In [76]: None == None
Out[76]: True

In [77]: np.nan == np.nan
\\\\\\\\\\\\\\Out[77]: False
```

1.11.2.5 HDFStore dropna behavior

The default behavior for HDFStore write functions with `format='table'` is now to keep rows that are all missing. Previously, the behavior was to drop rows that were all missing save the index. The previous behavior can be replicated using the `dropna=True` option. (GH9382)

Previous Behavior:

```
In [78]: df_with_missing = pd.DataFrame({'col1':[0, np.nan, 2],
   ....:                                 'col2':[1, np.nan, np.nan]})
   ....:

In [79]: df_with_missing
Out[79]:
   col1  col2
0   0.0   1.0
1   NaN   NaN
2   2.0   NaN
```

```
In [27]:
df_with_missing.to_hdf('file.h5',
                       'df_with_missing',
                       format='table',
                       mode='w')

In [28]: pd.read_hdf('file.h5', 'df_with_missing')

Out [28]:
      col1  col2
  0     0     1
  2     2   NaN
```

New Behavior:

```
In [80]: df_with_missing.to_hdf('file.h5',
   ....:                        'df_with_missing',
   ....:                         format='table',
   ....:                         mode='w')
   ....:

In [81]: pd.read_hdf('file.h5', 'df_with_missing')
Out[81]:
   col1  col2
0   0.0   1.0
1   NaN   NaN
2   2.0   NaN
```

See the *docs* for more details.

1.11.2.6 Changes to `display.precision` option

The `display.precision` option has been clarified to refer to decimal places (GH10451).

Earlier versions of pandas would format floating point numbers to have one less decimal place than the value in `display.precision`.

```
In [1]: pd.set_option('display.precision', 2)

In [2]: pd.DataFrame({'x': [123.456789]})
Out[2]:
       x
0  123.5
```

If interpreting precision as "significant figures" this did work for scientific notation but that same interpretation did not work for values with standard formatting. It was also out of step with how numpy handles formatting.

Going forward the value of `display.precision` will directly control the number of places after the decimal, for regular formatting as well as scientific notation, similar to how numpy's `precision` print option works.

```
In [82]: pd.set_option('display.precision', 2)

In [83]: pd.DataFrame({'x': [123.456789]})
Out[83]:
        x
0  123.46
```

To preserve output behavior with prior versions the default value of `display.precision` has been reduced to `6` from `7`.

1.11.2.7 Changes to `Categorical.unique`

`Categorical.unique` now returns new `Categoricals` with `categories` and `codes` that are unique, rather than returning `np.array` (GH10508)

- unordered category: values and categories are sorted by appearance order.
- ordered category: values are sorted by appearance order, categories keep existing order.

```
In [84]: cat = pd.Categorical(['C', 'A', 'B', 'C'],
   ....:                      categories=['A', 'B', 'C'],
   ....:                      ordered=True)
   ....:

In [85]: cat
Out[85]:
[C, A, B, C]
Categories (3, object): [A < B < C]

In [86]: cat.unique()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[86]:
[C, A, B]
Categories (3, object): [A < B < C]

In [87]: cat = pd.Categorical(['C', 'A', 'B', 'C'],
   ....:                      categories=['A', 'B', 'C'])
   ....:

In [88]: cat
Out[88]:
[C, A, B, C]
Categories (3, object): [A, B, C]

In [89]: cat.unique()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[89]:
[C, A, B]
Categories (3, object): [C, A, B]
```

1.11.2.8 Changes to `bool` passed as `header` in Parsers

In earlier versions of pandas, if a bool was passed the `header` argument of `read_csv`, `read_excel`, or `read_html` it was implicitly converted to an integer, resulting in `header=0` for `False` and `header=1` for `True` (GH6113)

A `bool` input to `header` will now raise a `TypeError`

```
In [29]: df = pd.read_csv('data.csv', header=False)
TypeError: Passing a bool to header is invalid. Use header=None for no header or
header=int or list-like of ints to specify the row(s) making up the column names
```

1.11.2.9 Other API Changes

- Line and kde plot with `subplots=True` now uses default colors, not all black. Specify `color='k'` to draw all lines in black (GH9894)
- Calling the `.value_counts()` method on a Series with a `categorical` dtype now returns a Series with a `CategoricalIndex` (GH10704)
- The metadata properties of subclasses of pandas objects will now be serialized (GH10553).
- `groupby` using `Categorical` follows the same rule as `Categorical.unique` described above (GH10508)
- When constructing `DataFrame` with an array of `complex64` dtype previously meant the corresponding column was automatically promoted to the `complex128` dtype. Pandas will now preserve the itemsize of the

input for complex data (GH10952)

- some numeric reduction operators would return `ValueError`, rather than `TypeError` on object types that includes strings and numbers (GH11131)
- Passing currently unsupported `chunksize` argument to `read_excel` or `ExcelFile.parse` will now raise `NotImplementedError` (GH8011)
- Allow an `ExcelFile` object to be passed into `read_excel` (GH11198)
- `DatetimeIndex.union` does not infer `freq` if `self` and the input have `None` as `freq` (GH11086)
- `NaT`'s methods now either raise `ValueError`, or return `np.nan` or `NaT` (GH9513)

Behavior	Methods
return `np.nan`	`weekday`, `isoweekday`
return `NaT`	`date`, `now`, `replace`, `to_datetime`, `today`
return `np.datetime64('NaT')`	`to_datetime64` (unchanged)
raise `ValueError`	All other public methods (names not beginning with underscores)

1.11.2.10 Deprecations

- For `Series` the following indexing functions are deprecated (GH10177).

Deprecated Function	Replacement
`.irow(i)`	`.iloc[i]` or `.iat[i]`
`.iget(i)`	`.iloc[i]` or `.iat[i]`
`.iget_value(i)`	`.iloc[i]` or `.iat[i]`

- For `DataFrame` the following indexing functions are deprecated (GH10177).

Deprecated Function	Replacement
`.irow(i)`	`.iloc[i]`
`.iget_value(i, j)`	`.iloc[i, j]` or `.iat[i, j]`
`.icol(j)`	`.iloc[:, j]`

Note: These indexing function have been deprecated in the documentation since 0.11.0.

- `Categorical.name` was deprecated to make `Categorical` more `numpy.ndarray` like. Use `Series(cat, name="whatever")` instead (GH10482).
- Setting missing values (NaN) in a `Categorical`'s `categories` will issue a warning (GH10748). You can still have missing values in the `values`.
- `drop_duplicates` and `duplicated`'s `take_last` keyword was deprecated in favor of `keep`. (GH6511, GH8505)
- `Series.nsmallest` and `nlargest`'s `take_last` keyword was deprecated in favor of `keep`. (GH10792)
- `DataFrame.combineAdd` and `DataFrame.combineMult` are deprecated. They can easily be replaced by using the `add` and `mul` methods: `DataFrame.add(other, fill_value=0)` and `DataFrame.mul(other, fill_value=1.)` (GH10735).
- `TimeSeries` deprecated in favor of `Series` (note that this has been an alias since 0.13.0), (GH10890)
- `SparsePanel` deprecated and will be removed in a future version (GH11157).
- `Series.is_time_series` deprecated in favor of `Series.index.is_all_dates` (GH11135)
- Legacy offsets (like `'A@JAN'`) are deprecated (note that this has been alias since 0.8.0) (GH10878)

- `WidePanel` deprecated in favor of `Panel`, `LongPanel` in favor of `DataFrame` (note these have been aliases since < 0.11.0), (GH10892)
- `DataFrame.convert_objects` has been deprecated in favor of type-specific functions `pd.to_datetime`, `pd.to_timestamp` and `pd.to_numeric` (new in 0.17.0) (GH11133).

1.11.2.11 Removal of prior version deprecations/changes

- Removal of `na_last` parameters from `Series.order()` and `Series.sort()`, in favor of `na_position`. (GH5231)
- Remove of `percentile_width` from `.describe()`, in favor of `percentiles`. (GH7088)
- Removal of `colSpace` parameter from `DataFrame.to_string()`, in favor of `col_space`, circa 0.8.0 version.
- Removal of automatic time-series broadcasting (GH2304)

```
In [90]: np.random.seed(1234)

In [91]: df = DataFrame(np.random.randn(5,2),columns=list('AB'),index=date_range(
↪'20130101',periods=5))

In [92]: df
Out[92]:
                   A         B
2013-01-01  0.471435 -1.190976
2013-01-02  1.432707 -0.312652
2013-01-03 -0.720589  0.887163
2013-01-04  0.859588 -0.636524
2013-01-05  0.015696 -2.242685
```

Previously

```
In [3]: df + df.A
FutureWarning: TimeSeries broadcasting along DataFrame index by default is␣
↪deprecated.
Please use DataFrame.<op> to explicitly broadcast arithmetic operations along the␣
↪index

Out[3]:
                    A         B
2013-01-01  0.942870 -0.719541
2013-01-02  2.865414  1.120055
2013-01-03 -1.441177  0.166574
2013-01-04  1.719177  0.223065
2013-01-05  0.031393 -2.226989
```

Current

```
In [93]: df.add(df.A,axis='index')
Out[93]:
                   A         B
2013-01-01  0.942870 -0.719541
2013-01-02  2.865414  1.120055
2013-01-03 -1.441177  0.166574
2013-01-04  1.719177  0.223065
2013-01-05  0.031393 -2.226989
```

- Remove `table` keyword in `HDFStore.put/append`, in favor of using `format=` (GH4645)
- Remove `kind` in `read_excel/ExcelFile` as its unused (GH4712)
- Remove `infer_type` keyword from `pd.read_html` as its unused (GH4770, GH7032)
- Remove `offset` and `timeRule` keywords from `Series.tshift/shift`, in favor of `freq` (GH4853, GH4864)
- Remove `pd.load/pd.save` aliases in favor of `pd.to_pickle/pd.read_pickle` (GH3787)

1.11.3 Performance Improvements

- Development support for benchmarking with the Air Speed Velocity library (GH8361)
- Added vbench benchmarks for alternative ExcelWriter engines and reading Excel files (GH7171)
- Performance improvements in `Categorical.value_counts` (GH10804)
- Performance improvements in `SeriesGroupBy.nunique` and `SeriesGroupBy.value_counts` and `SeriesGroupby.transform` (GH10820, GH11077)
- Performance improvements in `DataFrame.drop_duplicates` with integer dtypes (GH10917)
- Performance improvements in `DataFrame.duplicated` with wide frames. (GH10161, GH11180)
- 4x improvement in `timedelta` string parsing (GH6755, GH10426)
- 8x improvement in `timedelta64` and `datetime64` ops (GH6755)
- Significantly improved performance of indexing `MultiIndex` with slicers (GH10287)
- 8x improvement in `iloc` using list-like input (GH10791)
- Improved performance of `Series.isin` for datetimelike/integer Series (GH10287)
- 20x improvement in `concat` of Categoricals when categories are identical (GH10587)
- Improved performance of `to_datetime` when specified format string is ISO8601 (GH10178)
- 2x improvement of `Series.value_counts` for float dtype (GH10821)
- Enable `infer_datetime_format` in `to_datetime` when date components do not have 0 padding (GH11142)
- Regression from 0.16.1 in constructing `DataFrame` from nested dictionary (GH11084)
- Performance improvements in addition/subtraction operations for `DateOffset` with `Series` or `DatetimeIndex` (GH10744, GH11205)

1.11.4 Bug Fixes

- Bug in incorrection computation of `.mean()` on `timedelta64[ns]` because of overflow (GH9442)
- Bug in `.isin` on older numpies (:issue: *11232*)
- Bug in `DataFrame.to_html(index=False)` renders unnecessary `name` row (GH10344)
- Bug in `DataFrame.to_latex()` the `column_format` argument could not be passed (GH9402)
- Bug in `DatetimeIndex` when localizing with `NaT` (GH10477)
- Bug in `Series.dt` ops in preserving meta-data (GH10477)
- Bug in preserving `NaT` when passed in an otherwise invalid `to_datetime` construction (GH10477)

- Bug in `DataFrame.apply` when function returns categorical series. (GH9573)
- Bug in `to_datetime` with invalid dates and formats supplied (GH10154)
- Bug in `Index.drop_duplicates` dropping name(s) (GH10115)
- Bug in `Series.quantile` dropping name (GH10881)
- Bug in `pd.Series` when setting a value on an empty `Series` whose index has a frequency. (GH10193)
- Bug in `pd.Series.interpolate` with invalid `order` keyword values. (GH10633)
- Bug in `DataFrame.plot` raises `ValueError` when color name is specified by multiple characters (GH10387)
- Bug in `Index` construction with a mixed list of tuples (GH10697)
- Bug in `DataFrame.reset_index` when index contains `NaT`. (GH10388)
- Bug in `ExcelReader` when worksheet is empty (GH6403)
- Bug in `BinGrouper.group_info` where returned values are not compatible with base class (GH10914)
- Bug in clearing the cache on `DataFrame.pop` and a subsequent inplace op (GH10912)
- Bug in indexing with a mixed-integer `Index` causing an `ImportError` (GH10610)
- Bug in `Series.count` when index has nulls (GH10946)
- Bug in pickling of a non-regular freq `DatetimeIndex` (GH11002)
- Bug causing `DataFrame.where` to not respect the `axis` parameter when the frame has a symmetric shape. (GH9736)
- Bug in `Table.select_column` where name is not preserved (GH10392)
- Bug in `offsets.generate_range` where `start` and `end` have finer precision than `offset` (GH9907)
- Bug in `pd.rolling_*` where `Series.name` would be lost in the output (GH10565)
- Bug in `stack` when index or columns are not unique. (GH10417)
- Bug in setting a `Panel` when an axis has a multi-index (GH10360)
- Bug in `USFederalHolidayCalendar` where `USMemorialDay` and `USMartinLutherKingJr` were incorrect (GH10278 and GH9760)
- Bug in `.sample()` where returned object, if set, gives unnecessary `SettingWithCopyWarning` (GH10738)
- Bug in `.sample()` where weights passed as `Series` were not aligned along axis before being treated positionally, potentially causing problems if weight indices were not aligned with sampled object. (GH10738)
- Regression fixed in (GH9311, GH6620, GH9345), where groupby with a datetime-like converting to float with certain aggregators (GH10979)
- Bug in `DataFrame.interpolate` with `axis=1` and `inplace=True` (GH10395)
- Bug in `io.sql.get_schema` when specifying multiple columns as primary key (GH10385).
- Bug in `groupby(sort=False)` with datetime-like `Categorical` raises `ValueError` (GH10505)
- Bug in `groupby(axis=1)` with `filter()` throws `IndexError` (GH11041)
- Bug in `test_categorical` on big-endian builds (GH10425)
- Bug in `Series.shift` and `DataFrame.shift` not supporting categorical data (GH9416)
- Bug in `Series.map` using categorical `Series` raises `AttributeError` (GH10324)

- Bug in `MultiIndex.get_level_values` including `Categorical` raises `AttributeError` (GH10460)
- Bug in `pd.get_dummies` with `sparse=True` not returning `SparseDataFrame` (GH10531)
- Bug in `Index` subtypes (such as `PeriodIndex`) not returning their own type for `.drop` and `.insert` methods (GH10620)
- Bug in `algos.outer_join_indexer` when `right` array is empty (GH10618)
- Bug in `filter` (regression from 0.16.0) and `transform` when grouping on multiple keys, one of which is datetime-like (GH10114)
- Bug in `to_datetime` and `to_timedelta` causing `Index` name to be lost (GH10875)
- Bug in `len(DataFrame.groupby)` causing `IndexError` when there's a column containing only NaNs (:issue: *11016*)
- Bug that caused segfault when resampling an empty Series (GH10228)
- Bug in `DatetimeIndex` and `PeriodIndex.value_counts` resets name from its result, but retains in result's `Index`. (GH10150)
- Bug in `pd.eval` using `numexpr` engine coerces 1 element numpy array to scalar (GH10546)
- Bug in `pd.concat` with `axis=0` when column is of dtype `category` (GH10177)
- Bug in `read_msgpack` where input type is not always checked (GH10369, GH10630)
- Bug in `pd.read_csv` with kwargs `index_col=False`, `index_col=['a', 'b']` or `dtype` (GH10413, GH10467, GH10577)
- Bug in `Series.from_csv` with `header` kwarg not setting the `Series.name` or the `Series.index.name` (GH10483)
- Bug in `groupby.var` which caused variance to be inaccurate for small float values (GH10448)
- Bug in `Series.plot(kind='hist')` Y Label not informative (GH10485)
- Bug in `read_csv` when using a converter which generates a `uint8` type (GH9266)
- Bug causes memory leak in time-series line and area plot (GH9003)
- Bug when setting a `Panel` sliced along the major or minor axes when the right-hand side is a `DataFrame` (GH11014)
- Bug that returns `None` and does not raise `NotImplementedError` when operator functions (e.g. `.add`) of `Panel` are not implemented (GH7692)
- Bug in line and kde plot cannot accept multiple colors when `subplots=True` (GH9894)
- Bug in `DataFrame.plot` raises `ValueError` when color name is specified by multiple characters (GH10387)
- Bug in left and right `align` of `Series` with `MultiIndex` may be inverted (GH10665)
- Bug in left and right `join` of with `MultiIndex` may be inverted (GH10741)
- Bug in `read_stata` when reading a file with a different order set in `columns` (GH10757)
- Bug in `Categorical` may not representing properly when category contains `tz` or `Period` (GH10713)
- Bug in `Categorical.__iter__` may not returning correct `datetime` and `Period` (GH10713)
- Bug in indexing with a `PeriodIndex` on an object with a `PeriodIndex` (GH4125)
- Bug in `read_csv` with `engine='c'`: EOF preceded by a comment, blank line, etc. was not handled correctly (GH10728, GH10548)

- Reading "famafrench" data via `DataReader` results in HTTP 404 error because of the website url is changed (GH10591).
- Bug in `read_msgpack` where DataFrame to decode has duplicate column names (GH9618)
- Bug in `io.common.get_filepath_or_buffer` which caused reading of valid S3 files to fail if the bucket also contained keys for which the user does not have read permission (GH10604)
- Bug in vectorised setting of timestamp columns with python `datetime.date` and numpy `datetime64` (GH10408, GH10412)
- Bug in `Index.take` may add unnecessary `freq` attribute (GH10791)
- Bug in `merge` with empty `DataFrame` may raise `IndexError` (GH10824)
- Bug in `to_latex` where unexpected keyword argument for some documented arguments (GH10888)
- Bug in indexing of large `DataFrame` where `IndexError` is uncaught (GH10645 and GH10692)
- Bug in `read_csv` when using the `nrows` or `chunksize` parameters if file contains only a header line (GH9535)
- Bug in serialization of `category` types in HDF5 in presence of alternate encodings. (GH10366)
- Bug in `pd.DataFrame` when constructing an empty DataFrame with a string dtype (GH9428)
- Bug in `pd.DataFrame.diff` when DataFrame is not consolidated (GH10907)
- Bug in `pd.unique` for arrays with the `datetime64` or `timedelta64` dtype that meant an array with object dtype was returned instead the original dtype (GH9431)
- Bug in `Timedelta` raising error when slicing from 0s (GH10583)
- Bug in `DatetimeIndex.take` and `TimedeltaIndex.take` may not raise `IndexError` against invalid index (GH10295)
- Bug in `Series([np.nan]).astype('M8[ms]')`, which now returns `Series([pd.NaT])` (GH10747)
- Bug in `PeriodIndex.order` reset freq (GH10295)
- Bug in `date_range` when `freq` divides `end` as nanos (GH10885)
- Bug in `iloc` allowing memory outside bounds of a Series to be accessed with negative integers (GH10779)
- Bug in `read_msgpack` where encoding is not respected (GH10581)
- Bug preventing access to the first index when using `iloc` with a list containing the appropriate negative integer (GH10547, GH10779)
- Bug in `TimedeltaIndex` formatter causing error while trying to save `DataFrame` with `TimedeltaIndex` using `to_csv` (GH10833)
- Bug in `DataFrame.where` when handling Series slicing (GH10218, GH9558)
- Bug where `pd.read_gbq` throws `ValueError` when Bigquery returns zero rows (GH10273)
- Bug in `to_json` which was causing segmentation fault when serializing 0-rank ndarray (GH9576)
- Bug in plotting functions may raise `IndexError` when plotted on `GridSpec` (GH10819)
- Bug in plot result may show unnecessary minor ticklabels (GH10657)
- Bug in `groupby` incorrect computation for aggregation on `DataFrame` with `NaT` (E.g `first`, `last`, `min`). (GH10590, GH11010)
- Bug when constructing `DataFrame` where passing a dictionary with only scalar values and specifying columns did not raise an error (GH10856)

- Bug in `.var()` causing roundoff errors for highly similar values (GH10242)
- Bug in `DataFrame.plot(subplots=True)` with duplicated columns outputs incorrect result (GH10962)
- Bug in `Index` arithmetic may result in incorrect class (GH10638)
- Bug in `date_range` results in empty if freq is negative annualy, quarterly and monthly (GH11018)
- Bug in `DatetimeIndex` cannot infer negative freq (GH11018)
- Remove use of some deprecated numpy comparison operations, mainly in tests. (GH10569)
- Bug in `Index` dtype may not applied properly (GH11017)
- Bug in `io.gbq` when testing for minimum google api client version (GH10652)
- Bug in `DataFrame` construction from nested `dict` with `timedelta` keys (GH11129)
- Bug in `.fillna` against may raise `TypeError` when data contains datetime dtype (GH7095, GH11153)
- Bug in `.groupby` when number of keys to group by is same as length of index (GH11185)
- Bug in `convert_objects` where converted values might not be returned if all null and `coerce` (GH9589)
- Bug in `convert_objects` where `copy` keyword was not respected (GH9589)

1.12 v0.16.2 (June 12, 2015)

This is a minor bug-fix release from 0.16.1 and includes a a large number of bug fixes along some new features (`pipe()` method), enhancements, and performance improvements.

We recommend that all users upgrade to this version.

Highlights include:

- A new `pipe` method, see *here*
- Documentation on how to use numba with *pandas*, see *here*

What's new in v0.16.2

1.12.1 New features

1.12.1.1 Pipe

We've introduced a new method `DataFrame.pipe()`. As suggested by the name, `pipe` should be used to pipe data through a chain of function calls. The goal is to avoid confusing nested function calls like

```
# df is a DataFrame
# f, g, and h are functions that take and return DataFrames
f(g(h(df), arg1=1), arg2=2, arg3=3)
```

The logic flows from inside out, and function names are separated from their keyword arguments. This can be rewritten as

```
(df.pipe(h)
   .pipe(g, arg1=1)
   .pipe(f, arg2=2, arg3=3)
)
```

Now both the code and the logic flow from top to bottom. Keyword arguments are next to their functions. Overall the code is much more readable.

In the example above, the functions `f`, `g`, and `h` each expected the DataFrame as the first positional argument. When the function you wish to apply takes its data anywhere other than the first argument, pass a tuple of `(function, keyword)` indicating where the DataFrame should flow. For example:

```
In [1]: import statsmodels.formula.api as sm

In [2]: bb = pd.read_csv('data/baseball.csv', index_col='id')

# sm.poisson takes (formula, data)
In [3]: (bb.query('h > 0')
   ...:    .assign(ln_h = lambda df: np.log(df.h))
   ...:    .pipe((sm.poisson, 'data'), 'hr ~ ln_h + year + g + C(lg)')
   ...:    .fit()
   ...:    .summary()
   ...: )
   ...:
Optimization terminated successfully.
         Current function value: 2.116284
         Iterations 24
Out[3]:
<class 'statsmodels.iolib.summary.Summary'>
"""
                          Poisson Regression Results
==============================================================================
Dep. Variable:                     hr   No. Observations:                   68
Model:                        Poisson   Df Residuals:                       63
Method:                           MLE   Df Model:                            4
Date:                Fri, 27 Oct 2017   Pseudo R-squ.:                  0.6878
Time:                        10:37:31   Log-Likelihood:                -143.91
converged:                       True   LL-Null:                       -460.91
                                        LLR p-value:                 6.774e-136
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept  -1267.3636    457.867     -2.768      0.006   -2164.767    -369.960
C(lg)[T.NL]   -0.2057      0.101     -2.044      0.041      -0.403      -0.008
ln_h           0.9280      0.191      4.866      0.000       0.554       1.302
year           0.6301      0.228      2.762      0.006       0.183       1.077
g              0.0099      0.004      2.754      0.006       0.003       0.017
==============================================================================
"""
```

The pipe method is inspired by unix pipes, which stream text through processes. More recently dplyr and magrittr

have introduced the popular `(%>%)` pipe operator for R.

See the *documentation* for more. (GH10129)

1.12.1.2 Other Enhancements

- Added *rsplit* to Index/Series StringMethods (GH10303)
- Removed the hard-coded size limits on the `DataFrame` HTML representation in the IPython notebook, and leave this to IPython itself (only for IPython v3.0 or greater). This eliminates the duplicate scroll bars that appeared in the notebook with large frames (GH10231).

  Note that the notebook has a `toggle output scrolling` feature to limit the display of very large frames (by clicking left of the output). You can also configure the way DataFrames are displayed using the pandas options, see here *here*.
- `axis` parameter of `DataFrame.quantile` now accepts also `index` and `column`. (GH9543)

1.12.2 API Changes

- `Holiday` now raises `NotImplementedError` if both `offset` and `observance` are used in the constructor instead of returning an incorrect result (GH10217).

1.12.3 Performance Improvements

- Improved `Series.resample` performance with `dtype=datetime64[ns]` (GH7754)
- Increase performance of `str.split` when `expand=True` (GH10081)

1.12.4 Bug Fixes

- Bug in `Series.hist` raises an error when a one row `Series` was given (GH10214)
- Bug where `HDFStore.select` modifies the passed columns list (GH7212)
- Bug in `Categorical` repr with `display.width` of `None` in Python 3 (GH10087)
- Bug in `to_json` with certain orients and a `CategoricalIndex` would segfault (GH10317)
- Bug where some of the nan funcs do not have consistent return dtypes (GH10251)
- Bug in `DataFrame.quantile` on checking that a valid axis was passed (GH9543)
- Bug in `groupby.apply` aggregation for `Categorical` not preserving categories (GH10138)
- Bug in `to_csv` where `date_format` is ignored if the `datetime` is fractional (GH10209)
- Bug in `DataFrame.to_json` with mixed data types (GH10289)
- Bug in cache updating when consolidating (GH10264)
- Bug in `mean()` where integer dtypes can overflow (GH10172)
- Bug where `Panel.from_dict` does not set dtype when specified (GH10058)
- Bug in `Index.union` raises `AttributeError` when passing array-likes. (GH10149)
- Bug in `Timestamp`'s' `microsecond`, `quarter`, `dayofyear`, `week` and `daysinmonth` properties return `np.int` type, not built-in `int`. (GH10050)

- Bug in `NaT` raises `AttributeError` when accessing to `daysinmonth`, `dayofweek` properties. (GH10096)
- Bug in Index repr when using the `max_seq_items=None` setting (GH10182).
- Bug in getting timezone data with `dateutil` on various platforms (GH9059, GH8639, GH9663, GH10121)
- Bug in displaying datetimes with mixed frequencies; display 'ms' datetimes to the proper precision. (GH10170)
- Bug in `setitem` where type promotion is applied to the entire block (GH10280)
- Bug in `Series` arithmetic methods may incorrectly hold names (GH10068)
- Bug in `GroupBy.get_group` when grouping on multiple keys, one of which is categorical. (GH10132)
- Bug in `DatetimeIndex` and `TimedeltaIndex` names are lost after timedelta arithmetics (GH9926)
- Bug in `DataFrame` construction from nested `dict` with `datetime64` (GH10160)
- Bug in `Series` construction from `dict` with `datetime64` keys (GH9456)
- Bug in `Series.plot(label="LABEL")` not correctly setting the label (GH10119)
- Bug in `plot` not defaulting to matplotlib `axes.grid` setting (GH9792)
- Bug causing strings containing an exponent, but no decimal to be parsed as `int` instead of `float` in `engine='python'` for the `read_csv` parser (GH9565)
- Bug in `Series.align` resets `name` when `fill_value` is specified (GH10067)
- Bug in `read_csv` causing index name not to be set on an empty DataFrame (GH10184)
- Bug in `SparseSeries.abs` resets `name` (GH10241)
- Bug in `TimedeltaIndex` slicing may reset freq (GH10292)
- Bug in `GroupBy.get_group` raises `ValueError` when group key contains `NaT` (GH6992)
- Bug in `SparseSeries` constructor ignores input data name (GH10258)
- Bug in `Categorical.remove_categories` causing a `ValueError` when removing the `NaN` category if underlying dtype is floating-point (GH10156)
- Bug where infer_freq infers timerule (WOM-5XXX) unsupported by to_offset (GH9425)
- Bug in `DataFrame.to_hdf()` where table format would raise a seemingly unrelated error for invalid (non-string) column names. This is now explicitly forbidden. (GH9057)
- Bug to handle masking empty `DataFrame` (GH10126).
- Bug where MySQL interface could not handle numeric table/column names (GH10255)
- Bug in `read_csv` with a `date_parser` that returned a `datetime64` array of other time resolution than `[ns]` (GH10245)
- Bug in `Panel.apply` when the result has ndim=0 (GH10332)
- Bug in `read_hdf` where `auto_close` could not be passed (GH9327).
- Bug in `read_hdf` where open stores could not be used (GH10330).
- Bug in adding empty `DataFrame``s, now results in a ``DataFrame` that `.equals` an empty `DataFrame` (GH10181).
- Bug in `to_hdf` and `HDFStore` which did not check that complib choices were valid (GH4582, GH8874).

1.13 v0.16.1 (May 11, 2015)

This is a minor bug-fix release from 0.16.0 and includes a a large number of bug fixes along several new features, enhancements, and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

- Support for a `CategoricalIndex`, a category based index, see *here*
- New section on how-to-contribute to *pandas*, see *here*
- Revised "Merge, join, and concatenate" documentation, including graphical examples to make it easier to understand each operations, see *here*
- New method `sample` for drawing random samples from Series, DataFrames and Panels. See *here*
- The default `Index` printing has changed to a more uniform format, see *here*
- `BusinessHour` datetime-offset is now supported, see *here*
- Further enhancement to the `.str` accessor to make string operations easier, see *here*

What's new in v0.16.1

Warning: In pandas 0.17.0, the sub-package `pandas.io.data` will be removed in favor of a separately installable package. See *here for details* (GH8961)

1.13.1 Enhancements

1.13.1.1 CategoricalIndex

We introduce a `CategoricalIndex`, a new type of index object that is useful for supporting indexing with duplicates. This is a container around a `Categorical` (introduced in v0.15.0) and allows efficient indexing and storage of an index with a large number of duplicated elements. Prior to 0.16.1, setting the index of a `DataFrame/Series` with a `category` dtype would convert this to regular object-based `Index`.

```
In [1]: df = DataFrame({'A' : np.arange(6),
   ...:                 'B' : Series(list('aabbca')).astype('category',
   ...:                                                     categories=list('cab'))
   ...:                 })
   ...:

In [2]: df
Out[2]:
   A  B
0  0  a
1  1  a
2  2  b
3  3  b
4  4  c
5  5  a

In [3]: df.dtypes
Out[3]:
A       int64
B    category
dtype: object

In [4]: df.B.cat.categories
Out[4]: Index(['c', 'a', 'b'], dtype='object')
```

setting the index, will create create a `CategoricalIndex`

```
In [5]: df2 = df.set_index('B')

In [6]: df2.index
Out[6]: CategoricalIndex(['a', 'a', 'b', 'b', 'c', 'a'], categories=['c', 'a', 'b'],␣
↪ordered=False, name='B', dtype='category')
```

indexing with `__getitem__`/`.iloc`/`.loc`/`.ix` works similarly to an Index with duplicates. The indexers MUST be in the category or the operation will raise.

```
In [7]: df2.loc['a']
Out[7]:
   A
B
a  0
a  1
a  5
```

and preserves the `CategoricalIndex`

```
In [8]: df2.loc['a'].index
Out[8]: CategoricalIndex(['a', 'a', 'a'], categories=['c', 'a', 'b'], ordered=False,␣
↪name='B', dtype='category')
```

sorting will order by the order of the categories

```
In [9]: df2.sort_index()
Out[9]:
   A
B
c  4
a  0
```

```
a  1
a  5
b  2
b  3
```

groupby operations on the index will preserve the index nature as well

```
In [10]: df2.groupby(level=0).sum()
Out[10]:
   A
B
c  4
a  6
b  5

In [11]: df2.groupby(level=0).sum().index
Out[11]: CategoricalIndex(['c', 'a', 'b'], categories=['c', 'a', 'b'], ordered=False,␣
↪name='B', dtype='category')
```

reindexing operations, will return a resulting index based on the type of the passed indexer, meaning that passing a list will return a plain-old-`Index`; indexing with a `Categorical` will return a `CategoricalIndex`, indexed according to the categories of the PASSED `Categorical` dtype. This allows one to arbitrarly index these even with values NOT in the categories, similarly to how you can reindex ANY pandas index.

```
In [12]: df2.reindex(['a','e'])
Out[12]:
     A
B
a  0.0
a  1.0
a  5.0
e  NaN

In [13]: df2.reindex(['a','e']).index
Out[13]: Index(['a', 'a', 'a', 'e'], dtype='object', name='B')

In [14]: df2.reindex(pd.Categorical(['a','e'],categories=list('abcde')))
Out[14]:
     A
B
a  0.0
a  1.0
a  5.0
e  NaN

In [15]: df2.reindex(pd.Categorical(['a','e'],categories=list('abcde'))).index
Out[15]: CategoricalIndex(['a', 'a', 'a', 'e'], categories=['a', 'b', 'c', 'd', 'e'],␣
↪ordered=False, name='B', dtype='category')
```

See the *documentation* for more. (GH7629, GH10038, GH10039)

1.13.1.2 Sample

Series, DataFrames, and Panels now have a new method: `sample()`. The method accepts a specific number of rows or columns to return, or a fraction of the total number or rows or columns. It also has options for sampling with or without replacement, for passing in a column for weights for non-uniform sampling, and for setting seed values to

facilitate replication. (GH2419)

```
In [1]: example_series = Series([0,1,2,3,4,5])

# When no arguments are passed, returns 1
In [2]: example_series.sample()
Out[2]:
3    3
dtype: int64

# One may specify either a number of rows:
In [3]: example_series.sample(n=3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[3]:
5    5
1    1
4    4
dtype: int64

# Or a fraction of the rows:
In [4]: example_series.sample(frac=0.5)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[4]:
4    4
1    1
0    0
dtype: int64

# weights are accepted.
In [5]: example_weights = [0, 0, 0.2, 0.2, 0.2, 0.4]

In [6]: example_series.sample(n=3, weights=example_weights)
Out[6]:
2    2
3    3
5    5
dtype: int64

# weights will also be normalized if they do not sum to one,
# and missing values will be treated as zeros.
In [7]: example_weights2 = [0.5, 0, 0, 0, None, np.nan]

In [8]: example_series.sample(n=1, weights=example_weights2)
Out[8]:
0    0
dtype: int64
```

When applied to a DataFrame, one may pass the name of a column to specify sampling weights when sampling from rows.

```
In [9]: df = DataFrame({'col1':[9,8,7,6], 'weight_column':[0.5, 0.4, 0.1, 0]})

In [10]: df.sample(n=3, weights='weight_column')
Out[10]:
   col1  weight_column
0     9            0.5
1     8            0.4
2     7            0.1
```

1.13.1.3 String Methods Enhancements

Continuing from v0.16.0, the following enhancements make string operations easier and more consistent with standard python string operations.

- Added `StringMethods` (`.str` accessor) to `Index` (GH9068)

  The `.str` accessor is now available for both `Series` and `Index`.

  ```
  In [11]: idx = Index([' jack', 'jill ', ' jesse ', 'frank'])

  In [12]: idx.str.strip()
  Out[12]: Index(['jack', 'jill', 'jesse', 'frank'], dtype='object')
  ```

  One special case for the *.str* accessor on `Index` is that if a string method returns `bool`, the `.str` accessor will return a `np.array` instead of a boolean `Index` (GH8875). This enables the following expression to work naturally:

  ```
  In [13]: idx = Index(['a1', 'a2', 'b1', 'b2'])

  In [14]: s = Series(range(4), index=idx)

  In [15]: s
  Out[15]: 
  a1    0
  a2    1
  b1    2
  b2    3
  dtype: int64

  In [16]: idx.str.startswith('a')
  \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[16]: array([ True, ␣
  ↪True, False, False], dtype=bool)

  In [17]: s[s.index.str.startswith('a')]
  \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
  ↪
  a1    0
  a2    1
  dtype: int64
  ```

- The following new methods are accesible via `.str` accessor to apply the function to each values. (GH9766, GH9773, GH10031, GH10045, GH10052)

		Methods		
`capitalize()`	`swapcase()`	`normalize()`	`partition()`	`rpartition()`
`index()`	`rindex()`	`translate()`		

- `split` now takes `expand` keyword to specify whether to expand dimensionality. `return_type` is deprecated. (GH9847)

  ```
  In [18]: s = Series(['a,b', 'a,c', 'b,c'])

  # return Series
  In [19]: s.str.split(',')
  Out[19]: 
  0    [a, b]
  1    [a, c]
  2    [b, c]
  ```

```
dtype: object

# return DataFrame
In [20]: s.str.split(',', expand=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[20]:
   0  1
0  a  b
1  a  c
2  b  c

In [21]: idx = Index(['a,b', 'a,c', 'b,c'])

# return Index
In [22]: idx.str.split(',')
Out[22]: Index([['a', 'b'], ['a', 'c'], ['b', 'c']], dtype='object')

# return MultiIndex
In [23]: idx.str.split(',', expand=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[23]:
MultiIndex(levels=[['a', 'b'], ['b', 'c']],
           labels=[[0, 0, 1], [0, 1, 1]])
```

- Improved `extract` and `get_dummies` methods for `Index.str` (GH9980)

1.13.1.4 Other Enhancements

- `BusinessHour` offset is now supported, which represents business hours starting from 09:00 - 17:00 on `BusinessDay` by default. See *Here* for details. (GH7905)

```
In [24]: from pandas.tseries.offsets import BusinessHour

In [25]: Timestamp('2014-08-01 09:00') + BusinessHour()
Out[25]: Timestamp('2014-08-01 10:00:00')

In [26]: Timestamp('2014-08-01 07:00') + BusinessHour()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[26]: Timestamp('2014-08-01 10:00:00
↪')

In [27]: Timestamp('2014-08-01 16:30') + BusinessHour()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[27]:␣
↪Timestamp('2014-08-04 09:30:00')
```

- `DataFrame.diff` now takes an `axis` parameter that determines the direction of differencing (GH9727)
- Allow `clip`, `clip_lower`, and `clip_upper` to accept array-like arguments as thresholds (This is a regression from 0.11.0). These methods now have an `axis` parameter which determines how the Series or DataFrame will be aligned with the threshold(s). (GH6966)
- `DataFrame.mask()` and `Series.mask()` now support same keywords as `where` (GH8801)
- `drop` function can now accept `errors` keyword to suppress `ValueError` raised when any of label does not exist in the target data. (GH6736)

```
In [28]: df = DataFrame(np.random.randn(3, 3), columns=['A', 'B', 'C'])

In [29]: df.drop(['A', 'X'], axis=1, errors='ignore')
Out[29]:
```

```
          B         C
0  1.058969 -0.397840
1  1.047579  1.045938
2 -0.122092  0.124713
```

- Add support for separating years and quarters using dashes, for example 2014-Q1. (GH9688)
- Allow conversion of values with dtype `datetime64` or `timedelta64` to strings using `astype(str)` (GH9757)
- `get_dummies` function now accepts `sparse` keyword. If set to `True`, the return `DataFrame` is sparse, e.g. `SparseDataFrame`. (GH8823)
- `Period` now accepts `datetime64` as value input. (GH9054)
- Allow timedelta string conversion when leading zero is missing from time definition, ie *0:00:00* vs *00:00:00*. (GH9570)
- Allow `Panel.shift` with `axis='items'` (GH9890)
- Trying to write an excel file now raises `NotImplementedError` if the `DataFrame` has a `MultiIndex` instead of writing a broken Excel file. (GH9794)
- Allow `Categorical.add_categories` to accept `Series` or `np.array`. (GH9927)
- Add/delete `str/dt/cat` accessors dynamically from `__dir__`. (GH9910)
- Add `normalize` as a `dt` accessor method. (GH10047)
- `DataFrame` and `Series` now have `_constructor_expanddim` property as overridable constructor for one higher dimensionality data. This should be used only when it is really needed, see *here*
- `pd.lib.infer_dtype` now returns `'bytes'` in Python 3 where appropriate. (GH10032)

1.13.2 API changes

- When passing in an ax to `df.plot( ..., ax=ax)`, the *sharex* kwarg will now default to *False*. The result is that the visibility of xlabels and xticklabels will not anymore be changed. You have to do that by yourself for the right axes in your figure or set `sharex=True` explicitly (but this changes the visible for all axes in the figure, not only the one which is passed in!). If pandas creates the subplots itself (e.g. no passed in *ax* kwarg), then the default is still `sharex=True` and the visibility changes are applied.
- *`assign()`* now inserts new columns in alphabetical order. Previously the order was arbitrary. (GH9777)
- By default, `read_csv` and `read_table` will now try to infer the compression type based on the file extension. Set `compression=None` to restore the previous behavior (no decompression). (GH9770)

1.13.2.1 Deprecations

- `Series.str.split`'s `return_type` keyword was removed in favor of `expand` (GH9847)

1.13.3 Index Representation

The string representation of `Index` and its sub-classes have now been unified. These will show a single-line display if there are few values; a wrapped multi-line display for a lot of values (but less than `display.max_seq_items`; if lots of items (> `display.max_seq_items`) will show a truncated display (the head and tail of the data). The formatting for `MultiIndex` is unchanges (a multi-line wrapped display). The display width responds to the option `display.max_seq_items`, which is defaulted to 100. (GH6482)

Previous Behavior

```
In [2]: pd.Index(range(4),name='foo')
Out[2]: Int64Index([0, 1, 2, 3], dtype='int64')

In [3]: pd.Index(range(104),name='foo')
Out[3]: Int64Index([0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,␣
↪19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39,␣
↪40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60,␣
↪61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81,␣
↪82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, ...], dtype=
↪'int64')

In [4]: pd.date_range('20130101',periods=4,name='foo',tz='US/Eastern')
Out[4]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2013-01-01 00:00:00-05:00, ..., 2013-01-04 00:00:00-05:00]
Length: 4, Freq: D, Timezone: US/Eastern

In [5]: pd.date_range('20130101',periods=104,name='foo',tz='US/Eastern')
Out[5]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2013-01-01 00:00:00-05:00, ..., 2013-04-14 00:00:00-04:00]
Length: 104, Freq: D, Timezone: US/Eastern
```

New Behavior

```
In [30]: pd.set_option('display.width', 80)

In [31]: pd.Index(range(4), name='foo')
Out[31]: RangeIndex(start=0, stop=4, step=1, name='foo')

In [32]: pd.Index(range(30), name='foo')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[32]: RangeIndex(start=0,␣
↪stop=30, step=1, name='foo')

In [33]: pd.Index(range(104), name='foo')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪RangeIndex(start=0, stop=104, step=1, name='foo')

In [34]: pd.CategoricalIndex(['a','bb','ccc','dddd'], ordered=True, name='foobar')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪CategoricalIndex(['a', 'bb', 'ccc', 'dddd'], categories=['a', 'bb', 'ccc', 'dddd'],␣
↪ordered=True, name='foobar', dtype='category')

In [35]: pd.CategoricalIndex(['a','bb','ccc','dddd']*10, ordered=True, name='foobar')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
CategoricalIndex(['a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a',
                  'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb',
                  'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc',
                  'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd',
                  'a', 'bb', 'ccc', 'dddd'],
                 categories=['a', 'bb', 'ccc', 'dddd'], ordered=True, name='foobar',␣
↪dtype='category')

In [36]: pd.CategoricalIndex(['a','bb','ccc','dddd']*100, ordered=True, name='foobar')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
CategoricalIndex(['a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a',
                  'bb',
                  ...
                  'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc',
                  'dddd'],
                 categories=['a', 'bb', 'ccc', 'dddd'], ordered=True, name='foobar',␣
↪dtype='category', length=400)

In [37]: pd.date_range('20130101',periods=4, name='foo', tz='US/Eastern')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2013-01-01 00:00:00-05:00', '2013-01-02 00:00:00-05:00',
               '2013-01-03 00:00:00-05:00', '2013-01-04 00:00:00-05:00'],
              dtype='datetime64[ns, US/Eastern]', name='foo', freq='D')

In [38]: pd.date_range('20130101',periods=25, freq='D')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2013-01-01', '2013-01-02', '2013-01-03', '2013-01-04',
               '2013-01-05', '2013-01-06', '2013-01-07', '2013-01-08',
               '2013-01-09', '2013-01-10', '2013-01-11', '2013-01-12',
               '2013-01-13', '2013-01-14', '2013-01-15', '2013-01-16',
               '2013-01-17', '2013-01-18', '2013-01-19', '2013-01-20',
               '2013-01-21', '2013-01-22', '2013-01-23', '2013-01-24',
               '2013-01-25'],
              dtype='datetime64[ns]', freq='D')

In [39]: pd.date_range('20130101',periods=104, name='foo', tz='US/Eastern')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2013-01-01 00:00:00-05:00', '2013-01-02 00:00:00-05:00',
               '2013-01-03 00:00:00-05:00', '2013-01-04 00:00:00-05:00',
               '2013-01-05 00:00:00-05:00', '2013-01-06 00:00:00-05:00',
               '2013-01-07 00:00:00-05:00', '2013-01-08 00:00:00-05:00',
               '2013-01-09 00:00:00-05:00', '2013-01-10 00:00:00-05:00',
               ...
               '2013-04-05 00:00:00-04:00', '2013-04-06 00:00:00-04:00',
               '2013-04-07 00:00:00-04:00', '2013-04-08 00:00:00-04:00',
               '2013-04-09 00:00:00-04:00', '2013-04-10 00:00:00-04:00',
               '2013-04-11 00:00:00-04:00', '2013-04-12 00:00:00-04:00',
               '2013-04-13 00:00:00-04:00', '2013-04-14 00:00:00-04:00'],
              dtype='datetime64[ns, US/Eastern]', name='foo', length=104, freq='D')
```

1.13.4 Performance Improvements

- Improved csv write performance with mixed dtypes, including datetimes by up to 5x (GH9940)
- Improved csv write performance generally by 2x (GH9940)
- Improved the performance of `pd.lib.max_len_string_array` by 5-7x (GH10024)

1.13.5 Bug Fixes

- Bug where labels did not appear properly in the legend of `DataFrame.plot()`, passing `label=` arguments works, and Series indices are no longer mutated. (GH9542)

- Bug in json serialization causing a segfault when a frame had zero length. (GH9805)
- Bug in `read_csv` where missing trailing delimiters would cause segfault. (GH5664)
- Bug in retaining index name on appending (GH9862)
- Bug in `scatter_matrix` draws unexpected axis ticklabels (GH5662)
- Fixed bug in `StataWriter` resulting in changes to input `DataFrame` upon save (GH9795).
- Bug in `transform` causing length mismatch when null entries were present and a fast aggregator was being used (GH9697)
- Bug in `equals` causing false negatives when block order differed (GH9330)
- Bug in grouping with multiple `pd.Grouper` where one is non-time based (GH10063)
- Bug in `read_sql_table` error when reading postgres table with timezone (GH7139)
- Bug in `DataFrame` slicing may not retain metadata (GH9776)
- Bug where `TimdeltaIndex` were not properly serialized in fixed `HDFStore` (GH9635)
- Bug with `TimedeltaIndex` constructor ignoring `name` when given another `TimedeltaIndex` as data (GH10025).
- Bug in `DataFrameFormatter._get_formatted_index` with not applying `max_colwidth` to the `DataFrame` index (GH7856)
- Bug in `.loc` with a read-only ndarray data source (GH10043)
- Bug in `groupby.apply()` that would raise if a passed user defined function either returned only `None` (for all input). (GH9685)
- Always use temporary files in pytables tests (GH9992)
- Bug in plotting continuously using `secondary_y` may not show legend properly. (GH9610, GH9779)
- Bug in `DataFrame.plot(kind="hist")` results in `TypeError` when `DataFrame` contains non-numeric columns (GH9853)
- Bug where repeated plotting of `DataFrame` with a `DatetimeIndex` may raise `TypeError` (GH9852)
- Bug in `setup.py` that would allow an incompat cython version to build (GH9827)
- Bug in plotting `secondary_y` incorrectly attaches `right_ax` property to secondary axes specifying itself recursively. (GH9861)
- Bug in `Series.quantile` on empty Series of type `Datetime` or `Timedelta` (GH9675)
- Bug in `where` causing incorrect results when upcasting was required (GH9731)
- Bug in `FloatArrayFormatter` where decision boundary for displaying "small" floats in decimal format is off by one order of magnitude for a given display.precision (GH9764)
- Fixed bug where `DataFrame.plot()` raised an error when both `color` and `style` keywords were passed and there was no color symbol in the style strings (GH9671)
- Not showing a `DeprecationWarning` on combining list-likes with an `Index` (GH10083)
- Bug in `read_csv` and `read_table` when using `skip_rows` parameter if blank lines are present. (GH9832)
- Bug in `read_csv()` interprets `index_col=True` as `1` (GH9798)
- Bug in index equality comparisons using == failing on Index/MultiIndex type incompatibility (GH9785)
- Bug in which `SparseDataFrame` could not take *nan* as a column name (GH8822)
- Bug in `to_msgpack` and `read_msgpack` zlib and blosc compression support (GH9783)

- Bug `GroupBy.size` doesn't attach index name properly if grouped by `TimeGrouper` (GH9925)
- Bug causing an exception in slice assignments because `length_of_indexer` returns wrong results (GH9995)
- Bug in csv parser causing lines with initial whitespace plus one non-space character to be skipped. (GH9710)
- Bug in C csv parser causing spurious NaNs when data started with newline followed by whitespace. (GH10022)
- Bug causing elements with a null group to spill into the final group when grouping by a `Categorical` (GH9603)
- Bug where .iloc and .loc behavior is not consistent on empty dataframes (GH9964)
- Bug in invalid attribute access on a `TimedeltaIndex` incorrectly raised `ValueError` instead of `AttributeError` (GH9680)
- Bug in unequal comparisons between categorical data and a scalar, which was not in the categories (e.g. `Series(Categorical(list("abc"), ordered=True)) > "d"`. This returned `False` for all elements, but now raises a `TypeError`. Equality comparisons also now return `False` for == and `True` for `!=`. (GH9848)
- Bug in DataFrame `__setitem__` when right hand side is a dictionary (GH9874)
- Bug in `where` when dtype is `datetime64/timedelta64`, but dtype of other is not (GH9804)
- Bug in `MultiIndex.sortlevel()` results in unicode level name breaks (GH9856)
- Bug in which `groupby.transform` incorrectly enforced output dtypes to match input dtypes. (GH9807)
- Bug in `DataFrame` constructor when `columns` parameter is set, and `data` is an empty list (GH9939)
- Bug in bar plot with `log=True` raises `TypeError` if all values are less than 1 (GH9905)
- Bug in horizontal bar plot ignores `log=True` (GH9905)
- Bug in PyTables queries that did not return proper results using the index (GH8265, GH9676)
- Bug where dividing a dataframe containing values of type `Decimal` by another `Decimal` would raise. (GH9787)
- Bug where using DataFrames asfreq would remove the name of the index. (GH9885)
- Bug causing extra index point when resample BM/BQ (GH9756)
- Changed caching in `AbstractHolidayCalendar` to be at the instance level rather than at the class level as the latter can result in unexpected behaviour. (GH9552)
- Fixed latex output for multi-indexed dataframes (GH9778)
- Bug causing an exception when setting an empty range using `DataFrame.loc` (GH9596)
- Bug in hiding ticklabels with subplots and shared axes when adding a new plot to an existing grid of axes (GH9158)
- Bug in `transform` and `filter` when grouping on a categorical variable (GH9921)
- Bug in `transform` when groups are equal in number and dtype to the input index (GH9700)
- Google BigQuery connector now imports dependencies on a per-method basis.(GH9713)
- Updated BigQuery connector to no longer use deprecated `oauth2client.tools.run()` (GH8327)
- Bug in subclassed `DataFrame`. It may not return the correct class, when slicing or subsetting it. (GH9632)
- Bug in `.median()` where non-float null values are not handled correctly (GH10040)
- Bug in Series.fillna() where it raises if a numerically convertible string is given (GH10092)

1.14 v0.16.0 (March 22, 2015)

This is a major release from 0.15.2 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- `DataFrame.assign` method, see *here*
- `Series.to_coo/from_coo` methods to interact with `scipy.sparse`, see *here*
- Backwards incompatible change to `Timedelta` to conform the `.seconds` attribute with `datetime.timedelta`, see *here*
- Changes to the `.loc` slicing API to conform with the behavior of `.ix` see *here*
- Changes to the default for ordering in the `Categorical` constructor, see *here*
- Enhancement to the `.str` accessor to make string operations easier, see *here*
- The `pandas.tools.rplot`, `pandas.sandbox.qtpandas` and `pandas.rpy` modules are deprecated. We refer users to external packages like seaborn, pandas-qt and rpy2 for similar or equivalent functionality, see *here*

Check the *API Changes* and *deprecations* before updating.

What's new in v0.16.0

1.14.1 New features

1.14.1.1 DataFrame Assign

Inspired by dplyr's `mutate` verb, DataFrame has a new *`assign()`* method. The function signature for `assign` is simply `**kwargs`. The keys are the column names for the new fields, and the values are either a value to be inserted (for example, a `Series` or NumPy array), or a function of one argument to be called on the `DataFrame`. The new values are inserted, and the entire DataFrame (with all original and new columns) is returned.

```
In [1]: iris = read_csv('data/iris.data')

In [2]: iris.head()
Out[2]:
   SepalLength  SepalWidth  PetalLength  PetalWidth         Name
0          5.1         3.5          1.4         0.2  Iris-setosa
1          4.9         3.0          1.4         0.2  Iris-setosa
2          4.7         3.2          1.3         0.2  Iris-setosa
3          4.6         3.1          1.5         0.2  Iris-setosa
4          5.0         3.6          1.4         0.2  Iris-setosa

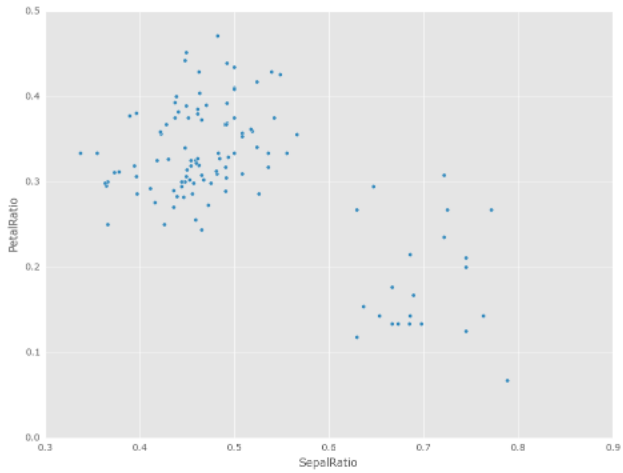
In [3]: iris.assign(sepal_ratio=iris['SepalWidth'] / iris['SepalLength']).head()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   SepalLength  SepalWidth  PetalLength  PetalWidth         Name  sepal_ratio
0          5.1         3.5          1.4         0.2  Iris-setosa     0.686275
1          4.9         3.0          1.4         0.2  Iris-setosa     0.612245
2          4.7         3.2          1.3         0.2  Iris-setosa     0.680851
3          4.6         3.1          1.5         0.2  Iris-setosa     0.673913
4          5.0         3.6          1.4         0.2  Iris-setosa     0.720000
```

Above was an example of inserting a precomputed value. We can also pass in a function to be evalutated.

```
In [4]: iris.assign(sepal_ratio = lambda x: (x['SepalWidth'] /
   ...:                                       x['SepalLength'])).head()
   ...:
Out[4]:
   SepalLength  SepalWidth  PetalLength  PetalWidth         Name  sepal_ratio
0          5.1         3.5          1.4         0.2  Iris-setosa     0.686275
1          4.9         3.0          1.4         0.2  Iris-setosa     0.612245
2          4.7         3.2          1.3         0.2  Iris-setosa     0.680851
3          4.6         3.1          1.5         0.2  Iris-setosa     0.673913
4          5.0         3.6          1.4         0.2  Iris-setosa     0.720000
```

The power of `assign` comes when used in chains of operations. For example, we can limit the DataFrame to just those with a Sepal Length greater than 5, calculate the ratio, and plot

```
In [5]: (iris.query('SepalLength > 5')
   ...:      .assign(SepalRatio = lambda x: x.SepalWidth / x.SepalLength,
   ...:              PetalRatio = lambda x: x.PetalWidth / x.PetalLength)
   ...:      .plot(kind='scatter', x='SepalRatio', y='PetalRatio'))
   ...:
Out[5]: <matplotlib.axes._subplots.AxesSubplot at 0x137e0f668>
```



See the *documentation* for more. (GH9229)

1.14.1.2 Interaction with scipy.sparse

Added `SparseSeries.to_coo()` and `SparseSeries.from_coo()` methods (GH8048) for converting to and from `scipy.sparse.coo_matrix` instances (see *here*). For example, given a SparseSeries with MultiIndex we can convert to a *scipy.sparse.coo_matrix* by specifying the row and column labels as index levels:

```
In [6]: from numpy import nan

In [7]: s = Series([3.0, nan, 1.0, 3.0, nan, nan])

In [8]: s.index = MultiIndex.from_tuples([(1, 2, 'a', 0),
   ...:                                   (1, 2, 'a', 1),
   ...:                                   (1, 1, 'b', 0),
   ...:                                   (1, 1, 'b', 1),
   ...:                                   (2, 1, 'b', 0),
   ...:                                   (2, 1, 'b', 1)],
   ...:                                  names=['A', 'B', 'C', 'D'])
   ...:

In [9]: s
Out[9]:
A  B  C  D
1  2  a  0    3.0
         1    NaN
   1  b  0    1.0
         1    3.0
2  1  b  0    NaN
         1    NaN
dtype: float64

# SparseSeries
In [10]: ss = s.to_sparse()

In [11]: ss
Out[11]:
A  B  C  D
1  2  a  0    3.0
         1    NaN
```

```
   1  b  0     1.0
         1     3.0
2  1  b  0     NaN
         1     NaN
dtype: float64
BlockIndex
Block locations: array([0, 2], dtype=int32)
Block lengths: array([1, 2], dtype=int32)

In [12]: A, rows, columns = ss.to_coo(row_levels=['A', 'B'],
   ....:                               column_levels=['C', 'D'],
   ....:                               sort_labels=False)
   ....:

In [13]: A
Out[13]:
<3x4 sparse matrix of type '<class 'numpy.float64'>'
        with 3 stored elements in COOrdinate format>

In [14]: A.todense()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
matrix([[3., 0., 0., 0.],
        [0., 0., 1., 3.],
        [0., 0., 0., 0.]])

In [15]: rows
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[(1, 2), (1, 1), (2, 1)]

In [16]: columns
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[('a', 0), ('a', 1), ('b', 0), ('b', 1)]
```

The from_coo method is a convenience method for creating a `SparseSeries` from a `scipy.sparse.coo_matrix`:

```
In [17]: from scipy import sparse

In [18]: A = sparse.coo_matrix(([3.0, 1.0, 2.0], ([1, 0, 0], [0, 2, 3])),
   ....:                       shape=(3, 4))
   ....:

In [19]: A
Out[19]:
<3x4 sparse matrix of type '<class 'numpy.float64'>'
        with 3 stored elements in COOrdinate format>

In [20]: A.todense()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
matrix([[0., 0., 1., 2.],
        [3., 0., 0., 0.],
        [0., 0., 0., 0.]])

In [21]: ss = SparseSeries.from_coo(A)

In [22]: ss
```

```
Out[22]:
0  2    1.0
   3    2.0
1  0    3.0
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([3], dtype=int32)
```

1.14.1.3 String Methods Enhancements

- Following new methods are accesible via `.str` accessor to apply the function to each values. This is intended to make it more consistent with standard methods on strings. (GH9282, GH9352, GH9386, GH9387, GH9439)

		Methods		
`isalnum()`	`isalpha()`	`isdigit()`	`isdigit()`	`isspace()`
`islower()`	`isupper()`	`istitle()`	`isnumeric()`	`isdecimal()`
`find()`	`rfind()`	`ljust()`	`rjust()`	`zfill()`

```
In [23]: s = Series(['abcd', '3456', 'EFGH'])

In [24]: s.str.isalpha()
Out[24]:
0     True
1    False
2     True
dtype: bool

In [25]: s.str.find('ab')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[25]:
0    0
1   -1
2   -1
dtype: int64
```

- `Series.str.pad()` and `Series.str.center()` now accept `fillchar` option to specify filling character (GH9352)

```
In [26]: s = Series(['12', '300', '25'])

In [27]: s.str.pad(5, fillchar='_')
Out[27]:
0    ___12
1    __300
2    ___25
dtype: object
```

- Added `Series.str.slice_replace()`, which previously raised `NotImplementedError` (GH8888)

```
In [28]: s = Series(['ABCD', 'EFGH', 'IJK'])

In [29]: s.str.slice_replace(1, 3, 'X')
Out[29]:
0    AXD
1    EXH
2     IX
```

```
dtype: object

# replaced with empty char
In [30]: s.str.slice_replace(0, 1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[30]:
0    BCD
1    FGH
2     JK
dtype: object
```

1.14.1.4 Other enhancements

- Reindex now supports `method='nearest'` for frames or series with a monotonic increasing or decreasing index (GH9258):

  ```
  In [31]: df = pd.DataFrame({'x': range(5)})

  In [32]: df.reindex([0.2, 1.8, 3.5], method='nearest')
  Out[32]:
       x
  0.2  0
  1.8  2
  3.5  4
  ```

  This method is also exposed by the lower level `Index.get_indexer` and `Index.get_loc` methods.

- The `read_excel()` function's *sheetname* argument now accepts a list and `None`, to get multiple or all sheets respectively. If more than one sheet is specified, a dictionary is returned. (GH9450)

  ```
  # Returns the 1st and 4th sheet, as a dictionary of DataFrames.
  pd.read_excel('path_to_file.xls',sheetname=['Sheet1',3])
  ```

- Allow Stata files to be read incrementally with an iterator; support for long strings in Stata files. See the docs *here* (GH9493:).
- Paths beginning with ~ will now be expanded to begin with the user's home directory (GH9066)
- Added time interval selection in `get_data_yahoo` (GH9071)
- Added `Timestamp.to_datetime64()` to complement `Timedelta.to_timedelta64()` (GH9255)
- `tseries.frequencies.to_offset()` now accepts `Timedelta` as input (GH9064)
- Lag parameter was added to the autocorrelation method of `Series`, defaults to lag-1 autocorrelation (GH9192)
- `Timedelta` will now accept `nanoseconds` keyword in constructor (GH9273)
- SQL code now safely escapes table and column names (GH8986)
- Added auto-complete for `Series.str.<tab>`, `Series.dt.<tab>` and `Series.cat.<tab>` (GH9322)
- `Index.get_indexer` now supports `method='pad'` and `method='backfill'` even for any target array, not just monotonic targets. These methods also work for monotonic decreasing as well as monotonic increasing indexes (GH9258).
- `Index.asof` now works on all index types (GH9258).
- A `verbose` argument has been augmented in `io.read_excel()`, defaults to False. Set to True to print sheet names as they are parsed. (GH9450)

- Added `days_in_month` (compatibility alias `daysinmonth`) property to `Timestamp`, `DatetimeIndex`, `Period`, `PeriodIndex`, and `Series.dt` (GH9572)
- Added `decimal` option in `to_csv` to provide formatting for non-'.' decimal separators (GH781)
- Added `normalize` option for `Timestamp` to normalized to midnight (GH8794)
- Added example for `DataFrame` import to R using HDF5 file and `rhdf5` library. See the *documentation* for more (GH9636).

1.14.2 Backwards incompatible API changes

1.14.2.1 Changes in Timedelta

In v0.15.0 a new scalar type `Timedelta` was introduced, that is a sub-class of `datetime.timedelta`. Mentioned *here* was a notice of an API change w.r.t. the `.seconds` accessor. The intent was to provide a user-friendly set of accessors that give the 'natural' value for that unit, e.g. if you had a `Timedelta('1 day, 10:11:12')`, then `.seconds` would return 12. However, this is at odds with the definition of `datetime.timedelta`, which defines `.seconds` as `10 * 3600 + 11 * 60 + 12 == 36672`.

So in v0.16.0, we are restoring the API to match that of `datetime.timedelta`. Further, the component values are still available through the `.components` accessor. This affects the `.seconds` and `.microseconds` accessors, and removes the `.hours`, `.minutes`, `.milliseconds` accessors. These changes affect `TimedeltaIndex` and the Series `.dt` accessor as well. (GH9185, GH9139)

Previous Behavior

```
In [2]: t = pd.Timedelta('1 day, 10:11:12.100123')

In [3]: t.days
Out[3]: 1

In [4]: t.seconds
Out[4]: 12

In [5]: t.microseconds
Out[5]: 123
```

New Behavior

```
In [33]: t = pd.Timedelta('1 day, 10:11:12.100123')

In [34]: t.days
Out[34]: 1

In [35]: t.seconds
\\\\\\\\\\\Out[35]: 36672

In [36]: t.microseconds
\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[36]: 100123
```

Using `.components` allows the full component access

```
In [37]: t.components
Out[37]: Components(days=1, hours=10, minutes=11, seconds=12, milliseconds=100,␣
↪microseconds=123, nanoseconds=0)
```

```
In [38]: t.components.seconds
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪12
```

1.14.2.2 Indexing Changes

The behavior of a small sub-set of edge cases for using `.loc` have changed (GH8613). Furthermore we have improved the content of the error messages that are raised:

- Slicing with `.loc` where the start and/or stop bound is not found in the index is now allowed; this previously would raise a `KeyError`. This makes the behavior the same as `.ix` in this case. This change is only for slicing, not when indexing with a single label.

```
In [39]: df = DataFrame(np.random.randn(5,4),
   ....:                columns=list('ABCD'),
   ....:                index=date_range('20130101',periods=5))
   ....:

In [40]: df
Out[40]:
                   A         B         C         D
2013-01-01 -0.322795  0.841675  2.390961  0.076200
2013-01-02 -0.566446  0.036142 -2.074978  0.247792
2013-01-03 -0.897157 -0.136795  0.018289  0.755414
2013-01-04  0.215269  0.841009 -1.445810 -1.401973
2013-01-05 -0.100918 -0.548242 -0.144620  0.354020

In [41]: s = Series(range(5),[-2,-1,1,2,3])

In [42]: s
Out[42]:
-2    0
-1    1
 1    2
 2    3
 3    4
dtype: int64
```

Previous Behavior

```
In [4]: df.loc['2013-01-02':'2013-01-10']
KeyError: 'stop bound [2013-01-10] is not in the [index]'

In [6]: s.loc[-10:3]
KeyError: 'start bound [-10] is not the [index]'
```

New Behavior

```
In [43]: df.loc['2013-01-02':'2013-01-10']
Out[43]:
                   A         B         C         D
2013-01-02 -0.566446  0.036142 -2.074978  0.247792
2013-01-03 -0.897157 -0.136795  0.018289  0.755414
2013-01-04  0.215269  0.841009 -1.445810 -1.401973
2013-01-05 -0.100918 -0.548242 -0.144620  0.354020
```

```
In [44]: s.loc[-10:3]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
-2    0
-1    1
 1    2
 2    3
 3    4
dtype: int64
```

- Allow slicing with float-like values on an integer index for `.ix`. Previously this was only enabled for `.loc`:

  Previous Behavior

  ```
  In [8]: s.ix[-1.0:2]
  TypeError: the slice start value [-1.0] is not a proper indexer for this index␣
  ↪type (Int64Index)
  ```

  New Behavior

  ```
  In [2]: s.ix[-1.0:2]
  Out[2]:
  -1    1
   1    2
   2    3
  dtype: int64
  ```

- Provide a useful exception for indexing with an invalid type for that index when using `.loc`. For example trying to use `.loc` on an index of type `DatetimeIndex` or `PeriodIndex` or `TimedeltaIndex`, with an integer (or a float).

  Previous Behavior

  ```
  In [4]: df.loc[2:3]
  KeyError: 'start bound [2] is not the [index]'
  ```

  New Behavior

  ```
  In [4]: df.loc[2:3]
  TypeError: Cannot do slice indexing on <class 'pandas.tseries.index.DatetimeIndex
  ↪'> with <type 'int'> keys
  ```

1.14.2.3 Categorical Changes

In prior versions, `Categoricals` that had an unspecified ordering (meaning no `ordered` keyword was passed) were defaulted as `ordered` Categoricals. Going forward, the `ordered` keyword in the `Categorical` constructor will default to `False`. Ordering must now be explicit.

Furthermore, previously you *could* change the `ordered` attribute of a Categorical by just setting the attribute, e.g. `cat.ordered=True`; This is now deprecated and you should use `cat.as_ordered()` or `cat.as_unordered()`. These will by default return a **new** object and not modify the existing object. (GH9347, GH9190)

Previous Behavior

```
In [3]: s = Series([0,1,2], dtype='category')
```

```
In [4]: s
Out[4]:
0    0
1    1
2    2
dtype: category
Categories (3, int64): [0 < 1 < 2]

In [5]: s.cat.ordered
Out[5]: True

In [6]: s.cat.ordered = False

In [7]: s
Out[7]:
0    0
1    1
2    2
dtype: category
Categories (3, int64): [0, 1, 2]
```

New Behavior

```
In [45]: s = Series([0,1,2], dtype='category')

In [46]: s
Out[46]:
0    0
1    1
2    2
dtype: category
Categories (3, int64): [0, 1, 2]

In [47]: s.cat.ordered
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[47]:␣
↪False

In [48]: s = s.cat.as_ordered()

In [49]: s
Out[49]:
0    0
1    1
2    2
dtype: category
Categories (3, int64): [0 < 1 < 2]

In [50]: s.cat.ordered
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[50]:␣
↪True

# you can set in the constructor of the Categorical
In [51]: s = Series(Categorical([0,1,2],ordered=True))

In [52]: s
Out[52]:
0    0
1    1
```

```
2    2
dtype: category
Categories (3, int64): [0 < 1 < 2]

In [53]: s.cat.ordered
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[53]:␣
↪True
```

For ease of creation of series of categorical data, we have added the ability to pass keywords when calling `.astype()`. These are passed directly to the constructor.

```
In [54]: s = Series(["a","b","c","a"]).astype('category',ordered=True)

In [55]: s
Out[55]:
0    a
1    b
2    c
3    a
dtype: category
Categories (3, object): [a < b < c]

In [56]: s = Series(["a","b","c","a"]).astype('category',categories=list('abcdef'),
↪ordered=False)

In [57]: s
Out[57]:
0    a
1    b
2    c
3    a
dtype: category
Categories (6, object): [a, b, c, d, e, f]
```

1.14.2.4 Other API Changes

- `Index.duplicated` now returns `np.array(dtype=bool)` rather than `Index(dtype=object)` containing `bool` values. (GH8875)
- `DataFrame.to_json` now returns accurate type serialisation for each column for frames of mixed dtype (GH9037)

  Previously data was coerced to a common dtype before serialisation, which for example resulted in integers being serialised to floats:

  ```
  In [2]: pd.DataFrame({'i': [1,2], 'f': [3.0, 4.2]}).to_json()
  Out[2]: '{"f":{"0":3.0,"1":4.2},"i":{"0":1.0,"1":2.0}}'
  ```

  Now each column is serialised using its correct dtype:

  ```
  In [2]:  pd.DataFrame({'i': [1,2], 'f': [3.0, 4.2]}).to_json()
  Out[2]: '{"f":{"0":3.0,"1":4.2},"i":{"0":1,"1":2}}'
  ```

- `DatetimeIndex`, `PeriodIndex` and `TimedeltaIndex.summary` now output the same format. (GH9116)
- `TimedeltaIndex.freqstr` now output the same string format as `DatetimeIndex`. (GH9116)

- Bar and horizontal bar plots no longer add a dashed line along the info axis. The prior style can be achieved with matplotlib's `axhline` or `axvline` methods (GH9088).
- `Series` accessors `.dt`, `.cat` and `.str` now raise `AttributeError` instead of `TypeError` if the series does not contain the appropriate type of data (GH9617). This follows Python's built-in exception hierarchy more closely and ensures that tests like `hasattr(s, 'cat')` are consistent on both Python 2 and 3.
- `Series` now supports bitwise operation for integral types (GH9016). Previously even if the input dtypes were integral, the output dtype was coerced to `bool`.

  Previous Behavior

```
In [2]: pd.Series([0,1,2,3], list('abcd')) | pd.Series([4,4,4,4], list('abcd'))
Out[2]:
a    True
b    True
c    True
d    True
dtype: bool
```

  New Behavior. If the input dtypes are integral, the output dtype is also integral and the output values are the result of the bitwise operation.

```
In [2]: pd.Series([0,1,2,3], list('abcd')) | pd.Series([4,4,4,4], list('abcd'))
Out[2]:
a    4
b    5
c    6
d    7
dtype: int64
```

- During division involving a `Series` or `DataFrame`, `0/0` and `0//0` now give `np.nan` instead of `np.inf`. (GH9144, GH8445)

  Previous Behavior

```
In [2]: p = pd.Series([0, 1])

In [3]: p / 0
Out[3]:
0    inf
1    inf
dtype: float64

In [4]: p // 0
Out[4]:
0    inf
1    inf
dtype: float64
```

  New Behavior

```
In [54]: p = pd.Series([0, 1])

In [55]: p / 0
Out[55]:
0    NaN
1    inf
dtype: float64
```

```
In [56]: p // 0
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[56]:
0    NaN
1    inf
dtype: float64
```

- `Series.values_counts` and `Series.describe` for categorical data will now put `NaN` entries at the end. (GH9443)
- `Series.describe` for categorical data will now give counts and frequencies of 0, not `NaN`, for unused categories (GH9443)
- Due to a bug fix, looking up a partial string label with `DatetimeIndex.asof` now includes values that match the string, even if they are after the start of the partial string label (GH9258).

  Old behavior:

  ```
  In [4]: pd.to_datetime(['2000-01-31', '2000-02-28']).asof('2000-02')
  Out[4]: Timestamp('2000-01-31 00:00:00')
  ```

  Fixed behavior:

  ```
  In [57]: pd.to_datetime(['2000-01-31', '2000-02-28']).asof('2000-02')
  Out[57]: Timestamp('2000-02-28 00:00:00')
  ```

  To reproduce the old behavior, simply add more precision to the label (e.g., use `2000-02-01` instead of `2000-02`).

1.14.2.5 Deprecations

- The `rplot` trellis plotting interface is deprecated and will be removed in a future version. We refer to external packages like seaborn for similar but more refined functionality (GH3445). The documentation includes some examples how to convert your existing code using `rplot` to seaborn: *rplot docs*.
- The `pandas.sandbox.qtpandas` interface is deprecated and will be removed in a future version. We refer users to the external package pandas-qt. (GH9615)
- The `pandas.rpy` interface is deprecated and will be removed in a future version. Similar functionaility can be accessed thru the rpy2 project (GH9602)
- Adding `DatetimeIndex/PeriodIndex` to another `DatetimeIndex/PeriodIndex` is being deprecated as a set-operation. This will be changed to a `TypeError` in a future version. `.union()` should be used for the union set operation. (GH9094)
- Subtracting `DatetimeIndex/PeriodIndex` from another `DatetimeIndex/PeriodIndex` is being deprecated as a set-operation. This will be changed to an actual numeric subtraction yielding a `TimeDeltaIndex` in a future version. `.difference()` should be used for the differencing set operation. (GH9094)

1.14.2.6 Removal of prior version deprecations/changes

- `DataFrame.pivot_table` and `crosstab`'s `rows` and `cols` keyword arguments were removed in favor of `index` and `columns` (GH6581)
- `DataFrame.to_excel` and `DataFrame.to_csv` `cols` keyword argument was removed in favor of `columns` (GH6581)

- Removed `convert_dummies` in favor of `get_dummies` (GH6581)
- Removed `value_range` in favor of `describe` (GH6581)

1.14.3 Performance Improvements

- Fixed a performance regression for `.loc` indexing with an array or list-like (GH9126:).
- `DataFrame.to_json` 30x performance improvement for mixed dtype frames. (GH9037)
- Performance improvements in `MultiIndex.duplicated` by working with labels instead of values (GH9125)
- Improved the speed of `nunique` by calling `unique` instead of `value_counts` (GH9129, GH7771)
- Performance improvement of up to 10x in `DataFrame.count` and `DataFrame.dropna` by taking advantage of homogeneous/heterogeneous dtypes appropriately (GH9136)
- Performance improvement of up to 20x in `DataFrame.count` when using a `MultiIndex` and the `level` keyword argument (GH9163)
- Performance and memory usage improvements in `merge` when key space exceeds `int64` bounds (GH9151)
- Performance improvements in multi-key `groupby` (GH9429)
- Performance improvements in `MultiIndex.sortlevel` (GH9445)
- Performance and memory usage improvements in `DataFrame.duplicated` (GH9398)
- Cythonized `Period` (GH9440)
- Decreased memory usage on `to_hdf` (GH9648)

1.14.4 Bug Fixes

- Changed `.to_html` to remove leading/trailing spaces in table body (GH4987)
- Fixed issue using `read_csv` on s3 with Python 3 (GH9452)
- Fixed compatibility issue in `DatetimeIndex` affecting architectures where `numpy.int_` defaults to `numpy.int32` (GH8943)
- Bug in Panel indexing with an object-like (GH9140)
- Bug in the returned `Series.dt.components` index was reset to the default index (GH9247)
- Bug in `Categorical.__getitem__/__setitem__` with listlike input getting incorrect results from indexer coercion (GH9469)
- Bug in partial setting with a DatetimeIndex (GH9478)
- Bug in groupby for integer and datetime64 columns when applying an aggregator that caused the value to be changed when the number was sufficiently large (GH9311, GH6620)
- Fixed bug in `to_sql` when mapping a `Timestamp` object column (datetime column with timezone info) to the appropriate sqlalchemy type (GH9085).
- Fixed bug in `to_sql` `dtype` argument not accepting an instantiated SQLAlchemy type (GH9083).
- Bug in `.loc` partial setting with a `np.datetime64` (GH9516)
- Incorrect dtypes inferred on datetimelike looking `Series` & on `.xs` slices (GH9477)

- Items in `Categorical.unique()` (and `s.unique()` if `s` is of dtype `category`) now appear in the order in which they are originally found, not in sorted order (GH9331). This is now consistent with the behavior for other dtypes in pandas.
- Fixed bug on big endian platforms which produced incorrect results in `StataReader` (GH8688).
- Bug in `MultiIndex.has_duplicates` when having many levels causes an indexer overflow (GH9075, GH5873)
- Bug in `pivot` and `unstack` where `nan` values would break index alignment (GH4862, GH7401, GH7403, GH7405, GH7466, GH9497)
- Bug in left `join` on multi-index with `sort=True` or null values (GH9210).
- Bug in `MultiIndex` where inserting new keys would fail (GH9250).
- Bug in `groupby` when key space exceeds `int64` bounds (GH9096).
- Bug in `unstack` with `TimedeltaIndex` or `DatetimeIndex` and nulls (GH9491).
- Bug in `rank` where comparing floats with tolerance will cause inconsistent behaviour (GH8365).
- Fixed character encoding bug in `read_stata` and `StataReader` when loading data from a URL (GH9231).
- Bug in adding `offsets.Nano` to other offets raises `TypeError` (GH9284)
- Bug in `DatetimeIndex` iteration, related to (GH8890), fixed in (GH9100)
- Bugs in `resample` around DST transitions. This required fixing offset classes so they behave correctly on DST transitions. (GH5172, GH8744, GH8653, GH9173, GH9468).
- Bug in binary operator method (eg `.mul()`) alignment with integer levels (GH9463).
- Bug in boxplot, scatter and hexbin plot may show an unnecessary warning (GH8877)
- Bug in subplot with `layout` kw may show unnecessary warning (GH9464)
- Bug in using grouper functions that need passed thru arguments (e.g. axis), when using wrapped function (e.g. `fillna`), (GH9221)
- `DataFrame` now properly supports simultaneous `copy` and `dtype` arguments in constructor (GH9099)
- Bug in `read_csv` when using skiprows on a file with CR line endings with the c engine. (GH9079)
- `isnull` now detects `NaT` in `PeriodIndex` (GH9129)
- Bug in groupby `.nth()` with a multiple column groupby (GH8979)
- Bug in `DataFrame.where` and `Series.where` coerce numerics to string incorrectly (GH9280)
- Bug in `DataFrame.where` and `Series.where` raise `ValueError` when string list-like is passed. (GH9280)
- Accessing `Series.str` methods on with non-string values now raises `TypeError` instead of producing incorrect results (GH9184)
- Bug in `DatetimeIndex.__contains__` when index has duplicates and is not monotonic increasing (GH9512)
- Fixed division by zero error for `Series.kurt()` when all values are equal (GH9197)
- Fixed issue in the `xlsxwriter` engine where it added a default 'General' format to cells if no other format wass applied. This prevented other row or column formatting being applied. (GH9167)
- Fixes issue with `index_col=False` when `usecols` is also specified in `read_csv`. (GH9082)
- Bug where `wide_to_long` would modify the input stubnames list (GH9204)

- Bug in `to_sql` not storing float64 values using double precision. (GH9009)
- `SparseSeries` and `SparsePanel` now accept zero argument constructors (same as their non-sparse counterparts) (GH9272).
- Regression in merging `Categorical` and `object` dtypes (GH9426)
- Bug in `read_csv` with buffer overflows with certain malformed input files (GH9205)
- Bug in groupby MultiIndex with missing pair (GH9049, GH9344)
- Fixed bug in `Series.groupby` where grouping on `MultiIndex` levels would ignore the sort argument (GH9444)
- Fix bug in `DataFrame.Groupby` where `sort=False` is ignored in the case of Categorical columns. (GH8868)
- Fixed bug with reading CSV files from Amazon S3 on python 3 raising a TypeError (GH9452)
- Bug in the Google BigQuery reader where the 'jobComplete' key may be present but False in the query results (GH8728)
- Bug in `Series.values_counts` with excluding `NaN` for categorical type `Series` with `dropna=True` (GH9443)
- Fixed mising numeric_only option for `DataFrame.std/var/sem` (GH9201)
- Support constructing `Panel` or `Panel4D` with scalar data (GH8285)
- `Series` text representation disconnected from *max_rows/max_columns* (GH7508).
- `Series` number formatting inconsistent when truncated (GH8532).

  Previous Behavior

```
In [2]: pd.options.display.max_rows = 10
In [3]: s = pd.Series([1,1,1,1,1,1,1,1,1,1,0.9999,1,1]*10)
In [4]: s
Out[4]:
0    1
1    1
2    1
...
127    0.9999
128    1.0000
129    1.0000
Length: 130, dtype: float64
```

  New Behavior

```
0      1.0000
1      1.0000
2      1.0000
3      1.0000
4      1.0000
...
125    1.0000
126    1.0000
127    0.9999
128    1.0000
129    1.0000
dtype: float64
```

- A Spurious `SettingWithCopy` Warning was generated when setting a new item in a frame in some cases (GH8730)

  The following would previously report a `SettingWithCopy` Warning.

```
In [1]: df1 = DataFrame({'x': Series(['a','b','c']), 'y': Series(['d','e','f'])})

In [2]: df2 = df1[['x']]

In [3]: df2['y'] = ['g', 'h', 'i']
```

1.15 v0.15.2 (December 12, 2014)

This is a minor release from 0.15.1 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements. A small number of API changes were necessary to fix existing bugs. We recommend that all users upgrade to this version.

- *Enhancements*
- *API Changes*
- *Performance Improvements*
- *Bug Fixes*

1.15.1 API changes

- Indexing in `MultiIndex` beyond lex-sort depth is now supported, though a lexically sorted index will have a better performance. (GH2646)

```
In [1]: df = pd.DataFrame({'jim':[0, 0, 1, 1],
   ...:                    'joe':['x', 'x', 'z', 'y'],
   ...:                    'jolie':np.random.rand(4)}).set_index(['jim', 'joe'])
   ...:

In [2]: df
Out[2]: 
            jolie
jim joe          
0   x    0.123943
    x    0.119381
1   z    0.738523
    y    0.587304

In [3]: df.index.lexsort_depth
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪1

# in prior versions this would raise a KeyError
# will now show a PerformanceWarning
In [4]: df.loc[(1, 'z')]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
            jolie
jim joe          
1   z    0.738523
```

```
# lexically sorting
In [5]: df2 = df.sort_index()

In [6]: df2
Out[6]:
            jolie
jim joe
0   x    0.123943
    x    0.119381
1   y    0.587304
    z    0.738523

In [7]: df2.index.lexsort_depth
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪2

In [8]: df2.loc[(1,'z')]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
            jolie
jim joe
1   z    0.738523
```

- Bug in unique of Series with `category` dtype, which returned all categories regardless whether they were "used" or not (see GH8559 for the discussion). Previous behaviour was to return all categories:

```
In [3]: cat = pd.Categorical(['a', 'b', 'a'], categories=['a', 'b', 'c'])

In [4]: cat
Out[4]:
[a, b, a]
Categories (3, object): [a < b < c]

In [5]: cat.unique()
Out[5]: array(['a', 'b', 'c'], dtype=object)
```

  Now, only the categories that do effectively occur in the array are returned:

```
In [9]: cat = pd.Categorical(['a', 'b', 'a'], categories=['a', 'b', 'c'])

In [10]: cat.unique()
Out[10]:
[a, b]
Categories (2, object): [a, b]
```

- `Series.all` and `Series.any` now support the `level` and `skipna` parameters. `Series.all`, `Series.any`, `Index.all`, and `Index.any` no longer support the `out` and `keepdims` parameters, which existed for compatibility with ndarray. Various index types no longer support the `all` and `any` aggregation functions and will now raise `TypeError`. (GH8302).
- Allow equality comparisons of Series with a categorical dtype and object dtype; previously these would raise `TypeError` (GH8938)
- Bug in `NDFrame`: conflicting attribute/column names now behave consistently between getting and setting. Previously, when both a column and attribute named `y` existed, `data.y` would return the attribute, while `data.y = z` would update the column (GH8994)

```
In [11]: data = pd.DataFrame({'x':[1, 2, 3]})

In [12]: data.y = 2

In [13]: data['y'] = [2, 4, 6]

In [14]: data
Out[14]:
   x  y
0  1  2
1  2  4
2  3  6

# this assignment was inconsistent
In [15]: data.y = 5
```

Old behavior:

```
In [6]: data.y
Out[6]: 2

In [7]: data['y'].values
Out[7]: array([5, 5, 5])
```

New behavior:

```
In [16]: data.y
Out[16]: 5

In [17]: data['y'].values
\\\\\\\\\\Out[17]: array([2, 4, 6])
```

- `Timestamp('now')` is now equivalent to `Timestamp.now()` in that it returns the local time rather than UTC. Also, `Timestamp('today')` is now equivalent to `Timestamp.today()` and both have `tz` as a possible argument. (GH9000)
- Fix negative step support for label-based slices (GH8753)

  Old behavior:

```
In [1]: s = pd.Series(np.arange(3), ['a', 'b', 'c'])
Out[1]:
a    0
b    1
c    2
dtype: int64

In [2]: s.loc['c':'a':-1]
Out[2]:
c    2
dtype: int64
```

  New behavior:

```
In [18]: s = pd.Series(np.arange(3), ['a', 'b', 'c'])

In [19]: s.loc['c':'a':-1]
Out[19]:
```

```
c    2
b    1
a    0
dtype: int64
```

1.15.2 Enhancements

`Categorical` enhancements:

- Added ability to export Categorical data to Stata (GH8633). See *here* for limitations of categorical variables exported to Stata data files.
- Added flag `order_categoricals` to `StataReader` and `read_stata` to select whether to order imported categorical data (GH8836). See *here* for more information on importing categorical variables from Stata data files.
- Added ability to export Categorical data to to/from HDF5 (GH7621). Queries work the same as if it was an object array. However, the `category` dtyped data is stored in a more efficient manner. See *here* for an example and caveats w.r.t. prior versions of pandas.
- Added support for `searchsorted()` on *Categorical* class (GH8420).

Other enhancements:

- Added the ability to specify the SQL type of columns when writing a DataFrame to a database (GH8778). For example, specifying to use the sqlalchemy `String` type instead of the default `Text` type for string columns:

```
from sqlalchemy.types import String
data.to_sql('data_dtype', engine, dtype={'Col_1': String})
```

- `Series.all` and `Series.any` now support the `level` and `skipna` parameters (GH8302):

```
In [20]: s = pd.Series([False, True, False], index=[0, 0, 1])

In [21]: s.any(level=0)
Out[21]:
0     True
1    False
dtype: bool
```

- `Panel` now supports the `all` and `any` aggregation functions. (GH8302):

```
In [22]: p = pd.Panel(np.random.rand(2, 5, 4) > 0.1)

In [23]: p.all()
Out[23]:
       0      1
0   True   True
1   True   True
2  False  False
3   True   True
```

- Added support for `utcfromtimestamp()`, `fromtimestamp()`, and `combine()` on *Timestamp* class (GH5351).
- Added Google Analytics (*pandas.io.ga*) basic documentation (GH8835). See **'here<http://pandas.pydata.org/pandas-docs/version/0.15.2/remote_data.html#remote-data-ga>'__**.

- `Timedelta` arithmetic returns `NotImplemented` in unknown cases, allowing extensions by custom classes (GH8813).
- `Timedelta` now supports arithemtic with `numpy.ndarray` objects of the appropriate dtype (numpy 1.8 or newer only) (GH8884).
- Added `Timedelta.to_timedelta64()` method to the public API (GH8884).
- Added `gbq.generate_bq_schema()` function to the gbq module (GH8325).
- `Series` now works with map objects the same way as generators (GH8909).
- Added context manager to `HDFStore` for automatic closing (GH8791).
- `to_datetime` gains an `exact` keyword to allow for a format to not require an exact match for a provided format string (if its `False`). `exact` defaults to `True` (meaning that exact matching is still the default) (GH8904)
- Added `axvlines` boolean option to parallel_coordinates plot function, determines whether vertical lines will be printed, default is True
- Added ability to read table footers to read_html (GH8552)
- `to_sql` now infers datatypes of non-NA values for columns that contain NA values and have dtype `object` (GH8778).

1.15.3 Performance

- Reduce memory usage when skiprows is an integer in read_csv (GH8681)
- Performance boost for `to_datetime` conversions with a passed `format=`, and the `exact=False` (GH8904)

1.15.4 Bug Fixes

- Bug in concat of Series with `category` dtype which were coercing to `object`. (GH8641)
- Bug in Timestamp-Timestamp not returning a Timedelta type and datelike-datelike ops with timezones (GH8865)
- Made consistent a timezone mismatch exception (either tz operated with None or incompatible timezone), will now return `TypeError` rather than `ValueError` (a couple of edge cases only), (GH8865)
- Bug in using a `pd.Grouper(key=...)` with no level/axis or level only (GH8795, GH8866)
- Report a `TypeError` when invalid/no parameters are passed in a groupby (GH8015)
- Bug in packaging pandas with `py2app/cx_Freeze` (GH8602, GH8831)
- Bug in `groupby` signatures that didn't include *args or **kwargs (GH8733).
- `io.data.Options` now raises `RemoteDataError` when no expiry dates are available from Yahoo and when it receives no data from Yahoo (GH8761), (GH8783).
- Unclear error message in csv parsing when passing dtype and names and the parsed data is a different data type (GH8833)
- Bug in slicing a multi-index with an empty list and at least one boolean indexer (GH8781)
- `io.data.Options` now raises `RemoteDataError` when no expiry dates are available from Yahoo (GH8761).
- `Timedelta` kwargs may now be numpy ints and floats (GH8757).

- Fixed several outstanding bugs for `Timedelta` arithmetic and comparisons (GH8813, GH5963, GH5436).
- `sql_schema` now generates dialect appropriate `CREATE TABLE` statements (GH8697)
- `slice` string method now takes step into account (GH8754)
- Bug in `BlockManager` where setting values with different type would break block integrity (GH8850)
- Bug in `DatetimeIndex` when using `time` object as key (GH8667)
- Bug in `merge` where `how='left'` and `sort=False` would not preserve left frame order (GH7331)
- Bug in `MultiIndex.reindex` where reindexing at level would not reorder labels (GH4088)
- Bug in certain operations with dateutil timezones, manifesting with dateutil 2.3 (GH8639)
- Regression in DatetimeIndex iteration with a Fixed/Local offset timezone (GH8890)
- Bug in `to_datetime` when parsing a nanoseconds using the `%f` format (GH8989)
- `io.data.Options` now raises `RemoteDataError` when no expiry dates are available from Yahoo and when it receives no data from Yahoo (GH8761), (GH8783).
- Fix: The font size was only set on x axis if vertical or the y axis if horizontal. (GH8765)
- Fixed division by 0 when reading big csv files in python 3 (GH8621)
- Bug in outputing a Multindex with `to_html,index=False` which would add an extra column (GH8452)
- Imported categorical variables from Stata files retain the ordinal information in the underlying data (GH8836).
- Defined `.size` attribute across `NDFrame` objects to provide compat with numpy >= 1.9.1; buggy with `np.array_split` (GH8846)
- Skip testing of histogram plots for matplotlib <= 1.2 (GH8648).
- Bug where `get_data_google` returned object dtypes (GH3995)
- Bug in `DataFrame.stack(..., dropna=False)` when the DataFrame's `columns` is a `MultiIndex` whose `labels` do not reference all its `levels`. (GH8844)
- Bug in that Option context applied on `__enter__` (GH8514)
- Bug in resample that causes a ValueError when resampling across multiple days and the last offset is not calculated from the start of the range (GH8683)
- Bug where `DataFrame.plot(kind='scatter')` fails when checking if an np.array is in the DataFrame (GH8852)
- Bug in `pd.infer_freq/DataFrame.inferred_freq` that prevented proper sub-daily frequency inference when the index contained DST days (GH8772).
- Bug where index name was still used when plotting a series with `use_index=False` (GH8558).
- Bugs when trying to stack multiple columns, when some (or all) of the level names are numbers (GH8584).
- Bug in `MultiIndex` where `__contains__` returns wrong result if index is not lexically sorted or unique (GH7724)
- BUG CSV: fix problem with trailing whitespace in skipped rows, (GH8679), (GH8661), (GH8983)
- Regression in `Timestamp` does not parse 'Z' zone designator for UTC (GH8771)
- Bug in *StataWriter* the produces writes strings with 244 characters irrespective of actual size (GH8969)
- Fixed ValueError raised by cummin/cummax when datetime64 Series contains NaT. (GH8965)
- Bug in Datareader returns object dtype if there are missing values (GH8980)

- Bug in plotting if sharex was enabled and index was a timeseries, would show labels on multiple axes (GH3964).
- Bug where passing a unit to the TimedeltaIndex constructor applied the to nano-second conversion twice. (GH9011).
- Bug in plotting of a period-like array (GH9012)

1.16 v0.15.1 (November 9, 2014)

This is a minor bug-fix release from 0.15.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

- *Enhancements*
- *API Changes*
- *Bug Fixes*

1.16.1 API changes

- `s.dt.hour` and other `.dt` accessors will now return `np.nan` for missing values (rather than previously -1), (GH8689)

```
In [1]: s = Series(date_range('20130101',periods=5,freq='D'))

In [2]: s.iloc[2] = np.nan

In [3]: s
Out[3]:
0   2013-01-01
1   2013-01-02
2          NaT
3   2013-01-04
4   2013-01-05
dtype: datetime64[ns]
```

previous behavior:

```
In [6]: s.dt.hour
Out[6]:
0    0
1    0
2   -1
3    0
4    0
dtype: int64
```

current behavior:

```
In [4]: s.dt.hour
Out[4]:
0    0.0
1    0.0
2    NaN
3    0.0
```

```
4    0.0
dtype: float64
```

- `groupby` with `as_index=False` will not add erroneous extra columns to result (GH8582):

```
In [5]: np.random.seed(2718281)

In [6]: df = pd.DataFrame(np.random.randint(0, 100, (10, 2)),
   ...:                   columns=['jim', 'joe'])
   ...:

In [7]: df.head()
Out[7]:
   jim  joe
0   61   81
1   96   49
2   55   65
3   72   51
4   77   12

In [8]: ts = pd.Series(5 * np.random.randint(0, 3, 10))
```

previous behavior:

```
In [4]: df.groupby(ts, as_index=False).max()
Out[4]:
   NaN  jim  joe
0    0   72   83
1    5   77   84
2   10   96   65
```

current behavior:

```
In [9]: df.groupby(ts, as_index=False).max()
Out[9]:
   jim  joe
0   72   83
1   77   84
2   96   65
```

- `groupby` will not erroneously exclude columns if the column name conflics with the grouper name (GH8112):

```
In [10]: df = pd.DataFrame({'jim': range(5), 'joe': range(5, 10)})

In [11]: df
Out[11]:
   jim  joe
0    0    5
1    1    6
2    2    7
3    3    8
4    4    9

In [12]: gr = df.groupby(df['jim'] < 2)
```

previous behavior (excludes 1st column from output):

```
In [4]: gr.apply(sum)
Out[4]:
       joe
jim
False   24
True    11
```

current behavior:

```
In [13]: gr.apply(sum)
Out[13]:
       jim  joe
jim
False    9   24
True     1   11
```

- Support for slicing with monotonic decreasing indexes, even if `start` or `stop` is not found in the index (GH7860):

```
In [14]: s = pd.Series(['a', 'b', 'c', 'd'], [4, 3, 2, 1])

In [15]: s
Out[15]:
4    a
3    b
2    c
1    d
dtype: object
```

previous behavior:

```
In [8]: s.loc[3.5:1.5]
KeyError: 3.5
```

current behavior:

```
In [16]: s.loc[3.5:1.5]
Out[16]:
3    b
2    c
dtype: object
```

- `io.data.Options` has been fixed for a change in the format of the Yahoo Options page (GH8612), (GH8741)

Note: As a result of a change in Yahoo's option page layout, when an expiry date is given, `Options` methods now return data for a single expiry date. Previously, methods returned all data for the selected month.

The `month` and `year` parameters have been undeprecated and can be used to get all options data for a given month.

If an expiry date that is not valid is given, data for the next expiry after the given date is returned.

Option data frames are now saved on the instance as `callsYYMMDD` or `putsYYMMDD`. Previously they were saved as `callsMMYY` and `putsMMYY`. The next expiry is saved as `calls` and `puts`.

New features:

- The expiry parameter can now be a single date or a list-like object containing dates.
- A new property `expiry_dates` was added, which returns all available expiry dates.

Current behavior:

```
In [17]: from pandas.io.data import Options

In [18]: aapl = Options('aapl','yahoo')

In [19]: aapl.get_call_data().iloc[0:5,0:1]
Out[19]:
                                            Last
Strike Expiry     Type Symbol
80     2014-11-14 call AAPL141114C00080000  29.05
84     2014-11-14 call AAPL141114C00084000  24.80
85     2014-11-14 call AAPL141114C00085000  24.05
86     2014-11-14 call AAPL141114C00086000  22.76
87     2014-11-14 call AAPL141114C00087000  21.74

In [20]: aapl.expiry_dates
Out[20]:
[datetime.date(2014, 11, 14),
 datetime.date(2014, 11, 22),
 datetime.date(2014, 11, 28),
 datetime.date(2014, 12, 5),
 datetime.date(2014, 12, 12),
 datetime.date(2014, 12, 20),
 datetime.date(2015, 1, 17),
 datetime.date(2015, 2, 20),
 datetime.date(2015, 4, 17),
 datetime.date(2015, 7, 17),
 datetime.date(2016, 1, 15),
 datetime.date(2017, 1, 20)]

In [21]: aapl.get_near_stock_price(expiry=aapl.expiry_dates[0:3]).iloc[0:5,0:1]
Out[21]:
                                           Last
Strike Expiry     Type Symbol
109    2014-11-22 call AAPL141122C00109000  1.48
       2014-11-28 call AAPL141128C00109000  1.79
110    2014-11-14 call AAPL141114C00110000  0.55
       2014-11-22 call AAPL141122C00110000  1.02
       2014-11-28 call AAPL141128C00110000  1.32
```

- pandas now also registers the `datetime64` dtype in matplotlib's units registry to plot such values as datetimes. This is activated once pandas is imported. In previous versions, plotting an array of `datetime64` values will have resulted in plotted integer values. To keep the previous behaviour, you can do `del matplotlib.units.registry[np.datetime64]` (GH8614).

1.16.2 Enhancements

- `concat` permits a wider variety of iterables of pandas objects to be passed as the first parameter (GH8645):

```
In [17]: from collections import deque

In [18]: df1 = pd.DataFrame([1, 2, 3])
```

```
In [19]: df2 = pd.DataFrame([4, 5, 6])
```

previous behavior:

```
In [7]: pd.concat(deque((df1, df2)))
TypeError: first argument must be a list-like of pandas objects, you passed an␣
↪object of type "deque"
```

current behavior:

```
In [20]: pd.concat(deque((df1, df2)))
Out[20]:
   0
0  1
1  2
2  3
0  4
1  5
2  6
```

- Represent `MultiIndex` labels with a dtype that utilizes memory based on the level size. In prior versions, the memory usage was a constant 8 bytes per element in each level. In addition, in prior versions, the *reported* memory usage was incorrect as it didn't show the usage for the memory occupied by the underling data array. (GH8456)

```
In [21]: dfi = DataFrame(1,index=pd.MultiIndex.from_product([['a'],range(1000)]),
↪columns=['A'])
```

previous behavior:

```
# this was underreported in prior versions
In [1]: dfi.memory_usage(index=True)
Out[1]:
Index    8000 # took about 24008 bytes in < 0.15.1
A        8000
dtype: int64
```

current behavior:

```
In [22]: dfi.memory_usage(index=True)
Out[22]:
Index    11040
A         8000
dtype: int64
```

- Added Index properties *is_monotonic_increasing* and *is_monotonic_decreasing* (GH8680).
- Added option to select columns when importing Stata files (GH7935)
- Qualify memory usage in `DataFrame.info()` by adding + if it is a lower bound (GH8578)
- Raise errors in certain aggregation cases where an argument such as `numeric_only` is not handled (GH8592).
- Added support for 3-character ISO and non-standard country codes in `io.wb.download()` (GH8482)
- World Bank data requests now will warn/raise based on an `errors` argument, as well as a list of hard-coded country codes and the World Bank's JSON response. In prior versions, the error messages didn't look at the World Bank's JSON response. Problem-inducing input were simply dropped prior to the request. The issue was

that many good countries were cropped in the hard-coded approach. All countries will work now, but some bad countries will raise exceptions because some edge cases break the entire response. (GH8482)

- Added option to `Series.str.split()` to return a `DataFrame` rather than a `Series` (GH8428)
- Added option to `df.info(null_counts=None|True|False)` to override the default display options and force showing of the null-counts (GH8701)

1.16.3 Bug Fixes

- Bug in unpickling of a `CustomBusinessDay` object (GH8591)
- Bug in coercing `Categorical` to a records array, e.g. `df.to_records()` (GH8626)
- Bug in `Categorical` not created properly with `Series.to_frame()` (GH8626)
- Bug in coercing in astype of a `Categorical` of a passed `pd.Categorical` (this now raises `TypeError` correctly), (GH8626)
- Bug in `cut`/`qcut` when using `Series` and `retbins=True` (GH8589)
- Bug in writing Categorical columns to an SQL database with `to_sql` (GH8624).
- Bug in comparing `Categorical` of datetime raising when being compared to a scalar datetime (GH8687)
- Bug in selecting from a `Categorical` with `.iloc` (GH8623)
- Bug in groupby-transform with a Categorical (GH8623)
- Bug in duplicated/drop_duplicates with a Categorical (GH8623)
- Bug in `Categorical` reflected comparison operator raising if the first argument was a numpy array scalar (e.g. np.int64) (GH8658)
- Bug in Panel indexing with a list-like (GH8710)
- Compat issue is `DataFrame.dtypes` when `options.mode.use_inf_as_null` is True (GH8722)
- Bug in `read_csv`, `dialect` parameter would not take a string (:issue: *8703*)
- Bug in slicing a multi-index level with an empty-list (GH8737)
- Bug in numeric index operations of add/sub with Float/Index Index with numpy arrays (GH8608)
- Bug in setitem with empty indexer and unwanted coercion of dtypes (GH8669)
- Bug in ix/loc block splitting on setitem (manifests with integer-like dtypes, e.g. datetime64) (GH8607)
- Bug when doing label based indexing with integers not found in the index for non-unique but monotonic indexes (GH8680).
- Bug when indexing a Float64Index with `np.nan` on numpy 1.7 (GH8980).
- Fix `shape` attribute for `MultiIndex` (GH8609)
- Bug in `GroupBy` where a name conflict between the grouper and columns would break `groupby` operations (GH7115, GH8112)
- Fixed a bug where plotting a column `y` and specifying a label would mutate the index name of the original DataFrame (GH8494)
- Fix regression in plotting of a DatetimeIndex directly with matplotlib (GH8614).
- Bug in `date_range` where partially-specified dates would incorporate current date (GH6961)
- Bug in Setting by indexer to a scalar value with a mixed-dtype *Panel4d* was failing (GH8702)

- Bug where `DataReader`'s would fail if one of the symbols passed was invalid. Now returns data for valid symbols and np.nan for invalid (GH8494)
- Bug in `get_quote_yahoo` that wouldn't allow non-float return values (GH5229).

1.17 v0.15.0 (October 18, 2014)

This is a major release from 0.14.1 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

> **Warning:** pandas >= 0.15.0 will no longer support compatibility with NumPy versions < 1.7.0. If you want to use the latest versions of pandas, please upgrade to NumPy >= 1.7.0 (GH7711)

- Highlights include:
  - The `Categorical` type was integrated as a first-class pandas type, see *here*
  - New scalar type `Timedelta`, and a new index type `TimedeltaIndex`, see *here*
  - New datetimelike properties accessor `.dt` for Series, see *Datetimelike Properties*
  - New DataFrame default display for `df.info()` to include memory usage, see *Memory Usage*
  - `read_csv` will now by default ignore blank lines when parsing, see *here*
  - API change in using Indexes in set operations, see *here*
  - Enhancements in the handling of timezones, see *here*
  - A lot of improvements to the rolling and expanding moment funtions, see *here*
  - Internal refactoring of the `Index` class to no longer sub-class `ndarray`, see *Internal Refactoring*
  - dropping support for `PyTables` less than version 3.0.0, and `numexpr` less than version 2.1 (GH7990)
  - Split indexing documentation into *Indexing and Selecting Data* and *MultiIndex / Advanced Indexing*
  - Split out string methods documentation into *Working with Text Data*
- Check the *API Changes* and *deprecations* before updating
- *Other Enhancements*
- *Performance Improvements*
- *Bug Fixes*

> **Warning:** In 0.15.0 `Index` has internally been refactored to no longer sub-class `ndarray` but instead subclass `PandasObject`, similarly to the rest of the pandas objects. This change allows very easy sub-classing and creation of new index types. This should be a transparent change with only very limited API implications (See the *Internal Refactoring*)

> **Warning:** The refactorings in *`Categorical`* changed the two argument constructor from "codes/labels and levels" to "values and levels (now called 'categories')". This can lead to subtle bugs. If you use *`Categorical`* directly, please audit your code before updating to this pandas version and change it to use the *`from_codes()`* constructor. See more on `Categorical` *here*

1.17.1 New features

1.17.1.1 Categoricals in Series/DataFrame

`Categorical` can now be included in *Series* and *DataFrames* and gained new methods to manipulate. Thanks to Jan Schulz for much of this API/implementation. (GH3943, GH5313, GH5314, GH7444, GH7839, GH7848, GH7864, GH7914, GH7768, GH8006, GH3678, GH8075, GH8076, GH8143, GH8453, GH8518).

For full docs, see the *categorical introduction* and the *API documentation*.

```
In [1]: df = DataFrame({"id":[1,2,3,4,5,6], "raw_grade":['a', 'b', 'b', 'a', 'a', 'e
↪']})

In [2]: df["grade"] = df["raw_grade"].astype("category")

In [3]: df["grade"]
Out[3]:
0    a
1    b
2    b
3    a
4    a
5    e
Name: grade, dtype: category
Categories (3, object): [a, b, e]

# Rename the categories
In [4]: df["grade"].cat.categories = ["very good", "good", "very bad"]

# Reorder the categories and simultaneously add the missing categories
In [5]: df["grade"] = df["grade"].cat.set_categories(["very bad", "bad", "medium",
↪"good", "very good"])

In [6]: df["grade"]
Out[6]:
0    very good
1         good
2         good
3    very good
4    very good
5     very bad
Name: grade, dtype: category
Categories (5, object): [very bad, bad, medium, good, very good]

In [7]: df.sort_values("grade")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   id raw_grade      grade
5   6         e   very bad
1   2         b       good
2   3         b       good
0   1         a  very good
3   4         a  very good
4   5         a  very good

In [8]: df.groupby("grade").size()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
grade
very bad     1
bad          0
medium       0
good         2
very good    3
dtype: int64
```

- `pandas.core.group_agg` and `pandas.core.factor_agg` were removed. As an alternative, construct a dataframe and use `df.groupby(<group>).agg(<func>)`.
- Supplying "codes/labels and levels" to the `Categorical` constructor is not supported anymore. Supplying two arguments to the constructor is now interpreted as "values and levels (now called 'categories')". Please change your code to use the `from_codes()` constructor.
- The `Categorical.labels` attribute was renamed to `Categorical.codes` and is read only. If you want to manipulate codes, please use one of the *API methods on Categoricals*.
- The `Categorical.levels` attribute is renamed to `Categorical.categories`.

1.17.1.2 TimedeltaIndex/Scalar

We introduce a new scalar type `Timedelta`, which is a subclass of `datetime.timedelta`, and behaves in a similar manner, but allows compatibility with `np.timedelta64` types as well as a host of custom representation, parsing, and attributes. This type is very similar to how `Timestamp` works for `datetimes`. It is a nice-API box for the type. See the *docs*. (GH3009, GH4533, GH8209, GH8187, GH8190, GH7869, GH7661, GH8345, GH8471)

Warning: `Timedelta` scalars (and `TimedeltaIndex`) component fields are *not the same* as the component fields on a `datetime.timedelta` object. For example, `.seconds` on a `datetime.timedelta` object returns the total number of seconds combined between `hours`, `minutes` and `seconds`. In contrast, the pandas `Timedelta` breaks out hours, minutes, microseconds and nanoseconds separately.

```
# Timedelta accessor
In [9]: tds = Timedelta('31 days 5 min 3 sec')

In [10]: tds.minutes
Out[10]: 5L

In [11]: tds.seconds
Out[11]: 3L

# datetime.timedelta accessor
# this is 5 minutes * 60 + 3 seconds
In [12]: tds.to_pytimedelta().seconds
Out[12]: 303
```

Note: this is no longer true starting from v0.16.0, where full compatibility with `datetime.timedelta` is introduced. See the *0.16.0 whatsnew entry*

Warning: Prior to 0.15.0 `pd.to_timedelta` would return a `Series` for list-like/Series input, and a `np.timedelta64` for scalar input. It will now return a `TimedeltaIndex` for list-like input, `Series` for Series input, and `Timedelta` for scalar input.

The arguments to `pd.to_timedelta` are now `(arg,unit='ns',box=True,coerce=False)`, previously were `(arg,box=True,unit='ns')` as these are more logical.

Consruct a scalar

```
In [9]: Timedelta('1 days 06:05:01.00003')
Out[9]: Timedelta('1 days 06:05:01.000030')

In [10]: Timedelta('15.5us')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[10]: Timedelta('0 days 00:00:00.000015
↪')

In [11]: Timedelta('1 hour 15.5us')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[11]:␣
↪Timedelta('0 days 01:00:00.000015')

# negative Timedeltas have this string repr
# to be more consistent with datetime.timedelta conventions
In [12]: Timedelta('-1us')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('-1 days +23:59:59.999999')

# a NaT
In [13]: Timedelta('nan')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪NaT
```

Access fields for a `Timedelta`

```
In [14]: td = Timedelta('1 hour 3m 15.5us')

In [15]: td.seconds
Out[15]: 3780

In [16]: td.microseconds
\\\\\\\\\\\\\\Out[16]: 15

In [17]: td.nanoseconds
\\\\\\\\\\\\\\\\\\\\\\\\\\Out[17]: 500
```

Construct a `TimedeltaIndex`

```
In [18]: TimedeltaIndex(['1 days','1 days, 00:00:05',
   ....:                 np.timedelta64(2,'D'),timedelta(days=2,seconds=2)])
   ....:
Out[18]:
TimedeltaIndex(['1 days 00:00:00', '1 days 00:00:05', '2 days 00:00:00',
                '2 days 00:00:02'],
               dtype='timedelta64[ns]', freq=None)
```

Constructing a `TimedeltaIndex` with a regular range

```
In [19]: timedelta_range('1 days',periods=5,freq='D')
Out[19]: TimedeltaIndex(['1 days', '2 days', '3 days', '4 days', '5 days'], dtype=
↪'timedelta64[ns]', freq='D')

In [20]: timedelta_range(start='1 days',end='2 days',freq='30T')
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
TimedeltaIndex(['1 days 00:00:00', '1 days 00:30:00', '1 days 01:00:00',
                '1 days 01:30:00', '1 days 02:00:00', '1 days 02:30:00',
                '1 days 03:00:00', '1 days 03:30:00', '1 days 04:00:00',
                '1 days 04:30:00', '1 days 05:00:00', '1 days 05:30:00',
                '1 days 06:00:00', '1 days 06:30:00', '1 days 07:00:00',
                '1 days 07:30:00', '1 days 08:00:00', '1 days 08:30:00',
                '1 days 09:00:00', '1 days 09:30:00', '1 days 10:00:00',
                '1 days 10:30:00', '1 days 11:00:00', '1 days 11:30:00',
                '1 days 12:00:00', '1 days 12:30:00', '1 days 13:00:00',
                '1 days 13:30:00', '1 days 14:00:00', '1 days 14:30:00',
                '1 days 15:00:00', '1 days 15:30:00', '1 days 16:00:00',
                '1 days 16:30:00', '1 days 17:00:00', '1 days 17:30:00',
                '1 days 18:00:00', '1 days 18:30:00', '1 days 19:00:00',
                '1 days 19:30:00', '1 days 20:00:00', '1 days 20:30:00',
                '1 days 21:00:00', '1 days 21:30:00', '1 days 22:00:00',
                '1 days 22:30:00', '1 days 23:00:00', '1 days 23:30:00',
                '2 days 00:00:00'],
               dtype='timedelta64[ns]', freq='30T')
```

You can now use a `TimedeltaIndex` as the index of a pandas object

```
In [21]: s = Series(np.arange(5),
   ....:            index=timedelta_range('1 days',periods=5,freq='s'))
   ....:

In [22]: s
Out[22]:
1 days 00:00:00    0
1 days 00:00:01    1
1 days 00:00:02    2
1 days 00:00:03    3
1 days 00:00:04    4
Freq: S, dtype: int64
```

You can select with partial string selections

```
In [23]: s['1 day 00:00:02']
Out[23]: 2

In [24]: s['1 day':'1 day 00:00:02']
\\\\\\\\\\\Out[24]:
1 days 00:00:00    0
1 days 00:00:01    1
1 days 00:00:02    2
Freq: S, dtype: int64
```

Finally, the combination of `TimedeltaIndex` with `DatetimeIndex` allow certain combination operations that are `NaT` preserving:

```
In [25]: tdi = TimedeltaIndex(['1 days',pd.NaT,'2 days'])

In [26]: tdi.tolist()
Out[26]: [Timedelta('1 days 00:00:00'), NaT, Timedelta('2 days 00:00:00')]

In [27]: dti = date_range('20130101',periods=3)
```

```
In [28]: dti.tolist()
Out[28]:
[Timestamp('2013-01-01 00:00:00', freq='D'),
 Timestamp('2013-01-02 00:00:00', freq='D'),
 Timestamp('2013-01-03 00:00:00', freq='D')]

In [29]: (dti + tdi).tolist()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[Timestamp('2013-01-02 00:00:00'), NaT, Timestamp('2013-01-05 00:00:00')]

In [30]: (dti - tdi).tolist()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[Timestamp('2012-12-31 00:00:00'), NaT, Timestamp('2013-01-01 00:00:00')]
```

- iteration of a `Series` e.g. `list(Series(...))` of `timedelta64[ns]` would prior to v0.15.0 return `np.timedelta64` for each element. These will now be wrapped in `Timedelta`.

1.17.1.3 Memory Usage

Implemented methods to find memory usage of a DataFrame. See the *FAQ* for more. (GH6852).

A new display option `display.memory_usage` (see *Options and Settings*) sets the default behavior of the `memory_usage` argument in the `df.info()` method. By default `display.memory_usage` is `True`.

```
In [31]: dtypes = ['int64', 'float64', 'datetime64[ns]', 'timedelta64[ns]',
   ....:           'complex128', 'object', 'bool']
   ....:

In [32]: n = 5000

In [33]: data = dict([ (t, np.random.randint(100, size=n).astype(t))
   ....:                 for t in dtypes])
   ....:

In [34]: df = DataFrame(data)

In [35]: df['categorical'] = df['object'].astype('category')

In [36]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 8 columns):
bool               5000 non-null bool
complex128         5000 non-null complex128
datetime64[ns]     5000 non-null datetime64[ns]
float64            5000 non-null float64
int64              5000 non-null int64
object             5000 non-null object
timedelta64[ns]    5000 non-null timedelta64[ns]
categorical        5000 non-null category
dtypes: bool(1), category(1), complex128(1), datetime64[ns](1), float64(1), int64(1),␣
↪object(1), timedelta64[ns](1)
memory usage: 289.1+ KB
```

Additionally *`memory_usage()`* is an available method for a dataframe object which returns the memory usage of each column.

```
In [37]: df.memory_usage(index=True)
Out[37]:
Index                80
bool               5000
complex128        80000
datetime64[ns]    40000
float64           40000
int64             40000
object            40000
timedelta64[ns]   40000
categorical       10920
dtype: int64
```

1.17.1.4 .dt accessor

`Series` has gained an accessor to succinctly return datetime like properties for the *values* of the Series, if its a datetime/period like Series. (GH7207) This will return a Series, indexed like the existing Series. See the *docs*

```
# datetime
In [38]: s = Series(date_range('20130101 09:10:12',periods=4))

In [39]: s
Out[39]:
0   2013-01-01 09:10:12
1   2013-01-02 09:10:12
2   2013-01-03 09:10:12
3   2013-01-04 09:10:12
dtype: datetime64[ns]

In [40]: s.dt.hour
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
0    9
1    9
2    9
3    9
dtype: int64

In [41]: s.dt.second
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
0    12
1    12
2    12
3    12
dtype: int64

In [42]: s.dt.day
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
0    1
1    2
2    3
3    4
dtype: int64
```

```
In [43]: s.dt.freq
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪'D'
```

This enables nice expressions like this:

```
In [44]: s[s.dt.day==2]
Out[44]:
1   2013-01-02 09:10:12
dtype: datetime64[ns]
```

You can easily produce tz aware transformations:

```
In [45]: stz = s.dt.tz_localize('US/Eastern')

In [46]: stz
Out[46]:
0   2013-01-01 09:10:12-05:00
1   2013-01-02 09:10:12-05:00
2   2013-01-03 09:10:12-05:00
3   2013-01-04 09:10:12-05:00
dtype: datetime64[ns, US/Eastern]

In [47]: stz.dt.tz
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪<DstTzInfo 'US/Eastern' LMT-1 day, 19:04:00 STD>
```

You can also chain these types of operations:

```
In [48]: s.dt.tz_localize('UTC').dt.tz_convert('US/Eastern')
Out[48]:
0   2013-01-01 04:10:12-05:00
1   2013-01-02 04:10:12-05:00
2   2013-01-03 04:10:12-05:00
3   2013-01-04 04:10:12-05:00
dtype: datetime64[ns, US/Eastern]
```

The `.dt` accessor works for period and timedelta dtypes.

```
# period
In [49]: s = Series(period_range('20130101',periods=4,freq='D'))

In [50]: s
Out[50]:
0   2013-01-01
1   2013-01-02
2   2013-01-03
3   2013-01-04
dtype: object

In [51]: s.dt.year
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[51]:␣
↪
0    2013
1    2013
2    2013
3    2013
dtype: int64
```

```
In [52]: s.dt.day
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    2
2    3
3    4
dtype: int64
```

```
# timedelta
In [53]: s = Series(timedelta_range('1 day 00:00:05',periods=4,freq='s'))

In [54]: s
Out[54]: 
0   1 days 00:00:05
1   1 days 00:00:06
2   1 days 00:00:07
3   1 days 00:00:08
dtype: timedelta64[ns]

In [55]: s.dt.days
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    1
2    1
3    1
dtype: int64

In [56]: s.dt.seconds
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    5
1    6
2    7
3    8
dtype: int64

In [57]: s.dt.components
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   days  hours  minutes  seconds  milliseconds  microseconds  nanoseconds
0     1      0        0        5             0             0            0
1     1      0        0        6             0             0            0
2     1      0        0        7             0             0            0
3     1      0        0        8             0             0            0
```

1.17.1.5 Timezone handling improvements

- `tz_localize(None)` for tz-aware `Timestamp` and `DatetimeIndex` now removes timezone holding local time, previously this resulted in `Exception` or `TypeError` (GH7812)

```
In [58]: ts = Timestamp('2014-08-01 09:00', tz='US/Eastern')

In [59]: ts
```

```
Out[59]: Timestamp('2014-08-01 09:00:00-0400', tz='US/Eastern')

In [60]: ts.tz_localize(None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[60]:␣
↪Timestamp('2014-08-01 09:00:00')

In [61]: didx = DatetimeIndex(start='2014-08-01 09:00', freq='H', periods=10, tz=
↪'US/Eastern')

In [62]: didx
Out[62]:
DatetimeIndex(['2014-08-01 09:00:00-04:00', '2014-08-01 10:00:00-04:00',
               '2014-08-01 11:00:00-04:00', '2014-08-01 12:00:00-04:00',
               '2014-08-01 13:00:00-04:00', '2014-08-01 14:00:00-04:00',
               '2014-08-01 15:00:00-04:00', '2014-08-01 16:00:00-04:00',
               '2014-08-01 17:00:00-04:00', '2014-08-01 18:00:00-04:00'],
              dtype='datetime64[ns, US/Eastern]', freq='H')

In [63]: didx.tz_localize(None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2014-08-01 09:00:00', '2014-08-01 10:00:00',
               '2014-08-01 11:00:00', '2014-08-01 12:00:00',
               '2014-08-01 13:00:00', '2014-08-01 14:00:00',
               '2014-08-01 15:00:00', '2014-08-01 16:00:00',
               '2014-08-01 17:00:00', '2014-08-01 18:00:00'],
              dtype='datetime64[ns]', freq='H')
```

- `tz_localize` now accepts the `ambiguous` keyword which allows for passing an array of bools indicating whether the date belongs in DST or not, 'NaT' for setting transition times to NaT, 'infer' for inferring DST/non-DST, and 'raise' (default) for an `AmbiguousTimeError` to be raised. See *the docs* for more details (GH7943)
- `DataFrame.tz_localize` and `DataFrame.tz_convert` now accepts an optional `level` argument for localizing a specific level of a MultiIndex (GH7846)
- `Timestamp.tz_localize` and `Timestamp.tz_convert` now raise `TypeError` in error cases, rather than `Exception` (GH8025)
- a timeseries/index localized to UTC when inserted into a Series/DataFrame will preserve the UTC timezone (rather than being a naive `datetime64[ns]`) as `object` dtype (GH8411)
- `Timestamp.__repr__` displays `dateutil.tz.tzoffset` info (GH7907)

1.17.1.6 Rolling/Expanding Moments improvements

- `rolling_min()`, `rolling_max()`, `rolling_cov()`, and `rolling_corr()` now return objects with all `NaN` when `len(arg) < min_periods <= window` rather than raising. (This makes all rolling functions consistent in this behavior). (GH7766)

  Prior to 0.15.0

  ```
  In [64]: s = Series([10, 11, 12, 13])
  ```

  ```
  In [15]: rolling_min(s, window=10, min_periods=5)
  ValueError: min_periods (5) must be <= window (4)
  ```

  New behavior

```
In [4]: pd.rolling_min(s, window=10, min_periods=5)
Out[4]:
0   NaN
1   NaN
2   NaN
3   NaN
dtype: float64
```

- `rolling_max()`, `rolling_min()`, `rolling_sum()`, `rolling_mean()`, `rolling_median()`, `rolling_std()`, `rolling_var()`, `rolling_skew()`, `rolling_kurt()`, `rolling_quantile()`, `rolling_cov()`, `rolling_corr()`, `rolling_corr_pairwise()`, `rolling_window()`, and `rolling_apply()` with `center=True` previously would return a result of the same structure as the input `arg` with `NaN` in the final `(window-1)/2` entries.

  Now the final `(window-1)/2` entries of the result are calculated as if the input `arg` were followed by `(window-1)/2 NaN` values (or with shrinking windows, in the case of `rolling_apply()`). (GH7925, GH8269)

  Prior behavior (note final value is `NaN`):

```
In [7]: rolling_sum(Series(range(4)), window=3, min_periods=0, center=True)
Out[7]:
0     1
1     3
2     6
3   NaN
dtype: float64
```

  New behavior (note final value is `5 = sum([2, 3, NaN])`):

```
In [7]: rolling_sum(Series(range(4)), window=3, min_periods=0, center=True)
Out[7]:
0    1
1    3
2    6
3    5
dtype: float64
```

- `rolling_window()` now normalizes the weights properly in rolling mean mode (*mean=True*) so that the calculated weighted means (e.g. 'triang', 'gaussian') are distributed about the same means as those calculated without weighting (i.e. 'boxcar'). See *the note on normalization* for further details. (GH7618)

```
In [65]: s = Series([10.5, 8.8, 11.4, 9.7, 9.3])
```

  Behavior prior to 0.15.0:

```
In [39]: rolling_window(s, window=3, win_type='triang', center=True)
Out[39]:
0         NaN
1    6.583333
2    6.883333
3    6.683333
4         NaN
dtype: float64
```

  New behavior

```
In [10]: pd.rolling_window(s, window=3, win_type='triang', center=True)
Out[10]:
0       NaN
1     9.875
2    10.325
3    10.025
4       NaN
dtype: float64
```

- Removed `center` argument from all `expanding_` functions (see *list*), as the results produced when `center=True` did not make much sense. (GH7925)
- Added optional `ddof` argument to `expanding_cov()` and `rolling_cov()`. The default value of `1` is backwards-compatible. (GH8279)
- Documented the `ddof` argument to `expanding_var()`, `expanding_std()`, `rolling_var()`, and `rolling_std()`. These functions' support of a `ddof` argument (with a default value of `1`) was previously undocumented. (GH8064)
- `ewma()`, `ewmstd()`, `ewmvol()`, `ewmvar()`, `ewmcov()`, and `ewmcorr()` now interpret `min_periods` in the same manner that the `rolling_*()` and `expanding_*()` functions do: a given result entry will be `NaN` if the (expanding, in this case) window does not contain at least `min_periods` values. The previous behavior was to set to `NaN` the `min_periods` entries starting with the first non- `NaN` value. (GH7977)

  Prior behavior (note values start at index `2`, which is `min_periods` after index `0` (the index of the first non-empty value)):

```
In [66]: s  = Series([1, None, None, None, 2, 3])
```

```
In [51]: ewma(s, com=3., min_periods=2)
Out[51]:
0         NaN
1         NaN
2    1.000000
3    1.000000
4    1.571429
5    2.189189
dtype: float64
```

  New behavior (note values start at index `4`, the location of the 2nd (since `min_periods=2`) non-empty value):

```
In [2]: pd.ewma(s, com=3., min_periods=2)
Out[2]:
0         NaN
1         NaN
2         NaN
3         NaN
4    1.759644
5    2.383784
dtype: float64
```

- `ewmstd()`, `ewmvol()`, `ewmvar()`, `ewmcov()`, and `ewmcorr()` now have an optional `adjust` argument, just like `ewma()` does, affecting how the weights are calculated. The default value of `adjust` is `True`, which is backwards-compatible. See *Exponentially weighted moment functions* for details. (GH7911)
- `ewma()`, `ewmstd()`, `ewmvol()`, `ewmvar()`, `ewmcov()`, and `ewmcorr()` now have an optional `ignore_na` argument. When `ignore_na=False` (the default), missing values are taken into account in

the weights calculation. When `ignore_na=True` (which reproduces the pre-0.15.0 behavior), missing values are ignored in the weights calculation. (GH7543)

```
In [7]: pd.ewma(Series([None, 1., 8.]), com=2.)
Out[7]:
0    NaN
1    1.0
2    5.2
dtype: float64

In [8]: pd.ewma(Series([1., None, 8.]), com=2., ignore_na=True)  # pre-0.15.0␣
↪behavior
Out[8]:
0    1.0
1    1.0
2    5.2
dtype: float64

In [9]: pd.ewma(Series([1., None, 8.]), com=2., ignore_na=False)  # new default
Out[9]:
0    1.000000
1    1.000000
2    5.846154
dtype: float64
```

Warning: By default (`ignore_na=False`) the `ewm*()` functions' weights calculation in the presence of missing values is different than in pre-0.15.0 versions. To reproduce the pre-0.15.0 calculation of weights in the presence of missing values one must specify explicitly `ignore_na=True`.

- Bug in `expanding_cov()`, `expanding_corr()`, `rolling_cov()`, `rolling_cor()`, `ewmcov()`, and `ewmcorr()` returning results with columns sorted by name and producing an error for non-unique columns; now handles non-unique columns and returns columns in original order (except for the case of two DataFrames with `pairwise=False`, where behavior is unchanged) (GH7542)
- Bug in `rolling_count()` and `expanding_*()` functions unnecessarily producing error message for zero-length data (GH8056)
- Bug in `rolling_apply()` and `expanding_apply()` interpreting `min_periods=0` as `min_periods=1` (GH8080)
- Bug in `expanding_std()` and `expanding_var()` for a single value producing a confusing error message (GH7900)
- Bug in `rolling_std()` and `rolling_var()` for a single value producing `0` rather than `NaN` (GH7900)
- Bug in `ewmstd()`, `ewmvol()`, `ewmvar()`, and `ewmcov()` calculation of de-biasing factors when `bias=False` (the default). Previously an incorrect constant factor was used, based on `adjust=True`, `ignore_na=True`, and an infinite number of observations. Now a different factor is used for each entry, based on the actual weights (analogous to the usual `N/(N-1)` factor). In particular, for a single point a value of `NaN` is returned when `bias=False`, whereas previously a value of (approximately) `0` was returned.

  For example, consider the following pre-0.15.0 results for `ewmvar(..., bias=False)`, and the corresponding debiasing factors:

```
In [67]: s = Series([1., 2., 0., 4.])
```

```
In [89]: ewmvar(s, com=2., bias=False)
Out[89]:
0   -2.775558e-16
1    3.000000e-01
2    9.556787e-01
3    3.585799e+00
dtype: float64

In [90]: ewmvar(s, com=2., bias=False) / ewmvar(s, com=2., bias=True)
Out[90]:
0    1.25
1    1.25
2    1.25
3    1.25
dtype: float64
```

Note that entry `0` is approximately 0, and the debiasing factors are a constant 1.25. By comparison, the following 0.15.0 results have a `NaN` for entry `0`, and the debiasing factors are decreasing (towards 1.25):

```
In [14]: pd.ewmvar(s, com=2., bias=False)
Out[14]:
0         NaN
1    0.500000
2    1.210526
3    4.089069
dtype: float64

In [15]: pd.ewmvar(s, com=2., bias=False) / pd.ewmvar(s, com=2., bias=True)
Out[15]:
0         NaN
1    2.083333
2    1.583333
3    1.425439
dtype: float64
```

See *Exponentially weighted moment functions* for details. (GH7912)

1.17.1.7 Improvements in the sql io module

- Added support for a `chunksize` parameter to `to_sql` function. This allows DataFrame to be written in chunks and avoid packet-size overflow errors (GH8062).
- Added support for a `chunksize` parameter to `read_sql` function. Specifying this argument will return an iterator through chunks of the query result (GH2908).
- Added support for writing `datetime.date` and `datetime.time` object columns with `to_sql` (GH6932).
- Added support for specifying a `schema` to read from/write to with `read_sql_table` and `to_sql` (GH7441, GH7952). For example:

```
df.to_sql('table', engine, schema='other_schema')
pd.read_sql_table('table', engine, schema='other_schema')
```

- Added support for writing `NaN` values with `to_sql` (GH2754).
- Added support for writing datetime64 columns with `to_sql` for all database flavors (GH7103).

1.17.2 Backwards incompatible API changes

1.17.2.1 Breaking changes

API changes related to `Categorical` (see *here* for more details):

- The `Categorical` constructor with two arguments changed from "codes/labels and levels" to "values and levels (now called 'categories')". This can lead to subtle bugs. If you use `Categorical` directly, please audit your code by changing it to use the `from_codes()` constructor.

  An old function call like (prior to 0.15.0):

  ```
  pd.Categorical([0,1,0,2,1], levels=['a', 'b', 'c'])
  ```

  will have to adapted to the following to keep the same behaviour:

  ```
  In [2]: pd.Categorical.from_codes([0,1,0,2,1], categories=['a', 'b', 'c'])
  Out[2]:
  [a, b, a, c, b]
  Categories (3, object): [a, b, c]
  ```

API changes related to the introduction of the `Timedelta` scalar (see *above* for more details):

- Prior to 0.15.0 `to_timedelta()` would return a `Series` for list-like/Series input, and a `np.timedelta64` for scalar input. It will now return a `TimedeltaIndex` for list-like input, `Series` for Series input, and `Timedelta` for scalar input.

For API changes related to the rolling and expanding functions, see detailed overview *above*.

Other notable API changes:

- Consistency when indexing with `.loc` and a list-like indexer when no values are found.

  ```
  In [68]: df = DataFrame([['a'],['b']],index=[1,2])

  In [69]: df
  Out[69]:
     0
  1  a
  2  b
  ```

  In prior versions there was a difference in these two constructs:

  - `df.loc[[3]]` would return a frame reindexed by 3 (with all `np.nan` values)
  - `df.loc[[3],:]` would raise `KeyError`.

  Both will now raise a `KeyError`. The rule is that *at least 1* indexer must be found when using a list-like and `.loc` (GH7999)

  Furthermore in prior versions these were also different:

  - `df.loc[[1,3]]` would return a frame reindexed by [1,3]
  - `df.loc[[1,3],:]` would raise `KeyError`.

  Both will now return a frame reindex by [1,3]. E.g.

  ```
  In [3]: df.loc[[1,3]]
  Out[3]:
       0
  1    a
  ```

```
3  NaN

In [4]: df.loc[[1,3],:]
Out[4]:
     0
1    a
3  NaN
```

This can also be seen in multi-axis indexing with a `Panel`.

```
In [70]: p = Panel(np.arange(2*3*4).reshape(2,3,4),
   ....:           items=['ItemA','ItemB'],
   ....:           major_axis=[1,2,3],
   ....:           minor_axis=['A','B','C','D'])
   ....:

In [71]: p
Out[71]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 3 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemB
Major_axis axis: 1 to 3
Minor_axis axis: A to D
```

The following would raise `KeyError` prior to 0.15.0:

```
In [5]:
Out[5]:
   ItemA  ItemD
1      3    NaN
2      7    NaN
3     11    NaN
```

Furthermore, `.loc` will raise If no values are found in a multi-index with a list-like indexer:

```
In [72]: s = Series(np.arange(3,dtype='int64'),
   ....:            index=MultiIndex.from_product([['A'],['foo','bar','baz']],
   ....:                                          names=['one','two'])
   ....:           ).sort_index()
   ....:

In [73]: s
Out[73]:
one  two
A    bar    1
     baz    2
     foo    0
dtype: int64

In [74]: try:
   ....:    s.loc[['D']]
   ....: except KeyError as e:
   ....:    print("KeyError: " + str(e))
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\KeyError:␣
↪"['D'] not in index"
```

- Assigning values to `None` now considers the dtype when choosing an 'empty' value (GH7941).

Previously, assigning to `None` in numeric containers changed the dtype to object (or errored, depending on the call). It now uses `NaN`:

```
In [75]: s = Series([1, 2, 3])

In [76]: s.loc[0] = None

In [77]: s
Out[77]:
0    NaN
1    2.0
2    3.0
dtype: float64
```

`NaT` is now used similarly for datetime containers.

For object containers, we now preserve `None` values (previously these were converted to `NaN` values).

```
In [78]: s = Series(["a", "b", "c"])

In [79]: s.loc[0] = None

In [80]: s
Out[80]:
0    None
1       b
2       c
dtype: object
```

To insert a `NaN`, you must explicitly use `np.nan`. See the *docs*.

- In prior versions, updating a pandas object inplace would not reflect in other python references to this object. (GH8511, GH5104)

```
In [81]: s = Series([1, 2, 3])

In [82]: s2 = s

In [83]: s += 1.5
```

Behavior prior to v0.15.0

```
# the original object
In [5]: s
Out[5]:
0    2.5
1    3.5
2    4.5
dtype: float64


# a reference to the original object
In [7]: s2
Out[7]:
0    1
1    2
2    3
dtype: int64
```

This is now the correct behavior

```
# the original object
In [84]: s
Out[84]:
0    2.5
1    3.5
2    4.5
dtype: float64

# a reference to the original object
In [85]: s2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[85]:
0    2.5
1    3.5
2    4.5
dtype: float64
```

- Made both the C-based and Python engines for *read_csv* and *read_table* ignore empty lines in input as well as whitespace-filled lines, as long as `sep` is not whitespace. This is an API change that can be controlled by the keyword parameter `skip_blank_lines`. See *the docs* (GH4466)
- A timeseries/index localized to UTC when inserted into a Series/DataFrame will preserve the UTC timezone and inserted as `object` dtype rather than being converted to a naive `datetime64[ns]` (GH8411).
- Bug in passing a `DatetimeIndex` with a timezone that was not being retained in DataFrame construction from a dict (GH7822)

  In prior versions this would drop the timezone, now it retains the timezone, but gives a column of `object` dtype:

```
In [86]: i = date_range('1/1/2011', periods=3, freq='10s', tz = 'US/Eastern')

In [87]: i
Out[87]:
DatetimeIndex(['2011-01-01 00:00:00-05:00', '2011-01-01 00:00:10-05:00',
               '2011-01-01 00:00:20-05:00'],
              dtype='datetime64[ns, US/Eastern]', freq='10S')

In [88]: df = DataFrame( {'a' : i } )

In [89]: df
Out[89]:
                          a
0 2011-01-01 00:00:00-05:00
1 2011-01-01 00:00:10-05:00
2 2011-01-01 00:00:20-05:00

In [90]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a    datetime64[ns, US/Eastern]
dtype: object
```

  Previously this would have yielded a column of `datetime64` dtype, but without timezone info.

  The behaviour of assigning a column to an existing dataframe as *df['a'] = i* remains unchanged (this already returned an `object` column with a timezone).

- When passing multiple levels to *`stack()`*, it will now raise a `ValueError` when the levels aren't all level

names or all level numbers (GH7660). See *Reshaping by stacking and unstacking*.

- Raise a `ValueError` in `df.to_hdf` with 'fixed' format, if `df` has non-unique columns as the resulting file will be broken (GH7761)
- `SettingWithCopy` raise/warnings (according to the option `mode.chained_assignment`) will now be issued when setting a value on a sliced mixed-dtype DataFrame using chained-assignment. (GH7845, GH7950)

```
In [1]: df = DataFrame(np.arange(0,9), columns=['count'])

In [2]: df['group'] = 'b'

In [3]: df.iloc[0:5]['group'] = 'a'
/usr/local/bin/ipython:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the the caveats in the documentation: http://pandas.pydata.org/pandas-docs/
↪stable/indexing.html#indexing-view-versus-copy
```

- `merge`, `DataFrame.merge`, and `ordered_merge` now return the same type as the `left` argument (GH7737).
- Previously an enlargement with a mixed-dtype frame would act unlike `.append` which will preserve dtypes (related GH2578, GH8176):

```
In [91]: df = DataFrame([[True, 1],[False, 2]],
   ....:                 columns=["female","fitness"])
   ....:

In [92]: df
Out[92]:
   female  fitness
0    True        1
1   False        2

In [93]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[93]:
female      bool
fitness    int64
dtype: object

# dtypes are now preserved
In [94]: df.loc[2] = df.loc[1]

In [95]: df
Out[95]:
   female  fitness
0    True        1
1   False        2
2   False        2

In [96]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[96]:␣
↪
female      bool
fitness    int64
dtype: object
```

- `Series.to_csv()` now returns a string when `path=None`, matching the behaviour of `DataFrame.to_csv()` (GH8215).
- `read_hdf` now raises `IOError` when a file that doesn't exist is passed in. Previously, a new, empty file was created, and a `KeyError` raised (GH7715).
- `DataFrame.info()` now ends its output with a newline character (GH8114)
- Concatenating no objects will now raise a `ValueError` rather than a bare `Exception`.
- Merge errors will now be sub-classes of `ValueError` rather than raw `Exception` (GH8501)
- `DataFrame.plot` and `Series.plot` keywords are now have consistent orders (GH8037)

1.17.2.2 Internal Refactoring

In 0.15.0 `Index` has internally been refactored to no longer sub-class `ndarray` but instead subclass `PandasObject`, similarly to the rest of the pandas objects. This change allows very easy sub-classing and creation of new index types. This should be a transparent change with only very limited API implications (GH5080, GH7439, GH7796, GH8024, GH8367, GH7997, GH8522):

- you may need to unpickle pandas version < 0.15.0 pickles using `pd.read_pickle` rather than `pickle.load`. See *pickle docs*
- when plotting with a `PeriodIndex`, the matplotlib internal axes will now be arrays of `Period` rather than a `PeriodIndex` (this is similar to how a `DatetimeIndex` passes arrays of `datetimes` now)
- MultiIndexes will now raise similary to other pandas objects w.r.t. truth testing, see *here* (GH7897).
- When plotting a DatetimeIndex directly with matplotlib's *plot* function, the axis labels will no longer be formatted as dates but as integers (the internal representation of a `datetime64`). **UPDATE** This is fixed in 0.15.1, see *here*.

1.17.2.3 Deprecations

- The attributes `Categorical labels` and `levels` attributes are deprecated and renamed to `codes` and `categories`.
- The `outtype` argument to `pd.DataFrame.to_dict` has been deprecated in favor of `orient`. (GH7840)
- The `convert_dummies` method has been deprecated in favor of `get_dummies` (GH8140)
- The `infer_dst` argument in `tz_localize` will be deprecated in favor of `ambiguous` to allow for more flexibility in dealing with DST transitions. Replace `infer_dst=True` with `ambiguous='infer'` for the same behavior (GH7943). See *the docs* for more details.
- The top-level `pd.value_range` has been deprecated and can be replaced by `.describe()` (GH8481)
- The `Index` set operations `+` and `-` were deprecated in order to provide these for numeric type operations on certain index types. `+` can be replaced by `.union()` or `|`, and `-` by `.difference()`. Further the method name `Index.diff()` is deprecated and can be replaced by `Index.difference()` (GH8226)

```
# +
Index(['a','b','c']) + Index(['b','c','d'])

# should be replaced by
Index(['a','b','c']).union(Index(['b','c','d']))
```

```
# -
Index(['a','b','c']) - Index(['b','c','d'])

# should be replaced by
Index(['a','b','c']).difference(Index(['b','c','d']))
```

- The `infer_types` argument to *`read_html()`* now has no effect and is deprecated (GH7762, GH7032).

1.17.2.4 Removal of prior version deprecations/changes

- Remove `DataFrame.delevel` method in favor of `DataFrame.reset_index`

1.17.3 Enhancements

Enhancements in the importing/exporting of Stata files:

- Added support for bool, uint8, uint16 and uint32 datatypes in `to_stata` (GH7097, GH7365)
- Added conversion option when importing Stata files (GH8527)
- `DataFrame.to_stata` and `StataWriter` check string length for compatibility with limitations imposed in dta files where fixed-width strings must contain 244 or fewer characters. Attempting to write Stata dta files with strings longer than 244 characters raises a `ValueError`. (GH7858)
- `read_stata` and `StataReader` can import missing data information into a `DataFrame` by setting the argument `convert_missing` to `True`. When using this options, missing values are returned as `StataMissingValue` objects and columns containing missing values have `object` data type. (GH8045)

Enhancements in the plotting functions:

- Added `layout` keyword to `DataFrame.plot`. You can pass a tuple of `(rows, columns)`, one of which can be `-1` to automatically infer (GH6667, GH8071).
- Allow to pass multiple axes to `DataFrame.plot`, `hist` and `boxplot` (GH5353, GH6970, GH7069)
- Added support for `c`, `colormap` and `colorbar` arguments for `DataFrame.plot` with `kind='scatter'` (GH7780)
- Histogram from `DataFrame.plot` with `kind='hist'` (GH7809), See *the docs*.
- Boxplot from `DataFrame.plot` with `kind='box'` (GH7998), See *the docs*.

Other:

- `read_csv` now has a keyword parameter `float_precision` which specifies which floating-point converter the C engine should use during parsing, see *here* (GH8002, GH8044)
- Added `searchsorted` method to `Series` objects (GH7447)
- `describe()` on mixed-types DataFrames is more flexible. Type-based column filtering is now possible via the `include`/`exclude` arguments. See the *docs* (GH8164).

```
In [97]: df = DataFrame({'catA': ['foo', 'foo', 'bar'] * 8,
   ....:                 'catB': ['a', 'b', 'c', 'd'] * 6,
   ....:                 'numC': np.arange(24),
   ....:                 'numD': np.arange(24.) + .5})
   ....:

In [98]: df.describe(include=["object"])
Out[98]:
```

```
       catA catB
count    24   24
unique    2    4
top     foo    d
freq     16    6

In [99]: df.describe(include=["number", "object"], exclude=["float"])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\C
↪
       catA catB       numC
count    24   24  24.000000
unique    2    4        NaN
top     foo    d        NaN
freq     16    6        NaN
mean    NaN  NaN  11.500000
std     NaN  NaN   7.071068
min     NaN  NaN   0.000000
25%     NaN  NaN   5.750000
50%     NaN  NaN  11.500000
75%     NaN  NaN  17.250000
max     NaN  NaN  23.000000
```

Requesting all columns is possible with the shorthand 'all'

```
In [100]: df.describe(include='all')
Out[100]:
       catA catB       numC       numD
count    24   24  24.000000  24.000000
unique    2    4        NaN        NaN
top     foo    d        NaN        NaN
freq     16    6        NaN        NaN
mean    NaN  NaN  11.500000  12.000000
std     NaN  NaN   7.071068   7.071068
min     NaN  NaN   0.000000   0.500000
25%     NaN  NaN   5.750000   6.250000
50%     NaN  NaN  11.500000  12.000000
75%     NaN  NaN  17.250000  17.750000
max     NaN  NaN  23.000000  23.500000
```

Without those arguments, 'describe' will behave as before, including only numerical columns or, if none are, only categorical columns. See also the *docs*

- Added `split` as an option to the `orient` argument in `pd.DataFrame.to_dict`. (GH7840)
- The `get_dummies` method can now be used on DataFrames. By default only catagorical columns are encoded as 0's and 1's, while other columns are left untouched.

```
In [101]: df = DataFrame({'A': ['a', 'b', 'a'], 'B': ['c', 'c', 'b'],
   .....:                 'C': [1, 2, 3]})
   .....:

In [102]: pd.get_dummies(df)
Out[102]:
   C  A_a  A_b  B_b  B_c
0  1    1    0    0    1
1  2    0    1    0    1
2  3    1    0    1    0
```

- `PeriodIndex` supports `resolution` as the same as `DatetimeIndex` (GH7708)

- `pandas.tseries.holiday` has added support for additional holidays and ways to observe holidays (GH7070)
- `pandas.tseries.holiday.Holiday` now supports a list of offsets in Python3 (GH7070)
- `pandas.tseries.holiday.Holiday` now supports a days_of_week parameter (GH7070)
- `GroupBy.nth()` now supports selecting multiple nth values (GH7910)

```
In [103]: business_dates = date_range(start='4/1/2014', end='6/30/2014', freq='B')

In [104]: df = DataFrame(1, index=business_dates, columns=['a', 'b'])

# get the first, 4th, and last date index for each month
In [105]: df.groupby((df.index.year, df.index.month)).nth([0, 3, -1])
Out[105]:
        a  b
2014 4  1  1
     4  1  1
     4  1  1
     5  1  1
     5  1  1
     5  1  1
     6  1  1
     6  1  1
     6  1  1
```

- `Period` and `PeriodIndex` supports addition/subtraction with `timedelta`-likes (GH7966)

  If `Period` freq is `D`, `H`, `T`, `S`, `L`, `U`, `N`, `Timedelta`-like can be added if the result can have same freq. Otherwise, only the same `offsets` can be added.

```
In [106]: idx = pd.period_range('2014-07-01 09:00', periods=5, freq='H')

In [107]: idx
Out[107]:
PeriodIndex(['2014-07-01 09:00', '2014-07-01 10:00', '2014-07-01 11:00',
             '2014-07-01 12:00', '2014-07-01 13:00'],
            dtype='period[H]', freq='H')

In [108]: idx + pd.offsets.Hour(2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
PeriodIndex(['2014-07-01 11:00', '2014-07-01 12:00', '2014-07-01 13:00',
             '2014-07-01 14:00', '2014-07-01 15:00'],
            dtype='period[H]', freq='H')

In [109]: idx + Timedelta('120m')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
PeriodIndex(['2014-07-01 11:00', '2014-07-01 12:00', '2014-07-01 13:00',
             '2014-07-01 14:00', '2014-07-01 15:00'],
            dtype='period[H]', freq='H')

In [110]: idx = pd.period_range('2014-07', periods=5, freq='M')

In [111]: idx
Out[111]: PeriodIndex(['2014-07', '2014-08', '2014-09', '2014-10', '2014-11'],␣
↪dtype='period[M]', freq='M')
```

```
In [112]: idx + pd.offsets.MonthEnd(3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪PeriodIndex(['2014-10', '2014-11', '2014-12', '2015-01', '2015-02'], dtype=
↪'period[M]', freq='M')
```

- Added experimental compatibility with `openpyxl` for versions >= 2.0. The `DataFrame.to_excel` method `engine` keyword now recognizes `openpyxl1` and `openpyxl2` which will explicitly require openpyxl v1 and v2 respectively, failing if the requested version is not available. The `openpyxl` engine is a now a meta-engine that automatically uses whichever version of openpyxl is installed. (GH7177)
- `DataFrame.fillna` can now accept a `DataFrame` as a fill value (GH8377)
- Passing multiple levels to *`stack()`* will now work when multiple level numbers are passed (GH7660). See *Reshaping by stacking and unstacking*.
- `set_names()`, `set_labels()`, and `set_levels()` methods now take an optional `level` keyword argument to all modification of specific level(s) of a MultiIndex. Additionally `set_names()` now accepts a scalar string value when operating on an `Index` or on a specific level of a `MultiIndex` (GH7792)

```
In [113]: idx = MultiIndex.from_product([['a'], range(3), list("pqr")], names=[
↪'foo', 'bar', 'baz'])

In [114]: idx.set_names('qux', level=0)
Out[114]:
MultiIndex(levels=[['a'], [0, 1, 2], ['p', 'q', 'r']],
           labels=[[0, 0, 0, 0, 0, 0, 0, 0, 0], [0, 0, 0, 1, 1, 1, 2, 2, 2], [0,␣
↪1, 2, 0, 1, 2, 0, 1, 2]],
           names=['qux', 'bar', 'baz'])

In [115]: idx.set_names(['qux','baz'], level=[0,1])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
MultiIndex(levels=[['a'], [0, 1, 2], ['p', 'q', 'r']],
           labels=[[0, 0, 0, 0, 0, 0, 0, 0, 0], [0, 0, 0, 1, 1, 1, 2, 2, 2], [0,␣
↪1, 2, 0, 1, 2, 0, 1, 2]],
           names=['qux', 'baz', 'baz'])

In [116]: idx.set_levels(['a','b','c'], level='bar')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
MultiIndex(levels=[['a'], ['a', 'b', 'c'], ['p', 'q', 'r']],
           labels=[[0, 0, 0, 0, 0, 0, 0, 0, 0], [0, 0, 0, 1, 1, 1, 2, 2, 2], [0,␣
↪1, 2, 0, 1, 2, 0, 1, 2]],
           names=['foo', 'bar', 'baz'])

In [117]: idx.set_levels([['a','b','c'],[1,2,3]], level=[1,2])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
MultiIndex(levels=[['a'], ['a', 'b', 'c'], [1, 2, 3]],
           labels=[[0, 0, 0, 0, 0, 0, 0, 0, 0], [0, 0, 0, 1, 1, 1, 2, 2, 2], [0,␣
↪1, 2, 0, 1, 2, 0, 1, 2]],
           names=['foo', 'bar', 'baz'])
```

- `Index.isin` now supports a `level` argument to specify which index level to use for membership tests (GH7892, GH7890)

```
In [1]: idx = MultiIndex.from_product([[0, 1], ['a', 'b', 'c']])
```

```
In [2]: idx.values
Out[2]: array([(0, 'a'), (0, 'b'), (0, 'c'), (1, 'a'), (1, 'b'), (1, 'c')],␣
 ↪dtype=object)

In [3]: idx.isin(['a', 'c', 'e'], level=1)
Out[3]: array([ True, False,  True,  True, False,  True], dtype=bool)
```

- `Index` now supports `duplicated` and `drop_duplicates`. (GH4060)

```
In [118]: idx = Index([1, 2, 3, 4, 1, 2])

In [119]: idx
Out[119]: Int64Index([1, 2, 3, 4, 1, 2], dtype='int64')

In [120]: idx.duplicated()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[120]: array([False,␣
 ↪False, False, False,  True,  True], dtype=bool)

In [121]: idx.drop_duplicates()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪Int64Index([1, 2, 3, 4], dtype='int64')
```

- add `copy=True` argument to `pd.concat` to enable pass thru of complete blocks (GH8252)
- Added support for numpy 1.8+ data types (`bool_`, `int_`, `float_`, `string_`) for conversion to R dataframe (GH8400)

1.17.4 Performance

- Performance improvements in `DatetimeIndex.__iter__` to allow faster iteration (GH7683)
- Performance improvements in `Period` creation (and `PeriodIndex` setitem) (GH5155)
- Improvements in Series.transform for significant performance gains (revised) (GH6496)
- Performance improvements in `StataReader` when reading large files (GH8040, GH8073)
- Performance improvements in `StataWriter` when writing large files (GH8079)
- Performance and memory usage improvements in multi-key `groupby` (GH8128)
- Performance improvements in groupby `.agg` and `.apply` where builtins max/min were not mapped to numpy/cythonized versions (GH7722)
- Performance improvement in writing to sql (`to_sql`) of up to 50% (GH8208).
- Performance benchmarking of groupby for large value of ngroups (GH6787)
- Performance improvement in `CustomBusinessDay`, `CustomBusinessMonth` (GH8236)
- Performance improvement for `MultiIndex.values` for multi-level indexes containing datetimes (GH8543)

1.17.5 Bug Fixes

- Bug in pivot_table, when using margins and a dict aggfunc (GH8349)
- Bug in `read_csv` where `squeeze=True` would return a view (GH8217)
- Bug in checking of table name in `read_sql` in certain cases (GH7826).

- Bug in `DataFrame.groupby` where `Grouper` does not recognize level when frequency is specified (GH7885)
- Bug in multiindexes dtypes getting mixed up when DataFrame is saved to SQL table (GH8021)
- Bug in `Series` 0-division with a float and integer operand dtypes (GH7785)
- Bug in `Series.astype("unicode")` not calling `unicode` on the values correctly (GH7758)
- Bug in `DataFrame.as_matrix()` with mixed `datetime64[ns]` and `timedelta64[ns]` dtypes (GH7778)
- Bug in `HDFStore.select_column()` not preserving UTC timezone info when selecting a `DatetimeIndex` (GH7777)
- Bug in `to_datetime` when `format='%Y%m%d'` and `coerce=True` are specified, where previously an object array was returned (rather than a coerced time-series with `NaT`), (GH7930)
- Bug in `DatetimeIndex` and `PeriodIndex` in-place addition and subtraction cause different result from normal one (GH6527)
- Bug in adding and subtracting `PeriodIndex` with `PeriodIndex` raise `TypeError` (GH7741)
- Bug in `combine_first` with `PeriodIndex` data raises `TypeError` (GH3367)
- Bug in multi-index slicing with missing indexers (GH7866)
- Bug in multi-index slicing with various edge cases (GH8132)
- Regression in multi-index indexing with a non-scalar type object (GH7914)
- Bug in `Timestamp` comparisons with == and `int64` dtype (GH8058)
- Bug in pickles contains `DateOffset` may raise `AttributeError` when `normalize` attribute is reffered internally (GH7748)
- Bug in `Panel` when using `major_xs` and `copy=False` is passed (deprecation warning fails because of missing `warnings`) (GH8152).
- Bug in pickle deserialization that failed for pre-0.14.1 containers with dup items trying to avoid ambiguity when matching block and manager items, when there's only one block there's no ambiguity (GH7794)
- Bug in putting a `PeriodIndex` into a `Series` would convert to `int64` dtype, rather than `object` of `Periods` (GH7932)
- Bug in `HDFStore` iteration when passing a where (GH8014)
- Bug in `DataFrameGroupby.transform` when transforming with a passed non-sorted key (GH8046, GH8430)
- Bug in repeated timeseries line and area plot may result in `ValueError` or incorrect kind (GH7733)
- Bug in inference in a `MultiIndex` with `datetime.date` inputs (GH7888)
- Bug in `get` where an `IndexError` would not cause the default value to be returned (GH7725)
- Bug in `offsets.apply`, `rollforward` and `rollback` may reset nanosecond (GH7697)
- Bug in `offsets.apply`, `rollforward` and `rollback` may raise `AttributeError` if `Timestamp` has `dateutil` tzinfo (GH7697)
- Bug in sorting a multi-index frame with a `Float64Index` (GH8017)
- Bug in inconsistent panel setitem with a rhs of a `DataFrame` for alignment (GH7763)
- Bug in `is_superperiod` and `is_subperiod` cannot handle higher frequencies than `S` (GH7760, GH7772, GH7803)

- Bug in 32-bit platforms with `Series.shift` (GH8129)
- Bug in `PeriodIndex.unique` returns int64 `np.ndarray` (GH7540)
- Bug in `groupby.apply` with a non-affecting mutation in the function (GH8467)
- Bug in `DataFrame.reset_index` which has `MultiIndex` contains `PeriodIndex` or `DatetimeIndex` with tz raises `ValueError` (GH7746, GH7793)
- Bug in `DataFrame.plot` with `subplots=True` may draw unnecessary minor xticks and yticks (GH7801)
- Bug in `StataReader` which did not read variable labels in 117 files due to difference between Stata documentation and implementation (GH7816)
- Bug in `StataReader` where strings were always converted to 244 characters-fixed width irrespective of underlying string size (GH7858)
- Bug in `DataFrame.plot` and `Series.plot` may ignore `rot` and `fontsize` keywords (GH7844)
- Bug in `DatetimeIndex.value_counts` doesn't preserve tz (GH7735)
- Bug in `PeriodIndex.value_counts` results in `Int64Index` (GH7735)
- Bug in `DataFrame.join` when doing left join on index and there are multiple matches (GH5391)
- Bug in `GroupBy.transform()` where int groups with a transform that didn't preserve the index were incorrectly truncated (GH7972).
- Bug in `groupby` where callable objects without name attributes would take the wrong path, and produce a `DataFrame` instead of a `Series` (GH7929)
- Bug in `groupby` error message when a DataFrame grouping column is duplicated (GH7511)
- Bug in `read_html` where the `infer_types` argument forced coercion of date-likes incorrectly (GH7762, GH7032).
- Bug in `Series.str.cat` with an index which was filtered as to not include the first item (GH7857)
- Bug in `Timestamp` cannot parse `nanosecond` from string (GH7878)
- Bug in `Timestamp` with string offset and `tz` results incorrect (GH7833)
- Bug in `tslib.tz_convert` and `tslib.tz_convert_single` may return different results (GH7798)
- Bug in `DatetimeIndex.intersection` of non-overlapping timestamps with tz raises `IndexError` (GH7880)
- Bug in alignment with TimeOps and non-unique indexes (GH8363)
- Bug in `GroupBy.filter()` where fast path vs. slow path made the filter return a non scalar value that appeared valid but wasn't (GH7870).
- Bug in `date_range()`/`DatetimeIndex()` when the timezone was inferred from input dates yet incorrect times were returned when crossing DST boundaries (GH7835, GH7901).
- Bug in `to_excel()` where a negative sign was being prepended to positive infinity and was absent for negative infinity (GH7949)
- Bug in area plot draws legend with incorrect `alpha` when `stacked=True` (GH8027)
- `Period` and `PeriodIndex` addition/subtraction with `np.timedelta64` results in incorrect internal representations (GH7740)
- Bug in `Holiday` with no offset or observance (GH7987)
- Bug in `DataFrame.to_latex` formatting when columns or index is a `MultiIndex` (GH7982).
- Bug in `DateOffset` around Daylight Savings Time produces unexpected results (GH5175).

- Bug in `DataFrame.shift` where empty columns would throw `ZeroDivisionError` on numpy 1.7 (GH8019)
- Bug in installation where `html_encoding/*.html` wasn't installed and therefore some tests were not running correctly (GH7927).
- Bug in `read_html` where `bytes` objects were not tested for in `_read` (GH7927).
- Bug in `DataFrame.stack()` when one of the column levels was a datelike (GH8039)
- Bug in broadcasting numpy scalars with `DataFrame` (GH8116)
- Bug in `pivot_table` performed with nameless `index` and `columns` raises `KeyError` (GH8103)
- Bug in `DataFrame.plot(kind='scatter')` draws points and errorbars with different colors when the color is specified by `c` keyword (GH8081)
- Bug in `Float64Index` where `iat` and `at` were not testing and were failing (GH8092).
- Bug in `DataFrame.boxplot()` where y-limits were not set correctly when producing multiple axes (GH7528, GH5517).
- Bug in `read_csv` where line comments were not handled correctly given a custom line terminator or `delim_whitespace=True` (GH8122).
- Bug in `read_html` where empty tables caused a `StopIteration` (GH7575)
- Bug in casting when setting a column in a same-dtype block (GH7704)
- Bug in accessing groups from a `GroupBy` when the original grouper was a tuple (GH8121).
- Bug in `.at` that would accept integer indexers on a non-integer index and do fallback (GH7814)
- Bug with kde plot and NaNs (GH8182)
- Bug in `GroupBy.count` with float32 data type were nan values were not excluded (GH8169).
- Bug with stacked barplots and NaNs (GH8175).
- Bug in resample with non evenly divisible offsets (e.g. '7s') (GH8371)
- Bug in interpolation methods with the `limit` keyword when no values needed interpolating (GH7173).
- Bug where `col_space` was ignored in `DataFrame.to_string()` when `header=False` (GH8230).
- Bug with `DatetimeIndex.asof` incorrectly matching partial strings and returning the wrong date (GH8245).
- Bug in plotting methods modifying the global matplotlib rcParams (GH8242).
- Bug in `DataFrame.__setitem__` that caused errors when setting a dataframe column to a sparse array (GH8131)
- Bug where `Dataframe.boxplot()` failed when entire column was empty (GH8181).
- Bug with messed variables in `radviz` visualization (GH8199).
- Bug in interpolation methods with the `limit` keyword when no values needed interpolating (GH7173).
- Bug where `col_space` was ignored in `DataFrame.to_string()` when `header=False` (GH8230).
- Bug in `to_clipboard` that would clip long column data (GH8305)
- Bug in `DataFrame` terminal display: Setting max_column/max_rows to zero did not trigger auto-resizing of dfs to fit terminal width/height (GH7180).
- Bug in OLS where running with "cluster" and "nw_lags" parameters did not work correctly, but also did not throw an error (GH5884).

- Bug in `DataFrame.dropna` that interpreted non-existent columns in the subset argument as the 'last column' (GH8303)
- Bug in `Index.intersection` on non-monotonic non-unique indexes (GH8362).
- Bug in masked series assignment where mismatching types would break alignment (GH8387)
- Bug in `NDFrame.equals` gives false negatives with dtype=object (GH8437)
- Bug in assignment with indexer where type diversity would break alignment (GH8258)
- Bug in `NDFrame.loc` indexing when row/column names were lost when target was a list/ndarray (GH6552)
- Regression in `NDFrame.loc` indexing when rows/columns were converted to Float64Index if target was an empty list/ndarray (GH7774)
- Bug in `Series` that allows it to be indexed by a `DataFrame` which has unexpected results. Such indexing is no longer permitted (GH8444)
- Bug in item assignment of a `DataFrame` with multi-index columns where right-hand-side columns were not aligned (GH7655)
- Suppress FutureWarning generated by NumPy when comparing object arrays containing NaN for equality (GH7065)
- Bug in `DataFrame.eval()` where the dtype of the `not` operator (~) was not correctly inferred as `bool`.

1.18 v0.14.1 (July 11, 2014)

This is a minor release from 0.14.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

- Highlights include:
  - New methods *`select_dtypes()`* to select columns based on the dtype and *`sem()`* to calculate the standard error of the mean.
  - Support for dateutil timezones (see *docs*).
  - Support for ignoring full line comments in the *`read_csv()`* text parser.
  - New documentation section on *Options and Settings*.
  - Lots of bug fixes.
- *Enhancements*
- *API Changes*
- *Performance Improvements*
- *Experimental Changes*
- *Bug Fixes*

1.18.1 API changes

- Openpyxl now raises a ValueError on construction of the openpyxl writer instead of warning on pandas import (GH7284).

- For `StringMethods.extract`, when no match is found, the result - only containing `NaN` values - now also has `dtype=object` instead of `float` (GH7242)
- `Period` objects no longer raise a `TypeError` when compared using == with another object that *isn't* a `Period`. Instead when comparing a `Period` with another object using == if the other object isn't a `Period` `False` is returned. (GH7376)
- Previously, the behaviour on resetting the time or not in `offsets.apply`, `rollforward` and `rollback` operations differed between offsets. With the support of the `normalize` keyword for all offsets(see below) with a default value of False (preserve time), the behaviour changed for certain offsets (BusinessMonthBegin, MonthEnd, BusinessMonthEnd, CustomBusinessMonthEnd, BusinessYearBegin, LastWeekOfMonth, FY5253Quarter, LastWeekOfMonth, Easter):

```
In [6]: from pandas.tseries import offsets

In [7]: d = pd.Timestamp('2014-01-01 09:00')

# old behaviour < 0.14.1
In [8]: d + offsets.MonthEnd()
Out[8]: Timestamp('2014-01-31 00:00:00')
```

  Starting from 0.14.1 all offsets preserve time by default. The old behaviour can be obtained with `normalize=True`

```
# new behaviour
In [1]: d + offsets.MonthEnd()
Out[1]: Timestamp('2014-01-31 09:00:00')

In [2]: d + offsets.MonthEnd(normalize=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[2]: Timestamp('2014-01-31 00:00:00')
```

  Note that for the other offsets the default behaviour did not change.

- Add back `#N/A N/A` as a default NA value in text parsing, (regresion from 0.12) (GH5521)
- Raise a `TypeError` on inplace-setting with a `.where` and a non `np.nan` value as this is inconsistent with a set-item expression like `df[mask] = None` (GH7656)

1.18.2 Enhancements

- Add `dropna` argument to `value_counts` and `nunique` (GH5569).
- Add *`select_dtypes()`* method to allow selection of columns based on dtype (GH7316). See *the docs*.
- All `offsets` suppports the `normalize` keyword to specify whether `offsets.apply`, `rollforward` and `rollback` resets the time (hour, minute, etc) or not (default `False`, preserves time) (GH7156):

```
In [3]: import pandas.tseries.offsets as offsets

In [4]: day = offsets.Day()

In [5]: day.apply(Timestamp('2014-01-01 09:00'))
Out[5]: Timestamp('2014-01-02 09:00:00')

In [6]: day = offsets.Day(normalize=True)

In [7]: day.apply(Timestamp('2014-01-01 09:00'))
Out[7]: Timestamp('2014-01-02 00:00:00')
```

- `PeriodIndex` is represented as the same format as `DatetimeIndex` (GH7601)
- `StringMethods` now work on empty Series (GH7242)
- The file parsers `read_csv` and `read_table` now ignore line comments provided by the parameter *comment*, which accepts only a single character for the C reader. In particular, they allow for comments before file data begins (GH2685)
- Add `NotImplementedError` for simultaneous use of `chunksize` and `nrows` for read_csv() (GH6774).
- Tests for basic reading of public S3 buckets now exist (GH7281).
- `read_html` now sports an `encoding` argument that is passed to the underlying parser library. You can use this to read non-ascii encoded web pages (GH7323).
- `read_excel` now supports reading from URLs in the same way that `read_csv` does. (GH6809)
- Support for dateutil timezones, which can now be used in the same way as pytz timezones across pandas. (GH4688)

```
In [8]: rng = date_range('3/6/2012 00:00', periods=10, freq='D',
   ...:                  tz='dateutil/Europe/London')
   ...:

In [9]: rng.tz
Out[9]: tzfile('/usr/share/zoneinfo/Europe/London')
```

See *the docs*.

- Implemented `sem` (standard error of the mean) operation for `Series`, `DataFrame`, `Panel`, and `Groupby` (GH6897)
- Add `nlargest` and `nsmallest` to the `Series` `groupby` whitelist, which means you can now use these methods on a `SeriesGroupBy` object (GH7053).
- All offsets `apply`, `rollforward` and `rollback` can now handle `np.datetime64`, previously results in `ApplyTypeError` (GH7452)
- `Period` and `PeriodIndex` can contain `NaT` in its values (GH7485)
- Support pickling `Series`, `DataFrame` and `Panel` objects with non-unique labels along *item* axis (`index`, `columns` and `items` respectively) (GH7370).
- Improved inference of datetime/timedelta with mixed null objects. Regression from 0.13.1 in interpretation of an object Index with all null elements (GH7431)

1.18.3 Performance

- Improvements in dtype inference for numeric operations involving yielding performance gains for dtypes: `int64`, `timedelta64`, `datetime64` (GH7223)
- Improvements in Series.transform for significant performance gains (GH6496)
- Improvements in DataFrame.transform with ufuncs and built-in grouper functions for signifcant performance gains (GH7383)
- Regression in groupby aggregation of datetime64 dtypes (GH7555)
- Improvements in *MultiIndex.from_product* for large iterables (GH7627)

1.18.4 Experimental

- `pandas.io.data.Options` has a new method, `get_all_data` method, and now consistently returns a multi-indexed `DataFrame` (GH5602)
- `io.gbq.read_gbq` and `io.gbq.to_gbq` were refactored to remove the dependency on the Google `bq.py` command line client. This submodule now uses `httplib2` and the Google `apiclient` and `oauth2client` API client libraries which should be more stable and, therefore, reliable than `bq.py`. See *the docs*. (GH6937).

1.18.5 Bug Fixes

- Bug in `DataFrame.where` with a symmetric shaped frame and a passed other of a DataFrame (GH7506)
- Bug in Panel indexing with a multi-index axis (GH7516)
- Regression in datetimelike slice indexing with a duplicated index and non-exact end-points (GH7523)
- Bug in setitem with list-of-lists and single vs mixed types (GH7551:)
- Bug in timeops with non-aligned Series (GH7500)
- Bug in timedelta inference when assigning an incomplete Series (GH7592)
- Bug in groupby `.nth` with a Series and integer-like column name (GH7559)
- Bug in `Series.get` with a boolean accessor (GH7407)
- Bug in `value_counts` where `NaT` did not qualify as missing (`NaN`) (GH7423)
- Bug in `to_timedelta` that accepted invalid units and misinterpreted 'm/h' (GH7611, GH6423)
- Bug in line plot doesn't set correct `xlim` if `secondary_y=True` (GH7459)
- Bug in grouped `hist` and `scatter` plots use old `figsize` default (GH7394)
- Bug in plotting subplots with `DataFrame.plot`, `hist` clears passed `ax` even if the number of subplots is one (GH7391).
- Bug in plotting subplots with `DataFrame.boxplot` with `by` kw raises `ValueError` if the number of subplots exceeds 1 (GH7391).
- Bug in subplots displays `ticklabels` and `labels` in different rule (GH5897)
- Bug in `Panel.apply` with a multi-index as an axis (GH7469)
- Bug in `DatetimeIndex.insert` doesn't preserve `name` and `tz` (GH7299)
- Bug in `DatetimeIndex.asobject` doesn't preserve `name` (GH7299)
- Bug in multi-index slicing with datetimelike ranges (strings and Timestamps), (GH7429)
- Bug in `Index.min` and `max` doesn't handle `nan` and `NaT` properly (GH7261)
- Bug in `PeriodIndex.min/max` results in `int` (GH7609)
- Bug in `resample` where `fill_method` was ignored if you passed `how` (GH2073)
- Bug in `TimeGrouper` doesn't exclude column specified by `key` (GH7227)
- Bug in `DataFrame` and `Series` bar and barh plot raises `TypeError` when `bottom` and `left` keyword is specified (GH7226)
- Bug in `DataFrame.hist` raises `TypeError` when it contains non numeric column (GH7277)
- Bug in `Index.delete` does not preserve `name` and `freq` attributes (GH7302)

- Bug in `DataFrame.query()/eval` where local string variables with the @ sign were being treated as temporaries attempting to be deleted (GH7300).
- Bug in `Float64Index` which didn't allow duplicates (GH7149).
- Bug in `DataFrame.replace()` where truthy values were being replaced (GH7140).
- Bug in `StringMethods.extract()` where a single match group Series would use the matcher's name instead of the group name (GH7313).
- Bug in `isnull()` when `mode.use_inf_as_null == True` where isnull wouldn't test `True` when it encountered an `inf`/`-inf` (GH7315).
- Bug in inferred_freq results in None for eastern hemisphere timezones (GH7310)
- Bug in `Easter` returns incorrect date when offset is negative (GH7195)
- Bug in broadcasting with `.div`, integer dtypes and divide-by-zero (GH7325)
- Bug in `CustomBusinessDay.apply` raiases `NameError` when `np.datetime64` object is passed (GH7196)
- Bug in `MultiIndex.append`, `concat` and `pivot_table` don't preserve timezone (GH6606)
- Bug in `.loc` with a list of indexers on a single-multi index level (that is not nested) (GH7349)
- Bug in `Series.map` when mapping a dict with tuple keys of different lengths (GH7333)
- Bug all `StringMethods` now work on empty Series (GH7242)
- Fix delegation of *read_sql* to *read_sql_query* when query does not contain 'select' (GH7324).
- Bug where a string column name assignment to a `DataFrame` with a `Float64Index` raised a `TypeError` during a call to `np.isnan` (GH7366).
- Bug where `NDFrame.replace()` didn't correctly replace objects with `Period` values (GH7379).
- Bug in `.ix` getitem should always return a Series (GH7150)
- Bug in multi-index slicing with incomplete indexers (GH7399)
- Bug in multi-index slicing with a step in a sliced level (GH7400)
- Bug where negative indexers in `DatetimeIndex` were not correctly sliced (GH7408)
- Bug where `NaT` wasn't repr'd correctly in a `MultiIndex` (GH7406, GH7409).
- Bug where bool objects were converted to `nan` in `convert_objects` (GH7416).
- Bug in `quantile` ignoring the axis keyword argument (:issue'7306')
- Bug where `nanops._maybe_null_out` doesn't work with complex numbers (GH7353)
- Bug in several `nanops` functions when `axis==0` for 1-dimensional `nan` arrays (GH7354)
- Bug where `nanops.nanmedian` doesn't work when `axis==None` (GH7352)
- Bug where `nanops._has_infs` doesn't work with many dtypes (GH7357)
- Bug in `StataReader.data` where reading a 0-observation dta failed (GH7369)
- Bug in `StataReader` when reading Stata 13 (117) files containing fixed width strings (GH7360)
- Bug in `StataWriter` where encoding was ignored (GH7286)
- Bug in `DatetimeIndex` comparison doesn't handle `NaT` properly (GH7529)
- Bug in passing input with `tzinfo` to some offsets `apply`, `rollforward` or `rollback` resets `tzinfo` or raises `ValueError` (GH7465)

- Bug in `DatetimeIndex.to_period`, `PeriodIndex.asobject`, `PeriodIndex.to_timestamp` doesn't preserve `name` (GH7485)
- Bug in `DatetimeIndex.to_period` and `PeriodIndex.to_timestanp` handle `NaT` incorrectly (GH7228)
- Bug in `offsets.apply`, `rollforward` and `rollback` may return normal `datetime` (GH7502)
- Bug in `resample` raises `ValueError` when target contains `NaT` (GH7227)
- Bug in `Timestamp.tz_localize` resets `nanosecond` info (GH7534)
- Bug in `DatetimeIndex.asobject` raises `ValueError` when it contains `NaT` (GH7539)
- Bug in `Timestamp.__new__` doesn't preserve nanosecond properly (GH7610)
- Bug in `Index.astype(float)` where it would return an `object` dtype `Index` (GH7464).
- Bug in `DataFrame.reset_index` loses `tz` (GH3950)
- Bug in `DatetimeIndex.freqstr` raises `AttributeError` when `freq` is `None` (GH7606)
- Bug in `GroupBy.size` created by `TimeGrouper` raises `AttributeError` (GH7453)
- Bug in single column bar plot is misaligned (GH7498).
- Bug in area plot with tz-aware time series raises `ValueError` (GH7471)
- Bug in non-monotonic `Index.union` may preserve `name` incorrectly (GH7458)
- Bug in `DatetimeIndex.intersection` doesn't preserve timezone (GH4690)
- Bug in `rolling_var` where a window larger than the array would raise an error(GH7297)
- Bug with last plotted timeseries dictating `xlim` (GH2960)
- Bug with `secondary_y` axis not being considered for timeseries `xlim` (GH3490)
- Bug in `Float64Index` assignment with a non scalar indexer (GH7586)
- Bug in `pandas.core.strings.str_contains` does not properly match in a case insensitive fashion when `regex=False` and `case=False` (GH7505)
- Bug in `expanding_cov`, `expanding_corr`, `rolling_cov`, and `rolling_corr` for two arguments with mismatched index (GH7512)
- Bug in `to_sql` taking the boolean column as text column (GH7678)
- Bug in grouped *hist* doesn't handle *rot* kw and *sharex* kw properly (GH7234)
- Bug in `.loc` performing fallback integer indexing with `object` dtype indices (GH7496)
- Bug (regression) in `PeriodIndex` constructor when passed `Series` objects (GH7701).

1.19 v0.14.0 (May 31 , 2014)

This is a major release from 0.13.1 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

- Highlights include:
  - Officially support Python 3.4
  - SQL interfaces updated to use `sqlalchemy`, See *Here*.

  - Display interface changes, See *Here*
  - MultiIndexing Using Slicers, See *Here*.
  - Ability to join a singly-indexed DataFrame with a multi-indexed DataFrame, see *Here*
  - More consistency in groupby results and more flexible groupby specifications, See *Here*
  - Holiday calendars are now supported in `CustomBusinessDay`, see *Here*
  - Several improvements in plotting functions, including: hexbin, area and pie plots, see *Here*.
  - Performance doc section on I/O operations, See *Here*

- *Other Enhancements*
- *API Changes*
- *Text Parsing API Changes*
- *Groupby API Changes*
- *Performance Improvements*
- *Prior Deprecations*
- *Deprecations*
- *Known Issues*
- *Bug Fixes*

Warning: In 0.14.0 all `NDFrame` based containers have undergone significant internal refactoring. Before that each block of homogeneous data had its own labels and extra care was necessary to keep those in sync with the parent container's labels. This should not have any visible user/API behavior changes (GH6745)

1.19.1 API changes

- `read_excel` uses 0 as the default sheet (GH6573)
- `iloc` will now accept out-of-bounds indexers for slices, e.g. a value that exceeds the length of the object being indexed. These will be excluded. This will make pandas conform more with python/numpy indexing of out-of-bounds values. A single indexer that is out-of-bounds and drops the dimensions of the object will still raise `IndexError` (GH6296, GH6299). This could result in an empty axis (e.g. an empty DataFrame being returned)

```
In [1]: dfl = DataFrame(np.random.randn(5,2),columns=list('AB'))

In [2]: dfl
Out[2]:
          A         B
0  1.583584 -0.438313
1 -0.402537 -0.780572
2 -0.141685  0.542241
3  0.370966 -0.251642
4  0.787484  1.666563

In [3]: dfl.iloc[:,2:3]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
Empty DataFrame
```

```
Columns: []
Index: [0, 1, 2, 3, 4]

In [4]: dfl.iloc[:,1:3]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          B
0 -0.438313
1 -0.780572
2  0.542241
3 -0.251642
4  1.666563

In [5]: dfl.iloc[4:6]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B
4  0.787484  1.666563
```

These are out-of-bounds selections

```
dfl.iloc[[4,5,6]]
IndexError: positional indexers are out-of-bounds

dfl.iloc[:,4]
IndexError: single positional indexer is out-of-bounds
```

- Slicing with negative start, stop & step values handles corner cases better (GH6531):
  - `df.iloc[:-len(df)]` is now empty
  - `df.iloc[len(df)::-1]` now enumerates all elements in reverse
- The `DataFrame.interpolate()` keyword `downcast` default has been changed from `infer` to `None`. This is to preseve the original dtype unless explicitly requested otherwise (GH6290).
- When converting a dataframe to HTML it used to return *Empty DataFrame*. This special case has been removed, instead a header with the column names is returned (GH6062).
- `Series` and `Index` now internall share more common operations, e.g. `factorize(),nunique(), value_counts()` are now supported on `Index` types as well. The `Series.weekday` property from is removed from Series for API consistency. Using a `DatetimeIndex/PeriodIndex` method on a Series will now raise a `TypeError`. (GH4551, GH4056, GH5519, GH6380, GH7206).
- Add `is_month_start`, `is_month_end`, `is_quarter_start`, `is_quarter_end`, `is_year_start`, `is_year_end` accessors for `DateTimeIndex` / `Timestamp` which return a boolean array of whether the timestamp(s) are at the start/end of the month/quarter/year defined by the frequency of the `DateTimeIndex` / `Timestamp` (GH4565, GH6998)
- Local variable usage has changed in *`pandas.eval()`*/`DataFrame.eval()`/`DataFrame.query()` (GH5987). For the *`DataFrame`* methods, two things have changed
  - Column names are now given precedence over locals
  - Local variables must be referred to explicitly. This means that even if you have a local variable that is *not* a column you must still refer to it with the `'@'` prefix.
  - You can have an expression like `df.query('@a < a')` with no complaints from `pandas` about ambiguity of the name `a`.

  - The top-level *`pandas.eval()`* function does not allow you use the `'@'` prefix and provides you with an error message telling you so.
  - `NameResolutionError` was removed because it isn't necessary anymore.
- Define and document the order of column vs index names in query/eval (GH6676)
- `concat` will now concatenate mixed Series and DataFrames using the Series name or numbering columns as needed (GH2385). See *the docs*
- Slicing and advanced/boolean indexing operations on `Index` classes as well as `Index.delete()` and `Index.drop()` methods will no longer change the type of the resulting index (GH6440, GH7040)

```
In [6]: i = pd.Index([1, 2, 3, 'a' , 'b', 'c'])

In [7]: i[[0,1,2]]
Out[7]: Index([1, 2, 3], dtype='object')

In [8]: i.drop(['a', 'b', 'c'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[8]: Index([1, 2, 3], dtype='object')
```

Previously, the above operation would return `Int64Index`. If you'd like to do this manually, use `Index.astype()`

```
In [9]: i[[0,1,2]].astype(np.int_)
Out[9]: Int64Index([1, 2, 3], dtype='int64')
```

- `set_index` no longer converts MultiIndexes to an Index of tuples. For example, the old behavior returned an Index in this case (GH6459):

```
# Old behavior, casted MultiIndex to an Index
In [10]: tuple_ind
Out[10]: Index([('a', 'c'), ('a', 'd'), ('b', 'c'), ('b', 'd')], dtype='object')

In [11]: df_multi.set_index(tuple_ind)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[11]:␣
↪
               0         1
(a, c)  0.471435 -1.190976
(a, d)  1.432707 -0.312652
(b, c) -0.720589  0.887163
(b, d)  0.859588 -0.636524

# New behavior
In [12]: mi
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
MultiIndex(levels=[['a', 'b'], ['c', 'd']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]])

In [13]: df_multi.set_index(mi)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
            0         1
a c  0.471435 -1.190976
  d  1.432707 -0.312652
b c -0.720589  0.887163
  d  0.859588 -0.636524
```

This also applies when passing multiple indices to `set_index`:

```
# Old output, 2-level MultiIndex of tuples
In [14]: df_multi.set_index([df_multi.index, df_multi.index])
Out[14]:
                      0         1
(a, c) (a, c)  0.471435 -1.190976
(a, d) (a, d)  1.432707 -0.312652
(b, c) (b, c) -0.720589  0.887163
(b, d) (b, d)  0.859588 -0.636524

# New output, 4-level MultiIndex
In [15]: df_multi.set_index([df_multi.index, df_multi.index])
Out[15]:
                0         1
a c a c  0.471435 -1.190976
  d a d  1.432707 -0.312652
b c b c -0.720589  0.887163
  d b d  0.859588 -0.636524
```

- `pairwise` keyword was added to the statistical moment functions `rolling_cov`, `rolling_corr`, `ewmcov`, `ewmcorr`, `expanding_cov`, `expanding_corr` to allow the calculation of moving window covariance and correlation matrices (GH4950). See *Computing rolling pairwise covariances and correlations* in the docs.

```
In [1]: df = DataFrame(np.random.randn(10,4),columns=list('ABCD'))

In [4]: covs = pd.rolling_cov(df[['A','B','C']], df[['B','C','D']], 5,␣
↪pairwise=True)

In [5]: covs[df.index[-1]]
Out[5]:
          B         C         D
A  0.035310  0.326593 -0.505430
B  0.137748 -0.006888 -0.005383
C -0.006888  0.861040  0.020762
```

- `Series.iteritems()` is now lazy (returns an iterator rather than a list). This was the documented behavior prior to 0.14. (GH6760)
- Added `nunique` and `value_counts` functions to `Index` for counting unique elements. (GH6734)
- `stack` and `unstack` now raise a `ValueError` when the `level` keyword refers to a non-unique item in the `Index` (previously raised a `KeyError`). (GH6738)
- drop unused order argument from `Series.sort`; args now are in the same order as `Series.order`; add `na_position` arg to conform to `Series.order` (GH6847)
- default sorting algorithm for `Series.order` is now `quicksort`, to conform with `Series.sort` (and numpy defaults)
- add `inplace` keyword to `Series.order/sort` to make them inverses (GH6859)
- `DataFrame.sort` now places NaNs at the beginning or end of the sort according to the `na_position` parameter. (GH3917)
- accept `TextFileReader` in `concat`, which was affecting a common user idiom (GH6583), this was a regression from 0.13.1
- Added `factorize` functions to `Index` and `Series` to get indexer and unique values (GH7090)

- `describe` on a DataFrame with a mix of Timestamp and string like objects returns a different Index (GH7088). Previously the index was unintentionally sorted.
- Arithmetic operations with **only** `bool` dtypes now give a warning indicating that they are evaluated in Python space for +, −, and * operations and raise for all others (GH7011, GH6762, GH7015, GH7210)

```
x = pd.Series(np.random.rand(10) > 0.5)
y = True
x + y  # warning generated: should do x | y instead
x / y  # this raises because it doesn't make sense

NotImplementedError: operator '/' not implemented for bool dtypes
```

- In `HDFStore`, `select_as_multiple` will always raise a `KeyError`, when a key or the selector is not found (GH6177)
- `df['col'] = value` and `df.loc[:,'col'] = value` are now completely equivalent; previously the `.loc` would not necessarily coerce the dtype of the resultant series (GH6149)
- `dtypes` and `ftypes` now return a series with `dtype=object` on empty containers (GH5740)
- `df.to_csv` will now return a string of the CSV data if neither a target path nor a buffer is provided (GH6061)
- `pd.infer_freq()` will now raise a `TypeError` if given an invalid `Series/Index` type (GH6407, GH6463)
- A tuple passed to `DataFame.sort_index` will be interpreted as the levels of the index, rather than requiring a list of tuple (GH4370)
- all offset operations now return `Timestamp` types (rather than datetime), Business/Week frequencies were incorrect (GH4069)
- `to_excel` now converts `np.inf` into a string representation, customizable by the `inf_rep` keyword argument (Excel has no native inf representation) (GH6782)
- Replace `pandas.compat.scipy.scoreatpercentile` with `numpy.percentile` (GH6810)
- `.quantile` on a `datetime[ns]` series now returns `Timestamp` instead of `np.datetime64` objects (GH6810)
- change `AssertionError` to `TypeError` for invalid types passed to `concat` (GH6583)
- Raise a `TypeError` when `DataFrame` is passed an iterator as the `data` argument (GH5357)

1.19.2 Display Changes

- The default way of printing large DataFrames has changed. DataFrames exceeding `max_rows` and/or `max_columns` are now displayed in a centrally truncated view, consistent with the printing of a *`pandas.Series`* (GH5603).

  In previous versions, a DataFrame was truncated once the dimension constraints were reached and an ellipse (...) signaled that part of the data was cut off.

```
In [1]: import pandas as pd

In [2]: import numpy as np

In [3]: pd.options.display.max_rows = 6

In [4]: pd.options.display.max_columns = 6

In [5]: index = pd.DatetimeIndex(start='20010101',freq='D',periods=10)

In [6]: pd.DataFrame(np.arange(10*10).reshape((10,10)),index=index)
Out[6]:
             0   1   2   3   4   5
2001-01-01   0   1   2   3   4   5 ...
2001-01-02  10  11  12  13  14  15 ...
2001-01-03  20  21  22  23  24  25 ...
2001-01-04  30  31  32  33  34  35 ...
2001-01-05  40  41  42  43  44  45 ...
2001-01-06  50  51  52  53  54  55 ...
           ... ... ... ... ... ...

[10 rows x 10 columns]
```

In the current version, large DataFrames are centrally truncated, showing a preview of head and tail in both dimensions.

```
In [24]: pd.DataFrame(np.arange(10*10).reshape((10,10)),index=index)
Out[24]:
             0   1   2 ...   7   8   9
2001-01-01   0   1   2 ...   7   8   9
2001-01-02  10  11  12 ...  17  18  19
2001-01-03  20  21  22 ...  27  28  29
...         ..  ..  .. ...  ..  ..  ..
2001-01-08  70  71  72 ...  77  78  79
2001-01-09  80  81  82 ...  87  88  89
2001-01-10  90  91  92 ...  97  98  99

[10 rows x 10 columns]
```

- allow option `'truncate'` for `display.show_dimensions` to only show the dimensions if the frame is truncated (GH6547).

  The default for `display.show_dimensions` will now be `truncate`. This is consistent with how Series display length.

```
In [16]: dfd = pd.DataFrame(np.arange(25).reshape(-1,5), index=[0,1,2,3,4],␣
↪columns=[0,1,2,3,4])

# show dimensions since this is truncated
In [17]: with pd.option_context('display.max_rows', 2, 'display.max_columns', 2,
   ....:                        'display.show_dimensions', 'truncate'):
   ....:     print(dfd)
   ....:
     0 ...   4
```

```
0    0 ...   4
..  .. ...  ..
4   20 ...  24

[5 rows x 5 columns]

# will not show dimensions since it is not truncated
In [18]: with pd.option_context('display.max_rows', 10, 'display.max_columns', 40,
   ....:                        'display.show_dimensions', 'truncate'):
   ....:     print(dfd)
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\␣
↪   0   1   2   3   4
0   0   1   2   3   4
1   5   6   7   8   9
2  10  11  12  13  14
3  15  16  17  18  19
4  20  21  22  23  24
```

- Regression in the display of a MultiIndexed Series with `display.max_rows` is less than the length of the series (GH7101)
- Fixed a bug in the HTML repr of a truncated Series or DataFrame not showing the class name with the *large_repr* set to 'info' (GH7105)
- The *verbose* keyword in `DataFrame.info()`, which controls whether to shorten the `info` representation, is now `None` by default. This will follow the global setting in `display.max_info_columns`. The global setting can be overriden with `verbose=True` or `verbose=False`.
- Fixed a bug with the *info* repr not honoring the *display.max_info_columns* setting (GH6939)
- Offset/freq info now in Timestamp __repr__ (GH4553)

1.19.3 Text Parsing API Changes

`read_csv()/read_table()` will now be noiser w.r.t invalid options rather than falling back to the `PythonParser`.

- Raise `ValueError` when `sep` specified with `delim_whitespace=True` in `read_csv()/read_table()` (GH6607)
- Raise `ValueError` when `engine='c'` specified with unsupported options in `read_csv()/read_table()` (GH6607)
- Raise `ValueError` when fallback to python parser causes options to be ignored (GH6607)
- Produce `ParserWarning` on fallback to python parser when no options are ignored (GH6607)
- Translate `sep='\s+'` to `delim_whitespace=True` in `read_csv()/read_table()` if no other C-unsupported options specified (GH6607)

1.19.4 Groupby API Changes

More consistent behaviour for some groupby methods:

- groupby `head` and `tail` now act more like `filter` rather than an aggregation:

```
In [19]: df = pd.DataFrame([[1, 2], [1, 4], [5, 6]], columns=['A', 'B'])

In [20]: g = df.groupby('A')

In [21]: g.head(1)   # filters DataFrame
Out[21]:
   A  B
0  1  2
2  5  6

In [22]: g.apply(lambda x: x.head(1))  # used to simply fall-through
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[22]:
     A  B
A
1 0  1  2
5 2  5  6
```

- groupby head and tail respect column selection:

```
In [23]: g[['B']].head(1)
Out[23]:
   B
0  2
2  6
```

- groupby `nth` now reduces by default; filtering can be achieved by passing `as_index=False`. With an optional `dropna` argument to ignore NaN. See *the docs*.

  Reducing

```
In [24]: df = DataFrame([[1, np.nan], [1, 4], [5, 6]], columns=['A', 'B'])

In [25]: g = df.groupby('A')

In [26]: g.nth(0)
Out[26]:
     B
A
1  NaN
5  6.0

# this is equivalent to g.first()
In [27]: g.nth(0, dropna='any')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[27]:
     B
A
1  4.0
5  6.0

# this is equivalent to g.last()
In [28]: g.nth(-1, dropna='any')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[28]:␣
↪
     B
A
1  4.0
5  6.0
```

Filtering

```
In [29]: gf = df.groupby('A',as_index=False)

In [30]: gf.nth(0)
Out[30]:
   A    B
0  1  NaN
2  5  6.0

In [31]: gf.nth(0, dropna='any')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[31]:
   A    B
A
1  1  4.0
5  5  6.0
```

- groupby will now not return the grouped column for non-cython functions (GH5610, GH5614, GH6732), as its already the index

```
In [32]: df = DataFrame([[1, np.nan], [1, 4], [5, 6], [5, 8]], columns=['A', 'B'])

In [33]: g = df.groupby('A')

In [34]: g.count()
Out[34]:
   B
A
1  1
5  2

In [35]: g.describe()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[35]:
      B
  count mean       std  min  25%  50%  75%  max
A
1   1.0  4.0       NaN  4.0  4.0  4.0  4.0  4.0
5   2.0  7.0  1.414214  6.0  6.5  7.0  7.5  8.0
```

- passing `as_index` will leave the grouped column in-place (this is not change in 0.14.0)

```
In [36]: df = DataFrame([[1, np.nan], [1, 4], [5, 6], [5, 8]], columns=['A', 'B'])

In [37]: g = df.groupby('A',as_index=False)

In [38]: g.count()
Out[38]:
   A  B
0  1  1
1  5  2

In [39]: g.describe()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[39]:
      A                                          B                          \
  count mean  std  min  25%  50%  75%  max count mean       std  min  25%
0   2.0  1.0  0.0  1.0  1.0  1.0  1.0  1.0   1.0  4.0       NaN  4.0  4.0
1   2.0  5.0  0.0  5.0  5.0  5.0  5.0  5.0   2.0  7.0  1.414214  6.0  6.5
```

```
   50%  75%  max
0  4.0  4.0  4.0
1  7.0  7.5  8.0
```

- Allow specification of a more complex groupby via `pd.Grouper`, such as grouping by a Time and a string field simultaneously. See *the docs*. (GH3794)
- Better propagation/preservation of Series names when performing groupby operations:
  - `SeriesGroupBy.agg` will ensure that the name attribute of the original series is propagated to the result (GH6265).
  - If the function provided to `GroupBy.apply` returns a named series, the name of the series will be kept as the name of the column index of the DataFrame returned by `GroupBy.apply` (GH6124). This facilitates `DataFrame.stack` operations where the name of the column index is used as the name of the inserted column containing the pivoted data.

1.19.5 SQL

The SQL reading and writing functions now support more database flavors through SQLAlchemy (GH2717, GH4163, GH5950, GH6292). All databases supported by SQLAlchemy can be used, such as PostgreSQL, MySQL, Oracle, Microsoft SQL server (see documentation of SQLAlchemy on included dialects).

The functionality of providing DBAPI connection objects will only be supported for sqlite3 in the future. The `'mysql'` flavor is deprecated.

The new functions *`read_sql_query()`* and *`read_sql_table()`* are introduced. The function *`read_sql()`* is kept as a convenience wrapper around the other two and will delegate to specific function depending on the provided input (database table name or sql query).

In practice, you have to provide a SQLAlchemy `engine` to the sql functions. To connect with SQLAlchemy you use the `create_engine()` function to create an engine object from database URI. You only need to create the engine once per database you are connecting to. For an in-memory sqlite database:

```
In [40]: from sqlalchemy import create_engine

# Create your connection.
In [41]: engine = create_engine('sqlite:///:memory:')
```

This `engine` can then be used to write or read data to/from this database:

```
In [42]: df = pd.DataFrame({'A': [1,2,3], 'B': ['a', 'b', 'c']})

In [43]: df.to_sql('db_table', engine, index=False)
```

You can read data from a database by specifying the table name:

```
In [44]: pd.read_sql_table('db_table', engine)
Out[44]:
   A  B
0  1  a
1  2  b
2  3  c
```

or by specifying a sql query:

```
In [45]: pd.read_sql_query('SELECT * FROM db_table', engine)
Out[45]:
   A  B
0  1  a
1  2  b
2  3  c
```

Some other enhancements to the sql functions include:

- support for writing the index. This can be controlled with the `index` keyword (default is True).
- specify the column label to use when writing the index with `index_label`.
- specify string columns to parse as datetimes withh the `parse_dates` keyword in *read_sql_query()* and *read_sql_table()*.

Warning: Some of the existing functions or function aliases have been deprecated and will be removed in future versions. This includes: `tquery`, `uquery`, `read_frame`, `frame_query`, `write_frame`.

Warning: The support for the 'mysql' flavor when using DBAPI connection objects has been deprecated. MySQL will be further supported with SQLAlchemy engines (GH6900).

1.19.6 MultiIndexing Using Slicers

In 0.14.0 we added a new way to slice multi-indexed objects. You can slice a multi-index by providing multiple indexers.

You can provide any of the selectors as if you are indexing by label, see *Selection by Label*, including slices, lists of labels, labels, and boolean indexers.

You can use `slice(None)` to select all the contents of *that* level. You do not need to specify all the *deeper* levels, they will be implied as `slice(None)`.

As usual, **both sides** of the slicers are included as this is label indexing.

See *the docs* See also issues (GH6134, GH4036, GH3057, GH2598, GH5641, GH7106)

Warning: You should specify all axes in the `.loc` specifier, meaning the indexer for the **index** and for the **columns**. Their are some ambiguous cases where the passed indexer could be mis-interpreted as indexing *both* axes, rather than into say the MuliIndex for the rows.

You should do this:

```
df.loc[(slice('A1','A3'),.....),:]
```

rather than this:

```
df.loc[(slice('A1','A3'),.....)]
```

Warning: You will need to make sure that the selection axes are fully lexsorted!

```
In [46]: def mklbl(prefix,n):
   ....:     return ["%s%s" % (prefix,i)  for i in range(n)]
   ....:

In [47]: index = MultiIndex.from_product([mklbl('A',4),
   ....:                                  mklbl('B',2),
   ....:                                  mklbl('C',4),
   ....:                                  mklbl('D',2)])
   ....:

In [48]: columns = MultiIndex.from_tuples([('a','foo'),('a','bar'),
   ....:                                   ('b','foo'),('b','bah')],
   ....:                                    names=['lvl0', 'lvl1'])
   ....:

In [49]: df = DataFrame(np.arange(len(index)*len(columns)).reshape((len(index),
↪len(columns))),
   ....:                index=index,
   ....:                columns=columns).sort_index().sort_index(axis=1)
   ....:

In [50]: df
Out[50]:
lvl0           a         b
lvl1         bar  foo  bah  foo
A0 B0 C0 D0    1    0    3    2
         D1    5    4    7    6
      C1 D0    9    8   11   10
         D1   13   12   15   14
      C2 D0   17   16   19   18
         D1   21   20   23   22
      C3 D0   25   24   27   26
...          ...  ...  ...  ...
A3 B1 C0 D1  229  228  231  230
      C1 D0  233  232  235  234
         D1  237  236  239  238
      C2 D0  241  240  243  242
         D1  245  244  247  246
      C3 D0  249  248  251  250
         D1  253  252  255  254

[64 rows x 4 columns]
```

Basic multi-index slicing using slices, lists, and labels.

```
In [51]: df.loc[(slice('A1','A3'),slice(None), ['C1','C3']),:]
Out[51]:
lvl0           a         b
lvl1         bar  foo  bah  foo
A1 B0 C1 D0   73   72   75   74
         D1   77   76   79   78
      C3 D0   89   88   91   90
         D1   93   92   95   94
   B1 C1 D0  105  104  107  106
         D1  109  108  111  110
      C3 D0  121  120  123  122
...          ...  ...  ...  ...
A3 B0 C1 D1  205  204  207  206
```

```
      C3 D0  217  216  219  218
         D1  221  220  223  222
   B1 C1 D0  233  232  235  234
         D1  237  236  239  238
      C3 D0  249  248  251  250
         D1  253  252  255  254

[24 rows x 4 columns]
```

You can use a `pd.IndexSlice` to shortcut the creation of these slices

```
In [52]: idx = pd.IndexSlice

In [53]: df.loc[idx[:,:,['C1','C3']],idx[:,'foo']]
Out[53]:
lvl0           a    b
lvl1         foo  foo
A0 B0 C1 D0    8   10
         D1   12   14
      C3 D0   24   26
         D1   28   30
   B1 C1 D0   40   42
         D1   44   46
      C3 D0   56   58
...          ...  ...
A3 B0 C1 D1  204  206
      C3 D0  216  218
         D1  220  222
   B1 C1 D0  232  234
         D1  236  238
      C3 D0  248  250
         D1  252  254

[32 rows x 2 columns]
```

It is possible to perform quite complicated selections using this method on multiple axes at the same time.

```
In [54]: df.loc['A1',(slice(None),'foo')]
Out[54]:
lvl0        a    b
lvl1      foo  foo
B0 C0 D0   64   66
      D1   68   70
   C1 D0   72   74
      D1   76   78
   C2 D0   80   82
      D1   84   86
   C3 D0   88   90
...       ...  ...
B1 C0 D1  100  102
   C1 D0  104  106
      D1  108  110
   C2 D0  112  114
      D1  116  118
   C3 D0  120  122
      D1  124  126

[16 rows x 2 columns]
```

```
In [55]: df.loc[idx[:,:,['C1','C3']],idx[:,'foo']]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
lvl0           a    b
lvl1         foo  foo
A0 B0 C1 D0    8   10
         D1   12   14
      C3 D0   24   26
         D1   28   30
   B1 C1 D0   40   42
         D1   44   46
      C3 D0   56   58
...          ...  ...
A3 B0 C1 D1  204  206
      C3 D0  216  218
         D1  220  222
   B1 C1 D0  232  234
         D1  236  238
      C3 D0  248  250
         D1  252  254

[32 rows x 2 columns]
```

Using a boolean indexer you can provide selection related to the *values*.

```
In [56]: mask = df[('a','foo')]>200

In [57]: df.loc[idx[mask,:,['C1','C3']],idx[:,'foo']]
Out[57]:
lvl0           a    b
lvl1         foo  foo
A3 B0 C1 D1  204  206
      C3 D0  216  218
         D1  220  222
   B1 C1 D0  232  234
         D1  236  238
      C3 D0  248  250
         D1  252  254
```

You can also specify the `axis` argument to `.loc` to interpret the passed slicers on a single axis.

```
In [58]: df.loc(axis=0)[:,:,['C1','C3']]
Out[58]:
lvl0           a         b
lvl1         bar  foo  bah  foo
A0 B0 C1 D0    9    8   11   10
         D1   13   12   15   14
      C3 D0   25   24   27   26
         D1   29   28   31   30
   B1 C1 D0   41   40   43   42
         D1   45   44   47   46
      C3 D0   57   56   59   58
...          ...  ...  ...  ...
A3 B0 C1 D1  205  204  207  206
      C3 D0  217  216  219  218
         D1  221  220  223  222
   B1 C1 D0  233  232  235  234
```

```
         D1  237  236  239  238
      C3 D0  249  248  251  250
         D1  253  252  255  254

[32 rows x 4 columns]
```

Furthermore you can *set* the values using these methods

```
In [59]: df2 = df.copy()

In [60]: df2.loc(axis=0)[:,:,['C1','C3']] = -10

In [61]: df2
Out[61]:
lvl0           a         b
lvl1         bar  foo  bah  foo
A0 B0 C0 D0    1    0    3    2
         D1    5    4    7    6
      C1 D0  -10  -10  -10  -10
         D1  -10  -10  -10  -10
      C2 D0   17   16   19   18
         D1   21   20   23   22
      C3 D0  -10  -10  -10  -10
...          ...  ...  ...  ...
A3 B1 C0 D1  229  228  231  230
      C1 D0  -10  -10  -10  -10
         D1  -10  -10  -10  -10
      C2 D0  241  240  243  242
         D1  245  244  247  246
      C3 D0  -10  -10  -10  -10
         D1  -10  -10  -10  -10

[64 rows x 4 columns]
```

You can use a right-hand-side of an alignable object as well.

```
In [62]: df2 = df.copy()

In [63]: df2.loc[idx[:,:,['C1','C3']],:] = df2*1000

In [64]: df2
Out[64]:
lvl0              a               b
lvl1            bar     foo     bah     foo
A0 B0 C0 D0       1       0       3       2
         D1       5       4       7       6
      C1 D0    9000    8000   11000   10000
         D1   13000   12000   15000   14000
      C2 D0      17      16      19      18
         D1      21      20      23      22
      C3 D0   25000   24000   27000   26000
...             ...     ...     ...     ...
A3 B1 C0 D1     229     228     231     230
      C1 D0  233000  232000  235000  234000
         D1  237000  236000  239000  238000
      C2 D0     241     240     243     242
         D1     245     244     247     246
      C3 D0  249000  248000  251000  250000
```

```
         D1  253000  252000  255000  254000

[64 rows x 4 columns]
```

1.19.7 Plotting

- Hexagonal bin plots from `DataFrame.plot` with `kind='hexbin'` (GH5478), See *the docs*.
- `DataFrame.plot` and `Series.plot` now supports area plot with specifying `kind='area'` (GH6656), See *the docs*
- Pie plots from `Series.plot` and `DataFrame.plot` with `kind='pie'` (GH6976), See *the docs*.
- Plotting with Error Bars is now supported in the `.plot` method of `DataFrame` and `Series` objects (GH3796, GH6834), See *the docs*.
- `DataFrame.plot` and `Series.plot` now support a `table` keyword for plotting `matplotlib.Table`, See *the docs*. The `table` keyword can receive the following values.
  - `False`: Do nothing (default).
  - `True`: Draw a table using the `DataFrame` or `Series` called `plot` method. Data will be transposed to meet matplotlib's default layout.
  - `DataFrame` or `Series`: Draw matplotlib.table using the passed data. The data will be drawn as displayed in print method (not transposed automatically). Also, helper function `pandas.tools.plotting.table` is added to create a table from `DataFrame` and `Series`, and add it to an `matplotlib.Axes`.
- `plot(legend='reverse')` will now reverse the order of legend labels for most plot kinds. (GH6014)
- Line plot and area plot can be stacked by `stacked=True` (GH6656)
- Following keywords are now acceptable for `DataFrame.plot()` with `kind='bar'` and `kind='barh'`:
  - *width*: Specify the bar width. In previous versions, static value 0.5 was passed to matplotlib and it cannot be overwritten. (GH6604)
  - *align*: Specify the bar alignment. Default is *center* (different from matplotlib). In previous versions, pandas passes *align='edge'* to matplotlib and adjust the location to *center* by itself, and it results *align* keyword is not applied as expected. (GH4525)
  - *position*: Specify relative alignments for bar plot layout. From 0 (left/bottom-end) to 1(right/top-end). Default is 0.5 (center). (GH6604)

  Because of the default *align* value changes, coordinates of bar plots are now located on integer values (0.0, 1.0, 2.0 ...). This is intended to make bar plot be located on the same coodinates as line plot. However, bar plot may differs unexpectedly when you manually adjust the bar location or drawing area, such as using *set_xlim*, *set_ylim*, etc. In this cases, please modify your script to meet with new coordinates.
- The `parallel_coordinates()` function now takes argument `color` instead of `colors`. A `FutureWarning` is raised to alert that the old `colors` argument will not be supported in a future release. (GH6956)
- The `parallel_coordinates()` and `andrews_curves()` functions now take positional argument `frame` instead of `data`. A `FutureWarning` is raised if the old `data` argument is used by name. (GH6956)
- `DataFrame.boxplot()` now supports `layout` keyword (GH6769)
- `DataFrame.boxplot()` has a new keyword argument, *return_type*. It accepts `'dict'`, `'axes'`, or `'both'`, in which case a namedtuple with the matplotlib axes and a dict of matplotlib Lines is returned.

1.19.8 Prior Version Deprecations/Changes

There are prior version deprecations that are taking effect as of 0.14.0.

- Remove `DateRange` in favor of `DatetimeIndex` (GH6816)
- Remove `column` keyword from `DataFrame.sort` (GH4370)
- Remove `precision` keyword from `set_eng_float_format()` (GH395)
- Remove `force_unicode` keyword from `DataFrame.to_string()`, `DataFrame.to_latex()`, and `DataFrame.to_html()`; these function encode in unicode by default (GH2224, GH2225)
- Remove `nanRep` keyword from `DataFrame.to_csv()` and `DataFrame.to_string()` (GH275)
- Remove `unique` keyword from `HDFStore.select_column()` (GH3256)
- Remove `inferTimeRule` keyword from `Timestamp.offset()` (GH391)
- Remove `name` keyword from `get_data_yahoo()` and `get_data_google()` (commit b921d1a)
- Remove `offset` keyword from `DatetimeIndex` constructor (commit 3136390)
- Remove `time_rule` from several rolling-moment statistical functions, such as `rolling_sum()` (GH1042)
- Removed neg − boolean operations on numpy arrays in favor of inv ~, as this is going to be deprecated in numpy 1.9 (GH6960)

1.19.9 Deprecations

- The `pivot_table()`/`DataFrame.pivot_table()` and `crosstab()` functions now take arguments `index` and `columns` instead of `rows` and `cols`. A `FutureWarning` is raised to alert that the old `rows` and `cols` arguments will not be supported in a future release (GH5505)
- The `DataFrame.drop_duplicates()` and `DataFrame.duplicated()` methods now take argument `subset` instead of `cols` to better align with `DataFrame.dropna()`. A `FutureWarning` is raised to alert that the old `cols` arguments will not be supported in a future release (GH6680)
- The `DataFrame.to_csv()` and `DataFrame.to_excel()` functions now takes argument `columns` instead of `cols`. A `FutureWarning` is raised to alert that the old `cols` arguments will not be supported in a future release (GH6645)
- Indexers will warn `FutureWarning` when used with a scalar indexer and a non-floating point Index (GH4892, GH6960)

```
# non-floating point indexes can only be indexed by integers / labels
In [1]: Series(1,np.arange(5))[3.0]
        pandas/core/index.py:469: FutureWarning: scalar indexers for index type␣
↪Int64Index should be integers and not floating point
Out[1]: 1

In [2]: Series(1,np.arange(5)).iloc[3.0]
        pandas/core/index.py:469: FutureWarning: scalar indexers for index type␣
↪Int64Index should be integers and not floating point
Out[2]: 1

In [3]: Series(1,np.arange(5)).iloc[3.0:4]
        pandas/core/index.py:527: FutureWarning: slice indexers when using iloc␣
↪should be integers and not floating point
Out[3]:
        3    1
```

```
        dtype: int64

# these are Float64Indexes, so integer or floating point is acceptable
In [4]: Series(1,np.arange(5.))[3]
Out[4]: 1

In [5]: Series(1,np.arange(5.))[3.0]
Out[6]: 1
```

- Numpy 1.9 compat w.r.t. deprecation warnings (GH6960)
- `Panel.shift()` now has a function signature that matches `DataFrame.shift()`. The old positional argument `lags` has been changed to a keyword argument `periods` with a default value of 1. A `FutureWarning` is raised if the old argument `lags` is used by name. (GH6910)
- The `order` keyword argument of `factorize()` will be removed. (GH6926).
- Remove the `copy` keyword from `DataFrame.xs()`, `Panel.major_xs()`, `Panel.minor_xs()`. A view will be returned if possible, otherwise a copy will be made. Previously the user could think that `copy=False` would ALWAYS return a view. (GH6894)
- The `parallel_coordinates()` function now takes argument `color` instead of `colors`. A `FutureWarning` is raised to alert that the old `colors` argument will not be supported in a future release. (GH6956)
- The `parallel_coordinates()` and `andrews_curves()` functions now take positional argument `frame` instead of `data`. A `FutureWarning` is raised if the old `data` argument is used by name. (GH6956)
- The support for the 'mysql' flavor when using DBAPI connection objects has been deprecated. MySQL will be further supported with SQLAlchemy engines (GH6900).
- The following `io.sql` functions have been deprecated: `tquery`, `uquery`, `read_frame`, `frame_query`, `write_frame`.
- The *percentile_width* keyword argument in `describe()` has been deprecated. Use the *percentiles* keyword instead, which takes a list of percentiles to display. The default output is unchanged.
- The default return type of `boxplot()` will change from a dict to a matpltolib Axes in a future release. You can use the future behavior now by passing `return_type='axes'` to boxplot.

1.19.10 Known Issues

- OpenPyXL 2.0.0 breaks backwards compatibility (GH7169)

1.19.11 Enhancements

- DataFrame and Series will create a MultiIndex object if passed a tuples dict, See *the docs* (GH3323)

```
In [65]: Series({('a', 'b'): 1, ('a', 'a'): 0,
   ....:         ('a', 'c'): 2, ('b', 'a'): 3, ('b', 'b'): 4})
   ....:
Out[65]:
a  a    0
   b    1
   c    2
b  a    3
   b    4
dtype: int64
```

```
In [66]: DataFrame({('a', 'b'): {('A', 'B'): 1, ('A', 'C'): 2},
   ....:            ('a', 'a'): {('A', 'C'): 3, ('A', 'B'): 4},
   ....:            ('a', 'c'): {('A', 'B'): 5, ('A', 'C'): 6},
   ....:            ('b', 'a'): {('A', 'C'): 7, ('A', 'B'): 8},
   ....:            ('b', 'b'): {('A', 'D'): 9, ('A', 'B'): 10}})
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[66]:
       a              b
       a    b    c    a     b
A B  4.0  1.0  5.0  8.0  10.0
  C  3.0  2.0  6.0  7.0   NaN
  D  NaN  NaN  NaN  NaN   9.0
```

- Added the `sym_diff` method to `Index` (GH5543)
- `DataFrame.to_latex` now takes a longtable keyword, which if True will return a table in a longtable environment. (GH6617)
- Add option to turn off escaping in `DataFrame.to_latex` (GH6472)
- `pd.read_clipboard` will, if the keyword `sep` is unspecified, try to detect data copied from a spreadsheet and parse accordingly. (GH6223)
- Joining a singly-indexed DataFrame with a multi-indexed DataFrame (GH3662)

  See *the docs*. Joining multi-index DataFrames on both the left and right is not yet supported ATM.

```
In [67]: household = DataFrame(dict(household_id = [1,2,3],
   ....:                            male = [0,1,0],
   ....:                            wealth = [196087.3,316478.7,294750]),
   ....:                       columns = ['household_id','male','wealth']
   ....:                      ).set_index('household_id')
   ....:

In [68]: household
Out[68]:
              male    wealth
household_id
1                0  196087.3
2                1  316478.7
3                0  294750.0

In [69]: portfolio = DataFrame(dict(household_id = [1,2,2,3,3,3,4],
   ....:                            asset_id = ["nl0000301109","nl0000289783",
↪"gb00b03mlx29",
   ....:                                        "gb00b03mlx29","lu0197800237",
↪"nl0000289965",np.nan],
   ....:                            name = ["ABN Amro","Robeco","Royal Dutch Shell
↪","Royal Dutch Shell",
   ....:                                    "AAB Eastern Europe Equity Fund",
↪"Postbank BioTech Fonds",np.nan],
   ....:                            share = [1.0,0.4,0.6,0.15,0.6,0.25,1.0]),
   ....:                       columns = ['household_id','asset_id','name','share
↪']
   ....:                      ).set_index(['household_id','asset_id'])
   ....:

In [70]: portfolio
Out[70]:
```

```
                                                     name  share
household_id asset_id
1            nl0000301109                        ABN Amro   1.00
2            nl0000289783                          Robeco   0.40
             gb00b03mlx29               Royal Dutch Shell   0.60
3            gb00b03mlx29               Royal Dutch Shell   0.15
             lu0197800237  AAB Eastern Europe Equity Fund   0.60
             nl0000289965          Postbank BioTech Fonds   0.25
4            NaN                                      NaN   1.00

In [71]: household.join(portfolio, how='inner')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                           male    wealth                            name  \
household_id asset_id
1            nl0000301109     0  196087.3                        ABN Amro
2            nl0000289783     1  316478.7                          Robeco
             gb00b03mlx29     1  316478.7               Royal Dutch Shell
3            gb00b03mlx29     0  294750.0               Royal Dutch Shell
             lu0197800237     0  294750.0  AAB Eastern Europe Equity Fund
             nl0000289965     0  294750.0          Postbank BioTech Fonds

                           share
household_id asset_id
1            nl0000301109   1.00
2            nl0000289783   0.40
             gb00b03mlx29   0.60
3            gb00b03mlx29   0.15
             lu0197800237   0.60
             nl0000289965   0.25
```

- `quotechar`, `doublequote`, and `escapechar` can now be specified when using `DataFrame.to_csv` (GH5414, GH4528)
- Partially sort by only the specified levels of a MultiIndex with the `sort_remaining` boolean kwarg. (GH3984)
- Added `to_julian_date` to `TimeStamp` and `DatetimeIndex`. The Julian Date is used primarily in astronomy and represents the number of days from noon, January 1, 4713 BC. Because nanoseconds are used to define the time in pandas the actual range of dates that you can use is 1678 AD to 2262 AD. (GH4041)
- `DataFrame.to_stata` will now check data for compatibility with Stata data types and will upcast when needed. When it is not possible to losslessly upcast, a warning is issued (GH6327)
- `DataFrame.to_stata` and `StataWriter` will accept keyword arguments time_stamp and data_label which allow the time stamp and dataset label to be set when creating a file. (GH6545)
- `pandas.io.gbq` now handles reading unicode strings properly. (GH5940)
- *Holidays Calendars* are now available and can be used with the `CustomBusinessDay` offset (GH6719)
- `Float64Index` is now backed by a `float64` dtype ndarray instead of an `object` dtype array (GH6471).
- Implemented `Panel.pct_change` (GH6904)
- Added `how` option to rolling-moment functions to dictate how to handle resampling; `rolling_max()` defaults to max, `rolling_min()` defaults to min, and all others default to mean (GH6297)
- `CustomBuisnessMonthBegin` and `CustomBusinessMonthEnd` are now available (GH6866)
- `Series.quantile()` and `DataFrame.quantile()` now accept an array of quantiles.

- `describe()` now accepts an array of percentiles to include in the summary statistics (GH4196)
- `pivot_table` can now accept `Grouper` by `index` and `columns` keywords (GH6913)

```
In [72]: import datetime

In [73]: df = DataFrame({
   ....:   'Branch' : 'A A A A A B'.split(),
   ....:   'Buyer': 'Carl Mark Carl Carl Joe Joe'.split(),
   ....:   'Quantity': [1, 3, 5, 1, 8, 1],
   ....:   'Date' : [datetime.datetime(2013,11,1,13,0), datetime.datetime(2013,9,
↪1,13,5),
   ....:             datetime.datetime(2013,10,1,20,0), datetime.datetime(2013,10,
↪2,10,0),
   ....:             datetime.datetime(2013,11,1,20,0), datetime.datetime(2013,10,
↪2,10,0)],
   ....:   'PayDay' : [datetime.datetime(2013,10,4,0,0), datetime.datetime(2013,
↪10,15,13,5),
   ....:               datetime.datetime(2013,9,5,20,0), datetime.datetime(2013,
↪11,2,10,0),
   ....:               datetime.datetime(2013,10,7,20,0), datetime.datetime(2013,
↪9,5,10,0)]})
   ....:

In [74]: df
Out[74]:
  Branch Buyer                Date              PayDay  Quantity
0      A  Carl 2013-11-01 13:00:00 2013-10-04 00:00:00         1
1      A  Mark 2013-09-01 13:05:00 2013-10-15 13:05:00         3
2      A  Carl 2013-10-01 20:00:00 2013-09-05 20:00:00         5
3      A  Carl 2013-10-02 10:00:00 2013-11-02 10:00:00         1
4      A   Joe 2013-11-01 20:00:00 2013-10-07 20:00:00         8
5      B   Joe 2013-10-02 10:00:00 2013-09-05 10:00:00         1

In [75]: pivot_table(df, index=Grouper(freq='M', key='Date'),
   ....:             columns=Grouper(freq='M', key='PayDay'),
   ....:             values='Quantity', aggfunc=np.sum)
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
PayDay      2013-09-30  2013-10-31  2013-11-30
Date
2013-09-30         NaN         3.0         NaN
2013-10-31         6.0         NaN         1.0
2013-11-30         NaN         9.0         NaN
```

- Arrays of strings can be wrapped to a specified width (`str.wrap`) (GH6999)
- Add `nsmallest()` and `Series.nlargest()` methods to Series, See *the docs* (GH3960)
- *PeriodIndex* fully supports partial string indexing like *DatetimeIndex* (GH7043)

```
In [76]: prng = period_range('2013-01-01 09:00', periods=100, freq='H')

In [77]: ps = Series(np.random.randn(len(prng)), index=prng)

In [78]: ps
Out[78]:
2013-01-01 09:00    0.015696
2013-01-01 10:00   -2.242685
```

```
2013-01-01 11:00    1.150036
2013-01-01 12:00    0.991946
2013-01-01 13:00    0.953324
2013-01-01 14:00   -2.021255
2013-01-01 15:00   -0.334077
                      ...
2013-01-05 06:00    0.566534
2013-01-05 07:00    0.503592
2013-01-05 08:00    0.285296
2013-01-05 09:00    0.484288
2013-01-05 10:00    1.363482
2013-01-05 11:00   -0.781105
2013-01-05 12:00   -0.468018
Freq: H, Length: 100, dtype: float64

In [79]: ps['2013-01-02']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2013-01-02 00:00    0.553439
2013-01-02 01:00    1.318152
2013-01-02 02:00   -0.469305
2013-01-02 03:00    0.675554
2013-01-02 04:00   -1.817027
2013-01-02 05:00   -0.183109
2013-01-02 06:00    1.058969
                      ...
2013-01-02 17:00    0.076200
2013-01-02 18:00   -0.566446
2013-01-02 19:00    0.036142
2013-01-02 20:00   -2.074978
2013-01-02 21:00    0.247792
2013-01-02 22:00   -0.897157
2013-01-02 23:00   -0.136795
Freq: H, Length: 24, dtype: float64
```

- `read_excel` can now read milliseconds in Excel dates and times with xlrd >= 0.9.3. (GH5945)
- `pd.stats.moments.rolling_var` now uses Welford's method for increased numerical stability (GH6817)
- pd.expanding_apply and pd.rolling_apply now take args and kwargs that are passed on to the func (GH6289)
- `DataFrame.rank()` now has a percentage rank option (GH5971)
- `Series.rank()` now has a percentage rank option (GH5971)
- `Series.rank()` and `DataFrame.rank()` now accept `method='dense'` for ranks without gaps (GH6514)
- Support passing `encoding` with xlwt (GH3710)
- Refactor Block classes removing *Block.items* attributes to avoid duplication in item handling (GH6745, GH6988).
- Testing statements updated to use specialized asserts (GH6175)

1.19.12 Performance

- Performance improvement when converting `DatetimeIndex` to floating ordinals using `DatetimeConverter` (GH6636)
- Performance improvement for `DataFrame.shift` (GH5609)
- Performance improvement in indexing into a multi-indexed Series (GH5567)
- Performance improvements in single-dtyped indexing (GH6484)
- Improve performance of DataFrame construction with certain offsets, by removing faulty caching (e.g. MonthEnd,BusinessMonthEnd), (GH6479)
- Improve performance of `CustomBusinessDay` (GH6584)
- improve performance of slice indexing on Series with string keys (GH6341, GH6372)
- Performance improvement for `DataFrame.from_records` when reading a specified number of rows from an iterable (GH6700)
- Performance improvements in timedelta conversions for integer dtypes (GH6754)
- Improved performance of compatible pickles (GH6899)
- Improve performance in certain reindexing operations by optimizing `take_2d` (GH6749)
- `GroupBy.count()` is now implemented in Cython and is much faster for large numbers of groups (GH7016).

1.19.13 Experimental

There are no experimental changes in 0.14.0

1.19.14 Bug Fixes

- Bug in Series ValueError when index doesn't match data (GH6532)
- Prevent segfault due to MultiIndex not being supported in HDFStore table format (GH1848)
- Bug in `pd.DataFrame.sort_index` where mergesort wasn't stable when `ascending=False` (GH6399)
- Bug in `pd.tseries.frequencies.to_offset` when argument has leading zeroes (GH6391)
- Bug in version string gen. for dev versions with shallow clones / install from tarball (GH6127)
- Inconsistent tz parsing `Timestamp` / `to_datetime` for current year (GH5958)
- Indexing bugs with reordered indexes (GH6252, GH6254)
- Bug in `.xs` with a Series multiindex (GH6258, GH5684)
- Bug in conversion of a string types to a DatetimeIndex with a specified frequency (GH6273, GH6274)
- Bug in `eval` where type-promotion failed for large expressions (GH6205)
- Bug in interpolate with `inplace=True` (GH6281)
- `HDFStore.remove` now handles start and stop (GH6177)
- `HDFStore.select_as_multiple` handles start and stop the same way as `select` (GH6177)
- `HDFStore.select_as_coordinates` and `select_column` works with a `where` clause that results in filters (GH6177)

- Regression in join of non_unique_indexes (GH6329)
- Issue with groupby `agg` with a single function and a a mixed-type frame (GH6337)
- Bug in `DataFrame.replace()` when passing a non- `bool` `to_replace` argument (GH6332)
- Raise when trying to align on different levels of a multi-index assignment (GH3738)
- Bug in setting complex dtypes via boolean indexing (GH6345)
- Bug in TimeGrouper/resample when presented with a non-monotonic DatetimeIndex that would return invalid results. (GH4161)
- Bug in index name propogation in TimeGrouper/resample (GH4161)
- TimeGrouper has a more compatible API to the rest of the groupers (e.g. `groups` was missing) (GH3881)
- Bug in multiple grouping with a TimeGrouper depending on target column order (GH6764)
- Bug in `pd.eval` when parsing strings with possible tokens like `'&'` (GH6351)
- Bug correctly handle placements of `-inf` in Panels when dividing by integer 0 (GH6178)
- `DataFrame.shift` with `axis=1` was raising (GH6371)
- Disabled clipboard tests until release time (run locally with `nosetests -A disabled`) (GH6048).
- Bug in `DataFrame.replace()` when passing a nested `dict` that contained keys not in the values to be replaced (GH6342)
- `str.match` ignored the na flag (GH6609).
- Bug in take with duplicate columns that were not consolidated (GH6240)
- Bug in interpolate changing dtypes (GH6290)
- Bug in `Series.get`, was using a buggy access method (GH6383)
- Bug in hdfstore queries of the form `where=[('date', '>=', datetime(2013,1,1)), ('date', '<=', datetime(2014,1,1))]` (GH6313)
- Bug in `DataFrame.dropna` with duplicate indices (GH6355)
- Regression in chained getitem indexing with embedded list-like from 0.12 (GH6394)
- `Float64Index` with nans not comparing correctly (GH6401)
- `eval`/`query` expressions with strings containing the `@` character will now work (GH6366).
- Bug in `Series.reindex` when specifying a `method` with some nan values was inconsistent (noted on a resample) (GH6418)
- Bug in `DataFrame.replace()` where nested dicts were erroneously depending on the order of dictionary keys and values (GH5338).
- Perf issue in concatting with empty objects (GH3259)
- Clarify sorting of `sym_diff` on `Index` objects with `NaN` values (GH6444)
- Regression in `MultiIndex.from_product` with a `DatetimeIndex` as input (GH6439)
- Bug in `str.extract` when passed a non-default index (GH6348)
- Bug in `str.split` when passed `pat=None` and `n=1` (GH6466)
- Bug in `io.data.DataReader` when passed `"F-F_Momentum_Factor"` and `data_source="famafrench"` (GH6460)
- Bug in `sum` of a `timedelta64[ns]` series (GH6462)

- Bug in `resample` with a timezone and certain offsets (GH6397)
- Bug in `iat/iloc` with duplicate indices on a Series (GH6493)
- Bug in `read_html` where nan's were incorrectly being used to indicate missing values in text. Should use the empty string for consistency with the rest of pandas (GH5129).
- Bug in `read_html` tests where redirected invalid URLs would make one test fail (GH6445).
- Bug in multi-axis indexing using `.loc` on non-unique indices (GH6504)
- Bug that caused _ref_locs corruption when slice indexing across columns axis of a DataFrame (GH6525)
- Regression from 0.13 in the treatment of numpy `datetime64` non-ns dtypes in Series creation (GH6529)
- `.names` attribute of MultiIndexes passed to `set_index` are now preserved (GH6459).
- Bug in setitem with a duplicate index and an alignable rhs (GH6541)
- Bug in setitem with `.loc` on mixed integer Indexes (GH6546)
- Bug in `pd.read_stata` which would use the wrong data types and missing values (GH6327)
- Bug in `DataFrame.to_stata` that lead to data loss in certain cases, and could be exported using the wrong data types and missing values (GH6335)
- `StataWriter` replaces missing values in string columns by empty string (GH6802)
- Inconsistent types in `Timestamp` addition/subtraction (GH6543)
- Bug in preserving frequency across Timestamp addition/subtraction (GH4547)
- Bug in empty list lookup caused `IndexError` exceptions (GH6536, GH6551)
- `Series.quantile` raising on an `object` dtype (GH6555)
- Bug in `.xs` with a `nan` in level when dropped (GH6574)
- Bug in fillna with `method='bfill/ffill'` and `datetime64[ns]` dtype (GH6587)
- Bug in sql writing with mixed dtypes possibly leading to data loss (GH6509)
- Bug in `Series.pop` (GH6600)
- Bug in `iloc` indexing when positional indexer matched `Int64Index` of the corresponding axis and no reordering happened (GH6612)
- Bug in `fillna` with `limit` and `value` specified
- Bug in `DataFrame.to_stata` when columns have non-string names (GH4558)
- Bug in compat with `np.compress`, surfaced in (GH6658)
- Bug in binary operations with a rhs of a Series not aligning (GH6681)
- Bug in `DataFrame.to_stata` which incorrectly handles nan values and ignores `with_index` keyword argument (GH6685)
- Bug in resample with extra bins when using an evenly divisible frequency (GH4076)
- Bug in consistency of groupby aggregation when passing a custom function (GH6715)
- Bug in resample when `how=None` resample freq is the same as the axis frequency (GH5955)
- Bug in downcasting inference with empty arrays (GH6733)
- Bug in `obj.blocks` on sparse containers dropping all but the last items of same for dtype (GH6748)
- Bug in unpickling `NaT (NaTType)` (GH4606)

- Bug in `DataFrame.replace()` where regex metacharacters were being treated as regexs even when `regex=False` (GH6777).
- Bug in timedelta ops on 32-bit platforms (GH6808)
- Bug in setting a tz-aware index directly via `.index` (GH6785)
- Bug in expressions.py where numexpr would try to evaluate arithmetic ops (GH6762).
- Bug in Makefile where it didn't remove Cython generated C files with `make clean` (GH6768)
- Bug with numpy < 1.7.2 when reading long strings from `HDFStore` (GH6166)
- Bug in `DataFrame._reduce` where non bool-like (0/1) integers were being coverted into bools. (GH6806)
- Regression from 0.13 with `fillna` and a Series on datetime-like (GH6344)
- Bug in adding `np.timedelta64` to `DatetimeIndex` with timezone outputs incorrect results (GH6818)
- Bug in `DataFrame.replace()` where changing a dtype through replacement would only replace the first occurrence of a value (GH6689)
- Better error message when passing a frequency of 'MS' in `Period` construction (GH5332)
- Bug in `Series.__unicode__` when `max_rows=None` and the Series has more than 1000 rows. (GH6863)
- Bug in `groupby.get_group` where a datetlike wasn't always accepted (GH5267)
- Bug in `groupBy.get_group` created by `TimeGrouper` raises `AttributeError` (GH6914)
- Bug in `DatetimeIndex.tz_localize` and `DatetimeIndex.tz_convert` converting `NaT` incorrectly (GH5546)
- Bug in arithmetic operations affecting `NaT` (GH6873)
- Bug in `Series.str.extract` where the resulting `Series` from a single group match wasn't renamed to the group name
- Bug in `DataFrame.to_csv` where setting `index=False` ignored the `header` kwarg (GH6186)
- Bug in `DataFrame.plot` and `Series.plot`, where the legend behave inconsistently when plotting to the same axes repeatedly (GH6678)
- Internal tests for patching `__finalize__` / bug in merge not finalizing (GH6923, GH6927)
- accept `TextFileReader` in `concat`, which was affecting a common user idiom (GH6583)
- Bug in C parser with leading whitespace (GH3374)
- Bug in C parser with `delim_whitespace=True` and `\r`-delimited lines
- Bug in python parser with explicit multi-index in row following column header (GH6893)
- Bug in `Series.rank` and `DataFrame.rank` that caused small floats (<1e-13) to all receive the same rank (GH6886)
- Bug in `DataFrame.apply` with functions that used *args`` or **kwargs and returned an empty result (GH6952)
- Bug in sum/mean on 32-bit platforms on overflows (GH6915)
- Moved `Panel.shift` to `NDFrame.slice_shift` and fixed to respect multiple dtypes. (GH6959)
- Bug in enabling `subplots=True` in `DataFrame.plot` only has single column raises `TypeError`, and `Series.plot` raises `AttributeError` (GH6951)
- Bug in `DataFrame.plot` draws unnecessary axes when enabling `subplots` and `kind=scatter` (GH6951)

- Bug in `read_csv` from a filesystem with non-utf-8 encoding (GH6807)
- Bug in `iloc` when setting / aligning (GH6766)
- Bug causing UnicodeEncodeError when get_dummies called with unicode values and a prefix (GH6885)
- Bug in timeseries-with-frequency plot cursor display (GH5453)
- Bug surfaced in `groupby.plot` when using a `Float64Index` (GH7025)
- Stopped tests from failing if options data isn't able to be downloaded from Yahoo (GH7034)
- Bug in `parallel_coordinates` and `radviz` where reordering of class column caused possible color/class mismatch (GH6956)
- Bug in `radviz` and `andrews_curves` where multiple values of 'color' were being passed to plotting method (GH6956)
- Bug in `Float64Index.isin()` where containing `nan` s would make indices claim that they contained all the things (GH7066).
- Bug in `DataFrame.boxplot` where it failed to use the axis passed as the `ax` argument (GH3578)
- Bug in the `XlsxWriter` and `XlwtWriter` implementations that resulted in datetime columns being formatted without the time (GH7075) were being passed to plotting method
- `read_fwf()` treats `None` in `colspec` like regular python slices. It now reads from the beginning or until the end of the line when `colspec` contains a `None` (previously raised a `TypeError`)
- Bug in cache coherence with chained indexing and slicing; add `_is_view` property to `NDFrame` to correctly predict views; mark `is_copy` on `xs` only if its an actual copy (and not a view) (GH7084)
- Bug in DatetimeIndex creation from string ndarray with `dayfirst=True` (GH5917)
- Bug in `MultiIndex.from_arrays` created from `DatetimeIndex` doesn't preserve `freq` and `tz` (GH7090)
- Bug in `unstack` raises `ValueError` when `MultiIndex` contains `PeriodIndex` (GH4342)
- Bug in `boxplot` and `hist` draws unnecessary axes (GH6769)
- Regression in `groupby.nth()` for out-of-bounds indexers (GH6621)
- Bug in `quantile` with datetime values (GH6965)
- Bug in `Dataframe.set_index`, `reindex` and `pivot` don't preserve `DatetimeIndex` and `PeriodIndex` attributes (GH3950, GH5878, GH6631)
- Bug in `MultiIndex.get_level_values` doesn't preserve `DatetimeIndex` and `PeriodIndex` attributes (GH7092)
- Bug in `Groupby` doesn't preserve `tz` (GH3950)
- Bug in `PeriodIndex` partial string slicing (GH6716)
- Bug in the HTML repr of a truncated Series or DataFrame not showing the class name with the *large_repr* set to 'info' (GH7105)
- Bug in `DatetimeIndex` specifying `freq` raises `ValueError` when passed value is too short (GH7098)
- Fixed a bug with the *info* repr not honoring the *display.max_info_columns* setting (GH6939)
- Bug `PeriodIndex` string slicing with out of bounds values (GH5407)
- Fixed a memory error in the hashtable implementation/factorizer on resizing of large tables (GH7157)
- Bug in `isnull` when applied to 0-dimensional object arrays (GH7176)

- Bug in `query/eval` where global constants were not looked up correctly (GH7178)
- Bug in recognizing out-of-bounds positional list indexers with `iloc` and a multi-axis tuple indexer (GH7189)
- Bug in setitem with a single value, multi-index and integer indices (GH7190, GH7218)
- Bug in expressions evaluation with reversed ops, showing in series-dataframe ops (GH7198, GH7192)
- Bug in multi-axis indexing with > 2 ndim and a multi-index (GH7199)
- Fix a bug where invalid eval/query operations would blow the stack (GH5198)

1.20 v0.13.1 (February 3, 2014)

This is a minor release from 0.13.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Added `infer_datetime_format` keyword to `read_csv/to_datetime` to allow speedups for homogeneously formatted datetimes.
- Will intelligently limit display precision for datetime/timedelta formats.
- Enhanced Panel *`apply()`* method.
- Suggested tutorials in new *Tutorials* section.
- Our pandas ecosystem is growing, We now feature related projects in a new *Pandas Ecosystem* section.
- Much work has been taking place on improving the docs, and a new *Contributing* section has been added.
- Even though it may only be of interest to devs, we <3 our new CI status page: ScatterCI.

Warning: 0.13.1 fixes a bug that was caused by a combination of having numpy < 1.8, and doing chained assignment on a string-like array. Please review *the docs*, chained indexing can have unexpected results and should generally be avoided.

This would previously segfault:

```
In [1]: df = DataFrame(dict(A = np.array(['foo','bar','bah','foo','bar'])))

In [2]: df['A'].iloc[0] = np.nan

In [3]: df
Out[3]:
     A
0  NaN
1  bar
2  bah
3  foo
4  bar
```

The recommended way to do this type of assignment is:

```
In [4]: df = DataFrame(dict(A = np.array(['foo','bar','bah','foo','bar'])))

In [5]: df.loc[0,'A'] = np.nan

In [6]: df
Out[6]:
     A
0  NaN
1  bar
2  bah
3  foo
4  bar
```

1.20.1 Output Formatting Enhancements

- df.info() view now display dtype info per column (GH5682)
- df.info() now honors the option `max_info_rows`, to disable null counts for large frames (GH5974)

```
In [7]: max_info_rows = pd.get_option('max_info_rows')

In [8]: df = DataFrame(dict(A = np.random.randn(10),
   ...:                     B = np.random.randn(10),
   ...:                     C = date_range('20130101',periods=10)))
   ...:

In [9]: df.iloc[3:6,[0,2]] = np.nan
```

```
# set to not display the null counts
In [10]: pd.set_option('max_info_rows',0)

In [11]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 3 columns):
A    float64
B    float64
C    datetime64[ns]
dtypes: datetime64[ns](1), float64(2)
memory usage: 320.0 bytes
```

```
# this is the default (same as in 0.13.0)
In [12]: pd.set_option('max_info_rows',max_info_rows)

In [13]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 3 columns):
A    7 non-null float64
B    10 non-null float64
C    7 non-null datetime64[ns]
dtypes: datetime64[ns](1), float64(2)
memory usage: 320.0 bytes
```

- Add `show_dimensions` display option for the new DataFrame repr to control whether the dimensions print.

```
In [14]: df = DataFrame([[1, 2], [3, 4]])

In [15]: pd.set_option('show_dimensions', False)

In [16]: df
Out[16]:
   0  1
0  1  2
1  3  4

In [17]: pd.set_option('show_dimensions', True)

In [18]: df
Out[18]:
   0  1
0  1  2
1  3  4

[2 rows x 2 columns]
```

- The `ArrayFormatter` for `datetime` and `timedelta64` now intelligently limit precision based on the values in the array (GH3401)

  Previously output might look like:

```
  age                 today               diff
0 2001-01-01 00:00:00 2013-04-19 00:00:00 4491 days, 00:00:00
1 2004-06-01 00:00:00 2013-04-19 00:00:00 3244 days, 00:00:00
```

  Now the output looks like:

```
In [19]: df = DataFrame([ Timestamp('20010101'),
   ....:                  Timestamp('20040601') ], columns=['age'])
   ....:

In [20]: df['today'] = Timestamp('20130419')

In [21]: df['diff'] = df['today']-df['age']

In [22]: df
Out[22]:
         age      today      diff
0 2001-01-01 2013-04-19 4491 days
1 2004-06-01 2013-04-19 3244 days

[2 rows x 3 columns]
```

1.20.2 API changes

- Add `-NaN` and `-nan` to the default set of NA values (GH5952). See *NA Values*.
- Added `Series.str.get_dummies` vectorized string method (GH6021), to extract dummy/indicator variables for separated string columns:

```
In [23]: s = Series(['a', 'a|b', np.nan, 'a|c'])

In [24]: s.str.get_dummies(sep='|')
```

```
Out[24]:
   a  b  c
0  1  0  0
1  1  1  0
2  0  0  0
3  1  0  1

[4 rows x 3 columns]
```

- Added the `NDFrame.equals()` method to compare if two NDFrames are equal have equal axes, dtypes, and values. Added the `array_equivalent` function to compare if two ndarrays are equal. NaNs in identical locations are treated as equal. (GH5283) See also *the docs* for a motivating example.

```
In [25]: df = DataFrame({'col':['foo', 0, np.nan]})

In [26]: df2 = DataFrame({'col':[np.nan, 0, 'foo']}, index=[2,1,0])

In [27]: df.equals(df2)
Out[27]: False

In [28]: df.equals(df2.sort_index())
\\\\\\\\\\\\\\Out[28]: True

In [29]: import pandas.core.common as com

In [30]: com.array_equivalent(np.array([0, np.nan]), np.array([0, np.nan]))
Out[30]: True

In [31]: np.array_equal(np.array([0, np.nan]), np.array([0, np.nan]))
\\\\\\\\\\\\\\Out[31]: False
```

- `DataFrame.apply` will use the `reduce` argument to determine whether a `Series` or a `DataFrame` should be returned when the `DataFrame` is empty (GH6007).

  Previously, calling `DataFrame.apply` an empty `DataFrame` would return either a `DataFrame` if there were no columns, or the function being applied would be called with an empty `Series` to guess whether a `Series` or `DataFrame` should be returned:

```
In [32]: def applied_func(col):
   ....:     print("Apply function being called with: ", col)
   ....:     return col.sum()
   ....:

In [33]: empty = DataFrame(columns=['a', 'b'])

In [34]: empty.apply(applied_func)
Apply function being called with:  Series([], Length: 0, dtype: float64)
Out[34]:
a   NaN
b   NaN
Length: 2, dtype: float64
```

  Now, when `apply` is called on an empty `DataFrame`: if the `reduce` argument is `True` a `Series` will returned, if it is `False` a `DataFrame` will be returned, and if it is `None` (the default) the function being applied will be called with an empty series to try and guess the return type.

```
In [35]: empty.apply(applied_func, reduce=True)
Out[35]:
```

```
a    NaN
b    NaN
Length: 2, dtype: float64

In [36]: empty.apply(applied_func, reduce=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[36]:
Empty DataFrame
Columns: [a, b]
Index: []

[0 rows x 2 columns]
```

1.20.3 Prior Version Deprecations/Changes

There are no announced changes in 0.13 or prior that are taking effect as of 0.13.1

1.20.4 Deprecations

There are no deprecations of prior behavior in 0.13.1

1.20.5 Enhancements

- `pd.read_csv` and `pd.to_datetime` learned a new `infer_datetime_format` keyword which greatly improves parsing perf in many cases. Thanks to @lexual for suggesting and @danbirken for rapidly implementing. (GH5490, GH6021)

  If `parse_dates` is enabled and this flag is set, pandas will attempt to infer the format of the datetime strings in the columns, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by ~5-10x.

```
# Try to infer the format for the index column
df = pd.read_csv('foo.csv', index_col=0, parse_dates=True,
                 infer_datetime_format=True)
```

- `date_format` and `datetime_format` keywords can now be specified when writing to `excel` files (GH4133)
- `MultiIndex.from_product` convenience function for creating a MultiIndex from the cartesian product of a set of iterables (GH6055):

```
In [37]: shades = ['light', 'dark']

In [38]: colors = ['red', 'green', 'blue']

In [39]: MultiIndex.from_product([shades, colors], names=['shade', 'color'])
Out[39]:
MultiIndex(levels=[['dark', 'light'], ['blue', 'green', 'red']],
           labels=[[1, 1, 1, 0, 0, 0], [2, 1, 0, 2, 1, 0]],
           names=['shade', 'color'])
```

- Panel *`apply()`* will work on non-ufuncs. See *the docs*.

```
In [40]: import pandas.util.testing as tm

In [41]: panel = tm.makePanel(5)

In [42]: panel
Out[42]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D

In [43]: panel['ItemA']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-03  0.694103  1.893534 -1.735349 -0.850346
2000-01-04  0.678630  0.639633  1.210384  1.176812
2000-01-05  0.239556 -0.962029  0.797435 -0.524336
2000-01-06  0.151227 -2.085266 -0.379811  0.700908
2000-01-07  0.816127  1.930247  0.702562  0.984188

[5 rows x 4 columns]
```

Specifying an `apply` that operates on a Series (to return a single element)

```
In [44]: panel.apply(lambda x: x.dtype, axis='items')
Out[44]:
                  A        B        C        D
2000-01-03  float64  float64  float64  float64
2000-01-04  float64  float64  float64  float64
2000-01-05  float64  float64  float64  float64
2000-01-06  float64  float64  float64  float64
2000-01-07  float64  float64  float64  float64

[5 rows x 4 columns]
```

A similar reduction type operation

```
In [45]: panel.apply(lambda x: x.sum(), axis='major_axis')
Out[45]:
      ItemA     ItemB     ItemC
A  2.579643  3.062757  0.379252
B  1.416120 -1.960855  0.923558
C  0.595222 -1.079772 -3.118269
D  1.487226 -0.734611 -1.979310

[4 rows x 3 columns]
```

This is equivalent to

```
In [46]: panel.sum('major_axis')
Out[46]:
      ItemA     ItemB     ItemC
A  2.579643  3.062757  0.379252
B  1.416120 -1.960855  0.923558
C  0.595222 -1.079772 -3.118269
D  1.487226 -0.734611 -1.979310
```

```

[4 rows x 3 columns]
```

A transformation operation that returns a Panel, but is computing the z-score across the major_axis

```
In [47]: result = panel.apply(
   ....:            lambda x: (x-x.mean())/x.std(),
   ....:            axis='major_axis')
   ....:

In [48]: result
Out[48]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D

In [49]: result['ItemA']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-03  0.595800  0.907552 -1.556260 -1.244875
2000-01-04  0.544058  0.200868  0.915883  0.953747
2000-01-05 -0.924165 -0.701810  0.569325 -0.891290
2000-01-06 -1.219530 -1.334852 -0.418654  0.437589
2000-01-07  1.003837  0.928242  0.489705  0.744830

[5 rows x 4 columns]
```

- Panel *apply()* operating on cross-sectional slabs. (GH1148)

```
In [50]: f = lambda x: ((x.T-x.mean(1))/x.std(1)).T

In [51]: result = panel.apply(f, axis = ['items','major_axis'])

In [52]: result
Out[52]:
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 5 (major_axis) x 3 (minor_axis)
Items axis: A to D
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: ItemA to ItemC

In [53]: result.loc[:,:,'ItemA']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-03  0.331409  1.071034 -0.914540 -0.510587
2000-01-04 -0.741017 -0.118794  0.383277  0.537212
2000-01-05  0.065042 -0.767353  0.655436  0.069467
2000-01-06  0.027932 -0.569477  0.908202  0.610585
2000-01-07  1.116434  1.133591  0.871287  1.004064

[5 rows x 4 columns]
```

This is equivalent to the following

```
In [54]: result = Panel(dict([ (ax,f(panel.loc[:,:,ax]))
   ....:                         for ax in panel.minor_axis ]))
   ....:

In [55]: result
Out[55]:
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 5 (major_axis) x 3 (minor_axis)
Items axis: A to D
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: ItemA to ItemC

In [56]: result.loc[:,:,'ItemA']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-03  0.331409  1.071034 -0.914540 -0.510587
2000-01-04 -0.741017 -0.118794  0.383277  0.537212
2000-01-05  0.065042 -0.767353  0.655436  0.069467
2000-01-06  0.027932 -0.569477  0.908202  0.610585
2000-01-07  1.116434  1.133591  0.871287  1.004064

[5 rows x 4 columns]
```

1.20.6 Performance

Performance improvements for 0.13.1

- Series datetime/timedelta binary operations (GH5801)
- DataFrame `count/dropna` for `axis=1`
- Series.str.contains now has a *regex=False* keyword which can be faster for plain (non-regex) string patterns. (GH5879)
- Series.str.extract (GH5944)
- `dtypes/ftypes` methods (GH5968)
- indexing with object dtypes (GH5968)
- `DataFrame.apply` (GH6013)
- Regression in JSON IO (GH5765)
- Index construction from Series (GH6150)

1.20.7 Experimental

There are no experimental changes in 0.13.1

1.20.8 Bug Fixes

See *V0.13.1 Bug Fixes* for an extensive list of bugs that have been fixed in 0.13.1.

See the *full release notes* or issue tracker on GitHub for a complete list of all API changes, Enhancements and Bug Fixes.

1.21 v0.13.0 (January 3, 2014)

This is a major release from 0.12.0 and includes a number of API changes, several new features and enhancements along with a large number of bug fixes.

Highlights include:

- support for a new index type `Float64Index`, and other Indexing enhancements
- `HDFStore` has a new string based syntax for query specification
- support for new methods of interpolation
- updated `timedelta` operations
- a new string manipulation method `extract`
- Nanosecond support for Offsets
- `isin` for DataFrames

Several experimental features are added, including:

- new `eval/query` methods for expression evaluation
- support for `msgpack` serialization
- an i/o interface to Google's `BigQuery`

Their are several new or updated docs sections including:

- *Comparison with SQL*, which should be useful for those familiar with SQL but still learning pandas.
- *Comparison with R*, idiom translations from R to pandas.
- *Enhancing Performance*, ways to enhance pandas performance with `eval/query`.

> **Warning:** In 0.13.0 `Series` has internally been refactored to no longer sub-class `ndarray` but instead subclass `NDFrame`, similar to the rest of the pandas containers. This should be a transparent change with only very limited API implications. See *Internal Refactoring*

1.21.1 API changes

- `read_excel` now supports an integer in its `sheetname` argument giving the index of the sheet to read in (GH4301).
- Text parser now treats anything that reads like inf ("inf", "Inf", "-Inf", "iNf", etc.) as infinity. (GH4220, GH4219), affecting `read_table`, `read_csv`, etc.
- `pandas` now is Python 2/3 compatible without the need for 2to3 thanks to @jtratner. As a result, pandas now uses iterators more extensively. This also led to the introduction of substantive parts of the Benjamin Peterson's `six` library into compat. (GH4384, GH4375, GH4372)
- `pandas.util.compat` and `pandas.util.py3compat` have been merged into `pandas.compat`. `pandas.compat` now includes many functions allowing 2/3 compatibility. It contains both list and iterator versions of range, filter, map and zip, plus other necessary elements for Python 3 compatibility. `lmap`, `lzip`, `lrange` and `lfilter` all produce lists instead of iterators, for compatibility with `numpy`, subscripting and `pandas` constructors.(GH4384, GH4375, GH4372)
- `Series.get` with negative indexers now returns the same as `[]` (GH4390)

- Changes to how `Index` and `MultiIndex` handle metadata (`levels`, `labels`, and `names`) (GH4039):

```
# previously, you would have set levels or labels directly
index.levels = [[1, 2, 3, 4], [1, 2, 4, 4]]

# now, you use the set_levels or set_labels methods
index = index.set_levels([[1, 2, 3, 4], [1, 2, 4, 4]])

# similarly, for names, you can rename the object
# but setting names is not deprecated
index = index.set_names(["bob", "cranberry"])

# and all methods take an inplace kwarg - but return None
index.set_names(["bob", "cranberry"], inplace=True)
```

- **All** division with `NDFrame` objects is now *truedivision*, regardless of the future import. This means that operating on pandas objects will by default use *floating point* division, and return a floating point dtype. You can use `//` and `floordiv` to do integer division.

  Integer division

```
In [3]: arr = np.array([1, 2, 3, 4])

In [4]: arr2 = np.array([5, 3, 2, 1])

In [5]: arr / arr2
Out[5]: array([0, 0, 1, 4])

In [6]: Series(arr) // Series(arr2)
Out[6]:
0    0
1    0
2    1
3    4
dtype: int64
```

  True Division

```
In [7]: pd.Series(arr) / pd.Series(arr2) # no future import required
Out[7]:
0    0.200000
1    0.666667
2    1.500000
3    4.000000
dtype: float64
```

- Infer and downcast dtype if `downcast='infer'` is passed to `fillna/ffill/bfill` (GH4604)
- `__nonzero__` for all NDFrame objects, will now raise a `ValueError`, this reverts back to (GH1073, GH4633) behavior. See *gotchas* for a more detailed discussion.

  This prevents doing boolean comparison on *entire* pandas objects, which is inherently ambiguous. These all will raise a `ValueError`.

```
if df:
    ....
df1 and df2
s1 and s2
```

Added the `.bool()` method to `NDFrame` objects to facilitate evaluating of single-element boolean Series:

```
In [1]: Series([True]).bool()
Out[1]: True

In [2]: Series([False]).bool()
\\\\\\\\\\\\\Out[2]: False

In [3]: DataFrame([[True]]).bool()
\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[3]: True

In [4]: DataFrame([[False]]).bool()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[4]: False
```

- All non-Index NDFrames (`Series`, `DataFrame`, `Panel`, `Panel4D`, `SparsePanel`, etc.), now support the entire set of arithmetic operators and arithmetic flex methods (add, sub, mul, etc.). `SparsePanel` does not support `pow` or `mod` with non-scalars. (GH3765)
- `Series` and `DataFrame` now have a `mode()` method to calculate the statistical mode(s) by axis/Series. (GH5367)
- Chained assignment will now by default warn if the user is assigning to a copy. This can be changed with the option `mode.chained_assignment`, allowed options are `raise/warn/None`. See *the docs*.

```
In [5]: dfc = DataFrame({'A':['aaa','bbb','ccc'],'B':[1,2,3]})

In [6]: pd.set_option('chained_assignment','warn')
```

The following warning / exception will show if this is attempted.

```
In [7]: dfc.loc[0]['A'] = 1111
```

```
Traceback (most recent call last)
   ...
SettingWithCopyWarning:
   A value is trying to be set on a copy of a slice from a DataFrame.
   Try using .loc[row_index,col_indexer] = value instead
```

Here is the correct method of assignment.

```
In [8]: dfc.loc[0,'A'] = 11

In [9]: dfc
Out[9]:
     A  B
0   11  1
1  bbb  2
2  ccc  3

[3 rows x 2 columns]
```

- **`Panel.reindex` has the following call signature `Panel.reindex(items=None, major_axis=None, minor_a`**
  to conform with other `NDFrame` objects. See *Internal Refactoring* for more information.
- **`Series.argmin` and `Series.argmax` are now aliased to `Series.idxmin` and `Series.idxmax`. These return the *i***
  min or max element respectively. Prior to 0.13.0 these would return the position of the min / max element. (GH6214)

1.21.2 Prior Version Deprecations/Changes

These were announced changes in 0.12 or prior that are taking effect as of 0.13.0

- Remove deprecated `Factor` (GH3650)
- Remove deprecated `set_printoptions/reset_printoptions` (GH3046)
- Remove deprecated `_verbose_info` (GH3215)
- Remove deprecated `read_clipboard/to_clipboard/ExcelFile/ExcelWriter` from `pandas.io.parsers` (GH3717) These are available as functions in the main pandas namespace (e.g. `pd.read_clipboard`)
- default for `tupleize_cols` is now `False` for both `to_csv` and `read_csv`. Fair warning in 0.12 (GH3604)
- default for *display.max_seq_len* is now 100 rather then *None*. This activates truncated display ("...") of long sequences in various places. (GH3391)

1.21.3 Deprecations

Deprecated in 0.13.0

- deprecated `iterkv`, which will be removed in a future release (this was an alias of iteritems used to bypass `2to3`'s changes). (GH4384, GH4375, GH4372)
- deprecated the string method `match`, whose role is now performed more idiomatically by `extract`. In a future release, the default behavior of `match` will change to become analogous to `contains`, which returns a boolean indexer. (Their distinction is strictness: `match` relies on `re.match` while `contains` relies on `re.search`.) In this release, the deprecated behavior is the default, but the new behavior is available through the keyword argument `as_indexer=True`.

1.21.4 Indexing API Changes

Prior to 0.13, it was impossible to use a label indexer (`.loc/.ix`) to set a value that was not contained in the index of a particular axis. (GH2578). See *the docs*

In the `Series` case this is effectively an appending operation

```
In [10]: s = Series([1,2,3])

In [11]: s
Out[11]:
0    1
1    2
2    3
Length: 3, dtype: int64

In [12]: s[5] = 5.

In [13]: s
Out[13]:
0    1.0
1    2.0
2    3.0
5    5.0
Length: 4, dtype: float64
```

```
In [14]: dfi = DataFrame(np.arange(6).reshape(3,2),
   ....:                 columns=['A','B'])
   ....:

In [15]: dfi
Out[15]:
   A  B
0  0  1
1  2  3
2  4  5

[3 rows x 2 columns]
```

This would previously `KeyError`

```
In [16]: dfi.loc[:,'C'] = dfi.loc[:,'A']

In [17]: dfi
Out[17]:
   A  B  C
0  0  1  0
1  2  3  2
2  4  5  4

[3 rows x 3 columns]
```

This is like an `append` operation.

```
In [18]: dfi.loc[3] = 5

In [19]: dfi
Out[19]:
   A  B  C
0  0  1  0
1  2  3  2
2  4  5  4
3  5  5  5

[4 rows x 3 columns]
```

A Panel setting operation on an arbitrary axis aligns the input to the Panel

```
In [20]: p = pd.Panel(np.arange(16).reshape(2,4,2),
   ....:             items=['Item1','Item2'],
   ....:             major_axis=pd.date_range('2001/1/12',periods=4),
   ....:             minor_axis=['A','B'],dtype='float64')
   ....:

In [21]: p
Out[21]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 4 (major_axis) x 2 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2001-01-12 00:00:00 to 2001-01-15 00:00:00
Minor_axis axis: A to B

In [22]: p.loc[:,:,'C'] = Series([30,32],index=p.items)
```

```
In [23]: p
Out[23]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 4 (major_axis) x 3 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2001-01-12 00:00:00 to 2001-01-15 00:00:00
Minor_axis axis: A to C

In [24]: p.loc[:,:,'C']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
            Item1  Item2
2001-01-12   30.0   32.0
2001-01-13   30.0   32.0
2001-01-14   30.0   32.0
2001-01-15   30.0   32.0

[4 rows x 2 columns]
```

1.21.5 Float64Index API Change

- Added a new index type, `Float64Index`. This will be automatically created when passing floating values in index creation. This enables a pure label-based slicing paradigm that makes `[],ix,loc` for scalar indexing and slicing work exactly the same. See *the docs*, (GH263)

  Construction is by default for floating type values.

```
In [25]: index = Index([1.5, 2, 3, 4.5, 5])

In [26]: index
Out[26]: Float64Index([1.5, 2.0, 3.0, 4.5, 5.0], dtype='float64')

In [27]: s = Series(range(5),index=index)

In [28]: s
Out[28]:
1.5    0
2.0    1
3.0    2
4.5    3
5.0    4
Length: 5, dtype: int64
```

  Scalar selection for `[],.ix,.loc` will always be label based. An integer will match an equal float index (e.g. `3` is equivalent to `3.0`)

```
In [29]: s[3]
Out[29]: 2

In [30]: s.loc[3]
\\\\\\\\\\\Out[30]: 2
```

  The only positional indexing is via `iloc`

```
In [31]: s.iloc[3]
Out[31]: 3
```

A scalar index that is not found will raise `KeyError`

Slicing is ALWAYS on the values of the index, for `[],ix,loc` and ALWAYS positional with `iloc`

```
In [32]: s[2:4]
Out[32]:
2.0    1
3.0    2
Length: 2, dtype: int64

In [33]: s.loc[2:4]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[33]:
2.0    1
3.0    2
Length: 2, dtype: int64

In [34]: s.iloc[2:4]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
3.0    2
4.5    3
Length: 2, dtype: int64
```

In float indexes, slicing using floats are allowed

```
In [35]: s[2.1:4.6]
Out[35]:
3.0    2
4.5    3
Length: 2, dtype: int64

In [36]: s.loc[2.1:4.6]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[36]:
3.0    2
4.5    3
Length: 2, dtype: int64
```

- Indexing on other index types are preserved (and positional fallback for `[],ix`), with the exception, that floating point slicing on indexes on non `Float64Index` will now raise a `TypeError`.

```
In [1]: Series(range(5))[3.5]
TypeError: the label [3.5] is not a proper indexer for this index type␣
↪(Int64Index)

In [1]: Series(range(5))[3.5:4.5]
TypeError: the slice start [3.5] is not a proper indexer for this index type␣
↪(Int64Index)
```

Using a scalar float indexer will be deprecated in a future version, but is allowed for now.

```
In [3]: Series(range(5))[3.0]
Out[3]: 3
```

1.21.6 HDFStore API Changes

- Query Format Changes. A much more string-like query format is now supported. See *the docs*.

```
In [37]: path = 'test.h5'

In [38]: dfq = DataFrame(randn(10,4),
   ....:          columns=list('ABCD'),
   ....:          index=date_range('20130101',periods=10))
   ....:

In [39]: dfq.to_hdf(path,'dfq',format='table',data_columns=True)
```

Use boolean expressions, with in-line function evaluation.

```
In [40]: read_hdf(path,'dfq',
   ....:     where="index>Timestamp('20130104') & columns=['A', 'B']")
   ....:
Out[40]:
                   A         B
2013-01-05  1.057633 -0.791489
2013-01-06  1.910759  0.787965
2013-01-07  1.043945  2.107785
2013-01-08  0.749185 -0.675521
2013-01-09 -0.276646  1.924533
2013-01-10  0.226363 -2.078618

[6 rows x 2 columns]
```

Use an inline column reference

```
In [41]: read_hdf(path,'dfq',
   ....:     where="A>0 or C>0")
   ....:
Out[41]:
                   A         B         C         D
2013-01-01 -0.414505 -1.425795  0.209395 -0.592886
2013-01-02 -1.473116 -0.896581  1.104352 -0.431550
2013-01-03 -0.161137  0.889157  0.288377 -1.051539
2013-01-04 -0.319561 -0.619993  0.156998 -0.571455
2013-01-05  1.057633 -0.791489 -0.524627  0.071878
2013-01-06  1.910759  0.787965  0.513082 -0.546416
2013-01-07  1.043945  2.107785  1.459927  1.015405
2013-01-08  0.749185 -0.675521  0.440266  0.688972
2013-01-09 -0.276646  1.924533  0.411204  0.890765
2013-01-10  0.226363 -2.078618 -0.387886 -0.087107

[10 rows x 4 columns]
```

- the `format` keyword now replaces the `table` keyword; allowed values are `fixed(f)` or `table(t)` the same defaults as prior < 0.13.0 remain, e.g. `put` implies `fixed` format and `append` implies `table` format. This default format can be set as an option by setting `io.hdf.default_format`.

```
In [42]: path = 'test.h5'

In [43]: df = pd.DataFrame(np.random.randn(10,2))

In [44]: df.to_hdf(path,'df_table',format='table')

In [45]: df.to_hdf(path,'df_table2',append=True)

In [46]: df.to_hdf(path,'df_fixed')
```

```
In [47]: with pd.HDFStore(path) as store:
   ....:     print(store)
   ....:
<class 'pandas.io.pytables.HDFStore'>
File path: test.h5
```

- Significant table writing performance improvements
- handle a passed `Series` in table format (GH4330)
- can now serialize a `timedelta64[ns]` dtype in a table (GH3577), See *the docs*.
- added an `is_open` property to indicate if the underlying file handle is_open; a closed store will now report 'CLOSED' when viewing the store (rather than raising an error) (GH4409)
- a close of a `HDFStore` now will close that instance of the `HDFStore` but will only close the actual file if the ref count (by `PyTables`) w.r.t. all of the open handles are 0. Essentially you have a local instance of `HDFStore` referenced by a variable. Once you close it, it will report closed. Other references (to the same file) will continue to operate until they themselves are closed. Performing an action on a closed file will raise `ClosedFileError`

```
In [48]: path = 'test.h5'

In [49]: df = DataFrame(randn(10,2))

In [50]: store1 = HDFStore(path)

In [51]: store2 = HDFStore(path)

In [52]: store1.append('df',df)

In [53]: store2.append('df2',df)

In [54]: store1
Out[54]:
<class 'pandas.io.pytables.HDFStore'>
File path: test.h5

In [55]: store2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[55]:
<class 'pandas.io.pytables.HDFStore'>
File path: test.h5

In [56]: store1.close()

In [57]: store2
Out[57]:
<class 'pandas.io.pytables.HDFStore'>
File path: test.h5

In [58]: store2.close()

In [59]: store2
Out[59]:
<class 'pandas.io.pytables.HDFStore'>
File path: test.h5
```

- removed the `_quiet` attribute, replace by a `DuplicateWarning` if retrieving duplicate rows from a table

(GH4367)

- removed the `warn` argument from `open`. Instead a `PossibleDataLossError` exception will be raised if you try to use `mode='w'` with an OPEN file handle (GH4367)
- allow a passed locations array or mask as a `where` condition (GH4467). See *the docs* for an example.
- add the keyword `dropna=True` to `append` to change whether ALL nan rows are not written to the store (default is `True`, ALL nan rows are NOT written), also settable via the option `io.hdf.dropna_table` (GH4625)
- pass thru store creation arguments; can be used to support in-memory stores

1.21.7 DataFrame repr Changes

The HTML and plain text representations of `DataFrame` now show a truncated view of the table once it exceeds a certain size, rather than switching to the short info view (GH4886, GH5550). This makes the representation more consistent as small DataFrames get larger.

2010-03-29	13.70	13.88	13.39	13.57	158225000	12.98
2010-03-30	13.55	13.64	13.18	13.28	142055200	12.70
	...	...	...	...	...	...

771 rows × 6 columns

To get the info view, call `DataFrame.info()`. If you prefer the info view as the repr for large DataFrames, you can set this by running `set_option('display.large_repr', 'info')`.

1.21.8 Enhancements

- `df.to_clipboard()` learned a new `excel` keyword that let's you paste df data directly into excel (enabled by default). (GH5070).
- `read_html` now raises a `URLError` instead of catching and raising a `ValueError` (GH4303, GH4305)
- Added a test for `read_clipboard()` and `to_clipboard()` (GH4282)
- Clipboard functionality now works with PySide (GH4282)
- Added a more informative error message when plot arguments contain overlapping color and style arguments (GH4402)
- `to_dict` now takes `records` as a possible outtype. Returns an array of column-keyed dictionaries. (GH4936)
- `NaN` handing in get_dummies (GH4446) with *dummy_na*

```
# previously, nan was erroneously counted as 2 here
# now it is not counted at all
In [60]: get_dummies([1, 2, np.nan])
Out[60]:
   1.0  2.0
0    1    0
1    0    1
```

```
2    0    0

[3 rows x 2 columns]

# unless requested
In [61]: get_dummies([1, 2, np.nan], dummy_na=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[61]:␣
↪
    1.0  2.0  NaN
0     1     0     0
1     0     1     0
2     0     0     1

[3 rows x 3 columns]
```

- `timedelta64[ns]` operations. See *the docs*.

> **Warning:** Most of these operations require `numpy >= 1.7`

Using the new top-level `to_timedelta`, you can convert a scalar or array from the standard timedelta format (produced by `to_csv`) into a timedelta type (`np.timedelta64` in `nanoseconds`).

```
In [62]: to_timedelta('1 days 06:05:01.00003')
Out[62]: Timedelta('1 days 06:05:01.000030')

In [63]: to_timedelta('15.5us')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[63]: Timedelta('0 days 00:00:00.
↪000015')

In [64]: to_timedelta(['1 days 06:05:01.00003','15.5us','nan'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[64
↪TimedeltaIndex(['1 days 06:05:01.000030', '0 days 00:00:00.000015', NaT], dtype=
↪'timedelta64[ns]', freq=None)

In [65]: to_timedelta(np.arange(5),unit='s')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪TimedeltaIndex(['00:00:00', '00:00:01', '00:00:02', '00:00:03', '00:00:04'],␣
↪dtype='timedelta64[ns]', freq=None)

In [66]: to_timedelta(np.arange(5),unit='d')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪TimedeltaIndex(['0 days', '1 days', '2 days', '3 days', '4 days'], dtype=
↪'timedelta64[ns]', freq=None)
```

A Series of dtype `timedelta64[ns]` can now be divided by another `timedelta64[ns]` object, or astyped to yield a `float64` dtyped Series. This is frequency conversion. See *the docs* for the docs.

```
In [67]: from datetime import timedelta

In [68]: td = Series(date_range('20130101',periods=4))-Series(date_range('20121201
↪',periods=4))

In [69]: td[2] += np.timedelta64(timedelta(minutes=5,seconds=3))

In [70]: td[3] = np.nan
```

```
In [71]: td
Out[71]:
0   31 days 00:00:00
1   31 days 00:00:00
2   31 days 00:05:03
3                NaT
Length: 4, dtype: timedelta64[ns]

# to days
In [72]: td / np.timedelta64(1,'D')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    31.000000
1    31.000000
2    31.003507
3          NaN
Length: 4, dtype: float64

In [73]: td.astype('timedelta64[D]')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    31.0
1    31.0
2    31.0
3     NaN
Length: 4, dtype: float64

# to seconds
In [74]: td / np.timedelta64(1,'s')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    2678400.0
1    2678400.0
2    2678703.0
3          NaN
Length: 4, dtype: float64

In [75]: td.astype('timedelta64[s]')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    2678400.0
1    2678400.0
2    2678703.0
3          NaN
Length: 4, dtype: float64
```

Dividing or multiplying a `timedelta64[ns]` Series by an integer or integer Series

```
In [76]: td * -1
Out[76]:
0   -31 days +00:00:00
1   -31 days +00:00:00
2   -32 days +23:54:57
3                  NaT
Length: 4, dtype: timedelta64[ns]

In [77]: td * Series([1,2,3,4])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
0   31 days 00:00:00
1   62 days 00:00:00
2   93 days 00:15:09
3                NaT
Length: 4, dtype: timedelta64[ns]
```

Absolute `DateOffset` objects can act equivalently to `timedeltas`

```
In [78]: from pandas import offsets

In [79]: td + offsets.Minute(5) + offsets.Milli(5)
Out[79]:
0   31 days 00:05:00.005000
1   31 days 00:05:00.005000
2   31 days 00:10:03.005000
3                       NaT
Length: 4, dtype: timedelta64[ns]
```

Fillna is now supported for timedeltas

```
In [80]: td.fillna(0)
Out[80]:
0   31 days 00:00:00
1   31 days 00:00:00
2   31 days 00:05:03
3    0 days 00:00:00
Length: 4, dtype: timedelta64[ns]

In [81]: td.fillna(timedelta(days=1,seconds=5))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   31 days 00:00:00
1   31 days 00:00:00
2   31 days 00:05:03
3    1 days 00:00:05
Length: 4, dtype: timedelta64[ns]
```

You can do numeric reduction operations on timedeltas.

```
In [82]: td.mean()
Out[82]: Timedelta('31 days 00:01:41')

In [83]: td.quantile(.1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[83]: Timedelta('31 days 00:00:00')
```

- `plot(kind='kde')` now accepts the optional parameters `bw_method` and `ind`, passed to scipy.stats.gaussian_kde() (for scipy >= 0.11.0) to set the bandwidth, and to gkde.evaluate() to specify the indices at which it is evaluated, respectively. See scipy docs. (GH4298)
- DataFrame constructor now accepts a numpy masked record array (GH3478)
- The new vectorized string method `extract` return regular expression matches more conveniently.

```
In [84]: Series(['a1', 'b2', 'c3']).str.extract('[ab](\d)')
Out[84]:
0       1
1       2
```

```
2    NaN
Length: 3, dtype: object
```

Elements that do not match return `NaN`. Extracting a regular expression with more than one group returns a DataFrame with one column per group.

```
In [85]: Series(['a1', 'b2', 'c3']).str.extract('([ab])(\d)')
Out[85]:
     0    1
0    a    1
1    b    2
2  NaN  NaN

[3 rows x 2 columns]
```

Elements that do not match return a row of `NaN`. Thus, a Series of messy strings can be *converted* into a like-indexed Series or DataFrame of cleaned-up or more useful strings, without necessitating `get()` to access tuples or `re.match` objects.

Named groups like

```
In [86]: Series(['a1', 'b2', 'c3']).str.extract(
   ....:         '(?P<letter>[ab])(?P<digit>\d)')
   ....:
Out[86]:
  letter digit
0      a     1
1      b     2
2    NaN   NaN

[3 rows x 2 columns]
```

and optional groups can also be used.

```
In [87]: Series(['a1', 'b2', '3']).str.extract(
   ....:          '(?P<letter>[ab])?(?P<digit>\d)')
   ....:
Out[87]:
  letter digit
0      a     1
1      b     2
2    NaN     3

[3 rows x 2 columns]
```

- `read_stata` now accepts Stata 13 format (GH4291)
- `read_fwf` now infers the column specifications from the first 100 rows of the file if the data has correctly separated and properly aligned columns using the delimiter provided to the function (GH4488).
- support for nanosecond times as an offset

> **Warning:** These operations require `numpy >= 1.7`

Period conversions in the range of seconds and below were reworked and extended up to nanoseconds. Periods in the nanosecond range are now available.

```
In [88]: date_range('2013-01-01', periods=5, freq='5N')
Out[88]:
DatetimeIndex(['2013-01-01', '2013-01-01', '2013-01-01', '2013-01-01',
               '2013-01-01'],
              dtype='datetime64[ns]', freq='5N')
```

or with frequency as offset

```
In [89]: date_range('2013-01-01', periods=5, freq=pd.offsets.Nano(5))
Out[89]:
DatetimeIndex(['2013-01-01', '2013-01-01', '2013-01-01', '2013-01-01',
               '2013-01-01'],
              dtype='datetime64[ns]', freq='5N')
```

Timestamps can be modified in the nanosecond range

```
In [90]: t = Timestamp('20130101 09:01:02')

In [91]: t + pd.tseries.offsets.Nano(123)
Out[91]: Timestamp('2013-01-01 09:01:02.000000123')
```

- A new method, `isin` for DataFrames, which plays nicely with boolean indexing. The argument to `isin`, what we're comparing the DataFrame to, can be a DataFrame, Series, dict, or array of values. See *the docs* for more.

  To get the rows where any of the conditions are met:

```
In [92]: dfi = DataFrame({'A': [1, 2, 3, 4], 'B': ['a', 'b', 'f', 'n']})

In [93]: dfi
Out[93]:
   A  B
0  1  a
1  2  b
2  3  f
3  4  n

[4 rows x 2 columns]

In [94]: other = DataFrame({'A': [1, 3, 3, 7], 'B': ['e', 'f', 'f', 'e']})

In [95]: mask = dfi.isin(other)

In [96]: mask
Out[96]:
       A      B
0   True  False
1  False  False
2   True   True
3  False  False

[4 rows x 2 columns]

In [97]: dfi[mask.any(1)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   A  B
0  1  a
2  3  f
```

```
[2 rows x 2 columns]
```

- `Series` now supports a `to_frame` method to convert it to a single-column DataFrame (GH5164)
- All R datasets listed here http://stat.ethz.ch/R-manual/R-devel/library/datasets/html/00Index.html can now be loaded into Pandas objects

```
# note that pandas.rpy was deprecated in v0.16.0
import pandas.rpy.common as com
com.load_data('Titanic')
```

- `tz_localize` can infer a fall daylight savings transition based on the structure of the unlocalized data (GH4230), see *the docs*
- `DatetimeIndex` is now in the API documentation, see *the docs*
- *`json_normalize()`* is a new method to allow you to create a flat table from semi-structured JSON data. See *the docs* (GH1067)
- Added PySide support for the qtpandas DataFrameModel and DataFrameWidget.
- Python csv parser now supports usecols (GH4335)
- Frequencies gained several new offsets:
  - `LastWeekOfMonth` (GH4637)
  - `FY5253`, and `FY5253Quarter` (GH4511)
- DataFrame has a new `interpolate` method, similar to Series (GH4434, GH1892)

```
In [98]: df = DataFrame({'A': [1, 2.1, np.nan, 4.7, 5.6, 6.8],
   ....:                 'B': [.25, np.nan, np.nan, 4, 12.2, 14.4]})
   ....:

In [99]: df.interpolate()
Out[99]:
     A      B
0  1.0   0.25
1  2.1   1.50
2  3.4   2.75
3  4.7   4.00
4  5.6  12.20
5  6.8  14.40

[6 rows x 2 columns]
```

Additionally, the `method` argument to `interpolate` has been expanded to include `'nearest'`, `'zero'`, `'slinear'`, `'quadratic'`, `'cubic'`, `'barycentric'`, `'krogh'`, `'piecewise_polynomial'`, `'pchip'`, `` `polynomial` ``, `'spline'` The new methods require scipy. Consult the Scipy reference guide and documentation for more information about when the various methods are appropriate. See *the docs*.

Interpolate now also accepts a `limit` keyword argument. This works similar to `fillna`'s limit:

```
In [100]: ser = Series([1, 3, np.nan, np.nan, np.nan, 11])

In [101]: ser.interpolate(limit=2)
Out[101]:
0     1.0
```

```
1      3.0
2      5.0
3      7.0
4      NaN
5     11.0
Length: 6, dtype: float64
```

- Added `wide_to_long` panel data convenience function. See *the docs*.

```
In [102]: np.random.seed(123)

In [103]: df = pd.DataFrame({"A1970" : {0 : "a", 1 : "b", 2 : "c"},
   .....:                    "A1980" : {0 : "d", 1 : "e", 2 : "f"},
   .....:                    "B1970" : {0 : 2.5, 1 : 1.2, 2 : .7},
   .....:                    "B1980" : {0 : 3.2, 1 : 1.3, 2 : .1},
   .....:                    "X"     : dict(zip(range(3), np.random.randn(3)))
   .....:                   })
   .....:

In [104]: df["id"] = df.index

In [105]: df
Out[105]:
  A1970 A1980  B1970  B1980         X  id
0     a     d    2.5    3.2 -1.085631   0
1     b     e    1.2    1.3  0.997345   1
2     c     f    0.7    0.1  0.282978   2

[3 rows x 6 columns]

In [106]: wide_to_long(df, ["A", "B"], i="id", j="year")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                X  A    B
id year
0  1970 -1.085631  a  2.5
1  1970  0.997345  b  1.2
2  1970  0.282978  c  0.7
0  1980 -1.085631  d  3.2
1  1980  0.997345  e  1.3
2  1980  0.282978  f  0.1

[6 rows x 3 columns]
```

- `to_csv` now takes a `date_format` keyword argument that specifies how output datetime objects should be formatted. Datetimes encountered in the index, columns, and values will all have this formatting applied. (GH4313)
- `DataFrame.plot` will scatter plot x versus y by passing `kind='scatter'` (GH2215)
- Added support for Google Analytics v3 API segment IDs that also supports v2 IDs. (GH5271)

1.21.9 Experimental

- The new *`eval()`* function implements expression evaluation using `numexpr` behind the scenes. This results in large speedups for complicated expressions involving large DataFrames/Series. For example,

```
In [107]: nrows, ncols = 20000, 100

In [108]: df1, df2, df3, df4 = [DataFrame(randn(nrows, ncols))
   .....:                       for _ in range(4)]
   .....:
```

```
# eval with NumExpr backend
In [109]: %timeit pd.eval('df1 + df2 + df3 + df4')
8.36 ms +- 271 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

```
# pure Python evaluation
In [110]: %timeit df1 + df2 + df3 + df4
12 ms +- 507 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

For more details, see the *the docs*

- Similar to `pandas.eval`, *`DataFrame`* has a new `DataFrame.eval` method that evaluates an expression in the context of the `DataFrame`. For example,

```
In [111]: df = DataFrame(randn(10, 2), columns=['a', 'b'])

In [112]: df.eval('a + b')
Out[112]:
0   -0.685204
1    1.589745
2    0.325441
3   -1.784153
4   -0.432893
5    0.171850
6    1.895919
7    3.065587
8   -0.092759
9    1.391365
Length: 10, dtype: float64
```

- *`query()`* method has been added that allows you to select elements of a `DataFrame` using a natural query syntax nearly identical to Python syntax. For example,

```
In [113]: n = 20

In [114]: df = DataFrame(np.random.randint(n, size=(n, 3)), columns=['a', 'b', 'c
↪'])

In [115]: df.query('a < b < c')
Out[115]:
    a   b   c
11  1   5   8
15  8  16  19

[2 rows x 3 columns]
```

selects all the rows of `df` where `a < b < c` evaluates to `True`. For more details see the *the docs*.

- `pd.read_msgpack()` and `pd.to_msgpack()` are now a supported method of serialization of arbitrary pandas (and python objects) in a lightweight portable binary format. See *the docs*

Warning: Since this is an EXPERIMENTAL LIBRARY, the storage format may not be stable until a future release.

```
In [116]: df = DataFrame(np.random.rand(5,2),columns=list('AB'))

In [117]: df.to_msgpack('foo.msg')

In [118]: pd.read_msgpack('foo.msg')
Out[118]:
          A         B
0  0.251082  0.017357
1  0.347915  0.929879
2  0.546233  0.203368
3  0.064942  0.031722
4  0.355309  0.524575

[5 rows x 2 columns]

In [119]: s = Series(np.random.rand(5),index=date_range('20130101',periods=5))

In [120]: pd.to_msgpack('foo.msg', df, s)

In [121]: pd.read_msgpack('foo.msg')
Out[121]:
[          A         B
 0  0.251082  0.017357
 1  0.347915  0.929879
 2  0.546233  0.203368
 3  0.064942  0.031722
 4  0.355309  0.524575

 [5 rows x 2 columns], 2013-01-01    0.022321
 2013-01-02    0.227025
 2013-01-03    0.383282
 2013-01-04    0.193225
 2013-01-05    0.110977
 Freq: D, Length: 5, dtype: float64]
```

You can pass `iterator=True` to iterator over the unpacked results

```
In [122]: for o in pd.read_msgpack('foo.msg',iterator=True):
   .....:    print(o)
   .....:
          A         B
0  0.251082  0.017357
1  0.347915  0.929879
2  0.546233  0.203368
3  0.064942  0.031722
4  0.355309  0.524575

[5 rows x 2 columns]
2013-01-01    0.022321
2013-01-02    0.227025
2013-01-03    0.383282
2013-01-04    0.193225
2013-01-05    0.110977
Freq: D, Length: 5, dtype: float64
```

- `pandas.io.gbq` provides a simple way to extract from, and load data into, Google's BigQuery Data Sets by way of pandas DataFrames. BigQuery is a high performance SQL-like database service, useful for performing ad-hoc queries against extremely large datasets. *See the docs*

```
from pandas.io import gbq

# A query to select the average monthly temperatures in the
# in the year 2000 across the USA. The dataset,
# publicata:samples.gsod, is available on all BigQuery accounts,
# and is based on NOAA gsod data.

query = """SELECT station_number as STATION,
month as MONTH, AVG(mean_temp) as MEAN_TEMP
FROM publicdata:samples.gsod
WHERE YEAR = 2000
GROUP BY STATION, MONTH
ORDER BY STATION, MONTH ASC"""

# Fetch the result set for this query

# Your Google BigQuery Project ID
# To find this, see your dashboard:
# https://console.developers.google.com/iam-admin/projects?authuser=0
projectid = xxxxxxxxx;

df = gbq.read_gbq(query, project_id = projectid)

# Use pandas to process and reshape the dataset

df2 = df.pivot(index='STATION', columns='MONTH', values='MEAN_TEMP')
df3 = pandas.concat([df2.min(), df2.mean(), df2.max()],
                    axis=1,keys=["Min Tem", "Mean Temp", "Max Temp"])
```

The resulting DataFrame is:

```
> df3
            Min Tem  Mean Temp    Max Temp
 MONTH
 1     -53.336667  39.827892   89.770968
 2     -49.837500  43.685219   93.437932
 3     -77.926087  48.708355   96.099998
 4     -82.892858  55.070087   97.317240
 5     -92.378261  61.428117  102.042856
 6     -77.703334  65.858888  102.900000
 7     -87.821428  68.169663  106.510714
 8     -89.431999  68.614215  105.500000
 9     -86.611112  63.436935  107.142856
 10    -78.209677  56.880838   92.103333
 11    -50.125000  48.861228   94.996428
 12    -50.332258  42.286879   94.396774
```

> **Warning:** To use this module, you will need a BigQuery account. See <https://cloud.google.com/products/big-query> for details.
>
> As of 10/10/13, there is a bug in Google's API preventing result sets from being larger than 100,000 rows.

A patch is scheduled for the week of 10/14/13.

1.21.10 Internal Refactoring

In 0.13.0 there is a major refactor primarily to subclass `Series` from `NDFrame`, which is the base class currently for `DataFrame` and `Panel`, to unify methods and behaviors. Series formerly subclassed directly from `ndarray`. (GH4080, GH3862, GH816)

Warning: There are two potential incompatibilities from < 0.13.0

- Using certain numpy functions would previously return a `Series` if passed a `Series` as an argument. This seems only to affect `np.ones_like`, `np.empty_like`, `np.diff` and `np.where`. These now return `ndarrays`.

  ```
  In [123]: s = Series([1,2,3,4])
  ```

  Numpy Usage

  ```
  In [124]: np.ones_like(s)
  Out[124]: array([1, 1, 1, 1])

  In [125]: np.diff(s)
  \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[125]: array([1, 1, 1])

  In [126]: np.where(s>1,s,np.nan)
  \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[126]: array([nan,␣
  ↪ 2.,  3.,  4.])
  ```

  Pandonic Usage

  ```
  In [127]: Series(1,index=s.index)
  Out[127]:
  0    1
  1    1
  2    1
  3    1
  Length: 4, dtype: int64

  In [128]: s.diff()
  \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[128]:
  0    NaN
  1    1.0
  2    1.0
  3    1.0
  Length: 4, dtype: float64

  In [129]: s.where(s>1)
  \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
  ↪
  0    NaN
  1    2.0
  2    3.0
  3    4.0
  Length: 4, dtype: float64
  ```

- Passing a `Series` directly to a cython function expecting an `ndarray` type will no long work directly, you must pass `Series.values`, See *Enhancing Performance*
- `Series(0.5)` would previously return the scalar `0.5`, instead this will return a 1-element `Series`
- This change breaks `rpy2<=2.3.8`. an Issue has been opened against rpy2 and a workaround is detailed in GH5698. Thanks @JanSchulz.

- Pickle compatibility is preserved for pickles created prior to 0.13. These must be unpickled with `pd.read_pickle`, see *Pickling*.
- Refactor of series.py/frame.py/panel.py to move common code to generic.py
  - added `_setup_axes` to created generic NDFrame structures
  - moved methods
    * `from_axes,_wrap_array,axes,ix,loc,iloc,shape,empty,swapaxes,transpose,pop`
    * `__iter__,keys,__contains__,__len__,__neg__,__invert__`
    * `convert_objects,as_blocks,as_matrix,values`
    * `__getstate__,__setstate__` (compat remains in frame/panel)
    * `__getattr__,__setattr__`
    * `_indexed_same,reindex_like,align,where,mask`
    * `fillna,replace` (`Series` replace is now consistent with `DataFrame`)
    * `filter` (also added axis argument to selectively filter on a different axis)
    * `reindex,reindex_axis,take`
    * `truncate` (moved to become part of `NDFrame`)
- These are API changes which make `Panel` more consistent with `DataFrame`
  - `swapaxes` on a `Panel` with the same axes specified now return a copy
  - support attribute access for setting
  - filter supports the same API as the original `DataFrame` filter
- Reindex called with no arguments will now return a copy of the input object
- `TimeSeries` is now an alias for `Series`. the property `is_time_series` can be used to distinguish (if desired)
- Refactor of Sparse objects to use BlockManager
  - Created a new block type in internals, `SparseBlock`, which can hold multi-dtypes and is non-consolidatable. `SparseSeries` and `SparseDataFrame` now inherit more methods from there hierarchy (Series/DataFrame), and no longer inherit from `SparseArray` (which instead is the object of the `SparseBlock`)
  - Sparse suite now supports integration with non-sparse data. Non-float sparse data is supportable (partially implemented)
  - Operations on sparse structures within DataFrames should preserve sparseness, merging type operations will convert to dense (and back to sparse), so might be somewhat inefficient
  - enable setitem on `SparseSeries` for boolean/integer/slices
  - `SparsePanels` implementation is unchanged (e.g. not using BlockManager, needs work)

- added `ftypes` method to Series/DataFrame, similar to `dtypes`, but indicates if the underlying is sparse/dense (as well as the dtype)
- All `NDFrame` objects can now use `__finalize__()` to specify various values to propagate to new objects from an existing one (e.g. `name` in `Series` will follow more automatically now)
- Internal type checking is now done via a suite of generated classes, allowing `isinstance(value, klass)` without having to directly import the klass, courtesy of @jtratner
- Bug in Series update where the parent frame is not updating its cache based on changes (GH4080) or types (GH3217), fillna (GH3386)
- Indexing with dtype conversions fixed (GH4463, GH4204)
- Refactor `Series.reindex` to core/generic.py (GH4604, GH4618), allow `method=` in reindexing on a Series to work
- `Series.copy` no longer accepts the `order` parameter and is now consistent with `NDFrame` copy
- Refactor `rename` methods to core/generic.py; fixes `Series.rename` for (GH4605), and adds `rename` with the same signature for `Panel`
- Refactor `clip` methods to core/generic.py (GH4798)
- Refactor of `_get_numeric_data/_get_bool_data` to core/generic.py, allowing Series/Panel functionality
- `Series` (for index) / `Panel` (for items) now allow attribute access to its elements (GH1903)

```
In [130]: s = Series([1,2,3],index=list('abc'))

In [131]: s.b
Out[131]: 2

In [132]: s.a = 5

In [133]: s
Out[133]:
a    5
b    2
c    3
Length: 3, dtype: int64
```

1.21.11 Bug Fixes

See *V0.13.0 Bug Fixes* for an extensive list of bugs that have been fixed in 0.13.0.

See the *full release notes* or issue tracker on GitHub for a complete list of all API changes, Enhancements and Bug Fixes.

1.22 v0.12.0 (July 24, 2013)

This is a major release from 0.11.0 and includes several new features and enhancements along with a large number of bug fixes.

Highlights include a consistent I/O API naming scheme, routines to read html, write multi-indexes to csv files, read & write STATA data files, read & write JSON format files, Python 3 support for `HDFStore`, filtering of groupby expressions via `filter`, and a revamped `replace` routine that accepts regular expressions.

1.22.1 API changes

- The I/O API is now much more consistent with a set of top level `reader` functions accessed like `pd.read_csv()` that generally return a `pandas` object.
  - `read_csv`
  - `read_excel`
  - `read_hdf`
  - `read_sql`
  - `read_json`
  - `read_html`
  - `read_stata`
  - `read_clipboard`

  The corresponding `writer` functions are object methods that are accessed like `df.to_csv()`
  - `to_csv`
  - `to_excel`
  - `to_hdf`
  - `to_sql`
  - `to_json`
  - `to_html`
  - `to_stata`
  - `to_clipboard`
- Fix modulo and integer division on Series,DataFrames to act similary to `float` dtypes to return `np.nan` or `np.inf` as appropriate (GH3590). This correct a numpy bug that treats `integer` and `float` dtypes differently.

```
In [1]: p = DataFrame({ 'first' : [4,5,8], 'second' : [0,0,3] })

In [2]: p % 0
Out[2]:
   first  second
0    NaN     NaN
1    NaN     NaN
2    NaN     NaN

[3 rows x 2 columns]

In [3]: p % p
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   first  second
0    0.0     NaN
1    0.0     NaN
2    0.0     0.0

[3 rows x 2 columns]

In [4]: p / p
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   first  second
0    1.0     NaN
1    1.0     NaN
2    1.0     1.0

[3 rows x 2 columns]

In [5]: p / 0
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   first  second
0    inf     NaN
1    inf     NaN
2    inf     inf

[3 rows x 2 columns]
```

- Add `squeeze` keyword to `groupby` to allow reduction from DataFrame -> Series if groups are unique. This is a Regression from 0.10.1. We are reverting back to the prior behavior. This means groupby will return the same shaped objects whether the groups are unique or not. Revert this issue (GH2893) with (GH3596).

```
In [6]: df2 = DataFrame([{"val1": 1, "val2" : 20}, {"val1":1, "val2": 19},
   ...:                  {"val1":1, "val2": 27}, {"val1":1, "val2": 12}])
   ...:

In [7]: def func(dataf):
   ...:     return dataf["val2"]  - dataf["val2"].mean()
   ...:

# squeezing the result frame to a series (because we have unique groups)
In [8]: df2.groupby("val1", squeeze=True).apply(func)
Out[8]:
0    0.5
1   -0.5
2    7.5
3   -7.5
Name: 1, Length: 4, dtype: float64

# no squeezing (the default, and behavior in 0.10.1)
In [9]: df2.groupby("val1").apply(func)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[9]:␣
↪
val2    0    1    2    3
val1
1     0.5 -0.5  7.5 -7.5

[1 rows x 4 columns]
```

- Raise on `iloc` when boolean indexing with a label based indexer mask e.g. a boolean Series, even with integer labels, will raise. Since `iloc` is purely positional based, the labels on the Series are not alignable (GH3631)

  This case is rarely used, and there are plently of alternatives. This preserves the `iloc` API to be *purely* positional based.

```
In [10]: df = DataFrame(lrange(5), list('ABCDE'), columns=['a'])
```

```
In [11]: mask = (df.a%2 == 0)

In [12]: mask
Out[12]:
A     True
B    False
C     True
D    False
E     True
Name: a, Length: 5, dtype: bool

# this is what you should use
In [13]: df.loc[mask]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a
A  0
C  2
E  4

[3 rows x 1 columns]

# this will work as well
In [14]: df.iloc[mask.values]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a
A  0
C  2
E  4

[3 rows x 1 columns]
```

`df.iloc[mask]` will raise a `ValueError`

- The `raise_on_error` argument to plotting functions is removed. Instead, plotting functions raise a `TypeError` when the `dtype` of the object is `object` to remind you to avoid `object` arrays whenever possible and thus you should cast to an appropriate numeric dtype if you need to plot something.
- Add `colormap` keyword to DataFrame plotting methods. Accepts either a matplotlib colormap object (ie, matplotlib.cm.jet) or a string name of such an object (ie, 'jet'). The colormap is sampled to select the color for each column. Please see *Colormaps* for more information. (GH3860)
- `DataFrame.interpolate()` is now deprecated. Please use `DataFrame.fillna()` and `DataFrame.replace()` instead. (GH3582, GH3675, GH3676)
- the `method` and `axis` arguments of `DataFrame.replace()` are deprecated
- `DataFrame.replace` 's `infer_types` parameter is removed and now performs conversion by default. (GH3907)
- Add the keyword `allow_duplicates` to `DataFrame.insert` to allow a duplicate column to be inserted if `True`, default is `False` (same as prior to 0.12) (GH3679)
- Implement `__nonzero__` for `NDFrame` objects (GH3691, GH3696)
- IO api
  - added top-level function `read_excel` to replace the following, The original API is deprecated and will be removed in a future version

```
from pandas.io.parsers import ExcelFile
xls = ExcelFile('path_to_file.xls')
xls.parse('Sheet1', index_col=None, na_values=['NA'])
```

With

```
import pandas as pd
pd.read_excel('path_to_file.xls', 'Sheet1', index_col=None, na_values=['NA'])
```

– added top-level function `read_sql` that is equivalent to the following

```
from pandas.io.sql import read_frame
read_frame(....)
```

- `DataFrame.to_html` and `DataFrame.to_latex` now accept a path for their first argument (GH3702)
- Do not allow astypes on `datetime64[ns]` except to `object`, and `timedelta64[ns]` to `object/int` (GH3425)
- The behavior of `datetime64` dtypes has changed with respect to certain so-called reduction operations (GH3726). The following operations now raise a `TypeError` when perfomed on a `Series` and return an *empty* `Series` when performed on a `DataFrame` similar to performing these operations on, for example, a `DataFrame` of `slice` objects:
  – sum, prod, mean, std, var, skew, kurt, corr, and cov
- `read_html` now defaults to `None` when reading, and falls back on `bs4` + `html5lib` when lxml fails to parse. a list of parsers to try until success is also valid
- The internal `pandas` class hierarchy has changed (slightly). The previous `PandasObject` now is called `PandasContainer` and a new `PandasObject` has become the baseclass for `PandasContainer` as well as `Index`, `Categorical`, `GroupBy`, `SparseList`, and `SparseArray` (+ their base classes). Currently, `PandasObject` provides string methods (from `StringMixin`). (GH4090, GH4092)
- New `StringMixin` that, given a `__unicode__` method, gets python 2 and python 3 compatible string methods (`__str__`, `__bytes__`, and `__repr__`). Plus string safety throughout. Now employed in many places throughout the pandas library. (GH4090, GH4092)

1.22.2 I/O Enhancements

- `pd.read_html()` can now parse HTML strings, files or urls and return DataFrames, courtesy of @cpcloud. (GH3477, GH3605, GH3606, GH3616). It works with a *single* parser backend: BeautifulSoup4 + html5lib *See the docs*

  You can use `pd.read_html()` to read the output from `DataFrame.to_html()` like so

```
In [15]: df = DataFrame({'a': range(3), 'b': list('abc')})

In [16]: print(df)
   a  b
0  0  a
1  1  b
2  2  c

[3 rows x 2 columns]

In [17]: html = df.to_html()
```

```
In [18]: alist = pd.read_html(html, index_col=0)

In [19]: print(df == alist[0])
      a     b
0  True  True
1  True  True
2  True  True

[3 rows x 2 columns]
```

Note that `alist` here is a Python `list` so `pd.read_html()` and `DataFrame.to_html()` are not inverses.

- `pd.read_html()` no longer performs hard conversion of date strings (GH3656).

> **Warning:** You may have to install an older version of BeautifulSoup4, *See the installation docs*

- Added module for reading and writing Stata files: `pandas.io.stata` (GH1512) accessable via `read_stata` top-level function for reading, and `to_stata` DataFrame method for writing, *See the docs*
- Added module for reading and writing json format files: `pandas.io.json` accessable via `read_json` top-level function for reading, and `to_json` DataFrame method for writing, *See the docs* various issues (GH1226, GH3804, GH3876, GH3867, GH1305)
- `MultiIndex` column support for reading and writing csv format files
  - The `header` option in `read_csv` now accepts a list of the rows from which to read the index.
  - The option, `tupleize_cols` can now be specified in both `to_csv` and `read_csv`, to provide compatiblity for the pre 0.12 behavior of writing and reading `MultIndex` columns via a list of tuples. The default in 0.12 is to write lists of tuples and *not* interpret list of tuples as a `MultiIndex` column.

    Note: The default behavior in 0.12 remains unchanged from prior versions, but starting with 0.13, the default *to* write and read `MultiIndex` columns will be in the new format. (GH3571, GH1651, GH3141)
  - If an `index_col` is not specified (e.g. you don't have an index, or wrote it with `df.to_csv(..., index=False)`, then any `names` on the columns index will be *lost*.

```
In [20]: from pandas.util.testing import makeCustomDataframe as mkdf

In [21]: df = mkdf(5, 3, r_idx_nlevels=2, c_idx_nlevels=4)

In [22]: df.to_csv('mi.csv')

In [23]: print(open('mi.csv').read())
C0,,C_l0_g0,C_l0_g1,C_l0_g2
C1,,C_l1_g0,C_l1_g1,C_l1_g2
C2,,C_l2_g0,C_l2_g1,C_l2_g2
C3,,C_l3_g0,C_l3_g1,C_l3_g2
R0,R1,,,
R_l0_g0,R_l1_g0,R0C0,R0C1,R0C2
R_l0_g1,R_l1_g1,R1C0,R1C1,R1C2
R_l0_g2,R_l1_g2,R2C0,R2C1,R2C2
R_l0_g3,R_l1_g3,R3C0,R3C1,R3C2
R_l0_g4,R_l1_g4,R4C0,R4C1,R4C2


In [24]: pd.read_csv('mi.csv', header=[0,1,2,3], index_col=[0,1])
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
C0                C_l0_g0 C_l0_g1 C_l0_g2
C1                C_l1_g0 C_l1_g1 C_l1_g2
C2                C_l2_g0 C_l2_g1 C_l2_g2
C3                C_l3_g0 C_l3_g1 C_l3_g2
R0       R1
R_l0_g0 R_l1_g0     R0C0    R0C1    R0C2
R_l0_g1 R_l1_g1     R1C0    R1C1    R1C2
R_l0_g2 R_l1_g2     R2C0    R2C1    R2C2
R_l0_g3 R_l1_g3     R3C0    R3C1    R3C2
R_l0_g4 R_l1_g4     R4C0    R4C1    R4C2

[5 rows x 3 columns]
```

- Support for `HDFStore` (via `PyTables 3.0.0`) on Python3
- Iterator support via `read_hdf` that automatically opens and closes the store when iteration is finished. This is only for *tables*

```
In [25]: path = 'store_iterator.h5'

In [26]: DataFrame(randn(10,2)).to_hdf(path,'df',table=True)

In [27]: for df in read_hdf(path,'df', chunksize=3):
   ....:    print df
   ....:
          0         1
0  0.713216 -0.778461
1 -0.661062  0.862877
2  0.344342  0.149565
          0         1
3 -0.626968 -0.875772
4 -0.930687 -0.218983
5  0.949965 -0.442354
          0         1
6 -0.402985  1.111358
7 -0.241527 -0.670477
8  0.049355  0.632633
          0         1
9 -1.502767 -1.225492
```

- `read_csv` will now throw a more informative error message when a file contains no columns, e.g., all newline characters

1.22.3 Other Enhancements

- `DataFrame.replace()` now allows regular expressions on contained `Series` with object dtype. See the examples section in the regular docs *Replacing via String Expression*

  For example you can do

```
In [25]: df = DataFrame({'a': list('ab..'), 'b': [1, 2, 3, 4]})

In [26]: df.replace(regex=r'\s*\.\s*', value=np.nan)
Out[26]:
     a  b
```

```
0    a  1
1    b  2
2  NaN  3
3  NaN  4

[4 rows x 2 columns]
```

to replace all occurrences of the string `'.'` with zero or more instances of surrounding whitespace with `NaN`.

Regular string replacement still works as expected. For example, you can do

```
In [27]: df.replace('.', np.nan)
Out[27]:
     a  b
0    a  1
1    b  2
2  NaN  3
3  NaN  4

[4 rows x 2 columns]
```

to replace all occurrences of the string `'.'` with `NaN`.

- `pd.melt()` now accepts the optional parameters `var_name` and `value_name` to specify custom column names of the returned DataFrame.
- `pd.set_option()` now allows N option, value pairs (GH3667).

  Let's say that we had an option `'a.b'` and another option `'b.c'`. We can set them at the same time:

```
In [28]: pd.get_option('a.b')
Out[28]: 2

In [29]: pd.get_option('b.c')
\\\\\\\\\\\Out[29]: 3

In [30]: pd.set_option('a.b', 1, 'b.c', 4)

In [31]: pd.get_option('a.b')
Out[31]: 1

In [32]: pd.get_option('b.c')
\\\\\\\\\\\Out[32]: 4
```

- The `filter` method for group objects returns a subset of the original object. Suppose we want to take only elements that belong to groups with a group sum greater than 2.

```
In [33]: sf = Series([1, 1, 2, 3, 3, 3])

In [34]: sf.groupby(sf).filter(lambda x: x.sum() > 2)
Out[34]:
3    3
4    3
5    3
Length: 3, dtype: int64
```

The argument of `filter` must a function that, applied to the group as a whole, returns `True` or `False`.

Another useful operation is filtering out elements that belong to groups with only a couple members.

```
In [35]: dff = DataFrame({'A': np.arange(8), 'B': list('aabbbbcc')})

In [36]: dff.groupby('B').filter(lambda x: len(x) > 2)
Out[36]:
   A  B
2  2  b
3  3  b
4  4  b
5  5  b

[4 rows x 2 columns]
```

Alternatively, instead of dropping the offending groups, we can return a like-indexed objects where the groups that do not pass the filter are filled with NaNs.

```
In [37]: dff.groupby('B').filter(lambda x: len(x) > 2, dropna=False)
Out[37]:
     A    B
0  NaN  NaN
1  NaN  NaN
2  2.0    b
3  3.0    b
4  4.0    b
5  5.0    b
6  NaN  NaN
7  NaN  NaN

[8 rows x 2 columns]
```

- Series and DataFrame hist methods now take a `figsize` argument (GH3834)
- DatetimeIndexes no longer try to convert mixed-integer indexes during join operations (GH3877)
- Timestamp.min and Timestamp.max now represent valid Timestamp instances instead of the default datetime.min and datetime.max (respectively), thanks @SleepingPills
- `read_html` now raises when no tables are found and BeautifulSoup==4.2.0 is detected (GH4214)

1.22.4 Experimental Features

- Added experimental `CustomBusinessDay` class to support `DateOffsets` with custom holiday calendars and custom weekmasks. (GH2301)

Note: This uses the `numpy.busdaycalendar` API introduced in Numpy 1.7 and therefore requires Numpy 1.7.0 or newer.

```
In [38]: from pandas.tseries.offsets import CustomBusinessDay

In [39]: from datetime import datetime

# As an interesting example, let's look at Egypt where
# a Friday-Saturday weekend is observed.
In [40]: weekmask_egypt = 'Sun Mon Tue Wed Thu'

# They also observe International Workers' Day so let's
```

```
# add that for a couple of years
In [41]: holidays = ['2012-05-01', datetime(2013, 5, 1), np.datetime64('2014-05-01
↪')]

In [42]: bday_egypt = CustomBusinessDay(holidays=holidays, weekmask=weekmask_
↪egypt)

In [43]: dt = datetime(2013, 4, 30)

In [44]: print(dt + 2 * bday_egypt)
2013-05-05 00:00:00

In [45]: dts = date_range(dt, periods=5, freq=bday_egypt)

In [46]: print(Series(dts.weekday, dts).map(Series('Mon Tue Wed Thu Fri Sat Sun'.
↪split())))
2013-04-30    Tue
2013-05-02    Thu
2013-05-05    Sun
2013-05-06    Mon
2013-05-07    Tue
Freq: C, Length: 5, dtype: object
```

1.22.5 Bug Fixes

- Plotting functions now raise a `TypeError` before trying to plot anything if the associated objects have have a dtype of `object` (GH1818, GH3572, GH3911, GH3912), but they will try to convert object arrays to numeric arrays if possible so that you can still plot, for example, an object array with floats. This happens before any drawing takes place which elimnates any spurious plots from showing up.
- `fillna` methods now raise a `TypeError` if the `value` parameter is a list or tuple.
- `Series.str` now supports iteration (GH3638). You can iterate over the individual elements of each string in the `Series`. Each iteration yields yields a `Series` with either a single character at each index of the original `Series` or `NaN`. For example,

```
In [47]: strs = 'go', 'bow', 'joe', 'slow'

In [48]: ds = Series(strs)

In [49]: for s in ds.str:
   ....:     print(s)
   ....:
0    g
1    b
2    j
3    s
Length: 4, dtype: object
0    o
1    o
2    o
3    l
Length: 4, dtype: object
0    NaN
1      w
2      e
3      o
```

```
Length: 4, dtype: object
0    NaN
1    NaN
2    NaN
3      w
Length: 4, dtype: object

In [50]: s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    NaN
1    NaN
2    NaN
3      w
Length: 4, dtype: object

In [51]: s.dropna().values.item() == 'w'
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪True
```

The last element yielded by the iterator will be a `Series` containing the last element of the longest string in the `Series` with all other elements being `NaN`. Here since `'slow'` is the longest string and there are no other strings with the same length `'w'` is the only non-null string in the yielded `Series`.

- `HDFStore`
  - will retain index attributes (freq,tz,name) on recreation (GH3499)
  - will warn with a `AttributeConflictWarning` if you are attempting to append an index with a different frequency than the existing, or attempting to append an index with a different name than the existing
  - support datelike columns with a timezone as data_columns (GH2852)
- Non-unique index support clarified (GH3468).
  - Fix assigning a new index to a duplicate index in a DataFrame would fail (GH3468)
  - Fix construction of a DataFrame with a duplicate index
  - ref_locs support to allow duplicative indices across dtypes, allows iget support to always find the index (even across dtypes) (GH2194)
  - applymap on a DataFrame with a non-unique index now works (removed warning) (GH2786), and fix (GH3230)
  - Fix to_csv to handle non-unique columns (GH3495)
  - Duplicate indexes with getitem will return items in the correct order (GH3455, GH3457) and handle missing elements like unique indices (GH3561)
  - Duplicate indexes with and empty DataFrame.from_records will return a correct frame (GH3562)
  - Concat to produce a non-unique columns when duplicates are across dtypes is fixed (GH3602)
  - Allow insert/delete to non-unique columns (GH3679)
  - Non-unique indexing with a slice via `loc` and friends fixed (GH3659)
  - Allow insert/delete to non-unique columns (GH3679)
  - Extend `reindex` to correctly deal with non-unique indices (GH3679)
  - `DataFrame.itertuples()` now works with frames with duplicate column names (GH3873)

  - Bug in non-unique indexing via `iloc` (GH4017); added `takeable` argument to `reindex` for location-based taking
  - Allow non-unique indexing in series via `.ix/.loc` and `__getitem__` (GH4246)
  - Fixed non-unique indexing memory allocation issue with `.ix/.loc` (GH4280)
- `DataFrame.from_records` did not accept empty recarrays (GH3682)
- `read_html` now correctly skips tests (GH3741)
- Fixed a bug where `DataFrame.replace` with a compiled regular expression in the `to_replace` argument wasn't working (GH3907)
- Improved `network` test decorator to catch `IOError` (and therefore `URLError` as well). Added `with_connectivity_check` decorator to allow explicitly checking a website as a proxy for seeing if there is network connectivity. Plus, new `optional_args` decorator factory for decorators. (GH3910, GH3914)
- Fixed testing issue where too many sockets where open thus leading to a connection reset issue (GH3982, GH3985, GH4028, GH4054)
- Fixed failing tests in test_yahoo, test_google where symbols were not retrieved but were being accessed (GH3982, GH3985, GH4028, GH4054)
- `Series.hist` will now take the figure from the current environment if one is not passed
- Fixed bug where a 1xN DataFrame would barf on a 1xN mask (GH4071)
- Fixed running of `tox` under python3 where the pickle import was getting rewritten in an incompatible way (GH4062, GH4063)
- Fixed bug where sharex and sharey were not being passed to grouped_hist (GH4089)
- Fixed bug in `DataFrame.replace` where a nested dict wasn't being iterated over when regex=False (GH4115)
- Fixed bug in the parsing of microseconds when using the `format` argument in `to_datetime` (GH4152)
- Fixed bug in `PandasAutoDateLocator` where `invert_xaxis` triggered incorrectly `MilliSecondLocator` (GH3990)
- Fixed bug in plotting that wasn't raising on invalid colormap for matplotlib 1.1.1 (GH4215)
- Fixed the legend displaying in `DataFrame.plot(kind='kde')` (GH4216)
- Fixed bug where Index slices weren't carrying the name attribute (GH4226)
- Fixed bug in initializing `DatetimeIndex` with an array of strings in a certain time zone (GH4229)
- Fixed bug where html5lib wasn't being properly skipped (GH4265)
- Fixed bug where get_data_famafrench wasn't using the correct file edges (GH4281)

See the *full release notes* or issue tracker on GitHub for a complete list.

1.23 v0.11.0 (April 22, 2013)

This is a major release from 0.10.1 and includes many new features and enhancements along with a large number of bug fixes. The methods of Selecting Data have had quite a number of additions, and Dtype support is now full-fledged. There are also a number of important API changes that long-time pandas users should pay close attention to.

There is a new section in the documentation, *10 Minutes to Pandas*, primarily geared to new users.

There is a new section in the documentation, *Cookbook*, a collection of useful recipes in pandas (and that we want contributions!).

There are several libraries that are now *Recommended Dependencies*

1.23.1 Selection Choices

Starting in 0.11.0, object selection has had a number of user-requested additions in order to support more explicit location based indexing. Pandas now supports three types of multi-axis indexing.

- `.loc` is strictly label based, will raise `KeyError` when the items are not found, allowed inputs are:
  - A single label, e.g. `5` or `'a'`, (note that `5` is interpreted as a *label* of the index. This use is **not** an integer position along the index)
  - A list or array of labels `['a', 'b', 'c']`
  - A slice object with labels `'a':'f'`, (note that contrary to usual python slices, **both** the start and the stop are included!)
  - A boolean array

  See more at *Selection by Label*
- `.iloc` is strictly integer position based (from `0` to `length-1` of the axis), will raise `IndexError` when the requested indicies are out of bounds. Allowed inputs are:
  - An integer e.g. `5`
  - A list or array of integers `[4, 3, 0]`
  - A slice object with ints `1:7`
  - A boolean array

  See more at *Selection by Position*
- `.ix` supports mixed integer and label based access. It is primarily label based, but will fallback to integer positional access. `.ix` is the most general and will support any of the inputs to `.loc` and `.iloc`, as well as support for floating point label schemes. `.ix` is especially useful when dealing with mixed positional and label based hierarchial indexes.

  As using integer slices with `.ix` have different behavior depending on whether the slice is interpreted as position based or label based, it's usually better to be explicit and use `.iloc` or `.loc`.

  See more at *Advanced Indexing* and *Advanced Hierarchical*.

1.23.2 Selection Deprecations

Starting in version 0.11.0, these methods *may* be deprecated in future versions.

- `irow`
- `icol`
- `iget_value`

See the section *Selection by Position* for substitutes.

1.23.3 Dtypes

Numeric dtypes will propagate and can coexist in DataFrames. If a dtype is passed (either directly via the `dtype` keyword, a passed `ndarray`, or a passed `Series`, then it will be preserved in DataFrame operations. Furthermore, different numeric dtypes will **NOT** be combined. The following example will give you a taste.

```
In [1]: df1 = DataFrame(randn(8, 1), columns = ['A'], dtype = 'float32')

In [2]: df1
Out[2]:
          A
0  1.392665
1 -0.123497
2 -0.402761
3 -0.246604
4 -0.288433
5 -0.763434
6  2.069526
7 -1.203569

[8 rows x 1 columns]

In [3]: df1.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    float32
Length: 1, dtype: object

In [4]: df2 = DataFrame(dict( A = Series(randn(8),dtype='float16'),
   ...:                       B = Series(randn(8)),
   ...:                       C = Series(randn(8),dtype='uint8') ))
   ...:

In [5]: df2
Out[5]:
          A         B    C
0  0.591797 -0.038605    0
1  0.841309 -0.460478    1
2 -0.500977 -0.310458    0
3 -0.816406  0.866493  254
4 -0.207031  0.245972    0
5 -0.664062  0.319442    1
6  0.580566  1.378512    1
7 -0.965820  0.292502  255

[8 rows x 3 columns]

In [6]: df2.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    float16
B    float64
C      uint8
Length: 3, dtype: object

# here you get some upcasting
In [7]: df3 = df1.reindex_like(df2).fillna(value=0.0) + df2
```

```
In [8]: df3
Out[8]:
          A         B      C
0  1.984462 -0.038605    0.0
1  0.717812 -0.460478    1.0
2 -0.903737 -0.310458    0.0
3 -1.063011  0.866493  254.0
4 -0.495465  0.245972    0.0
5 -1.427497  0.319442    1.0
6  2.650092  1.378512    1.0
7 -2.169390  0.292502  255.0

[8 rows x 3 columns]

In [9]: df3.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
A    float32
B    float64
C    float64
Length: 3, dtype: object
```

1.23.4 Dtype Conversion

This is lower-common-denomicator upcasting, meaning you get the dtype which can accomodate all of the types

```
In [10]: df3.values.dtype
Out[10]: dtype('float64')
```

Conversion

```
In [11]: df3.astype('float32').dtypes
Out[11]:
A    float32
B    float32
C    float32
Length: 3, dtype: object
```

Mixed Conversion

```
In [12]: df3['D'] = '1.'

In [13]: df3['E'] = '1'

In [14]: df3.convert_objects(convert_numeric=True).dtypes
Out[14]:
A    float32
B    float64
C    float64
D    float64
E      int64
Length: 5, dtype: object

# same, but specific dtype conversion
In [15]: df3['D'] = df3['D'].astype('float16')
```

```
In [16]: df3['E'] = df3['E'].astype('int32')

In [17]: df3.dtypes
Out[17]:
A    float32
B    float64
C    float64
D    float16
E      int32
Length: 5, dtype: object
```

Forcing Date coercion (and setting `NaT` when not datelike)

```
In [18]: from datetime import datetime

In [19]: s = Series([datetime(2001,1,1,0,0), 'foo', 1.0, 1,
   ....:             Timestamp('20010104'), '20010105'],dtype='O')
   ....:

In [20]: s.convert_objects(convert_dates='coerce')
Out[20]:
0   2001-01-01
1          NaT
2          NaT
3          NaT
4   2001-01-04
5   2001-01-05
Length: 6, dtype: datetime64[ns]
```

1.23.5 Dtype Gotchas

Platform Gotchas

Starting in 0.11.0, construction of DataFrame/Series will use default dtypes of `int64` and `float64`, *regardless of platform*. This is not an apparent change from earlier versions of pandas. If you specify dtypes, they *WILL* be respected, however (GH2837)

The following will all result in `int64` dtypes

```
In [21]: DataFrame([1,2],columns=['a']).dtypes
Out[21]:
a    int64
Length: 1, dtype: object

In [22]: DataFrame({'a' : [1,2] }).dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[22]:
a    int64
Length: 1, dtype: object

In [23]: DataFrame({'a' : 1 }, index=range(2)).dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[23]:
↪
a    int64
Length: 1, dtype: object
```

Keep in mind that `DataFrame(np.array([1,2]))` **WILL** result in `int32` on 32-bit platforms!

Upcasting Gotchas

Performing indexing operations on integer type data can easily upcast the data. The dtype of the input data will be preserved in cases where `nans` are not introduced.

```
In [24]: dfi = df3.astype('int32')

In [25]: dfi['D'] = dfi['D'].astype('int64')

In [26]: dfi
Out[26]:
   A  B    C  D  E
0  1  0    0  1  1
1  0  0    1  1  1
2  0  0    0  1  1
3 -1  0  254  1  1
4  0  0    0  1  1
5 -1  0    1  1  1
6  2  1    1  1  1
7 -2  0  255  1  1

[8 rows x 5 columns]

In [27]: dfi.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
A    int32
B    int32
C    int32
D    int64
E    int32
Length: 5, dtype: object

In [28]: casted = dfi[dfi>0]

In [29]: casted
Out[29]:
     A    B      C  D  E
0  1.0  NaN    NaN  1  1
1  NaN  NaN    1.0  1  1
2  NaN  NaN    NaN  1  1
3  NaN  NaN  254.0  1  1
4  NaN  NaN    NaN  1  1
5  NaN  NaN    1.0  1  1
6  2.0  1.0    1.0  1  1
7  NaN  NaN  255.0  1  1

[8 rows x 5 columns]

In [30]: casted.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
A    float64
B    float64
C    float64
D      int64
E      int32
Length: 5, dtype: object
```

While float dtypes are unchanged.

```
In [31]: df4 = df3.copy()

In [32]: df4['A'] = df4['A'].astype('float32')

In [33]: df4.dtypes
Out[33]:
A    float32
B    float64
C    float64
D    float16
E      int32
Length: 5, dtype: object

In [34]: casted = df4[df4>0]

In [35]: casted
Out[35]:
          A         B      C    D  E
0  1.984462       NaN    NaN  1.0  1
1  0.717812       NaN    1.0  1.0  1
2       NaN       NaN    NaN  1.0  1
3       NaN  0.866493  254.0  1.0  1
4       NaN  0.245972    NaN  1.0  1
5       NaN  0.319442    1.0  1.0  1
6  2.650092  1.378512    1.0  1.0  1
7       NaN  0.292502  255.0  1.0  1

[8 rows x 5 columns]

In [36]: casted.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    float32
B    float64
C    float64
D    float16
E      int32
Length: 5, dtype: object
```

1.23.6 Datetimes Conversion

Datetime64[ns] columns in a DataFrame (or a Series) allow the use of `np.nan` to indicate a nan value, in addition to the traditional `NaT`, or not-a-time. This allows convenient nan setting in a generic way. Furthermore `datetime64[ns]` columns are created by default, when passed datetimelike objects (*this change was introduced in 0.10.1*) (GH2809, GH2810)

```
In [37]: df = DataFrame(randn(6,2),date_range('20010102',periods=6),columns=['A','B'])

In [38]: df['timestamp'] = Timestamp('20010103')

In [39]: df
Out[39]:
                   A         B  timestamp
2001-01-02  1.023958  0.660103 2001-01-03
2001-01-03  1.236475 -2.170629 2001-01-03
```

```
2001-01-04 -0.270630 -1.685677 2001-01-03
2001-01-05 -0.440747 -0.115070 2001-01-03
2001-01-06 -0.632102 -0.585977 2001-01-03
2001-01-07 -1.444787 -0.201135 2001-01-03

[6 rows x 3 columns]

# datetime64[ns] out of the box
In [40]: df.get_dtype_counts()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
datetime64[ns]    1
float64           2
Length: 2, dtype: int64

# use the traditional nan, which is mapped to NaT internally
In [41]: df.loc[df.index[2:4], ['A','timestamp']] = np.nan

In [42]: df
Out[42]: 
                   A         B  timestamp
2001-01-02  1.023958  0.660103 2001-01-03
2001-01-03  1.236475 -2.170629 2001-01-03
2001-01-04       NaN -1.685677        NaT
2001-01-05       NaN -0.115070        NaT
2001-01-06 -0.632102 -0.585977 2001-01-03
2001-01-07 -1.444787 -0.201135 2001-01-03

[6 rows x 3 columns]
```

Astype conversion on `datetime64[ns]` to `object`, implicity converts `NaT` to `np.nan`

```
In [43]: import datetime

In [44]: s = Series([datetime.datetime(2001, 1, 2, 0, 0) for i in range(3)])

In [45]: s.dtype
Out[45]: dtype('<M8[ns]')

In [46]: s[1] = np.nan

In [47]: s
Out[47]: 
0   2001-01-02
1          NaT
2   2001-01-02
Length: 3, dtype: datetime64[ns]

In [48]: s.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[48]:␣
↪dtype('<M8[ns]')

In [49]: s = s.astype('O')

In [50]: s
Out[50]: 
0    2001-01-02 00:00:00
1                    NaT
```

```
2    2001-01-02 00:00:00
Length: 3, dtype: object

In [51]: s.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪dtype('O')
```

1.23.7 API changes

- Added to_series() method to indicies, to facilitate the creation of indexers (GH3275)
- `HDFStore`
    - added the method `select_column` to select a single column from a table as a Series.
    - deprecated the `unique` method, can be replicated by `select_column(key,column).unique()`
    - `min_itemsize` parameter to `append` will now automatically create data_columns for passed keys

1.23.8 Enhancements

- Improved performance of df.to_csv() by up to 10x in some cases. (GH3059)
- Numexpr is now a *Recommended Dependencies*, to accelerate certain types of numerical and boolean operations
- Bottleneck is now a *Recommended Dependencies*, to accelerate certain types of `nan` operations
- `HDFStore`
    - support `read_hdf/to_hdf` API similar to `read_csv/to_csv`

```
In [52]: df = DataFrame(dict(A=lrange(5), B=lrange(5)))

In [53]: df.to_hdf('store.h5','table',append=True)

In [54]: read_hdf('store.h5', 'table', where = ['index>2'])
Out[54]:
   A  B
3  3  3
4  4  4

[2 rows x 2 columns]
```

    - provide dotted attribute access to `get` from stores, e.g. `store.df == store['df']`
    - new keywords `iterator=boolean`, and `chunksize=number_in_a_chunk` are provided to support iteration on `select` and `select_as_multiple` (GH3076)
- You can now select timestamps from an *unordered* timeseries similarly to an *ordered* timeseries (GH2437)
- You can now select with a string from a DataFrame with a datelike index, in a similar way to a Series (GH3070)

```
In [55]: idx = date_range("2001-10-1", periods=5, freq='M')

In [56]: ts = Series(np.random.rand(len(idx)),index=idx)

In [57]: ts['2001']
Out[57]:
2001-10-31    0.663256
```

```
2001-11-30    0.079126
2001-12-31    0.587699
Freq: M, Length: 3, dtype: float64

In [58]: df = DataFrame(dict(A = ts))

In [59]: df['2001']
Out[59]: 
                   A
2001-10-31  0.663256
2001-11-30  0.079126
2001-12-31  0.587699

[3 rows x 1 columns]
```

- `Squeeze` to possibly remove length 1 dimensions from an object.

```
In [60]: p = Panel(randn(3,4,4),items=['ItemA','ItemB','ItemC'],
   ....:                    major_axis=date_range('20010102',periods=4),
   ....:                    minor_axis=['A','B','C','D'])
   ....: 

In [61]: p
Out[61]: 
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 4 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2001-01-02 00:00:00 to 2001-01-05 00:00:00
Minor_axis axis: A to D

In [62]: p.reindex(items=['ItemA']).squeeze()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2001-01-02 -1.203403  0.425882 -0.436045 -0.982462
2001-01-03  0.348090 -0.969649  0.121731  0.202798
2001-01-04  1.215695 -0.218549 -0.631381 -0.337116
2001-01-05  0.404238  0.907213 -0.865657  0.483186

[4 rows x 4 columns]

In [63]: p.reindex(items=['ItemA'],minor=['B']).squeeze()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2001-01-02    0.425882
2001-01-03   -0.969649
2001-01-04   -0.218549
2001-01-05    0.907213
Freq: D, Name: B, Length: 4, dtype: float64
```

- In `pd.io.data.Options`,
  - Fix bug when trying to fetch data for the current month when already past expiry.
  - Now using lxml to scrape html instead of BeautifulSoup (lxml was faster).
  - New instance variables for calls and puts are automatically created when a method that creates them is called. This works for current month where the instance variables are simply `calls` and `puts`. Also works for future expiry months and save the instance variable as `callsMMYY` or `putsMMYY`, where

MMYY are, respectively, the month and year of the option's expiry.

  - Options.get_near_stock_price now allows the user to specify the month for which to get relevant options data.
  - Options.get_forward_data now has optional kwargs near and above_below. This allows the user to specify if they would like to only return forward looking data for options near the current stock price. This just obtains the data from Options.get_near_stock_price instead of Options.get_xxx_data() (GH2758).

- Cursor coordinate information is now displayed in time-series plots.
- added option *display.max_seq_items* to control the number of elements printed per sequence pprinting it. (GH2979)
- added option *display.chop_threshold* to control display of small numerical values. (GH2739)
- added option *display.max_info_rows* to prevent verbose_info from being calculated for frames above 1M rows (configurable). (GH2807, GH2918)
- value_counts() now accepts a "normalize" argument, for normalized histograms. (GH2710).
- DataFrame.from_records now accepts not only dicts but any instance of the collections.Mapping ABC.
- added option *display.mpl_style* providing a sleeker visual style for plots. Based on https://gist.github.com/huyng/816622 (GH3075).
- Treat boolean values as integers (values 1 and 0) for numeric operations. (GH2641)
- to_html() now accepts an optional "escape" argument to control reserved HTML character escaping (enabled by default) and escapes &, in addition to < and >. (GH2919)

See the *full release notes* or issue tracker on GitHub for a complete list.

1.24 v0.10.1 (January 22, 2013)

This is a minor release from 0.10.0 and includes new features, enhancements, and bug fixes. In particular, there is substantial new HDFStore functionality contributed by Jeff Reback.

An undesired API breakage with functions taking the inplace option has been reverted and deprecation warnings added.

1.24.1 API changes

- Functions taking an inplace option return the calling object as before. A deprecation message has been added
- Groupby aggregations Max/Min no longer exclude non-numeric data (GH2700)
- Resampling an empty DataFrame now returns an empty DataFrame instead of raising an exception (GH2640)
- The file reader will now raise an exception when NA values are found in an explicitly specified integer column instead of converting the column to float (GH2631)
- DatetimeIndex.unique now returns a DatetimeIndex with the same name and
- timezone instead of an array (GH2563)

1.24.2 New features

- MySQL support for database (contribution from Dan Allan)

1.24.3 HDFStore

You may need to upgrade your existing data files. Please visit the **compatibility** section in the main docs.

You can designate (and index) certain columns that you want to be able to perform queries on a table, by passing a list to `data_columns`

```
In [1]: store = HDFStore('store.h5')

In [2]: df = DataFrame(randn(8, 3), index=date_range('1/1/2000', periods=8),
   ...:            columns=['A', 'B', 'C'])
   ...:

In [3]: df['string'] = 'foo'

In [4]: df.loc[df.index[4:6], 'string'] = np.nan

In [5]: df.loc[df.index[7:9], 'string'] = 'bar'

In [6]: df['string2'] = 'cool'

In [7]: df
Out[7]: 
                   A         B         C string string2
2000-01-01  1.885136 -0.183873  2.550850    foo    cool
2000-01-02  0.180759 -1.117089  0.061462    foo    cool
2000-01-03 -0.294467 -0.591411 -0.876691    foo    cool
2000-01-04  3.127110  1.451130  0.045152    foo    cool
2000-01-05 -0.242846  1.195819  1.533294    NaN    cool
2000-01-06  0.820521 -0.281201  1.651561    NaN    cool
2000-01-07 -0.034086  0.252394 -0.498772    foo    cool
2000-01-08 -2.290958 -1.601262 -0.256718    bar    cool

[8 rows x 5 columns]

# on-disk operations
In [8]: store.append('df', df, data_columns = ['B','C','string','string2'])

In [9]: store.select('df', "B>0 and string=='foo'")
Out[9]: 
                   A         B         C string string2
2000-01-04  3.127110  1.451130  0.045152    foo    cool
2000-01-07 -0.034086  0.252394 -0.498772    foo    cool

[2 rows x 5 columns]

# this is in-memory version of this type of selection
In [10]: df[(df.B > 0) & (df.string == 'foo')]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C string string2
2000-01-04  3.127110  1.451130  0.045152    foo    cool
2000-01-07 -0.034086  0.252394 -0.498772    foo    cool
```

```

[2 rows x 5 columns]
```

Retrieving unique values in an indexable or data column.

```
# note that this is deprecated as of 0.14.0
# can be replicated by: store.select_column('df','index').unique()
store.unique('df','index')
store.unique('df','string')
```

You can now store `datetime64` in data columns

```
In [11]: df_mixed                = df.copy()

In [12]: df_mixed['datetime64'] = Timestamp('20010102')

In [13]: df_mixed.loc[df_mixed.index[3:4], ['A','B']] = np.nan

In [14]: store.append('df_mixed', df_mixed)

In [15]: df_mixed1 = store.select('df_mixed')

In [16]: df_mixed1
Out[16]: 
                   A         B         C string string2 datetime64
2000-01-01  1.885136 -0.183873  2.550850    foo    cool 2001-01-02
2000-01-02  0.180759 -1.117089  0.061462    foo    cool 2001-01-02
2000-01-03 -0.294467 -0.591411 -0.876691    foo    cool 2001-01-02
2000-01-04       NaN       NaN  0.045152    foo    cool 2001-01-02
2000-01-05 -0.242846  1.195819  1.533294    NaN    cool 2001-01-02
2000-01-06  0.820521 -0.281201  1.651561    NaN    cool 2001-01-02
2000-01-07 -0.034086  0.252394 -0.498772    foo    cool 2001-01-02
2000-01-08 -2.290958 -1.601262 -0.256718    bar    cool 2001-01-02

[8 rows x 6 columns]

In [17]: df_mixed1.get_dtype_counts()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
datetime64[ns]    1
float64           3
object            2
Length: 3, dtype: int64
```

You can pass `columns` keyword to select to filter a list of the return columns, this is equivalent to passing a `Term('columns',list_of_columns_to_filter)`

```
In [18]: store.select('df',columns = ['A','B'])
Out[18]: 
                   A         B
2000-01-01  1.885136 -0.183873
2000-01-02  0.180759 -1.117089
2000-01-03 -0.294467 -0.591411
2000-01-04  3.127110  1.451130
2000-01-05 -0.242846  1.195819
2000-01-06  0.820521 -0.281201
2000-01-07 -0.034086  0.252394
2000-01-08 -2.290958 -1.601262
```

```

[8 rows x 2 columns]
```

`HDFStore` now serializes multi-index dataframes when appending tables.

```
In [19]: index = MultiIndex(levels=[['foo', 'bar', 'baz', 'qux'],
   ....:                            ['one', 'two', 'three']],
   ....:                    labels=[[0, 0, 0, 1, 1, 2, 2, 3, 3, 3],
   ....:                            [0, 1, 2, 0, 1, 1, 2, 0, 1, 2]],
   ....:                    names=['foo', 'bar'])
   ....:

In [20]: df = DataFrame(np.random.randn(10, 3), index=index,
   ....:                columns=['A', 'B', 'C'])
   ....:

In [21]: df
Out[21]:
                  A         B         C
foo bar
foo one    0.239369  0.174122 -1.131794
    two   -1.948006  0.980347 -0.674429
    three -0.361633 -0.761218  1.768215
bar one    0.152288 -0.862613 -0.210968
    two   -0.859278  1.498195  0.462413
baz two   -0.647604  1.511487 -0.727189
    three -0.342928 -0.007364  1.427674
qux one    0.104020  2.052171 -1.230963
    two   -0.019240 -1.713238  0.838912
    three -0.637855  0.215109 -1.515362

[10 rows x 3 columns]

In [22]: store.append('mi',df)

In [23]: store.select('mi')
Out[23]:
                  A         B         C
foo bar
foo one    0.239369  0.174122 -1.131794
    two   -1.948006  0.980347 -0.674429
    three -0.361633 -0.761218  1.768215
bar one    0.152288 -0.862613 -0.210968
    two   -0.859278  1.498195  0.462413
baz two   -0.647604  1.511487 -0.727189
    three -0.342928 -0.007364  1.427674
qux one    0.104020  2.052171 -1.230963
    two   -0.019240 -1.713238  0.838912
    three -0.637855  0.215109 -1.515362

[10 rows x 3 columns]

# the levels are automatically included as data columns
In [24]: store.select('mi', "foo='bar'")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                A         B         C
foo bar
```

```
bar one  0.152288 -0.862613 -0.210968
    two -0.859278  1.498195  0.462413

[2 rows x 3 columns]
```

Multi-table creation via `append_to_multiple` and selection via `select_as_multiple` can create/select from multiple tables and return a combined result, by using `where` on a selector table.

```
In [25]: df_mt = DataFrame(randn(8, 6), index=date_range('1/1/2000', periods=8),
   ....:                                columns=['A', 'B', 'C', 'D', 'E', 'F'])
   ....:

In [26]: df_mt['foo'] = 'bar'

# you can also create the tables individually
In [27]: store.append_to_multiple({ 'df1_mt' : ['A','B'], 'df2_mt' : None }, df_mt,␣
↪selector = 'df1_mt')

In [28]: store
Out[28]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

# indiviual tables were created
In [29]: store.select('df1_mt')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[29]:
                   A         B
2000-01-01  1.586924 -0.447974
2000-01-02 -0.102206  0.870302
2000-01-03  1.249874  1.458210
2000-01-04 -0.616293  0.150468
2000-01-05 -0.431163  0.016640
2000-01-06  0.800353 -0.451572
2000-01-07  1.239198  0.185437
2000-01-08 -0.040863  0.290110

[8 rows x 2 columns]

In [30]: store.select('df2_mt')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   C         D         E         F  foo
2000-01-01 -1.573998  0.630925 -0.071659 -1.277640  bar
2000-01-02  1.275280 -1.199212  1.060780  1.673018  bar
2000-01-03 -0.710542  0.825392  1.557329  1.993441  bar
2000-01-04  0.132104  0.580923 -0.128750  1.445964  bar
2000-01-05  0.904578 -1.645852 -0.688741  0.228006  bar
2000-01-06  0.831767  0.228760  0.932498 -2.200069  bar
2000-01-07 -0.540770 -0.370038  1.298390  1.662964  bar
2000-01-08 -0.096145  1.717830 -0.462446 -0.112019  bar

[8 rows x 5 columns]

# as a multiple
In [31]: store.select_as_multiple(['df1_mt','df2_mt'], where = [ 'A>0','B>0' ],␣
↪selector = 'df1_mt')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
                   A         B         C         D         E         F  foo
2000-01-03  1.249874  1.458210 -0.710542  0.825392  1.557329  1.993441  bar
2000-01-07  1.239198  0.185437 -0.540770 -0.370038  1.298390  1.662964  bar

[2 rows x 7 columns]
```

Enhancements

- `HDFStore` now can read native PyTables table format tables
- You can pass `nan_rep = 'my_nan_rep'` to append, to change the default nan representation on disk (which converts to/from *np.nan*), this defaults to *nan*.
- You can pass `index` to `append`. This defaults to `True`. This will automagically create indicies on the *indexables* and *data columns* of the table
- You can pass `chunksize=an integer` to `append`, to change the writing chunksize (default is 50000). This will signficantly lower your memory usage on writing.
- You can pass `expectedrows=an integer` to the first `append`, to set the TOTAL number of expectedrows that `PyTables` will expected. This will optimize read/write performance.
- `Select` now supports passing `start` and `stop` to provide selection space limiting in selection.
- Greatly improved ISO8601 (e.g., yyyy-mm-dd) date parsing for file parsers (GH2698)
- Allow `DataFrame.merge` to handle combinatorial sizes too large for 64-bit integer (GH2690)
- Series now has unary negation (-series) and inversion (~series) operators (GH2686)
- DataFrame.plot now includes a `logx` parameter to change the x-axis to log scale (GH2327)
- Series arithmetic operators can now handle constant and ndarray input (GH2574)
- ExcelFile now takes a `kind` argument to specify the file type (GH2613)
- A faster implementation for Series.str methods (GH2602)

Bug Fixes

- `HDFStore` tables can now store `float32` types correctly (cannot be mixed with `float64` however)
- Fixed Google Analytics prefix when specifying request segment (GH2713).
- Function to reset Google Analytics token store so users can recover from improperly setup client secrets (GH2687).
- Fixed groupby bug resulting in segfault when passing in MultiIndex (GH2706)
- Fixed bug where passing a Series with datetime64 values into *to_datetime* results in bogus output values (GH2699)
- Fixed bug in `pattern in HDFStore` expressions when pattern is not a valid regex (GH2694)
- Fixed performance issues while aggregating boolean data (GH2692)
- When given a boolean mask key and a Series of new values, Series __setitem__ will now align the incoming values with the original Series (GH2686)
- Fixed MemoryError caused by performing counting sort on sorting MultiIndex levels with a very large number of combinatorial values (GH2684)
- Fixed bug that causes plotting to fail when the index is a DatetimeIndex with a fixed-offset timezone (GH2683)
- Corrected businessday subtraction logic when the offset is more than 5 bdays and the starting date is on a weekend (GH2680)

- Fixed C file parser behavior when the file has more columns than data (GH2668)
- Fixed file reader bug that misaligned columns with data in the presence of an implicit column and a specified *usecols* value
- DataFrames with numerical or datetime indices are now sorted prior to plotting (GH2609)
- Fixed DataFrame.from_records error when passed columns, index, but empty records (GH2633)
- Several bug fixed for Series operations when dtype is datetime64 (GH2689, GH2629, GH2626)

See the *full release notes* or issue tracker on GitHub for a complete list.

1.25 v0.10.0 (December 17, 2012)

This is a major release from 0.9.1 and includes many new features and enhancements along with a large number of bug fixes. There are also a number of important API changes that long-time pandas users should pay close attention to.

1.25.1 File parsing new features

The delimited file parsing engine (the guts of `read_csv` and `read_table`) has been rewritten from the ground up and now uses a fraction the amount of memory while parsing, while being 40% or more faster in most use cases (in some cases much faster).

There are also many new features:

- Much-improved Unicode handling via the `encoding` option.
- Column filtering (`usecols`)
- Dtype specification (`dtype` argument)
- Ability to specify strings to be recognized as True/False
- Ability to yield NumPy record arrays (`as_recarray`)
- High performance `delim_whitespace` option
- Decimal format (e.g. European format) specification
- Easier CSV dialect options: `escapechar`, `lineterminator`, `quotechar`, etc.
- More robust handling of many exceptional kinds of files observed in the wild

1.25.2 API changes

Deprecated DataFrame BINOP TimeSeries special case behavior

The default behavior of binary operations between a DataFrame and a Series has always been to align on the DataFrame's columns and broadcast down the rows, **except** in the special case that the DataFrame contains time series. Since there are now method for each binary operator enabling you to specify how you want to broadcast, we are phasing out this special case (Zen of Python: *Special cases aren't special enough to break the rules*). Here's what I'm talking about:

```
In [1]: import pandas as pd

In [2]: df = pd.DataFrame(np.random.randn(6, 4),
   ...:                   index=pd.date_range('1/1/2000', periods=6))
```

```
   ...:

In [3]: df
Out[3]:
                   0         1         2         3
2000-01-01 -0.134024 -0.205969  1.348944 -1.198246
2000-01-02 -1.626124  0.982041  0.059493 -0.460111
2000-01-03 -1.565401 -0.025706  0.942864  2.502156
2000-01-04 -0.302741  0.261551 -0.066342  0.897097
2000-01-05  0.268766 -1.225092  0.582752 -1.490764
2000-01-06 -0.639757 -0.952750 -0.892402  0.505987

[6 rows x 4 columns]

# deprecated now
In [4]: df - df[0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
            2000-01-01 00:00:00  2000-01-02 00:00:00  2000-01-03 00:00:00  \
2000-01-01                  NaN                  NaN                  NaN
2000-01-02                  NaN                  NaN                  NaN
2000-01-03                  NaN                  NaN                  NaN
2000-01-04                  NaN                  NaN                  NaN
2000-01-05                  NaN                  NaN                  NaN
2000-01-06                  NaN                  NaN                  NaN

            2000-01-04 00:00:00  2000-01-05 00:00:00  2000-01-06 00:00:00   0  \
2000-01-01                  NaN                  NaN                  NaN NaN
2000-01-02                  NaN                  NaN                  NaN NaN
2000-01-03                  NaN                  NaN                  NaN NaN
2000-01-04                  NaN                  NaN                  NaN NaN
2000-01-05                  NaN                  NaN                  NaN NaN
2000-01-06                  NaN                  NaN                  NaN NaN

             1   2   3
2000-01-01 NaN NaN NaN
2000-01-02 NaN NaN NaN
2000-01-03 NaN NaN NaN
2000-01-04 NaN NaN NaN
2000-01-05 NaN NaN NaN
2000-01-06 NaN NaN NaN

[6 rows x 10 columns]

# Change your code to
In [5]: df.sub(df[0], axis=0) # align on axis 0 (rows)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
              0         1         2         3
2000-01-01  0.0 -0.071946  1.482967 -1.064223
2000-01-02  0.0  2.608165  1.685618  1.166013
2000-01-03  0.0  1.539695  2.508265  4.067556
2000-01-04  0.0  0.564293  0.236399  1.199839
2000-01-05  0.0 -1.493857  0.313986 -1.759530
2000-01-06  0.0 -0.312993 -0.252645  1.145744

[6 rows x 4 columns]
```

You will get a deprecation warning in the 0.10.x series, and the deprecated functionality will be removed in 0.11 or later.

Altered resample default behavior

The default time series `resample` binning behavior of daily `D` and *higher* frequencies has been changed to `closed='left', label='left'`. Lower nfrequencies are unaffected. The prior defaults were causing a great deal of confusion for users, especially resampling data to daily frequency (which labeled the aggregated group with the end of the interval: the next day).

```
In [1]: dates = pd.date_range('1/1/2000', '1/5/2000', freq='4h')

In [2]: series = Series(np.arange(len(dates)), index=dates)

In [3]: series
Out[3]:
2000-01-01 00:00:00     0
2000-01-01 04:00:00     1
2000-01-01 08:00:00     2
2000-01-01 12:00:00     3
2000-01-01 16:00:00     4
2000-01-01 20:00:00     5
2000-01-02 00:00:00     6
2000-01-02 04:00:00     7
2000-01-02 08:00:00     8
2000-01-02 12:00:00     9
2000-01-02 16:00:00    10
2000-01-02 20:00:00    11
2000-01-03 00:00:00    12
2000-01-03 04:00:00    13
2000-01-03 08:00:00    14
2000-01-03 12:00:00    15
2000-01-03 16:00:00    16
2000-01-03 20:00:00    17
2000-01-04 00:00:00    18
2000-01-04 04:00:00    19
2000-01-04 08:00:00    20
2000-01-04 12:00:00    21
2000-01-04 16:00:00    22
2000-01-04 20:00:00    23
2000-01-05 00:00:00    24
Freq: 4H, dtype: int64

In [4]: series.resample('D', how='sum')
Out[4]:
2000-01-01     15
2000-01-02     51
2000-01-03     87
2000-01-04    123
2000-01-05     24
Freq: D, dtype: int64

In [5]: # old behavior
In [6]: series.resample('D', how='sum', closed='right', label='right')
Out[6]:
2000-01-01      0
2000-01-02     21
2000-01-03     57
2000-01-04     93
```

```
2000-01-05    129
Freq: D, dtype: int64
```

- Infinity and negative infinity are no longer treated as NA by `isnull` and `notnull`. That they ever were was a relic of early pandas. This behavior can be re-enabled globally by the `mode.use_inf_as_null` option:

```
In [6]: s = pd.Series([1.5, np.inf, 3.4, -np.inf])

In [7]: pd.isnull(s)
Out[7]:
0    False
1    False
2    False
3    False
Length: 4, dtype: bool

In [8]: s.fillna(0)
Out[8]:
0    1.500000
1         inf
2    3.400000
3        -inf
Length: 4, dtype: float64

In [9]: pd.set_option('use_inf_as_null', True)

In [10]: pd.isnull(s)
Out[10]:
0    False
1     True
2    False
3     True
Length: 4, dtype: bool

In [11]: s.fillna(0)
Out[11]:
0    1.5
1    0.0
2    3.4
3    0.0
Length: 4, dtype: float64

In [12]: pd.reset_option('use_inf_as_null')
```

- Methods with the `inplace` option now all return `None` instead of the calling object. E.g. code written like `df = df.fillna(0, inplace=True)` may stop working. To fix, simply delete the unnecessary variable assignment.
- `pandas.merge` no longer sorts the group keys (`sort=False`) by default. This was done for performance reasons: the group-key sorting is often one of the more expensive parts of the computation and is often unnecessary.
- The default column names for a file with no header have been changed to the integers `0` through `N - 1`. This is to create consistency with the DataFrame constructor with no columns specified. The v0.9.0 behavior (names `X0`, `X1`, ...) can be reproduced by specifying `prefix='X'`:

```
In [6]: data= 'a,b,c\n1,Yes,2\n3,No,4'
```

```
In [7]: print(data)
a,b,c
1,Yes,2
3,No,4

In [8]: pd.read_csv(StringIO(data), header=None)
\\\\\\\\\\\\\\\\\\\\\Out[8]:
   0    1  2
0  a    b  c
1  1  Yes  2
2  3   No  4

[3 rows x 3 columns]

In [9]: pd.read_csv(StringIO(data), header=None, prefix='X')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
  X0   X1 X2
0  a    b  c
1  1  Yes  2
2  3   No  4

[3 rows x 3 columns]
```

- Values like `'Yes'` and `'No'` are not interpreted as boolean by default, though this can be controlled by new `true_values` and `false_values` arguments:

```
In [10]: print(data)
a,b,c
1,Yes,2
3,No,4

In [11]: pd.read_csv(StringIO(data))
\\\\\\\\\\\\\\\\\\\\\Out[11]:
   a    b  c
0  1  Yes  2
1  3   No  4

[2 rows x 3 columns]

In [12]: pd.read_csv(StringIO(data), true_values=['Yes'], false_values=['No'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[12]:
↪
   a      b  c
0  1   True  2
1  3  False  4

[2 rows x 3 columns]
```

- The file parsers will not recognize non-string values arising from a converter function as NA if passed in the `na_values` argument. It's better to do post-processing using the `replace` function instead.
- Calling `fillna` on Series or DataFrame with no arguments is no longer valid code. You must either specify a fill value or an interpolation method:

```
In [13]: s = Series([np.nan, 1., 2., np.nan, 4])

In [14]: s
```

```
Out[14]:
0    NaN
1    1.0
2    2.0
3    NaN
4    4.0
Length: 5, dtype: float64

In [15]: s.fillna(0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[15]:␣
↪
0    0.0
1    1.0
2    2.0
3    0.0
4    4.0
Length: 5, dtype: float64

In [16]: s.fillna(method='pad')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    NaN
1    1.0
2    2.0
3    2.0
4    4.0
Length: 5, dtype: float64
```

Convenience methods `ffill` and `bfill` have been added:

```
In [17]: s.ffill()
Out[17]:
0    NaN
1    1.0
2    2.0
3    2.0
4    4.0
Length: 5, dtype: float64
```

- `Series.apply` will now operate on a returned value from the applied function, that is itself a series, and possibly upcast the result to a DataFrame

  ```
  In [18]: def f(x):
     ....:     return Series([ x, x**2 ], index = ['x', 'x^2'])
     ....:

  In [19]: s = Series(np.random.rand(5))

  In [20]: s
  Out[20]:
  0    0.717478
  1    0.815199
  2    0.452478
  3    0.848385
  4    0.235477
  Length: 5, dtype: float64

  In [21]: s.apply(f)
  ```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          x       x^2
0  0.717478  0.514775
1  0.815199  0.664550
2  0.452478  0.204737
3  0.848385  0.719757
4  0.235477  0.055449

[5 rows x 2 columns]
```

- New API functions for working with pandas options (GH2097):
  - `get_option` / `set_option` - get/set the value of an option. Partial names are accepted. - `reset_option` - reset one or more options to their default value. Partial names are accepted. - `describe_option` - print a description of one or more options. When called with no arguments. print all registered options.

  Note: `set_printoptions`/ `reset_printoptions` are now deprecated (but functioning), the print options now live under "display.XYZ". For example:

```
In [22]: get_option("display.max_rows")
Out[22]: 15
```

- to_string() methods now always return unicode strings (GH2224).

1.25.3 New features

1.25.4 Wide DataFrame Printing

Instead of printing the summary information, pandas now splits the string representation across multiple rows by default:

```
In [23]: wide_frame = DataFrame(randn(5, 16))

In [24]: wide_frame
Out[24]:
         0         1         2         3         4         5         6   \
0 -0.681624  0.191356  1.180274 -0.834179  0.703043  0.166568 -0.583599
1  0.441522 -0.316864 -0.017062  1.570114 -0.360875 -0.880096  0.235532
2 -0.412451 -0.462580  0.422194  0.288403 -0.487393 -0.777639  0.055865
3 -0.277255  1.331263  0.585174 -0.568825 -0.719412  1.191340 -0.456362
4 -1.642511  0.432560  1.218080 -0.564705 -0.581790  0.286071  0.048725

         7         8         9         10        11        12        13  \
0 -1.201796 -1.422811 -0.882554  1.209871 -0.941235  0.863067 -0.336232
1  0.207232 -1.983857 -1.702547 -1.621234 -0.906840  1.014601 -0.475108
2  1.383381  0.085638  0.246392  0.965887  0.246354 -0.727728 -0.094414
3  0.089931  0.776079  0.752889 -1.195795 -1.425911 -0.548829  0.774225
4  1.002440  1.276582  0.054399  0.241963 -0.471786  0.314510 -0.059986

         14        15
0 -0.976847  0.033862
1 -0.358944  1.262942
2 -0.276854  0.158399
3  0.740501  1.510263
```

```
4 -2.069319 -1.115104

[5 rows x 16 columns]
```

The old behavior of printing out summary information can be achieved via the 'expand_frame_repr' print option:

```
In [25]: pd.set_option('expand_frame_repr', False)

In [26]: wide_frame
Out[26]:
         0         1         2         3         4         5         6         7
↪   8         9        10        11        12        13        14        15
0 -0.681624  0.191356  1.180274 -0.834179  0.703043  0.166568 -0.583599 -1.201796 -1.
↪422811 -0.882554  1.209871 -0.941235  0.863067 -0.336232 -0.976847  0.033862
1  0.441522 -0.316864 -0.017062  1.570114 -0.360875 -0.880096  0.235532  0.207232 -1.
↪983857 -1.702547 -1.621234 -0.906840  1.014601 -0.475108 -0.358944  1.262942
2 -0.412451 -0.462580  0.422194  0.288403 -0.487393 -0.777639  0.055865  1.383381  0.
↪085638  0.246392  0.965887  0.246354 -0.727728 -0.094414 -0.276854  0.158399
3 -0.277255  1.331263  0.585174 -0.568825 -0.719412  1.191340 -0.456362  0.089931  0.
↪776079  0.752889 -1.195795 -1.425911 -0.548829  0.774225  0.740501  1.510263
4 -1.642511  0.432560  1.218080 -0.564705 -0.581790  0.286071  0.048725  1.002440  1.
↪276582  0.054399  0.241963 -0.471786  0.314510 -0.059986 -2.069319 -1.115104

[5 rows x 16 columns]
```

The width of each line can be changed via 'line_width' (80 by default):

```
In [27]: pd.set_option('line_width', 40)

In [28]: wide_frame
Out[28]:
         0         1         2         3         4         5         6   \
0 -0.681624  0.191356  1.180274 -0.834179  0.703043  0.166568 -0.583599
1  0.441522 -0.316864 -0.017062  1.570114 -0.360875 -0.880096  0.235532
2 -0.412451 -0.462580  0.422194  0.288403 -0.487393 -0.777639  0.055865
3 -0.277255  1.331263  0.585174 -0.568825 -0.719412  1.191340 -0.456362
4 -1.642511  0.432560  1.218080 -0.564705 -0.581790  0.286071  0.048725

         7         8         9         10        11        12        13  \
0 -1.201796 -1.422811 -0.882554  1.209871 -0.941235  0.863067 -0.336232
1  0.207232 -1.983857 -1.702547 -1.621234 -0.906840  1.014601 -0.475108
2  1.383381  0.085638  0.246392  0.965887  0.246354 -0.727728 -0.094414
3  0.089931  0.776079  0.752889 -1.195795 -1.425911 -0.548829  0.774225
4  1.002440  1.276582  0.054399  0.241963 -0.471786  0.314510 -0.059986

         14        15
0 -0.976847  0.033862
1 -0.358944  1.262942
2 -0.276854  0.158399
3  0.740501  1.510263
4 -2.069319 -1.115104

[5 rows x 16 columns]
```

1.25.5 Updated PyTables Support

Docs for PyTables `Table` format & several enhancements to the api. Here is a taste of what to expect.

```
In [29]: store = HDFStore('store.h5')

In [30]: df = DataFrame(randn(8, 3), index=date_range('1/1/2000', periods=8),
   ....:             columns=['A', 'B', 'C'])
   ....:

In [31]: df
Out[31]:
                   A         B         C
2000-01-01 -0.369325 -1.502617 -0.376280
2000-01-02  0.511936 -0.116412 -0.625256
2000-01-03 -0.550627  1.261433 -0.552429
2000-01-04  1.695803 -1.025917 -0.910942
2000-01-05  0.426805 -0.131749  0.432600
2000-01-06  0.044671 -0.341265  1.844536
2000-01-07 -2.036047  0.000830 -0.955697
2000-01-08 -0.898872 -0.725411  0.059904

[8 rows x 3 columns]

# appending data frames
In [32]: df1 = df[0:4]

In [33]: df2 = df[4:]

In [34]: store.append('df', df1)

In [35]: store.append('df', df2)

In [36]: store
Out[36]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

# selecting the entire store
In [37]: store.select('df')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[37]:
                   A         B         C
2000-01-01 -0.369325 -1.502617 -0.376280
2000-01-02  0.511936 -0.116412 -0.625256
2000-01-03 -0.550627  1.261433 -0.552429
2000-01-04  1.695803 -1.025917 -0.910942
2000-01-05  0.426805 -0.131749  0.432600
2000-01-06  0.044671 -0.341265  1.844536
2000-01-07 -2.036047  0.000830 -0.955697
2000-01-08 -0.898872 -0.725411  0.059904

[8 rows x 3 columns]
```

```
In [38]: wp = Panel(randn(2, 5, 4), items=['Item1', 'Item2'],
   ....:         major_axis=date_range('1/1/2000', periods=5),
   ....:         minor_axis=['A', 'B', 'C', 'D'])
   ....:
```

```
In [39]: wp
Out[39]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to D

# storing a panel
In [40]: store.append('wp',wp)

# selecting via A QUERY
In [41]: store.select('wp', "major_axis>20000102 and minor_axis=['A','B']")
Out[41]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to B

# removing data from tables
In [42]: store.remove('wp', "major_axis>20000103")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪8

In [43]: store.select('wp')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 3 (major_axis) x 4 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-03 00:00:00
Minor_axis axis: A to D

# deleting a store
In [44]: del store['df']

In [45]: store
Out[45]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
```

Enhancements

- added ability to hierarchical keys

```
In [46]: store.put('foo/bar/bah', df)

In [47]: store.append('food/orange', df)

In [48]: store.append('food/apple',  df)

In [49]: store
Out[49]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

# remove all nodes under this level
```

```
In [50]: store.remove('food')

In [51]: store
Out[51]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
```

- added mixed-dtype support!

```
In [52]: df['string'] = 'string'

In [53]: df['int']    = 1

In [54]: store.append('df',df)

In [55]: df1 = store.select('df')

In [56]: df1
Out[56]:
                   A         B         C  string  int
2000-01-01 -0.369325 -1.502617 -0.376280  string    1
2000-01-02  0.511936 -0.116412 -0.625256  string    1
2000-01-03 -0.550627  1.261433 -0.552429  string    1
2000-01-04  1.695803 -1.025917 -0.910942  string    1
2000-01-05  0.426805 -0.131749  0.432600  string    1
2000-01-06  0.044671 -0.341265  1.844536  string    1
2000-01-07 -2.036047  0.000830 -0.955697  string    1
2000-01-08 -0.898872 -0.725411  0.059904  string    1

[8 rows x 5 columns]

In [57]: df1.get_dtype_counts()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
float64    3
int64      1
object     1
Length: 3, dtype: int64
```

- performance improvments on table writing
- support for arbitrarily indexed dimensions
- `SparseSeries` now has a `density` property (GH2384)
- enable `Series.str.strip/lstrip/rstrip` methods to take an input argument to strip arbitrary characters (GH2411)
- implement `value_vars` in `melt` to limit values to certain columns and add `melt` to pandas namespace (GH2412)

Bug Fixes

- added `Term` method of specifying where conditions (GH1996).
- `del store['df']` now call `store.remove('df')` for store deletion
- deleting of consecutive rows is much faster than before
- `min_itemsize` parameter can be specified in table creation to force a minimum size for indexing columns (the previous implementation would set the column size based on the first append)

- indexing support via `create_table_index` (requires PyTables >= 2.3) (GH698).
- appending on a store would fail if the table was not first created via `put`
- fixed issue with missing attributes after loading a pickled dataframe (GH2431)
- minor change to select and remove: require a table ONLY if where is also provided (and not None)

Compatibility

0.10 of `HDFStore` is backwards compatible for reading tables created in a prior version of pandas, however, query terms using the prior (undocumented) methodology are unsupported. You must read in the entire file and write it out using the new format to take advantage of the updates.

1.25.6 N Dimensional Panels (Experimental)

Adding experimental support for Panel4D and factory functions to create n-dimensional named panels. *Docs* for NDim. Here is a taste of what to expect.

```
In [58]: p4d = Panel4D(randn(2, 2, 5, 4),
   ....:       labels=['Label1','Label2'],
   ....:       items=['Item1', 'Item2'],
   ....:       major_axis=date_range('1/1/2000', periods=5),
   ....:       minor_axis=['A', 'B', 'C', 'D'])
   ....:

In [59]: p4d
Out[59]:
<class 'pandas.core.panelnd.Panel4D'>
Dimensions: 2 (labels) x 2 (items) x 5 (major_axis) x 4 (minor_axis)
Labels axis: Label1 to Label2
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to D
```

See the *full release notes* or issue tracker on GitHub for a complete list.

1.26 v0.9.1 (November 14, 2012)

This is a bugfix release from 0.9.0 and includes several new features and enhancements along with a large number of bug fixes. The new features include by-column sort order for DataFrame and Series, improved NA handling for the rank method, masking functions for DataFrame, and intraday time-series filtering for DataFrame.

1.26.1 New features

- *Series.sort*, *DataFrame.sort*, and *DataFrame.sort_index* can now be specified in a per-column manner to support multiple sort orders (GH928)

```
In [2]:  df = DataFrame(np.random.randint(0, 2, (6, 3)), columns=['A', 'B', 'C'])

In [3]: df.sort(['A', 'B'], ascending=[1, 0])

Out[3]:
   A  B  C
3  0  1  1
```

```
4  0  1  1
2  0  0  1
0  1  0  0
1  1  0  0
5  1  0  0
```

- *DataFrame.rank* now supports additional argument values for the *na_option* parameter so missing values can be assigned either the largest or the smallest rank (GH1508, GH2159)

```
In [1]: df = DataFrame(np.random.randn(6, 3), columns=['A', 'B', 'C'])

In [2]: df.loc[2:4] = np.nan

In [3]: df.rank()
Out[3]:
     A    B    C
0  3.0  1.0  3.0
1  2.0  2.0  1.0
2  NaN  NaN  NaN
3  NaN  NaN  NaN
4  NaN  NaN  NaN
5  1.0  3.0  2.0

[6 rows x 3 columns]

In [4]: df.rank(na_option='top')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     A    B    C
0  6.0  4.0  6.0
1  5.0  5.0  4.0
2  2.0  2.0  2.0
3  2.0  2.0  2.0
4  2.0  2.0  2.0
5  4.0  6.0  5.0

[6 rows x 3 columns]

In [5]: df.rank(na_option='bottom')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     A    B    C
0  3.0  1.0  3.0
1  2.0  2.0  1.0
2  5.0  5.0  5.0
3  5.0  5.0  5.0
4  5.0  5.0  5.0
5  1.0  3.0  2.0

[6 rows x 3 columns]
```

- DataFrame has new *where* and *mask* methods to select values according to a given boolean mask (GH2109, GH2151)

  > DataFrame currently supports slicing via a boolean vector the same length as the DataFrame (inside the *[]*). The returned DataFrame has the same number of columns as the original, but is sliced on its index.

```
In [6]: df = DataFrame(np.random.randn(5, 3), columns = ['A','B','C'])

In [7]: df
Out[7]:
          A         B         C
0  1.744738 -0.356939  0.092791
1  1.222637  1.909179  0.195946
2  0.481559 -0.404023 -1.115882
3  2.093925  0.010808 -1.775758
4  1.303175  0.025683 -1.795489

[5 rows x 3 columns]

In [8]: df[df['A'] > 0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B         C
0  1.744738 -0.356939  0.092791
1  1.222637  1.909179  0.195946
2  0.481559 -0.404023 -1.115882
3  2.093925  0.010808 -1.775758
4  1.303175  0.025683 -1.795489

[5 rows x 3 columns]
```

If a DataFrame is sliced with a DataFrame based boolean condition (with the same size as the original DataFrame), then a DataFrame the same size (index and columns) as the original is returned, with elements that do not meet the boolean condition as *NaN*. This is accomplished via the new method *DataFrame.where*. In addition, *where* takes an optional *other* argument for replacement.

```
In [9]: df[df>0]
Out[9]:
          A         B         C
0  1.744738       NaN  0.092791
1  1.222637  1.909179  0.195946
2  0.481559       NaN       NaN
3  2.093925  0.010808       NaN
4  1.303175  0.025683       NaN

[5 rows x 3 columns]

In [10]: df.where(df>0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B         C
0  1.744738       NaN  0.092791
1  1.222637  1.909179  0.195946
2  0.481559       NaN       NaN
3  2.093925  0.010808       NaN
4  1.303175  0.025683       NaN

[5 rows x 3 columns]

In [11]: df.where(df>0,-df)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B         C
0  1.744738  0.356939  0.092791
```

```
1  1.222637  1.909179  0.195946
2  0.481559  0.404023  1.115882
3  2.093925  0.010808  1.775758
4  1.303175  0.025683  1.795489

[5 rows x 3 columns]
```

Furthermore, *where* now aligns the input boolean condition (ndarray or DataFrame), such that partial selection with setting is possible. This is analagous to partial setting via *.ix* (but on the contents rather than the axis labels)

```
In [12]: df2 = df.copy()

In [13]: df2[ df2[1:4] > 0 ] = 3

In [14]: df2
Out[14]:
          A         B         C
0  1.744738 -0.356939  0.092791
1  3.000000  3.000000  3.000000
2  3.000000 -0.404023 -1.115882
3  3.000000  3.000000 -1.775758
4  1.303175  0.025683 -1.795489

[5 rows x 3 columns]
```

DataFrame.mask is the inverse boolean operation of *where*.

```
In [15]: df.mask(df<=0)
Out[15]:
          A         B         C
0  1.744738       NaN  0.092791
1  1.222637  1.909179  0.195946
2  0.481559       NaN       NaN
3  2.093925  0.010808       NaN
4  1.303175  0.025683       NaN

[5 rows x 3 columns]
```

- Enable referencing of Excel columns by their column names (GH1936)

```
In [16]: xl = ExcelFile('data/test.xls')

In [17]: xl.parse('Sheet1', index_col=0, parse_dates=True,
   ....:          parse_cols='A:D')
   ....:
Out[17]:
                   A         B         C         D
2000-01-03  0.980269  3.685731 -0.364217 -1.159738
2000-01-04  1.047916 -0.041232 -0.161812  0.212549
2000-01-05  0.498581  0.731168 -0.537677  1.346270
2000-01-06  1.120202  1.567621  0.003641  0.675253
2000-01-07 -0.487094  0.571455 -1.611639  0.103469
2000-01-10  0.836649  0.246462  0.588543  1.062782
2000-01-11 -0.157161  1.340307  1.195778 -1.097007

[7 rows x 4 columns]
```

- Added option to disable pandas-style tick locators and formatters using *series.plot(x_compat=True)* or *pandas.plot_params['x_compat'] = True* (GH2205)
- Existing TimeSeries methods *at_time* and *between_time* were added to DataFrame (GH2149)
- DataFrame.dot can now accept ndarrays (GH2042)
- DataFrame.drop now supports non-unique indexes (GH2101)
- Panel.shift now supports negative periods (GH2164)
- DataFrame now support unary ~ operator (GH2110)

1.26.2 API changes

- Upsampling data with a PeriodIndex will result in a higher frequency TimeSeries that spans the original time window

```
In [1]: prng = period_range('2012Q1', periods=2, freq='Q')

In [2]: s = Series(np.random.randn(len(prng)), prng)

In [4]: s.resample('M')
Out[4]:
2012-01   -1.471992
2012-02         NaN
2012-03         NaN
2012-04   -0.493593
2012-05         NaN
2012-06         NaN
Freq: M, dtype: float64
```

- Period.end_time now returns the last nanosecond in the time interval (GH2124, GH2125, GH1764)

```
In [18]: p = Period('2012')

In [19]: p.end_time
Out[19]: Timestamp('2012-12-31 23:59:59.999999999')
```

- File parsers no longer coerce to float or bool for columns that have custom converters specified (GH2184)

```
In [20]: data = 'A,B,C\n00001,001,5\n00002,002,6'

In [21]: read_csv(StringIO(data), converters={'A' : lambda x: x.strip()})
Out[21]:
       A  B  C
0  00001  1  5
1  00002  2  6

[2 rows x 3 columns]
```

See the *full release notes* or issue tracker on GitHub for a complete list.

1.27 v0.9.0 (October 7, 2012)

This is a major release from 0.8.1 and includes several new features and enhancements along with a large number of bug fixes. New features include vectorized unicode encoding/decoding for *Series.str*, *to_latex* method to DataFrame,

more flexible parsing of boolean values, and enabling the download of options data from Yahoo! Finance.

1.27.1 New features

- Add `encode` and `decode` for unicode handling to *vectorized string processing methods* in Series.str (GH1706)
- Add `DataFrame.to_latex` method (GH1735)
- Add convenient expanding window equivalents of all rolling_* ops (GH1785)
- Add Options class to pandas.io.data for fetching options data from Yahoo! Finance (GH1748, GH1739)
- More flexible parsing of boolean values (Yes, No, TRUE, FALSE, etc) (GH1691, GH1295)
- Add `level` parameter to `Series.reset_index`
- `TimeSeries.between_time` can now select times across midnight (GH1871)
- Series constructor can now handle generator as input (GH1679)
- `DataFrame.dropna` can now take multiple axes (tuple/list) as input (GH924)
- Enable `skip_footer` parameter in `ExcelFile.parse` (GH1843)

1.27.2 API changes

- The default column names when `header=None` and no columns names passed to functions like `read_csv` has changed to be more Pythonic and amenable to attribute access:

```
In [1]: data = '0,0,1\n1,1,0\n0,1,0'

In [2]: df = read_csv(StringIO(data), header=None)

In [3]: df
Out[3]:
   0  1  2
0  0  0  1
1  1  1  0
2  0  1  0

[3 rows x 3 columns]
```

- Creating a Series from another Series, passing an index, will cause reindexing to happen inside rather than treating the Series like an ndarray. Technically improper usages like `Series(df[col1], index=df[col2])` that worked before "by accident" (this was never intended) will lead to all NA Series in some cases. To be perfectly clear:

```
In [4]: s1 = Series([1, 2, 3])

In [5]: s1
Out[5]:
0    1
1    2
2    3
Length: 3, dtype: int64

In [6]: s2 = Series(s1, index=['foo', 'bar', 'baz'])

In [7]: s2
```

```
Out[7]:
foo   NaN
bar   NaN
baz   NaN
Length: 3, dtype: float64
```

- Deprecated `day_of_year` API removed from PeriodIndex, use `dayofyear` (GH1723)
- Don't modify NumPy suppress printoption to True at import time
- The internal HDF5 data arrangement for DataFrames has been transposed. Legacy files will still be readable by HDFStore (GH1834, GH1824)
- Legacy cruft removed: pandas.stats.misc.quantileTS
- Use ISO8601 format for Period repr: monthly, daily, and on down (GH1776)
- Empty DataFrame columns are now created as object dtype. This will prevent a class of TypeErrors that was occurring in code where the dtype of a column would depend on the presence of data or not (e.g. a SQL query having results) (GH1783)
- Setting parts of DataFrame/Panel using ix now aligns input Series/DataFrame (GH1630)
- `first` and `last` methods in `GroupBy` no longer drop non-numeric columns (GH1809)
- Resolved inconsistencies in specifying custom NA values in text parser. `na_values` of type dict no longer override default NAs unless `keep_default_na` is set to false explicitly (GH1657)
- `DataFrame.dot` will not do data alignment, and also work with Series (GH1915)

See the *full release notes* or issue tracker on GitHub for a complete list.

1.28 v0.8.1 (July 22, 2012)

This release includes a few new features, performance enhancements, and over 30 bug fixes from 0.8.0. New features include notably NA friendly string processing functionality and a series of new plot types and options.

1.28.1 New features

- Add *vectorized string processing methods* accessible via Series.str (GH620)
- Add option to disable adjustment in EWMA (GH1584)
- *Radviz plot* (GH1566)
- *Parallel coordinates plot*
- *Bootstrap plot*
- Per column styles and secondary y-axis plotting (GH1559)
- New datetime converters millisecond plotting (GH1599)
- Add option to disable "sparse" display of hierarchical indexes (GH1538)
- Series/DataFrame's `set_index` method can *append levels* to an existing Index/MultiIndex (GH1569, GH1577)

1.28.2 Performance improvements

- Improved implementation of rolling min and max (thanks to Bottleneck !)
- Add accelerated `'median'` GroupBy option (GH1358)
- Significantly improve the performance of parsing ISO8601-format date strings with `DatetimeIndex` or `to_datetime` (GH1571)
- Improve the performance of GroupBy on single-key aggregations and use with Categorical types
- Significant datetime parsing performance improvments

1.29 v0.8.0 (June 29, 2012)

This is a major release from 0.7.3 and includes extensive work on the time series handling and processing infrastructure as well as a great deal of new functionality throughout the library. It includes over 700 commits from more than 20 distinct authors. Most pandas 0.7.3 and earlier users should not experience any issues upgrading, but due to the migration to the NumPy datetime64 dtype, there may be a number of bugs and incompatibilities lurking. Lingering incompatibilities will be fixed ASAP in a 0.8.1 release if necessary. See the *full release notes* or issue tracker on GitHub for a complete list.

1.29.1 Support for non-unique indexes

All objects can now work with non-unique indexes. Data alignment / join operations work according to SQL join semantics (including, if application, index duplication in many-to-many joins)

1.29.2 NumPy datetime64 dtype and 1.6 dependency

Time series data are now represented using NumPy's datetime64 dtype; thus, pandas 0.8.0 now requires at least NumPy 1.6. It has been tested and verified to work with the development version (1.7+) of NumPy as well which includes some significant user-facing API changes. NumPy 1.6 also has a number of bugs having to do with nanosecond resolution data, so I recommend that you steer clear of NumPy 1.6's datetime64 API functions (though limited as they are) and only interact with this data using the interface that pandas provides.

See the end of the 0.8.0 section for a "porting" guide listing potential issues for users migrating legacy codebases from pandas 0.7 or earlier to 0.8.0.

Bug fixes to the 0.7.x series for legacy NumPy < 1.6 users will be provided as they arise. There will be no more further development in 0.7.x beyond bug fixes.

1.29.3 Time series changes and improvements

Note: With this release, legacy scikits.timeseries users should be able to port their code to use pandas.

Note: See *documentation* for overview of pandas timeseries API.

- New datetime64 representation **speeds up join operations and data alignment**, **reduces memory usage**, and improve serialization / deserialization performance significantly over datetime.datetime

- High performance and flexible **resample** method for converting from high-to-low and low-to-high frequency. Supports interpolation, user-defined aggregation functions, and control over how the intervals and result labeling are defined. A suite of high performance Cython/C-based resampling functions (including Open-High-Low-Close) have also been implemented.
- Revamp of *frequency aliases* and support for **frequency shortcuts** like '15min', or '1h30min'
- New *DatetimeIndex class* supports both fixed frequency and irregular time series. Replaces now deprecated DateRange class
- New `PeriodIndex` and `Period` classes for representing *time spans* and performing **calendar logic**, including the *12 fiscal quarterly frequencies <timeseries.quarterly>*. This is a partial port of, and a substantial enhancement to, elements of the scikits.timeseries codebase. Support for conversion between PeriodIndex and DatetimeIndex
- New Timestamp data type subclasses *datetime.datetime*, providing the same interface while enabling working with nanosecond-resolution data. Also provides *easy time zone conversions*.
- Enhanced support for *time zones*. Add *tz_convert* and `tz_lcoalize` methods to TimeSeries and DataFrame. All timestamps are stored as UTC; Timestamps from DatetimeIndex objects with time zone set will be localized to localtime. Time zone conversions are therefore essentially free. User needs to know very little about pytz library now; only time zone names as as strings are required. Time zone-aware timestamps are equal if and only if their UTC timestamps match. Operations between time zone-aware time series with different time zones will result in a UTC-indexed time series.
- Time series **string indexing conveniences /** shortcuts: slice years, year and month, and index values with strings
- Enhanced time series **plotting**; adaptation of scikits.timeseries matplotlib-based plotting code
- New `date_range`, `bdate_range`, and `period_range` *factory functions*
- Robust **frequency inference** function *infer_freq* and `inferred_freq` property of DatetimeIndex, with option to infer frequency on construction of DatetimeIndex
- to_datetime function efficiently **parses array of strings** to DatetimeIndex. DatetimeIndex will parse array or list of strings to datetime64
- **Optimized** support for datetime64-dtype data in Series and DataFrame columns
- New NaT (Not-a-Time) type to represent **NA** in timestamp arrays
- Optimize Series.asof for looking up **"as of" values** for arrays of timestamps
- Milli, Micro, Nano date offset objects
- Can index time series with datetime.time objects to select all data at particular **time of day** (`TimeSeries.at_time`) or **between two times** (`TimeSeries.between_time`)
- Add *tshift* method for leading/lagging using the frequency (if any) of the index, as opposed to a naive lead/lag using shift

1.29.4 Other new features

- New *cut* and `qcut` functions (like R's cut function) for computing a categorical variable from a continuous variable by binning values either into value-based (`cut`) or quantile-based (`qcut`) bins
- Rename `Factor` to `Categorical` and add a number of usability features
- Add *limit* argument to fillna/reindex
- More flexible multiple function application in GroupBy, and can pass list (name, function) tuples to get result in particular order with given names

- Add flexible *replace* method for efficiently substituting values
- Enhanced *read_csv/read_table* for reading time series data and converting multiple columns to dates
- Add *comments* option to parser functions: read_csv, etc.
- Add :ref'dayfirst <io.dayfirst>' option to parser functions for parsing international DD/MM/YYYY dates
- Allow the user to specify the CSV reader *dialect* to control quoting etc.
- Handling *thousands* separators in read_csv to improve integer parsing.
- Enable unstacking of multiple levels in one shot. Alleviate `pivot_table` bugs (empty columns being introduced)
- Move to klib-based hash tables for indexing; better performance and less memory usage than Python's dict
- Add first, last, min, max, and prod optimized GroupBy functions
- New *ordered_merge* function
- Add flexible *comparison* instance methods eq, ne, lt, gt, etc. to DataFrame, Series
- Improve *scatter_matrix* plotting function and add histogram or kernel density estimates to diagonal
- Add *'kde'* plot option for density plots
- Support for converting DataFrame to R data.frame through rpy2
- Improved support for complex numbers in Series and DataFrame
- Add *pct_change* method to all data structures
- Add max_colwidth configuration option for DataFrame console output
- *Interpolate* Series values using index values
- Can select multiple columns from GroupBy
- Add *update* methods to Series/DataFrame for updating values in place
- Add `any` and `all` method to DataFrame

1.29.5 New plotting methods

`Series.plot` now supports a `secondary_y` option:

```
In [1]: plt.figure()
Out[1]: <matplotlib.figure.Figure at 0x1298a9a58>

In [2]: fx['FR'].plot(style='g')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[2]: <matplotlib.axes._subplots.
↪AxesSubplot at 0x12b046ba8>

In [3]: fx['IT'].plot(style='k--', secondary_y=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪<matplotlib.axes._subplots.AxesSubplot at 0x129c83f98>
```

Vytautas Jancauskas, the 2012 GSOC participant, has added many new plot types. For example, `'kde'` is a new option:

```
In [4]: s = Series(np.concatenate((np.random.randn(1000),
   ...:                            np.random.randn(1000) * 0.5 + 3)))
   ...:
```

```
In [5]: plt.figure()
Out[5]: <matplotlib.figure.Figure at 0x1207ff9e8>

In [6]: s.hist(normed=True, alpha=0.2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[6]: <matplotlib.axes._subplots.
↪AxesSubplot at 0x1298a9668>

In [7]: s.plot(kind='kde')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪<matplotlib.axes._subplots.AxesSubplot at 0x1298a9668>
```

See *the plotting page* for much more.

1.29.6 Other API changes

- Deprecation of `offset`, `time_rule`, and `timeRule` arguments names in time series functions. Warnings will be printed until pandas 0.9 or 1.0.

1.29.7 Potential porting issues for pandas <= 0.7.3 users

The major change that may affect you in pandas 0.8.0 is that time series indexes use NumPy's `datetime64` data type instead of `dtype=object` arrays of Python's built-in `datetime.datetime` objects. `DateRange` has been replaced by `DatetimeIndex` but otherwise behaved identically. But, if you have code that converts `DateRange` or `Index` objects that used to contain `datetime.datetime` values to plain NumPy arrays, you may have bugs lurking with code using scalar values because you are handing control over to NumPy:

```
In [8]: import datetime

In [9]: rng = date_range('1/1/2000', periods=10)

In [10]: rng[5]
Out[10]: Timestamp('2000-01-06 00:00:00', freq='D')

In [11]: isinstance(rng[5], datetime.datetime)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[11]: True

In [12]: rng_asarray = np.asarray(rng)

In [13]: scalar_val = rng_asarray[5]

In [14]: type(scalar_val)
Out[14]: numpy.datetime64
```

pandas's `Timestamp` object is a subclass of `datetime.datetime` that has nanosecond support (the `nanosecond` field store the nanosecond value between 0 and 999). It should substitute directly into any code that used `datetime.datetime` values before. Thus, I recommend not casting `DatetimeIndex` to regular NumPy arrays.

If you have code that requires an array of `datetime.datetime` objects, you have a couple of options. First, the `asobject` property of `DatetimeIndex` produces an array of `Timestamp` objects:

```
In [15]: stamp_array = rng.asobject

In [16]: stamp_array
```

```
Out[16]:
Index([2000-01-01 00:00:00, 2000-01-02 00:00:00, 2000-01-03 00:00:00,
       2000-01-04 00:00:00, 2000-01-05 00:00:00, 2000-01-06 00:00:00,
       2000-01-07 00:00:00, 2000-01-08 00:00:00, 2000-01-09 00:00:00,
       2000-01-10 00:00:00],
      dtype='object')

In [17]: stamp_array[5]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2000-01-06 00:00:00', freq='D')
```

To get an array of proper `datetime.datetime` objects, use the `to_pydatetime` method:

```
In [18]: dt_array = rng.to_pydatetime()

In [19]: dt_array
Out[19]:
array([datetime.datetime(2000, 1, 1, 0, 0),
       datetime.datetime(2000, 1, 2, 0, 0),
       datetime.datetime(2000, 1, 3, 0, 0),
       datetime.datetime(2000, 1, 4, 0, 0),
       datetime.datetime(2000, 1, 5, 0, 0),
       datetime.datetime(2000, 1, 6, 0, 0),
       datetime.datetime(2000, 1, 7, 0, 0),
       datetime.datetime(2000, 1, 8, 0, 0),
       datetime.datetime(2000, 1, 9, 0, 0),
       datetime.datetime(2000, 1, 10, 0, 0)], dtype=object)

In [20]: dt_array[5]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪datetime.datetime(2000, 1, 6, 0, 0)
```

matplotlib knows how to handle `datetime.datetime` but not Timestamp objects. While I recommend that you plot time series using `TimeSeries.plot`, you can either use `to_pydatetime` or register a converter for the Timestamp type. See matplotlib documentation for more on this.

Warning: There are bugs in the user-facing API with the nanosecond datetime64 unit in NumPy 1.6. In particular, the string version of the array shows garbage values, and conversion to `dtype=object` is similarly broken.

```
In [21]: rng = date_range('1/1/2000', periods=10)

In [22]: rng
Out[22]:
DatetimeIndex(['2000-01-01', '2000-01-02', '2000-01-03', '2000-01-04',
               '2000-01-05', '2000-01-06', '2000-01-07', '2000-01-08',
               '2000-01-09', '2000-01-10'],
              dtype='datetime64[ns]', freq='D')

In [23]: np.asarray(rng)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
array(['2000-01-01T00:00:00.000000000', '2000-01-02T00:00:00.000000000',
       '2000-01-03T00:00:00.000000000', '2000-01-04T00:00:00.000000000',
       '2000-01-05T00:00:00.000000000', '2000-01-06T00:00:00.000000000',
       '2000-01-07T00:00:00.000000000', '2000-01-08T00:00:00.000000000',
       '2000-01-09T00:00:00.000000000', '2000-01-10T00:00:00.000000000'], dtype=
↪'datetime64[ns]')

In [24]: converted = np.asarray(rng, dtype=object)

In [25]: converted[5]
Out[25]: 947116800000000000
```

Trust me: don't panic. If you are using NumPy 1.6 and restrict your interaction with `datetime64` values to pandas's API you will be just fine. There is nothing wrong with the data-type (a 64-bit integer internally); all of the important data processing happens in pandas and is heavily tested. I strongly recommend that you **do not work directly with datetime64 arrays in NumPy 1.6** and only use the pandas API.

Support for non-unique indexes: In the latter case, you may have code inside a `try:... catch:` block that failed due to the index not being unique. In many cases it will no longer fail (some method like `append` still check for uniqueness unless disabled). However, all is not lost: you can inspect `index.is_unique` and raise an exception explicitly if it is `False` or go to a different code branch.

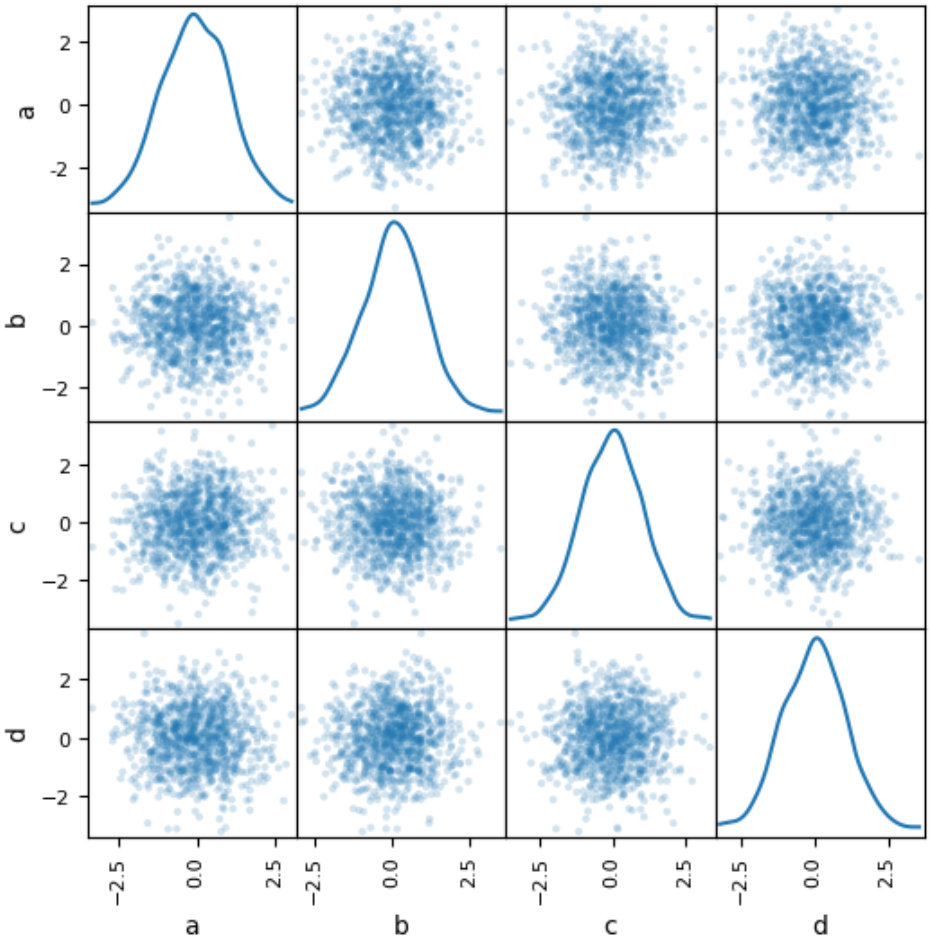
1.30 v.0.7.3 (April 12, 2012)

This is a minor release from 0.7.2 and fixes many minor bugs and adds a number of nice new features. There are also a couple of API changes to note; these should not affect very many users, and we are inclined to call them "bug fixes" even though they do constitute a change in behavior. See the *full release notes* or issue tracker on GitHub for a complete list.

1.30.1 New features

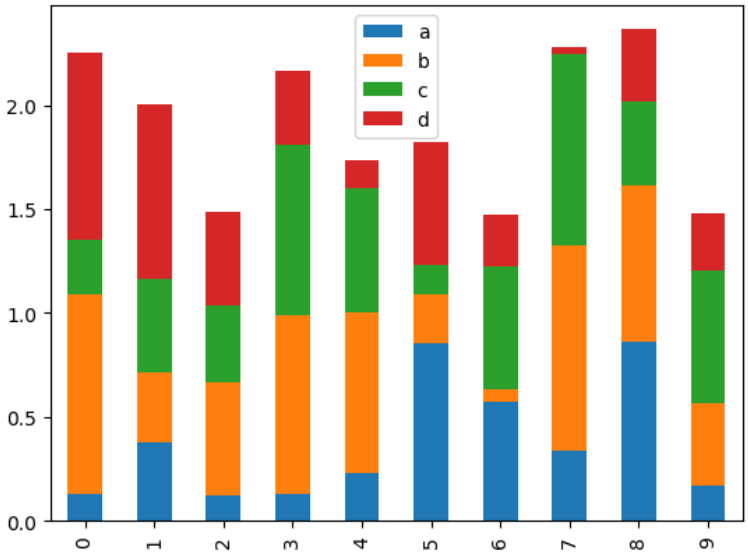
- New *fixed width file reader*, `read_fwf`
- New *scatter_matrix* function for making a scatter plot matrix

```
from pandas.tools.plotting import scatter_matrix
scatter_matrix(df, alpha=0.2)
```

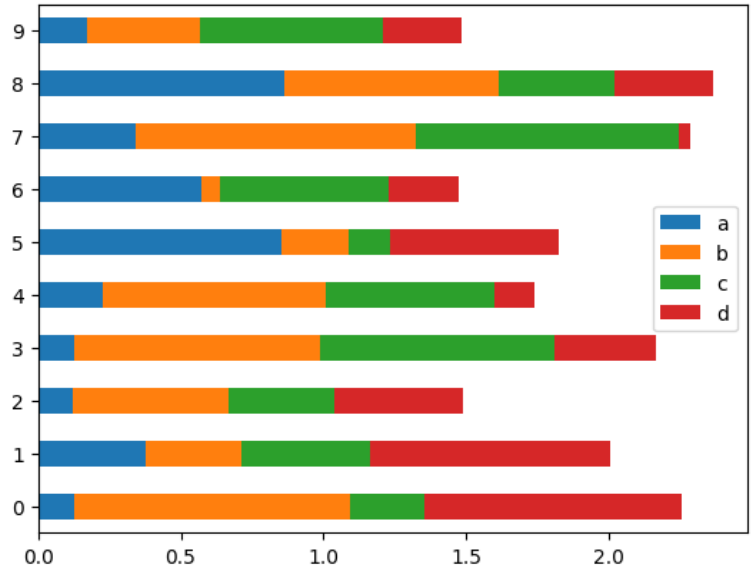


- Add `stacked` argument to Series and DataFrame's `plot` method for *stacked bar plots*.

```
df.plot(kind='bar', stacked=True)
```



```
df.plot(kind='barh', stacked=True)
```



- Add log x and y *scaling options* to `DataFrame.plot` and `Series.plot`
- Add `kurt` methods to Series and DataFrame for computing kurtosis

1.30.2 NA Boolean Comparison API Change

Reverted some changes to how NA values (represented typically as `NaN` or `None`) are handled in non-numeric Series:

```
In [1]: series = Series(['Steve', np.nan, 'Joe'])

In [2]: series == 'Steve'
Out[2]:
0     True
1    False
2    False
Length: 3, dtype: bool

In [3]: series != 'Steve'
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[3]:
0    False
1     True
2     True
Length: 3, dtype: bool
```

In comparisons, NA / NaN will always come through as `False` except with `!=` which is `True`. *Be very careful* with boolean arithmetic, especially negation, in the presence of NA data. You may wish to add an explicit NA filter into boolean array operations if you are worried about this:

```
In [4]: mask = series == 'Steve'

In [5]: series[mask & series.notnull()]
Out[5]:
0    Steve
Length: 1, dtype: object
```

While propagating NA in comparisons may seem like the right behavior to some users (and you could argue on purely technical grounds that this is the right thing to do), the evaluation was made that propagating NA everywhere, including in numerical arrays, would cause a large amount of problems for users. Thus, a "practicality beats purity" approach was taken. This issue may be revisited at some point in the future.

1.30.3 Other API Changes

When calling `apply` on a grouped Series, the return value will also be a Series, to be more consistent with the `groupby` behavior with DataFrame:

```
In [6]: df = DataFrame({'A' : ['foo', 'bar', 'foo', 'bar',
   ...:                        'foo', 'bar', 'foo', 'foo'],
   ...:                 'B' : ['one', 'one', 'two', 'three',
   ...:                          'two', 'two', 'one', 'three'],
   ...:                 'C' : np.random.randn(8), 'D' : np.random.randn(8)})
   ...:

In [7]: df
Out[7]:
     A      B         C         D
0  foo    one  1.075059 -0.449141
1  bar    one  0.785676  1.443014
2  foo    two  0.958157  0.612324
3  bar  three  1.477773 -0.178818
4  foo    two -1.006023  0.133072
5  bar    two -1.506997 -0.550981
6  foo    one  1.218042 -2.043335
7  foo  three -0.565878  0.753539

[8 rows x 4 columns]

In [8]: grouped = df.groupby('A')['C']

In [9]: grouped.describe()
Out[9]:
     count      mean       std       min       25%       50%       75%  \
A
bar    3.0  0.252151  1.562274 -1.506997 -0.360661  0.785676  1.131724
foo    5.0  0.335871  1.039915 -1.006023 -0.565878  0.958157  1.075059

          max
A
bar  1.477773
foo  1.218042

[2 rows x 8 columns]

In [10]: grouped.apply(lambda x: x.sort_values()[-2:]) # top 2 values
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A
bar  1    0.785676
     3    1.477773
foo  0    1.075059
     6    1.218042
Name: C, Length: 4, dtype: float64
```

1.31 v.0.7.2 (March 16, 2012)

This release targets bugs in 0.7.1, and adds a few minor features.

1.31.1 New features

- Add additional tie-breaking methods in DataFrame.rank (GH874)
- Add ascending parameter to rank in Series, DataFrame (GH875)
- Add coerce_float option to DataFrame.from_records (GH893)
- Add sort_columns parameter to allow unsorted plots (GH918)
- Enable column access via attributes on GroupBy (GH882)
- Can pass dict of values to DataFrame.fillna (GH661)
- Can select multiple hierarchical groups by passing list of values in .ix (GH134)
- Add `axis` option to DataFrame.fillna (GH174)
- Add level keyword to `drop` for dropping values from a level (GH159)

1.31.2 Performance improvements

- Use khash for Series.value_counts, add raw function to algorithms.py (GH861)
- Intercept __builtin__.sum in groupby (GH885)

1.32 v.0.7.1 (February 29, 2012)

This release includes a few new features and addresses over a dozen bugs in 0.7.0.

1.32.1 New features

- Add `to_clipboard` function to pandas namespace for writing objects to the system clipboard (GH774)
- Add `itertuples` method to DataFrame for iterating through the rows of a dataframe as tuples (GH818)
- Add ability to pass fill_value and method to DataFrame and Series align method (GH806, GH807)
- Add fill_value option to reindex, align methods (GH784)
- Enable concat to produce DataFrame from Series (GH787)
- Add `between` method to Series (GH802)
- Add HTML representation hook to DataFrame for the IPython HTML notebook (GH773)
- Support for reading Excel 2007 XML documents using openpyxl

1.32.2 Performance improvements

- Improve performance and memory usage of fillna on DataFrame
- Can concatenate a list of Series along axis=1 to obtain a DataFrame (GH787)

1.33 v.0.7.0 (February 9, 2012)

1.33.1 New features

- New unified *merge function* for efficiently performing full gamut of database / relational-algebra operations. Refactored existing join methods to use the new infrastructure, resulting in substantial performance gains (GH220, GH249, GH267)
- New *unified concatenation function* for concatenating Series, DataFrame or Panel objects along an axis. Can form union or intersection of the other axes. Improves performance of `Series.append` and `DataFrame.append` (GH468, GH479, GH273)
- *Can* pass multiple DataFrames to *DataFrame.append* to concatenate (stack) and multiple Series to `Series.append` too
- *Can* pass list of dicts (e.g., a list of JSON objects) to DataFrame constructor (GH526)
- You can now *set multiple columns* in a DataFrame via `__getitem__`, useful for transformation (GH342)
- Handle differently-indexed output values in `DataFrame.apply` (GH498)

```
In [1]: df = DataFrame(randn(10, 4))

In [2]: df.apply(lambda x: x.describe())
Out[2]:
               0          1          2          3
count  10.000000  10.000000  10.000000  10.000000
mean   -0.409608   0.539495   0.163276   0.051646
std     1.397779   0.968808   0.874489   0.719651
min    -2.539411  -0.737206  -1.202276  -1.050435
25%    -1.202202   0.021308  -0.368812  -0.383608
50%    -0.384480   0.306124   0.211431   0.165586
75%     0.186280   1.024039   0.730744   0.494457
max     2.524998   2.533114   1.334428   1.147396

[8 rows x 4 columns]
```

- *Add* `reorder_levels` method to Series and DataFrame (GH534)
- *Add* dict-like `get` function to DataFrame and Panel (GH521)
- *Add* `DataFrame.iterrows` method for efficiently iterating through the rows of a DataFrame
- *Add* `DataFrame.to_panel` with code adapted from `LongPanel.to_long`
- *Add* `reindex_axis` method added to DataFrame
- *Add* `level` option to binary arithmetic functions on `DataFrame` and `Series`
- *Add* `level` option to the `reindex` and `align` methods on Series and DataFrame for broadcasting values across a level (GH542, GH552, others)
- *Add* attribute-based item access to `Panel` and add IPython completion (GH563)
- *Add* `logy` option to `Series.plot` for log-scaling on the Y axis
- *Add* `index` and `header` options to `DataFrame.to_string`
- *Can* pass multiple DataFrames to `DataFrame.join` to join on index (GH115)
- *Can* pass multiple Panels to `Panel.join` (GH115)
- *Added* `justify` argument to `DataFrame.to_string` to allow different alignment of column headers

- *Add* `sort` option to GroupBy to allow disabling sorting of the group keys for potential speedups (GH595)
- *Can* pass MaskedArray to Series constructor (GH563)
- *Add* Panel item access via attributes and IPython completion (GH554)
- Implement `DataFrame.lookup`, fancy-indexing analogue for retrieving values given a sequence of row and column labels (GH338)
- Can pass a *list of functions* to aggregate with groupby on a DataFrame, yielding an aggregated result with hierarchical columns (GH166)
- Can call `cummin` and `cummax` on Series and DataFrame to get cumulative minimum and maximum, respectively (GH647)
- `value_range` added as utility function to get min and max of a dataframe (GH288)
- Added `encoding` argument to `read_csv`, `read_table`, `to_csv` and `from_csv` for non-ascii text (GH717)
- *Added* `abs` method to pandas objects
- *Added* `crosstab` function for easily computing frequency tables
- *Added* `isin` method to index objects
- *Added* `level` argument to `xs` method of DataFrame.

1.33.2 API Changes to integer indexing

One of the potentially riskiest API changes in 0.7.0, but also one of the most important, was a complete review of how **integer indexes** are handled with regard to label-based indexing. Here is an example:

```
In [3]: s = Series(randn(10), index=range(0, 20, 2))

In [4]: s
Out[4]:
0    -0.543429
2     1.425447
4    -0.408795
6    -1.489348
8    -1.166408
10   -0.481205
12   -0.810355
14   -0.985491
16   -0.336246
18   -0.629058
Length: 10, dtype: float64

In [5]: s[0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪-0.54342898765020686

In [6]: s[2]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪1.4254474252163707

In [7]: s[4]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪-0.40879476802408349
```

This is all exactly identical to the behavior before. However, if you ask for a key **not** contained in the Series, in versions 0.6.1 and prior, Series would *fall back* on a location-based lookup. This now raises a `KeyError`:

```
In [2]: s[1]
KeyError: 1
```

This change also has the same impact on DataFrame:

```
In [3]: df = DataFrame(randn(8, 4), index=range(0, 16, 2))

In [4]: df
    0        1       2       3
0   0.88427  0.3363 -0.1787  0.03162
2   0.14451 -0.1415  0.2504  0.58374
4  -1.44779 -0.9186 -1.4996  0.27163
6  -0.26598 -2.4184 -0.2658  0.11503
8  -0.58776  0.3144 -0.8566  0.61941
10  0.10940 -0.7175 -1.0108  0.47990
12 -1.16919 -0.3087 -0.6049 -0.43544
14 -0.07337  0.3410  0.0424 -0.16037

In [5]: df.ix[3]
KeyError: 3
```

In order to support purely integer-based indexing, the following methods have been added:

Method	Description
`Series.iget_value(i)`	Retrieve value stored at location `i`
`Series.iget(i)`	Alias for `iget_value`
`DataFrame.irow(i)`	Retrieve the `i`-th row
`DataFrame.icol(j)`	Retrieve the `j`-th column
`DataFrame.iget_value(i, j)`	Retrieve the value at row `i` and column `j`

1.33.3 API tweaks regarding label-based slicing

Label-based slicing using `ix` now requires that the index be sorted (monotonic) **unless** both the start and endpoint are contained in the index:

```
In [1]: s = Series(randn(6), index=list('gmkaec'))

In [2]: s
Out[2]:
g   -1.182230
m   -0.276183
k   -0.243550
a    1.628992
e    0.073308
c   -0.539890
dtype: float64
```

Then this is OK:

```
In [3]: s.ix['k':'e']
Out[3]:
k   -0.243550
a    1.628992
```

```
e    0.073308
dtype: float64
```

But this is not:

```
In [12]: s.ix['b':'h']
KeyError 'b'
```

If the index had been sorted, the "range selection" would have been possible:

```
In [4]: s2 = s.sort_index()

In [5]: s2
Out[5]:
a    1.628992
c   -0.539890
e    0.073308
g   -1.182230
k   -0.243550
m   -0.276183
dtype: float64

In [6]: s2.ix['b':'h']
Out[6]:
c   -0.539890
e    0.073308
g   -1.182230
dtype: float64
```

1.33.4 Changes to Series `[]` operator

As as notational convenience, you can pass a sequence of labels or a label slice to a Series when getting and setting values via `[]` (i.e. the `__getitem__` and `__setitem__` methods). The behavior will be the same as passing similar input to `ix` **except in the case of integer indexing**:

```
In [8]: s = Series(randn(6), index=list('acegkm'))

In [9]: s
Out[9]:
a   -0.297788
c    0.499769
e    0.810531
g    0.414649
k   -1.551478
m    1.012459
Length: 6, dtype: float64

In [10]: s[['m', 'a', 'c', 'e']]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
m    1.012459
a   -0.297788
c    0.499769
e    0.810531
Length: 4, dtype: float64
```

```
In [11]: s['b':'l']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
c    0.499769
e    0.810531
g    0.414649
k   -1.551478
Length: 4, dtype: float64

In [12]: s['c':'k']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
c    0.499769
e    0.810531
g    0.414649
k   -1.551478
Length: 4, dtype: float64
```

In the case of integer indexes, the behavior will be exactly as before (shadowing `ndarray`):

```
In [13]: s = Series(randn(6), index=range(0, 12, 2))

In [14]: s[[4, 0, 2]]
Out[14]:
4    0.928877
0    1.171752
2    0.026488
Length: 3, dtype: float64

In [15]: s[1:5]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[15]:␣
↪
2    0.026488
4    0.928877
6   -1.264991
8    0.419449
Length: 4, dtype: float64
```

If you wish to do indexing with sequences and slicing on an integer index with label semantics, use `ix`.

1.33.5 Other API Changes

- The deprecated `LongPanel` class has been completely removed
- If `Series.sort` is called on a column of a DataFrame, an exception will now be raised. Before it was possible to accidentally mutate a DataFrame's column by doing `df[col].sort()` instead of the side-effect free method `df[col].order()` (GH316)
- Miscellaneous renames and deprecations which will (harmlessly) raise `FutureWarning`
- `drop` added as an optional parameter to `DataFrame.reset_index` (GH699)

1.33.6 Performance improvements

- *Cythonized GroupBy aggregations* no longer presort the data, thus achieving a significant speedup (GH93). GroupBy aggregations with Python functions significantly sped up by clever manipulation of the ndarray data

type in Cython (GH496).

- Better error message in DataFrame constructor when passed column labels don't match data (GH497)
- Substantially improve performance of multi-GroupBy aggregation when a Python function is passed, reuse ndarray object in Cython (GH496)
- Can store objects indexed by tuples and floats in HDFStore (GH492)
- Don't print length by default in Series.to_string, add *length* option (GH489)
- Improve Cython code for multi-groupby to aggregate without having to sort the data (GH93)
- Improve MultiIndex reindexing speed by storing tuples in the MultiIndex, test for backwards unpickling compatibility
- Improve column reindexing performance by using specialized Cython take function
- Further performance tweaking of Series.__getitem__ for standard use cases
- Avoid Index dict creation in some cases (i.e. when getting slices, etc.), regression from prior versions
- Friendlier error message in setup.py if NumPy not installed
- Use common set of NA-handling operations (sum, mean, etc.) in Panel class also (GH536)
- Default name assignment when calling `reset_index` on DataFrame with a regular (non-hierarchical) index (GH476)
- Use Cythonized groupers when possible in Series/DataFrame stat ops with `level` parameter passed (GH545)
- Ported skiplist data structure to C to speed up `rolling_median` by about 5-10x in most typical use cases (GH374)

1.34 v.0.6.1 (December 13, 2011)

1.34.1 New features

- Can *append single rows* (as Series) to a DataFrame
- Add Spearman and Kendall rank *correlation* options to Series.corr and DataFrame.corr (GH428)
- *Added* `get_value` and `set_value` methods to Series, DataFrame, and Panel for very low-overhead access (>2x faster in many cases) to scalar elements (GH437, GH438). `set_value` is capable of producing an enlarged object.
- Add PyQt table widget to sandbox (GH435)
- DataFrame.align can *accept Series arguments* and an *axis option* (GH461)
- Implement new *SparseArray* and *SparseList* data structures. SparseSeries now derives from SparseArray (GH463)
- *Better console printing options* (GH453)
- Implement fast *data ranking* for Series and DataFrame, fast versions of scipy.stats.rankdata (GH428)
- Implement *DataFrame.from_items* alternate constructor (GH444)
- DataFrame.convert_objects method for *inferring better dtypes* for object columns (GH302)
- Add *rolling_corr_pairwise* function for computing Panel of correlation matrices (GH189)
- Add *margins* option to *pivot_table* for computing subgroup aggregates (GH114)

- Add `Series.from_csv` function (GH482)
- *Can pass* DataFrame/DataFrame and DataFrame/Series to rolling_corr/rolling_cov (GH #462)
- MultiIndex.get_level_values can *accept the level name*

1.34.2 Performance improvements

- Improve memory usage of *DataFrame.describe* (do not copy data unnecessarily) (PR #425)
- Optimize scalar value lookups in the general case by 25% or more in Series and DataFrame
- Fix performance regression in cross-sectional count in DataFrame, affecting DataFrame.dropna speed
- Column deletion in DataFrame copies no data (computes views on blocks) (GH #158)

1.35 v.0.6.0 (November 25, 2011)

1.35.1 New Features

- *Added* `melt` function to `pandas.core.reshape`
- *Added* `level` parameter to group by level in Series and DataFrame descriptive statistics (GH313)
- *Added* `head` and `tail` methods to Series, analogous to to DataFrame (GH296)
- *Added* `Series.isin` function which checks if each value is contained in a passed sequence (GH289)
- *Added* `float_format` option to `Series.to_string`
- *Added* `skip_footer` (GH291) and `converters` (GH343) options to `read_csv` and `read_table`
- *Added* `drop_duplicates` and `duplicated` functions for removing duplicate DataFrame rows and checking for duplicate rows, respectively (GH319)
- *Implemented* operators '&', '|', '^', '-' on DataFrame (GH347)
- *Added* `Series.mad`, mean absolute deviation
- *Added* `QuarterEnd` DateOffset (GH321)
- *Added* `dot` to DataFrame (GH65)
- *Added* `orient` option to `Panel.from_dict` (GH359, GH301)
- *Added* `orient` option to `DataFrame.from_dict`
- *Added* passing list of tuples or list of lists to `DataFrame.from_records` (GH357)
- *Added* multiple levels to groupby (GH103)
- *Allow* multiple columns in `by` argument of `DataFrame.sort_index` (GH92, GH362)
- *Added* fast `get_value` and `put_value` methods to DataFrame (GH360)
- *Added* `cov` instance methods to Series and DataFrame (GH194, GH362)
- *Added* `kind='bar'` option to `DataFrame.plot` (GH348)
- *Added* `idxmin` and `idxmax` to Series and DataFrame (GH286)
- *Added* `read_clipboard` function to parse DataFrame from clipboard (GH300)
- *Added* `nunique` function to Series for counting unique elements (GH297)

- *Made* DataFrame constructor use Series name if no columns passed (GH373)
- *Support* regular expressions in read_table/read_csv (GH364)
- *Added* `DataFrame.to_html` for writing DataFrame to HTML (GH387)
- *Added* support for MaskedArray data in DataFrame, masked values converted to NaN (GH396)
- *Added* `DataFrame.boxplot` function (GH368)
- *Can* pass extra args, kwds to DataFrame.apply (GH376)
- *Implement* `DataFrame.join` with vector `on` argument (GH312)
- *Added* `legend` boolean flag to `DataFrame.plot` (GH324)
- *Can* pass multiple levels to `stack` and `unstack` (GH370)
- *Can* pass multiple values columns to `pivot_table` (GH381)
- *Use* Series name in GroupBy for result index (GH363)
- *Added* `raw` option to `DataFrame.apply` for performance if only need ndarray (GH309)
- Added proper, tested weighted least squares to standard and panel OLS (GH303)

1.35.2 Performance Enhancements

- VBENCH Cythonized `cache_readonly`, resulting in substantial micro-performance enhancements throughout the codebase (GH361)
- VBENCH Special Cython matrix iterator for applying arbitrary reduction operations with 3-5x better performance than *np.apply_along_axis* (GH309)
- VBENCH Improved performance of `MultiIndex.from_tuples`
- VBENCH Special Cython matrix iterator for applying arbitrary reduction operations
- VBENCH + DOCUMENT Add `raw` option to `DataFrame.apply` for getting better performance when
- VBENCH Faster cythonized count by level in Series and DataFrame (GH341)
- VBENCH? Significant GroupBy performance enhancement with multiple keys with many "empty" combinations
- VBENCH New Cython vectorized function `map_infer` speeds up `Series.apply` and `Series.map` significantly when passed elementwise Python function, motivated by (GH355)
- VBENCH Significantly improved performance of `Series.order`, which also makes np.unique called on a Series faster (GH327)
- VBENCH Vastly improved performance of GroupBy on axes with a MultiIndex (GH299)

1.36 v.0.5.0 (October 24, 2011)

1.36.1 New Features

- *Added* `DataFrame.align` method with standard join options
- *Added* `parse_dates` option to `read_csv` and `read_table` methods to optionally try to parse dates in the index columns

- *Added* `nrows`, `chunksize`, and `iterator` arguments to `read_csv` and `read_table`. The last two return a new `TextParser` class capable of lazily iterating through chunks of a flat file (GH242)
- *Added* ability to join on multiple columns in `DataFrame.join` (GH214)
- Added private `_get_duplicates` function to `Index` for identifying duplicate values more easily (ENH5c)
- *Added* column attribute access to DataFrame.
- *Added* Python tab completion hook for DataFrame columns. (GH233, GH230)
- *Implemented* `Series.describe` for Series containing objects (GH241)
- *Added* inner join option to `DataFrame.join` when joining on key(s) (GH248)
- *Implemented* selecting DataFrame columns by passing a list to `__getitem__` (GH253)
- *Implemented* & and | to intersect / union Index objects, respectively (GH261)
- *Added* `pivot_table` convenience function to pandas namespace (GH234)
- *Implemented* `Panel.rename_axis` function (GH243)
- DataFrame will show index level names in console output (GH334)
- *Implemented* `Panel.take`
- *Added* `set_eng_float_format` for alternate DataFrame floating point string formatting (ENH61)
- *Added* convenience `set_index` function for creating a DataFrame index from its existing columns
- *Implemented* `groupby` hierarchical index level name (GH223)
- *Added* support for different delimiters in `DataFrame.to_csv` (GH244)
- TODO: DOCS ABOUT TAKE METHODS

1.36.2 Performance Enhancements

- VBENCH Major performance improvements in file parsing functions `read_csv` and `read_table`
- VBENCH Added Cython function for converting tuples to ndarray very fast. Speeds up many MultiIndex-related operations
- VBENCH Refactored merging / joining code into a tidy class and disabled unnecessary computations in the float/object case, thus getting about 10% better performance (GH211)
- VBENCH Improved speed of `DataFrame.xs` on mixed-type DataFrame objects by about 5x, regression from 0.3.0 (GH215)
- VBENCH With new `DataFrame.align` method, speeding up binary operations between differently-indexed DataFrame objects by 10-25%.
- VBENCH Significantly sped up conversion of nested dict into DataFrame (GH212)
- VBENCH Significantly speed up DataFrame `__repr__` and `count` on large mixed-type DataFrame objects

1.37 v.0.4.3 through v0.4.1 (September 25 - October 9, 2011)

1.37.1 New Features

- Added Python 3 support using 2to3 (GH200)

- *Added* `name` attribute to `Series`, now prints as part of `Series.__repr__`
- *Added* instance methods `isnull` and `notnull` to Series (GH209, GH203)
- *Added* `Series.align` method for aligning two series with choice of join method (ENH56)
- *Added* method `get_level_values` to `MultiIndex` (GH188)
- Set values in mixed-type `DataFrame` objects via `.ix` indexing attribute (GH135)
- Added new `DataFrame` *methods* `get_dtype_counts` and property `dtypes` (ENHdc)
- Added *ignore_index* option to `DataFrame.append` to stack DataFrames (ENH1b)
- `read_csv` tries to *sniff* delimiters using `csv.Sniffer` (GH146)
- `read_csv` can *read* multiple columns into a `MultiIndex`; DataFrame's `to_csv` method writes out a corresponding `MultiIndex` (GH151)
- `DataFrame.rename` has a new `copy` parameter to *rename* a DataFrame in place (ENHed)
- *Enable* unstacking by name (GH142)
- *Enable* `sortlevel` to work by level (GH141)

1.37.2 Performance Enhancements

- Altered binary operations on differently-indexed SparseSeries objects to use the integer-based (dense) alignment logic which is faster with a larger number of blocks (GH205)
- Wrote faster Cython data alignment / merging routines resulting in substantial speed increases
- Improved performance of `isnull` and `notnull`, a regression from v0.3.0 (GH187)
- Refactored code related to `DataFrame.join` so that intermediate aligned copies of the data in each `DataFrame` argument do not need to be created. Substantial performance increases result (GH176)
- Substantially improved performance of generic `Index.intersection` and `Index.union`
- Implemented `BlockManager.take` resulting in significantly faster `take` performance on mixed-type `DataFrame` objects (GH104)
- Improved performance of `Series.sort_index`
- Significant groupby performance enhancement: removed unnecessary integrity checks in DataFrame internals that were slowing down slicing operations to retrieve groups
- Optimized `_ensure_index` function resulting in performance savings in type-checking Index objects
- Wrote fast time series merging / joining methods in Cython. Will be integrated later into DataFrame.join and related functions

CHAPTER

TWO

INSTALLATION

The easiest way for the majority of users to install pandas is to install it as part of the Anaconda distribution, a cross platform distribution for data analysis and scientific computing. This is the recommended installation method for most users.

Instructions for installing from source, PyPI, various Linux distributions, or a development version are also provided.

2.1 Python version support

Officially Python 2.7, 3.5, and 3.6.

2.2 Installing pandas

2.2.1 Installing pandas with Anaconda

Installing pandas and the rest of the NumPy and SciPy stack can be a little difficult for inexperienced users.

The simplest way to install not only pandas, but Python and the most popular packages that make up the SciPy stack (IPython, NumPy, Matplotlib, ...) is with Anaconda, a cross-platform (Linux, Mac OS X, Windows) Python distribution for data analytics and scientific computing.

After running a simple installer, the user will have access to pandas and the rest of the SciPy stack without needing to install anything else, and without needing to wait for any software to be compiled.

Installation instructions for Anaconda can be found here.

A full list of the packages available as part of the Anaconda distribution can be found here.

An additional advantage of installing with Anaconda is that you don't require admin rights to install it, it will install in the user's home directory, and this also makes it trivial to delete Anaconda at a later date (just delete that folder).

2.2.2 Installing pandas with Miniconda

The previous section outlined how to get pandas installed as part of the Anaconda distribution. However this approach means you will install well over one hundred packages and involves downloading the installer which is a few hundred megabytes in size.

If you want to have more control on which packages, or have a limited internet bandwidth, then installing pandas with Miniconda may be a better solution.

Conda is the package manager that the Anaconda distribution is built upon. It is a package manager that is both cross-platform and language agnostic (it can play a similar role to a pip and virtualenv combination).

Miniconda allows you to create a minimal self contained Python installation, and then use the Conda command to install additional packages.

First you will need Conda to be installed and downloading and running the Miniconda will do this for you. The installer can be found here

The next step is to create a new conda environment (these are analogous to a virtualenv but they also allow you to specify precisely which Python version to install also). Run the following commands from a terminal window:

```
conda create -n name_of_my_env python
```

This will create a minimal environment with only Python installed in it. To put your self inside this environment run:

```
source activate name_of_my_env
```

On Windows the command is:

```
activate name_of_my_env
```

The final step required is to install pandas. This can be done with the following command:

```
conda install pandas
```

To install a specific pandas version:

```
conda install pandas=0.20.3
```

To install other packages, IPython for example:

```
conda install ipython
```

To install the full Anaconda distribution:

```
conda install anaconda
```

If you require any packages that are available to pip but not conda, simply install pip, and use pip to install these packages:

```
conda install pip
pip install django
```

2.2.3 Installing from PyPI

pandas can be installed via pip from PyPI.

```
pip install pandas
```

This will likely require the installation of a number of dependencies, including NumPy, will require a compiler to compile required bits of code, and can take a few minutes to complete.

2.2.4 Installing using your Linux distribution's package manager.

The commands in this table will install pandas for Python 2 from your distribution. To install pandas for Python 3 you may need to use the package `python3-pandas`.

Distribution	Status	Download / Repository Link	Install method
Debian	stable	official Debian repository	`sudo apt-get install python-pandas`
Debian & Ubuntu	unstable (latest packages)	NeuroDebian	`sudo apt-get install python-pandas`
Ubuntu	stable	official Ubuntu repository	`sudo apt-get install python-pandas`
Ubuntu	unstable (daily builds)	PythonXY PPA; activate by: `sudo add-apt-repository ppa:pythonxy/pythonxy-devel && sudo apt-get update`	`sudo apt-get install python-pandas`
OpenSuse	stable	OpenSuse Repository	`zypper in python-pandas`
Fedora	stable	official Fedora repository	`dnf install python-pandas`
Centos/RHEL	stable	EPEL repository	`yum install python-pandas`

2.2.5 Installing from source

See the *contributing documentation* for complete instructions on building from the git source tree. Further, see *creating a development environment* if you wish to create a *pandas* development environment.

2.2.6 Running the test suite

pandas is equipped with an exhaustive set of unit tests covering about 97% of the codebase as of this writing. To run it on your machine to verify that everything is working (and you have all of the dependencies, soft and hard, installed), make sure you have pytest and run:

```
>>> import pandas as pd
>>> pd.test()
running: pytest --skip-slow --skip-network C:\Users\TP\Anaconda3\envs\py36\lib\site-
↪packages\pandas
============================= test session starts ==============================
platform win32 -- Python 3.6.2, pytest-3.2.1, py-1.4.34, pluggy-0.4.0
rootdir: C:\Users\TP\Documents\Python\pandasdev\pandas, inifile: setup.cfg
collected 12145 items / 3 skipped

..................................................................S......
........S.......................................................................
......................................................................

==================== 12130 passed, 12 skipped in 368.339 seconds =====================
```

2.3 Dependencies

- setuptools

- NumPy: 1.9.0 or higher
- python-dateutil: 1.5 or higher
- pytz: Needed for time zone support

2.3.1 Recommended Dependencies

- numexpr: for accelerating certain numerical operations. `numexpr` uses multiple cores as well as smart chunking and caching to achieve large speedups. If installed, must be Version 2.4.6 or higher.
- bottleneck: for accelerating certain types of `nan` evaluations. `bottleneck` uses specialized cython routines to achieve large speedups. If installed, must be Version 1.0.0 or higher.

Note: You are highly encouraged to install these libraries, as they provide large speedups, especially if working with large data sets.

2.3.2 Optional Dependencies

- Cython: Only necessary to build development version. Version 0.23 or higher.
- SciPy: miscellaneous statistical functions, Version 0.14.0 or higher
- xarray: pandas like handling for > 2 dims, needed for converting Panels to xarray objects. Version 0.7.0 or higher is recommended.
- PyTables: necessary for HDF5-based storage. Version 3.0.0 or higher required, Version 3.2.1 or higher highly recommended.
- Feather Format: necessary for feather-based storage, version 0.3.1 or higher.
- Apache Parquet, either pyarrow (>= 0.4.1) or fastparquet (>= 0.0.6) for parquet-based storage. The snappy and brotli are available for compression support.
- SQLAlchemy: for SQL database support. Version 0.8.1 or higher recommended. Besides SQLAlchemy, you also need a database specific driver. You can find an overview of supported drivers for each SQL dialect in the SQLAlchemy docs. Some common drivers are:
  - psycopg2: for PostgreSQL
  - pymysql: for MySQL.
  - SQLite: for SQLite, this is included in Python's standard library by default.
- matplotlib: for plotting, Version 1.4.3 or higher.
- For Excel I/O:
  - xlrd/xlwt: Excel reading (xlrd) and writing (xlwt)
  - openpyxl: openpyxl version 1.6.1 or higher (but lower than 2.0.0), or version 2.2 or higher, for writing .xlsx files (xlrd >= 0.9.0)
  - XlsxWriter: Alternative Excel writer
- Jinja2: Template engine for conditional HTML formatting.
- s3fs: necessary for Amazon S3 access (s3fs >= 0.0.7).
- blosc: for msgpack compression using `blosc`

- One of PyQt4, PySide, pygtk, xsel, or xclip: necessary to use `read_clipboard()`. Most package managers on Linux distributions will have `xclip` and/or `xsel` immediately available for installation.
- For Google BigQuery I/O - see here
- Backports.lzma: Only for Python 2, for writing to and/or reading from an xz compressed DataFrame in CSV; Python 3 support is built into the standard library.
- One of the following combinations of libraries is needed to use the top-level `read_html()` function:
  - BeautifulSoup4 and html5lib (Any recent version of html5lib is okay.)
  - BeautifulSoup4 and lxml
  - BeautifulSoup4 and html5lib and lxml
  - Only lxml, although see *HTML Table Parsing* for reasons as to why you should probably **not** take this approach.

Warning:

- if you install BeautifulSoup4 you must install either lxml or html5lib or both. `read_html()` will **not** work with *only* BeautifulSoup4 installed.
- You are highly encouraged to read *HTML Table Parsing gotchas*. It explains issues surrounding the installation and usage of the above three libraries.
- You may need to install an older version of BeautifulSoup4: Versions 4.2.1, 4.1.3 and 4.0.2 have been confirmed for 64 and 32-bit Ubuntu/Debian

Note:

- if you're on a system with `apt-get` you can do

```
sudo apt-get build-dep python-lxml
```

  to get the necessary dependencies for installation of lxml. This will prevent further headaches down the line.

Note: Without the optional dependencies, many useful features will not work. Hence, it is highly recommended that you install these. A packaged distribution like Anaconda, or Enthought Canopy may be worth considering.

CHAPTER

THREE

CONTRIBUTING TO PANDAS

Table of contents:

3.1 Where to start?

All contributions, bug reports, bug fixes, documentation improvements, enhancements and ideas are welcome.

If you are simply looking to start working with the *pandas* codebase, navigate to the GitHub "issues" tab and start looking through interesting issues. There are a number of issues listed under Docs and Difficulty Novice where you could start out.

Or maybe through using *pandas* you have an idea of your own or are looking for something in the documentation and thinking 'this can be improved'...you can do something about it!

Feel free to ask questions on the mailing list or on Gitter.

3.2 Bug reports and enhancement requests

Bug reports are an important part of making *pandas* more stable. Having a complete bug report will allow others to reproduce the bug and provide insight into fixing. Because many versions of *pandas* are supported, knowing version information will also identify improvements made since previous versions. Trying the bug-producing code out on the *master* branch is often a worthwhile exercise to confirm the bug still exists. It is also worth searching existing bug reports and pull requests to see if the issue has already been reported and/or fixed.

Bug reports must:

1. Include a short, self-contained Python snippet reproducing the problem. You can format the code nicely by using GitHub Flavored Markdown:

   ```
   ```python
   >>> from pandas import DataFrame
   >>> df = DataFrame(...)
   ...
   ```
   ```

2. Include the full version string of *pandas* and its dependencies. You can use the built in function:

   ```
   >>> import pandas as pd
   >>> pd.show_versions()
   ```

3. Explain why the current behavior is wrong/not desired and what you expect instead.

The issue will then show up to the *pandas* community and be open to comments/ideas from others.

3.3 Working with the code

Now that you have an issue you want to fix, enhancement to add, or documentation to improve, you need to learn how to work with GitHub and the *pandas* code base.

3.3.1 Version control, Git, and GitHub

To the new user, working with Git is one of the more daunting aspects of contributing to *pandas*. It can very quickly become overwhelming, but sticking to the guidelines below will help keep the process straightforward and mostly trouble free. As always, if you are having difficulties please feel free to ask for help.

The code is hosted on GitHub. To contribute you will need to sign up for a free GitHub account. We use Git for version control to allow many people to work together on the project.

Some great resources for learning Git:

- the GitHub help pages.
- the NumPy's documentation.
- Matthew Brett's Pydagogue.

3.3.2 Getting started with Git

GitHub has instructions for installing git, setting up your SSH key, and configuring git. All these steps need to be completed before you can work seamlessly between your local repository and GitHub.

3.3.3 Forking

You will need your own fork to work on the code. Go to the pandas project page and hit the `Fork` button. You will want to clone your fork to your machine:

```
git clone https://github.com/your-user-name/pandas.git pandas-yourname
cd pandas-yourname
git remote add upstream git://github.com/pandas-dev/pandas.git
```

This creates the directory *pandas-yourname* and connects your repository to the upstream (main project) *pandas* repository.

3.3.4 Creating a branch

You want your master branch to reflect only production-ready code, so create a feature branch for making your changes. For example:

```
git branch shiny-new-feature
git checkout shiny-new-feature
```

The above can be simplified to:

```
git checkout -b shiny-new-feature
```

This changes your working directory to the shiny-new-feature branch. Keep any changes in this branch specific to one bug or feature so it is clear what the branch brings to *pandas*. You can have many shiny-new-features and switch in between them using the git checkout command.

To update this branch, you need to retrieve the changes from the master branch:

```
git fetch upstream
git rebase upstream/master
```

This will replay your commits on top of the latest pandas git master. If this leads to merge conflicts, you must resolve these before submitting your pull request. If you have uncommitted changes, you will need to `stash` them prior to updating. This will effectively store your changes and they can be reapplied after updating.

3.3.5 Creating a development environment

An easy way to create a *pandas* development environment is as follows.

- Install either *Anaconda* or *miniconda*
- Make sure that you have *cloned the repository*
- `cd` to the *pandas* source directory

Tell conda to create a new environment, named `pandas_dev`, or any other name you would like for this environment, by running:

```
conda create -n pandas_dev --file ci/requirements_dev.txt
```

For a python 3 environment:

```
conda create -n pandas_dev python=3 --file ci/requirements_dev.txt
```

> **Warning:** If you are on Windows, see *here for a fully compliant Windows environment*.

This will create the new environment, and not touch any of your existing environments, nor any existing python installation. It will install all of the basic dependencies of *pandas*, as well as the development and testing tools. If you would like to install other dependencies, you can install them as follows:

```
conda install -n pandas_dev -c pandas pytables scipy
```

To install *all* pandas dependencies you can do the following:

```
conda install -n pandas_dev -c conda-forge --file ci/requirements_all.txt
```

To work in this environment, Windows users should `activate` it as follows:

```
activate pandas_dev
```

Mac OSX / Linux users should use:

```
source activate pandas_dev
```

You will then see a confirmation message to indicate you are in the new development environment.

To view your environments:

```
conda info -e
```

To return to your home root environment in Windows:

```
deactivate
```

To return to your home root environment in OSX / Linux:

```
source deactivate
```

See the full conda docs here.

At this point you can easily do an *in-place* install, as detailed in the next section.

3.3.6 Creating a Windows development environment

To build on Windows, you need to have compilers installed to build the extensions. You will need to install the appropriate Visual Studio compilers, VS 2008 for Python 2.7, VS 2010 for 3.4, and VS 2015 for Python 3.5 and 3.6.

For Python 2.7, you can install the `mingw` compiler which will work equivalently to VS 2008:

```
conda install -n pandas_dev libpython
```

or use the Microsoft Visual Studio VC++ compiler for Python. Note that you have to check the `x64` box to install the `x64` extension building capability as this is not installed by default.

For Python 3.4, you can download and install the Windows 7.1 SDK. Read the references below as there may be various gotchas during the installation.

For Python 3.5 and 3.6, you can download and install the Visual Studio 2015 Community Edition.

Here are some references and blogs:

- https://blogs.msdn.microsoft.com/pythonengineering/2016/04/11/unable-to-find-vcvarsall-bat/
- https://github.com/conda/conda-recipes/wiki/Building-from-Source-on-Windows-32-bit-and-64-bit
- https://cowboyprogrammer.org/building-python-wheels-for-windows/
- https://blog.ionelmc.ro/2014/12/21/compiling-python-extensions-on-windows/
- https://support.enthought.com/hc/en-us/articles/204469260-Building-Python-extensions-with-Canopy

3.3.7 Making changes

Before making your code changes, it is often necessary to build the code that was just checked out. There are two primary methods of doing this.

1. The best way to develop *pandas* is to build the C extensions in-place by running:

   ```
   python setup.py build_ext --inplace
   ```

   If you startup the Python interpreter in the *pandas* source directory you will call the built C extensions

2. Another very common option is to do a `develop` install of *pandas*:

```
python setup.py develop
```

This makes a symbolic link that tells the Python interpreter to import *pandas* from your development directory. Thus, you can always be using the development version on your system without being inside the clone directory.

3.4 Contributing to the documentation

If you're not the developer type, contributing to the documentation is still of huge value. You don't even have to be an expert on *pandas* to do so! Something as simple as rewriting small passages for clarity as you reference the docs is a simple but effective way to contribute. The next person to read that passage will be in your debt!

In fact, there are sections of the docs that are worse off after being written by experts. If something in the docs doesn't make sense to you, updating the relevant section after you figure it out is a simple way to ensure it will help the next person.

Documentation:

- *About the* pandas *documentation*
- *How to build the* pandas *documentation*
  - *Requirements*
  - *Building the documentation*
  - *Building master branch documentation*

3.4.1 About the *pandas* documentation

The documentation is written in **reStructuredText**, which is almost like writing in plain English, and built using Sphinx. The Sphinx Documentation has an excellent introduction to reST. Review the Sphinx docs to perform more complex changes to the documentation as well.

Some other important things to know about the docs:

- The *pandas* documentation consists of two parts: the docstrings in the code itself and the docs in this folder `pandas/doc/`.

  The docstrings provide a clear explanation of the usage of the individual functions, while the documentation in this folder consists of tutorial-like overviews per topic together with some other information (what's new, installation, etc).

- The docstrings follow the **Numpy Docstring Standard**, which is used widely in the Scientific Python community. This standard specifies the format of the different sections of the docstring. See this document for a detailed explanation, or look at some of the existing functions to extend it in a similar manner.

- The tutorials make heavy use of the ipython directive sphinx extension. This directive lets you put code in the documentation which will be run during the doc build. For example:

```
.. ipython:: python

    x = 2
    x**3
```

will be rendered as:

```
In [1]: x = 2

In [2]: x**3
Out[2]: 8
```

Almost all code examples in the docs are run (and the output saved) during the doc build. This approach means that code examples will always be up to date, but it does make the doc building a bit more complex.

Note: The `.rst` files are used to automatically generate Markdown and HTML versions of the docs. For this reason, please do not edit `CONTRIBUTING.md` directly, but instead make any changes to `doc/source/contributing.rst`. Then, to generate `CONTRIBUTING.md`, use pandoc with the following command:

```
pandoc doc/source/contributing.rst -t markdown_github > CONTRIBUTING.md
```

The utility script `scripts/api_rst_coverage.py` can be used to compare the list of methods documented in `doc/source/api.rst` (which is used to generate the API Reference page) and the actual public methods. This will identify methods documented in in `doc/source/api.rst` that are not actually class methods, and existing methods that are not documented in `doc/source/api.rst`.

3.4.2 How to build the *pandas* documentation

3.4.2.1 Requirements

First, you need to have a development environment to be able to build pandas (see the docs on *creating a development environment above*). Further, to build the docs, there are some extra requirements: you will need to have `sphinx` and `ipython` installed. numpydoc is used to parse the docstrings that follow the Numpy Docstring Standard (see above), but you don't need to install this because a local copy of numpydoc is included in the *pandas* source code. nbsphinx is required to build the Jupyter notebooks included in the documentation.

If you have a conda environment named `pandas_dev`, you can install the extra requirements with:

```
conda install -n pandas_dev sphinx ipython nbconvert nbformat
conda install -n pandas_dev -c conda-forge nbsphinx
```

Furthermore, it is recommended to have all *optional dependencies*. installed. This is not strictly necessary, but be aware that you will see some error messages when building the docs. This happens because all the code in the documentation is executed during the doc build, and so code examples using optional dependencies will generate errors. Run `pd.show_versions()` to get an overview of the installed version of all dependencies.

Warning: You need to have `sphinx` version >= 1.3.2.

3.4.2.2 Building the documentation

So how do you build the docs? Navigate to your local `pandas/doc/` directory in the console and run:

```
python make.py html
```

Then you can find the HTML output in the folder `pandas/doc/build/html/`.

The first time you build the docs, it will take quite a while because it has to run all the code examples and build all the generated docstring pages. In subsequent evocations, sphinx will try to only build the pages that have been modified.

If you want to do a full clean build, do:

```
python make.py clean
python make.py html
```

Starting with *pandas* 0.13.1 you can tell `make.py` to compile only a single section of the docs, greatly reducing the turn-around time for checking your changes. You will be prompted to delete `.rst` files that aren't required. This is okay because the prior versions of these files can be checked out from git. However, you must make sure not to commit the file deletions to your Git repository!

```
#omit autosummary and API section
python make.py clean
python make.py --no-api

# compile the docs with only a single
# section, that which is in indexing.rst
python make.py clean
python make.py --single indexing
```

For comparison, a full documentation build may take 10 minutes, a `-no-api` build may take 3 minutes and a single section may take 15 seconds. Subsequent builds, which only process portions you have changed, will be faster. Open the following file in a web browser to see the full documentation you just built:

```
pandas/docs/build/html/index.html
```

And you'll have the satisfaction of seeing your new and improved documentation!

3.4.2.3 Building master branch documentation

When pull requests are merged into the *pandas* `master` branch, the main parts of the documentation are also built by Travis-CI. These docs are then hosted here, see also the *Continuous Integration* section.

3.5 Contributing to the code base

Code Base:

- *Running the performance test suite*
- *Documenting your code*

3.5.1 Code standards

Writing good code is not just about what you write. It is also about *how* you write it. During *Continuous Integration* testing, several tools will be run to check your code for stylistic errors. Generating any warnings will cause the test to fail. Thus, good style is a requirement for submitting code to *pandas*.

In addition, because a lot of people use our library, it is important that we do not make sudden changes to the code that could have the potential to break a lot of user code as a result, that is, we need it to be as *backwards compatible* as possible to avoid mass breakages.

Additional standards are outlined on the code style wiki page.

3.5.1.1 C (cpplint)

pandas uses the Google standard. Google provides an open source style checker called `cpplint`, but we use a fork of it that can be found here. Here are *some* of the more common `cpplint` issues:

- we restrict line-length to 80 characters to promote readability
- every header file must include a header guard to avoid name collisions if re-included

Continuous Integration. will run the cpplint tool and report any stylistic errors in your code. Therefore, it is helpful before submitting code to run the check yourself:

```
cpplint --extensions=c,h --headers=h --filter=-readability/casting,-runtime/int,-
↪build/include_subdir modified-c-file
```

You can also run this command on an entire directory if necessary:

```
cpplint --extensions=c,h --headers=h --filter=-readability/casting,-runtime/int,-
↪build/include_subdir --recursive modified-c-directory
```

To make your commits compliant with this standard, you can install the ClangFormat tool, which can be downloaded here. To configure, in your home directory, run the following command:

```
clang-format style=google -dump-config  > .clang-format
```

Then modify the file to ensure that any indentation width parameters are at least four. Once configured, you can run the tool as follows:

```
clang-format modified-c-file
```

This will output what your file will look like if the changes are made, and to apply them, just run the following command:

```
clang-format -i modified-c-file
```

To run the tool on an entire directory, you can run the following analogous commands:

```
clang-format modified-c-directory/*.c modified-c-directory/*.h
clang-format -i modified-c-directory/*.c modified-c-directory/*.h
```

Do note that this tool is best-effort, meaning that it will try to correct as many errors as possible, but it may not correct *all* of them. Thus, it is recommended that you run `cpplint` to double check and make any other style fixes manually.

3.5.1.2 Python (PEP8)

pandas uses the PEP8 standard. There are several tools to ensure you abide by this standard. Here are *some* of the more common `PEP8` issues:

- we restrict line-length to 79 characters to promote readability
- passing arguments should have spaces after commas, e.g. `foo(arg1, arg2, kw1='bar')`

Continuous Integration will run the flake8 tool and report any stylistic errors in your code. Therefore, it is helpful before submitting code to run the check yourself on the diff:

```
git diff master -u -- "*.py" | flake8 --diff
```

This command will catch any stylistic errors in your changes specifically, but be beware it may not catch all of them. For example, if you delete the only usage of an imported function, it is stylistically incorrect to import an unused function. However, style-checking the diff will not catch this because the actual import is not part of the diff. Thus, for completeness, you should run this command, though it will take longer:

```
git diff master --name-only -- "*.py" | grep "pandas/" | xargs -r flake8
```

Note that on OSX, the `-r` flag is not available, so you have to omit it and run this slightly modified command:

```
git diff master --name-only -- "*.py" | grep "pandas/" | xargs flake8
```

Note that on Windows, these commands are unfortunately not possible because commands like `grep` and `xargs` are not available natively. To imitate the behavior with the commands above, you should run:

```
git diff master --name-only -- "*.py"
```

This will list all of the Python files that have been modified. The only ones that matter during linting are any whose directory filepath begins with "pandas." For each filepath, copy and paste it after the `flake8` command as shown below:

> flake8 <python-filepath>

Alternatively, you can install the `grep` and `xargs` commands via the MinGW toolchain, and it will allow you to run the commands above.

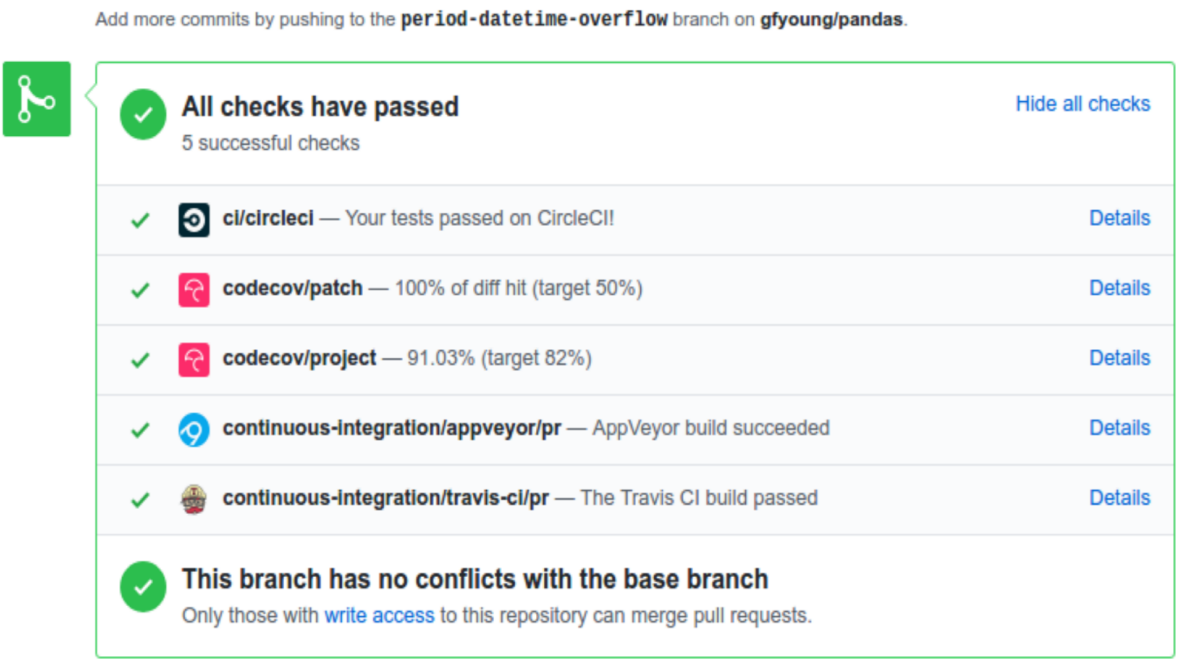
3.5.1.3 Backwards Compatibility

Please try to maintain backward compatibility. *pandas* has lots of users with lots of existing code, so don't break it if at all possible. If you think breakage is required, clearly state why as part of the pull request. Also, be careful when changing method signatures and add deprecation warnings where needed.

3.5.2 Testing With Continuous Integration

The *pandas* test suite will run automatically on Travis-CI, Appveyor, and Circle CI continuous integration services, once your pull request is submitted. However, if you wish to run the test suite on a branch prior to submitting the pull request, then the continuous integration services need to be hooked to your GitHub repository. Instructions are here for Travis-CI, Appveyor , and CircleCI.

A pull-request will be considered for merging when you have an all 'green' build. If any tests are failing, then you will get a red 'X', where you can click through to see the individual failed tests. This is an example of a green build.



Note: Each time you push to *your* fork, a *new* run of the tests will be triggered on the CI. Appveyor will auto-cancel any non-currently-running tests for that same pull-request. You can enable the auto-cancel feature for Travis-CI here and for CircleCI here.

3.5.3 Test-driven development/code writing

pandas is serious about testing and strongly encourages contributors to embrace test-driven development (TDD). This development process "relies on the repetition of a very short development cycle: first the developer writes an (initially failing) automated test case that defines a desired improvement or new function, then produces the minimum amount of code to pass that test." So, before actually writing any code, you should write your tests. Often the test can be taken from the original GitHub issue. However, it is always worth considering additional use cases and writing corresponding tests.

Adding tests is one of the most common requests after code is pushed to *pandas*. Therefore, it is worth getting in the habit of writing tests ahead of time so this is never an issue.

Like many packages, *pandas* uses pytest and the convenient extensions in numpy.testing.

Note: The earliest supported pytest version is 3.1.0.

3.5.3.1 Writing tests

All tests should go into the `tests` subdirectory of the specific package. This folder contains many current examples of tests, and we suggest looking to these for inspiration. If your test requires working with files or network connectivity, there is more information on the testing page of the wiki.

The `pandas.util.testing` module has many special `assert` functions that make it easier to make statements about whether Series or DataFrame objects are equivalent. The easiest way to verify that your code is correct is to explicitly construct the result you expect, then compare the actual result to the expected correct result:

```
def test_pivot(self):
    data = {
        'index' : ['A', 'B', 'C', 'C', 'B', 'A'],
        'columns' : ['One', 'One', 'One', 'Two', 'Two', 'Two'],
        'values' : [1., 2., 3., 3., 2., 1.]
    }

    frame = DataFrame(data)
    pivoted = frame.pivot(index='index', columns='columns', values='values')

    expected = DataFrame({
        'One' : {'A' : 1., 'B' : 2., 'C' : 3.},
        'Two' : {'A' : 1., 'B' : 2., 'C' : 3.}
    })

    assert_frame_equal(pivoted, expected)
```

3.5.3.2 Transitioning to `pytest`

pandas existing test structure is *mostly* classed based, meaning that you will typically find tests wrapped in a class.

```
class TestReallyCoolFeature(object):
    ....
```

Going forward, we are moving to a more *functional* style using the pytest framework, which offers a richer testing framework that will facilitate testing and developing. Thus, instead of writing test classes, we will write test functions like this:

```
def test_really_cool_feature():
    ....
```

3.5.3.3 Using `pytest`

Here is an example of a self-contained set of tests that illustrate multiple features that we like to use.

- functional style: tests are like `test_*` and *only* take arguments that are either fixtures or parameters
- `pytest.mark` can be used to set metadata on test functions, e.g. `skip` or `xfail`.
- using `parametrize`: allow testing of multiple cases
- to set a mark on a parameter, `pytest.param(..., marks=...)` syntax should be used
- `fixture`, code for object construction, on a per-test basis
- using bare `assert` for scalars and truth-testing
- `tm.assert_series_equal` (and its counter part `tm.assert_frame_equal`), for pandas object comparisons.
- the typical pattern of constructing an `expected` and comparing versus the `result`

We would name this file `test_cool_feature.py` and put in an appropriate place in the `pandas/tests/` structure.

```
import pytest
import numpy as np
import pandas as pd
from pandas.util import testing as tm

@pytest.mark.parametrize('dtype', ['int8', 'int16', 'int32', 'int64'])
def test_dtypes(dtype):
    assert str(np.dtype(dtype)) == dtype

@pytest.mark.parametrize('dtype', ['float32',
    pytest.param('int16', marks=pytest.mark.skip),
    pytest.param('int32',
                 marks=pytest.mark.xfail(reason='to show how it works'))])
def test_mark(dtype):
    assert str(np.dtype(dtype)) == 'float32'

@pytest.fixture
def series():
    return pd.Series([1, 2, 3])

@pytest.fixture(params=['int8', 'int16', 'int32', 'int64'])
def dtype(request):
    return request.param

def test_series(series, dtype):
    result = series.astype(dtype)
    assert result.dtype == dtype

    expected = pd.Series([1, 2, 3], dtype=dtype)
    tm.assert_series_equal(result, expected)
```

A test run of this yields

```
((pandas) bash-3.2$ pytest  test_cool_feature.py  -v
========================== test session starts ==========================
platform darwin -- Python 3.6.2, pytest-3.2.1, py-1.4.31, pluggy-0.4.0
collected 11 items

tester.py::test_dtypes[int8] PASSED
tester.py::test_dtypes[int16] PASSED
tester.py::test_dtypes[int32] PASSED
tester.py::test_dtypes[int64] PASSED
tester.py::test_mark[float32] PASSED
tester.py::test_mark[int16] SKIPPED
tester.py::test_mark[int32] xfail
tester.py::test_series[int8] PASSED
tester.py::test_series[int16] PASSED
tester.py::test_series[int32] PASSED
tester.py::test_series[int64] PASSED
```

Tests that we have `parametrized` are now accessible via the test name, for example we could run these with `-k int8` to sub-select *only* those tests which match `int8`.

```
((pandas) bash-3.2$ pytest  test_cool_feature.py  -v -k int8
========================== test session starts ==========================
platform darwin -- Python 3.6.2, pytest-3.2.1, py-1.4.31, pluggy-0.4.0
collected 11 items
```

```
test_cool_feature.py::test_dtypes[int8] PASSED
test_cool_feature.py::test_series[int8] PASSED
```

3.5.4 Running the test suite

The tests can then be run directly inside your Git clone (without having to install *pandas*) by typing:

```
pytest pandas
```

The tests suite is exhaustive and takes around 20 minutes to run. Often it is worth running only a subset of tests first around your changes before running the entire suite.

The easiest way to do this is with:

```
pytest pandas/path/to/test.py -k regex_matching_test_name
```

Or with one of the following constructs:

```
pytest pandas/tests/[test-module].py
pytest pandas/tests/[test-module].py::[TestClass]
pytest pandas/tests/[test-module].py::[TestClass]::[test_method]
```

Using pytest-xdist, one can speed up local testing on multicore machines. To use this feature, you will need to install *pytest-xdist* via:

```
pip install pytest-xdist
```

Two scripts are provided to assist with this. These scripts distribute testing across 4 threads.

On Unix variants, one can type:

```
test_fast.sh
```

On Windows, one can type:

```
test_fast.bat
```

This can significantly reduce the time it takes to locally run tests before submitting a pull request.

For more, see the pytest documentation.

> New in version 0.20.0.

Furthermore one can run

```
pd.test()
```

with an imported pandas to run tests similarly.

3.5.5 Running the performance test suite

Performance matters and it is worth considering whether your code has introduced performance regressions. *pandas* is in the process of migrating to asv benchmarks to enable easy monitoring of the performance of critical *pandas* operations. These benchmarks are all found in the `pandas/asv_bench` directory. asv supports both python2 and python3.

To use all features of asv, you will need either `conda` or `virtualenv`. For more details please check the asv installation webpage.

To install asv:

```
pip install git+https://github.com/spacetelescope/asv
```

If you need to run a benchmark, change your directory to `asv_bench/` and run:

```
asv continuous -f 1.1 upstream/master HEAD
```

You can replace `HEAD` with the name of the branch you are working on, and report benchmarks that changed by more than 10%. The command uses `conda` by default for creating the benchmark environments. If you want to use virtualenv instead, write:

```
asv continuous -f 1.1 -E virtualenv upstream/master HEAD
```

The `-E virtualenv` option should be added to all `asv` commands that run benchmarks. The default value is defined in `asv.conf.json`.

Running the full test suite can take up to one hour and use up to 3GB of RAM. Usually it is sufficient to paste only a subset of the results into the pull request to show that the committed changes do not cause unexpected performance regressions. You can run specific benchmarks using the `-b` flag, which takes a regular expression. For example, this will only run tests from a `pandas/asv_bench/benchmarks/groupby.py` file:

```
asv continuous -f 1.1 upstream/master HEAD -b ^groupby
```

If you want to only run a specific group of tests from a file, you can do it using `.` as a separator. For example:

```
asv continuous -f 1.1 upstream/master HEAD -b groupby.groupby_agg_builtins
```

will only run the `groupby_agg_builtins` benchmark defined in `groupby.py`.

You can also run the benchmark suite using the version of `pandas` already installed in your current Python environment. This can be useful if you do not have virtualenv or conda, or are using the `setup.py develop` approach discussed above; for the in-place build you need to set `PYTHONPATH`, e.g. `PYTHONPATH="$PWD/.." asv [remaining arguments]`. You can run benchmarks using an existing Python environment by:

```
asv run -e -E existing
```

or, to use a specific Python interpreter,:

```
asv run -e -E existing:python3.5
```

This will display stderr from the benchmarks, and use your local `python` that comes from your `$PATH`.

Information on how to write a benchmark and how to use asv can be found in the asv documentation.

3.5.6 Documenting your code

Changes should be reflected in the release notes located in `doc/source/whatsnew/vx.y.z.txt`. This file contains an ongoing change log for each release. Add an entry to this file to document your fix, enhancement or (unavoidable) breaking change. Make sure to include the GitHub issue number when adding your entry (using ‘‘ GH1234 ‘‘ where *1234* is the issue/pull request number).

If your code is an enhancement, it is most likely necessary to add usage examples to the existing documentation. This can be done following the section regarding documentation *above*. Further, to let users know when this feature was added, the `versionadded` directive is used. The sphinx syntax for that is:

```
.. versionadded:: 0.17.0
```

This will put the text *New in version 0.17.0* wherever you put the sphinx directive. This should also be put in the docstring when adding a new function or method (example) or a new keyword argument (example).

3.6 Contributing your changes to *pandas*

3.6.1 Committing your code

Keep style fixes to a separate commit to make your pull request more readable.

Once you've made changes, you can see them by typing:

```
git status
```

If you have created a new file, it is not being tracked by git. Add it by typing:

```
git add path/to/file-to-be-added.py
```

Doing 'git status' again should give something like:

```
# On branch shiny-new-feature
#
#       modified:   /relative/path/to/file-you-added.py
#
```

Finally, commit your changes to your local repository with an explanatory message. *Pandas* uses a convention for commit message prefixes and layout. Here are some common prefixes along with general guidelines for when to use them:

- ENH: Enhancement, new functionality
- BUG: Bug fix
- DOC: Additions/updates to documentation
- TST: Additions/updates to tests
- BLD: Updates to the build process/scripts
- PERF: Performance improvement
- CLN: Code cleanup

The following defines how a commit message should be structured. Please reference the relevant GitHub issues in your commit message using GH1234 or #1234. Either style is fine, but the former is generally preferred:

- a subject line with < *80* chars.
- One blank line.
- Optionally, a commit message body.

Now you can commit your changes in your local repository:

```
git commit -m
```

3.6.2 Combining commits

If you have multiple commits, you may want to combine them into one commit, often referred to as "squashing" or "rebasing". This is a common request by package maintainers when submitting a pull request as it maintains a more compact commit history. To rebase your commits:

```
git rebase -i HEAD~#
```

Where # is the number of commits you want to combine. Then you can pick the relevant commit message and discard others.

To squash to the master branch do:

```
git rebase -i master
```

Use the `s` option on a commit to `squash`, meaning to keep the commit messages, or `f` to `fixup`, meaning to merge the commit messages.

Then you will need to push the branch (see below) forcefully to replace the current commits with the new ones:

```
git push origin shiny-new-feature -f
```

3.6.3 Pushing your changes

When you want your changes to appear publicly on your GitHub page, push your forked feature branch's commits:

```
git push origin shiny-new-feature
```

Here `origin` is the default name given to your remote repository on GitHub. You can see the remote repositories:

```
git remote -v
```

If you added the upstream repository as described above you will see something like:

```
origin  git@github.com:yourname/pandas.git (fetch)
origin  git@github.com:yourname/pandas.git (push)
upstream        git://github.com/pandas-dev/pandas.git (fetch)
upstream        git://github.com/pandas-dev/pandas.git (push)
```

Now your code is on GitHub, but it is not yet a part of the *pandas* project. For that to happen, a pull request needs to be submitted on GitHub.

3.6.4 Review your code

When you're ready to ask for a code review, file a pull request. Before you do, once again make sure that you have followed all the guidelines outlined in this document regarding code style, tests, performance tests, and documentation. You should also double check your branch changes against the branch it was based on:

1. Navigate to your repository on GitHub – https://github.com/your-user-name/pandas
2. Click on `Branches`
3. Click on the `Compare` button for your feature branch
4. Select the `base` and `compare` branches, if necessary. This will be `master` and `shiny-new-feature`, respectively.

3.6.5 Finally, make the pull request

If everything looks good, you are ready to make a pull request. A pull request is how code from a local repository becomes available to the GitHub community and can be looked at and eventually merged into the master version. This pull request and its associated changes will eventually be committed to the master branch and available in the next release. To submit a pull request:

1. Navigate to your repository on GitHub
2. Click on the `Pull Request` button
3. You can then click on `Commits` and `Files Changed` to make sure everything looks okay one last time
4. Write a description of your changes in the `Preview Discussion` tab
5. Click `Send Pull Request`.

This request then goes to the repository maintainers, and they will review the code. If you need to make more changes, you can make them in your branch, push them to GitHub, and the pull request will be automatically updated. Pushing them to GitHub again is done by:

```
git push -f origin shiny-new-feature
```

This will automatically update your pull request with the latest code and restart the *Continuous Integration* tests.

3.6.6 Delete your merged branch (optional)

Once your feature branch is accepted into upstream, you'll probably want to get rid of the branch. First, merge upstream master into your branch so git knows it is safe to delete your branch:

```
git fetch upstream
git checkout master
git merge upstream/master
```

Then you can just do:

```
git branch -d shiny-new-feature
```

Make sure you use a lower-case `-d`, or else git won't warn you if your feature branch has not actually been merged.

The branch will still exist on GitHub, so to delete it there do:

```
git push origin --delete shiny-new-feature
```

CHAPTER

FOUR

PACKAGE OVERVIEW

pandas is an open source, BSD-licensed library providing high-performance, easy-to-use data structures and data analysis tools for the Python programming language.

pandas consists of the following elements

- A set of labeled array data structures, the primary of which are Series and DataFrame
- Index objects enabling both simple axis indexing and multi-level / hierarchical axis indexing
- An integrated group by engine for aggregating and transforming data sets
- Date range generation (date_range) and custom date offsets enabling the implementation of customized frequencies
- Input/Output tools: loading tabular data from flat files (CSV, delimited, Excel 2003), and saving and loading pandas objects from the fast and efficient PyTables/HDF5 format.
- Memory-efficient "sparse" versions of the standard data structures for storing data that is mostly missing or mostly constant (some fixed value)
- Moving window statistics (rolling mean, rolling standard deviation, etc.)

4.1 Data Structures

Dimensions	Name	Description
1	Series	1D labeled homogeneously-typed array
2	DataFrame	General 2D labeled, size-mutable tabular structure with potentially heterogeneously-typed column

4.1.1 Why more than one data structure?

The best way to think about the pandas data structures is as flexible containers for lower dimensional data. For example, DataFrame is a container for Series, and Series is a container for scalars. We would like to be able to insert and remove objects from these containers in a dictionary-like fashion.

Also, we would like sensible default behaviors for the common API functions which take into account the typical orientation of time series and cross-sectional data sets. When using ndarrays to store 2- and 3-dimensional data, a burden is placed on the user to consider the orientation of the data set when writing functions; axes are considered more or less equivalent (except when C- or Fortran-contiguousness matters for performance). In pandas, the axes are intended to lend more semantic meaning to the data; i.e., for a particular data set there is likely to be a "right" way to orient the data. The goal, then, is to reduce the amount of mental effort required to code up data transformations in downstream functions.

For example, with tabular data (DataFrame) it is more semantically helpful to think of the **index** (the rows) and the **columns** rather than axis 0 and axis 1. And iterating through the columns of the DataFrame thus results in more readable code:

```
for col in df.columns:
    series = df[col]
    # do something with series
```

4.2 Mutability and copying of data

All pandas data structures are value-mutable (the values they contain can be altered) but not always size-mutable. The length of a Series cannot be changed, but, for example, columns can be inserted into a DataFrame. However, the vast majority of methods produce new objects and leave the input data untouched. In general, though, we like to **favor immutability** where sensible.

4.3 Getting Support

The first stop for pandas issues and ideas is the Github Issue Tracker. If you have a general question, pandas community experts can answer through Stack Overflow.

4.4 Community

pandas is actively supported today by a community of like-minded individuals around the world who contribute their valuable time and energy to help make open source pandas possible. Thanks to all of our contributors.

If you're interested in contributing, please visit Contributing to pandas webpage.

pandas is a NUMFocus sponsored project. This will help ensure the success of development of pandas as a world-class open-source project, and makes it possible to donate to the project.

4.5 Project Governance

The governance process that pandas project has used informally since its inception in 2008 is formalized in Project Governance documents . The documents clarify how decisions are made and how the various elements of our community interact, including the relationship between open source collaborative development and work that may be funded by for-profit or non-profit entities.

Wes McKinney is the Benevolent Dictator for Life (BDFL).

4.6 Development Team

The list of the Core Team members and more detailed information can be found on the people's page of the governance repo.

4.7 Institutional Partners

The information about current institutional partners can be found on pandas website page

4.8 License

CHAPTER

FIVE

10 MINUTES TO PANDAS

This is a short introduction to pandas, geared mainly for new users. You can see more complex recipes in the *Cookbook*

Customarily, we import as follows:

```
In [1]: import pandas as pd

In [2]: import numpy as np

In [3]: import matplotlib.pyplot as plt
```

5.1 Object Creation

See the *Data Structure Intro section*

Creating a `Series` by passing a list of values, letting pandas create a default integer index:

```
In [4]: s = pd.Series([1,3,5,np.nan,6,8])

In [5]: s
Out[5]:
0    1.0
1    3.0
2    5.0
3    NaN
4    6.0
5    8.0
dtype: float64
```

Creating a `DataFrame` by passing a numpy array, with a datetime index and labeled columns:

```
In [6]: dates = pd.date_range('20130101', periods=6)

In [7]: dates
Out[7]:
DatetimeIndex(['2013-01-01', '2013-01-02', '2013-01-03', '2013-01-04',
               '2013-01-05', '2013-01-06'],
              dtype='datetime64[ns]', freq='D')

In [8]: df = pd.DataFrame(np.random.randn(6,4), index=dates, columns=list('ABCD'))

In [9]: df
Out[9]:
                   A          B          C          D
```

```
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
2013-01-05 -0.424972  0.567020  0.276232 -1.087401
2013-01-06 -0.673690  0.113648 -1.478427  0.524988
```

Creating a `DataFrame` by passing a dict of objects that can be converted to series-like.

```
In [10]: df2 = pd.DataFrame({ 'A' : 1.,
   ....:                      'B' : pd.Timestamp('20130102'),
   ....:                      'C' : pd.Series(1,index=list(range(4)),dtype='float32'),
   ....:                      'D' : np.array([3] * 4,dtype='int32'),
   ....:                      'E' : pd.Categorical(["test","train","test","train"]),
   ....:                      'F' : 'foo' })
   ....:

In [11]: df2
Out[11]:
     A          B    C  D      E    F
0  1.0 2013-01-02  1.0  3   test  foo
1  1.0 2013-01-02  1.0  3  train  foo
2  1.0 2013-01-02  1.0  3   test  foo
3  1.0 2013-01-02  1.0  3  train  foo
```

Having specific *dtypes*

```
In [12]: df2.dtypes
Out[12]:
A           float64
B    datetime64[ns]
C           float32
D             int32
E          category
F            object
dtype: object
```

If you're using IPython, tab completion for column names (as well as public attributes) is automatically enabled. Here's a subset of the attributes that will be completed:

```
In [13]: df2.<TAB>
df2.A                   df2.bool
df2.abs                 df2.boxplot
df2.add                 df2.C
df2.add_prefix          df2.clip
df2.add_suffix          df2.clip_lower
df2.align               df2.clip_upper
df2.all                 df2.columns
df2.any                 df2.combine
df2.append              df2.combine_first
df2.apply               df2.compound
df2.applymap            df2.consolidate
df2.D
```

As you can see, the columns `A`, `B`, `C`, and `D` are automatically tab completed. `E` is there as well; the rest of the attributes have been truncated for brevity.

5.2 Viewing Data

See the *Basics section*

See the top & bottom rows of the frame

```
In [14]: df.head()
Out[14]:
                   A         B         C         D
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
2013-01-05 -0.424972  0.567020  0.276232 -1.087401

In [15]: df.tail(3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
                   A         B         C         D
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
2013-01-05 -0.424972  0.567020  0.276232 -1.087401
2013-01-06 -0.673690  0.113648 -1.478427  0.524988
```

Display the index, columns, and the underlying numpy data

```
In [16]: df.index
Out[16]:
DatetimeIndex(['2013-01-01', '2013-01-02', '2013-01-03', '2013-01-04',
               '2013-01-05', '2013-01-06'],
              dtype='datetime64[ns]', freq='D')

In [17]: df.columns
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪Index(['A', 'B', 'C', 'D'], dtype='object')

In [18]: df.values
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
array([[ 0.4691, -0.2829, -1.5091, -1.1356],
       [ 1.2121, -0.1732,  0.1192, -1.0442],
       [-0.8618, -2.1046, -0.4949,  1.0718],
       [ 0.7216, -0.7068, -1.0396,  0.2719],
       [-0.425 ,  0.567 ,  0.2762, -1.0874],
       [-0.6737,  0.1136, -1.4784,  0.525 ]])
```

Describe shows a quick statistic summary of your data

```
In [19]: df.describe()
Out[19]:
              A         B         C         D
count  6.000000  6.000000  6.000000  6.000000
mean   0.073711 -0.431125 -0.687758 -0.233103
std    0.843157  0.922818  0.779887  0.973118
min   -0.861849 -2.104569 -1.509059 -1.135632
25%   -0.611510 -0.600794 -1.368714 -1.076610
50%    0.022070 -0.228039 -0.767252 -0.386188
75%    0.658444  0.041933 -0.034326  0.461706
max    1.212112  0.567020  0.276232  1.071804
```

Transposing your data

```
In [20]: df.T
Out[20]:
   2013-01-01  2013-01-02  2013-01-03  2013-01-04  2013-01-05  2013-01-06
A    0.469112    1.212112   -0.861849    0.721555   -0.424972   -0.673690
B   -0.282863   -0.173215   -2.104569   -0.706771    0.567020    0.113648
C   -1.509059    0.119209   -0.494929   -1.039575    0.276232   -1.478427
D   -1.135632   -1.044236    1.071804    0.271860   -1.087401    0.524988
```

Sorting by an axis

```
In [21]: df.sort_index(axis=1, ascending=False)
Out[21]:
                   D         C         B         A
2013-01-01 -1.135632 -1.509059 -0.282863  0.469112
2013-01-02 -1.044236  0.119209 -0.173215  1.212112
2013-01-03  1.071804 -0.494929 -2.104569 -0.861849
2013-01-04  0.271860 -1.039575 -0.706771  0.721555
2013-01-05 -1.087401  0.276232  0.567020 -0.424972
2013-01-06  0.524988 -1.478427  0.113648 -0.673690
```

Sorting by values

```
In [22]: df.sort_values(by='B')
Out[22]:
                   A         B         C         D
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-06 -0.673690  0.113648 -1.478427  0.524988
2013-01-05 -0.424972  0.567020  0.276232 -1.087401
```

5.3 Selection

Note: While standard Python / Numpy expressions for selecting and setting are intuitive and come in handy for interactive work, for production code, we recommend the optimized pandas data access methods, `.at`, `.iat`, `.loc`, `.iloc` and `.ix`.

See the indexing documentation *Indexing and Selecting Data* and *MultiIndex / Advanced Indexing*

5.3.1 Getting

Selecting a single column, which yields a `Series`, equivalent to `df.A`

```
In [23]: df['A']
Out[23]:
2013-01-01    0.469112
2013-01-02    1.212112
2013-01-03   -0.861849
2013-01-04    0.721555
2013-01-05   -0.424972
```

```
2013-01-06   -0.673690
Freq: D, Name: A, dtype: float64
```

Selecting via `[]`, which slices the rows.

```
In [24]: df[0:3]
Out[24]:
                   A         B         C         D
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804

In [25]: df['20130102':'20130104']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
```

5.3.2 Selection by Label

See more in *Selection by Label*

For getting a cross section using a label

```
In [26]: df.loc[dates[0]]
Out[26]:
A    0.469112
B   -0.282863
C   -1.509059
D   -1.135632
Name: 2013-01-01 00:00:00, dtype: float64
```

Selecting on a multi-axis by label

```
In [27]: df.loc[:,['A','B']]
Out[27]:
                   A         B
2013-01-01  0.469112 -0.282863
2013-01-02  1.212112 -0.173215
2013-01-03 -0.861849 -2.104569
2013-01-04  0.721555 -0.706771
2013-01-05 -0.424972  0.567020
2013-01-06 -0.673690  0.113648
```

Showing label slicing, both endpoints are *included*

```
In [28]: df.loc['20130102':'20130104',['A','B']]
Out[28]:
                   A         B
2013-01-02  1.212112 -0.173215
2013-01-03 -0.861849 -2.104569
2013-01-04  0.721555 -0.706771
```

Reduction in the dimensions of the returned object

```
In [29]: df.loc['20130102',['A','B']]
Out[29]:
A    1.212112
B   -0.173215
Name: 2013-01-02 00:00:00, dtype: float64
```

For getting a scalar value

```
In [30]: df.loc[dates[0],'A']
Out[30]: 0.46911229990718628
```

For getting fast access to a scalar (equiv to the prior method)

```
In [31]: df.at[dates[0],'A']
Out[31]: 0.46911229990718628
```

5.3.3 Selection by Position

See more in *Selection by Position*

Select via the position of the passed integers

```
In [32]: df.iloc[3]
Out[32]:
A    0.721555
B   -0.706771
C   -1.039575
D    0.271860
Name: 2013-01-04 00:00:00, dtype: float64
```

By integer slices, acting similar to numpy/python

```
In [33]: df.iloc[3:5,0:2]
Out[33]:
                   A         B
2013-01-04  0.721555 -0.706771
2013-01-05 -0.424972  0.567020
```

By lists of integer position locations, similar to the numpy/python style

```
In [34]: df.iloc[[1,2,4],[0,2]]
Out[34]:
                   A         C
2013-01-02  1.212112  0.119209
2013-01-03 -0.861849 -0.494929
2013-01-05 -0.424972  0.276232
```

For slicing rows explicitly

```
In [35]: df.iloc[1:3,:]
Out[35]:
                   A         B         C         D
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
```

For slicing columns explicitly

```
In [36]: df.iloc[:,1:3]
Out[36]:
                   B         C
2013-01-01 -0.282863 -1.509059
2013-01-02 -0.173215  0.119209
2013-01-03 -2.104569 -0.494929
2013-01-04 -0.706771 -1.039575
2013-01-05  0.567020  0.276232
2013-01-06  0.113648 -1.478427
```

For getting a value explicitly

```
In [37]: df.iloc[1,1]
Out[37]: -0.17321464905330858
```

For getting fast access to a scalar (equiv to the prior method)

```
In [38]: df.iat[1,1]
Out[38]: -0.17321464905330858
```

5.3.4 Boolean Indexing

Using a single column's values to select data.

```
In [39]: df[df.A > 0]
Out[39]:
                   A         B         C         D
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
```

Selecting values from a DataFrame where a boolean condition is met.

```
In [40]: df[df > 0]
Out[40]:
                   A         B         C         D
2013-01-01  0.469112       NaN       NaN       NaN
2013-01-02  1.212112       NaN  0.119209       NaN
2013-01-03       NaN       NaN       NaN  1.071804
2013-01-04  0.721555       NaN       NaN  0.271860
2013-01-05       NaN  0.567020  0.276232       NaN
2013-01-06       NaN  0.113648       NaN  0.524988
```

Using the `isin()` method for filtering:

```
In [41]: df2 = df.copy()

In [42]: df2['E'] = ['one', 'one','two','three','four','three']

In [43]: df2
Out[43]:
                   A         B         C         D      E
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632    one
2013-01-02  1.212112 -0.173215  0.119209 -1.044236    one
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804    two
2013-01-04  0.721555 -0.706771 -1.039575  0.271860  three
```

```
2013-01-05 -0.424972  0.567020  0.276232 -1.087401   four
2013-01-06 -0.673690  0.113648 -1.478427  0.524988  three

In [44]: df2[df2['E'].isin(['two','four'])]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D     E
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804   two
2013-01-05 -0.424972  0.567020  0.276232 -1.087401  four
```

5.3.5 Setting

Setting a new column automatically aligns the data by the indexes

```
In [45]: s1 = pd.Series([1,2,3,4,5,6], index=pd.date_range('20130102', periods=6))

In [46]: s1
Out[46]:
2013-01-02    1
2013-01-03    2
2013-01-04    3
2013-01-05    4
2013-01-06    5
2013-01-07    6
Freq: D, dtype: int64

In [47]: df['F'] = s1
```

Setting values by label

```
In [48]: df.at[dates[0],'A'] = 0
```

Setting values by position

```
In [49]: df.iat[0,1] = 0
```

Setting by assigning with a numpy array

```
In [50]: df.loc[:,'D'] = np.array([5] * len(df))
```

The result of the prior setting operations

```
In [51]: df
Out[51]:
                   A         B         C  D    F
2013-01-01  0.000000  0.000000 -1.509059  5  NaN
2013-01-02  1.212112 -0.173215  0.119209  5  1.0
2013-01-03 -0.861849 -2.104569 -0.494929  5  2.0
2013-01-04  0.721555 -0.706771 -1.039575  5  3.0
2013-01-05 -0.424972  0.567020  0.276232  5  4.0
2013-01-06 -0.673690  0.113648 -1.478427  5  5.0
```

A `where` operation with setting.

```
In [52]: df2 = df.copy()
```

```
In [53]: df2[df2 > 0] = -df2

In [54]: df2
Out[54]:
                   A         B         C  D    F
2013-01-01  0.000000  0.000000 -1.509059 -5  NaN
2013-01-02 -1.212112 -0.173215 -0.119209 -5 -1.0
2013-01-03 -0.861849 -2.104569 -0.494929 -5 -2.0
2013-01-04 -0.721555 -0.706771 -1.039575 -5 -3.0
2013-01-05 -0.424972 -0.567020 -0.276232 -5 -4.0
2013-01-06 -0.673690 -0.113648 -1.478427 -5 -5.0
```

5.4 Missing Data

pandas primarily uses the value `np.nan` to represent missing data. It is by default not included in computations. See the *Missing Data section*

Reindexing allows you to change/add/delete the index on a specified axis. This returns a copy of the data.

```
In [55]: df1 = df.reindex(index=dates[0:4], columns=list(df.columns) + ['E'])

In [56]: df1.loc[dates[0]:dates[1],'E'] = 1

In [57]: df1
Out[57]:
                   A         B         C  D    F    E
2013-01-01  0.000000  0.000000 -1.509059  5  NaN  1.0
2013-01-02  1.212112 -0.173215  0.119209  5  1.0  1.0
2013-01-03 -0.861849 -2.104569 -0.494929  5  2.0  NaN
2013-01-04  0.721555 -0.706771 -1.039575  5  3.0  NaN
```

To drop any rows that have missing data.

```
In [58]: df1.dropna(how='any')
Out[58]:
                   A         B         C  D    F    E
2013-01-02  1.212112 -0.173215  0.119209  5  1.0  1.0
```

Filling missing data

```
In [59]: df1.fillna(value=5)
Out[59]:
                   A         B         C  D    F    E
2013-01-01  0.000000  0.000000 -1.509059  5  5.0  1.0
2013-01-02  1.212112 -0.173215  0.119209  5  1.0  1.0
2013-01-03 -0.861849 -2.104569 -0.494929  5  2.0  5.0
2013-01-04  0.721555 -0.706771 -1.039575  5  3.0  5.0
```

To get the boolean mask where values are `nan`

```
In [60]: pd.isna(df1)
Out[60]:
                A      B      C      D      F      E
2013-01-01  False  False  False  False   True  False
2013-01-02  False  False  False  False  False  False
```

```
2013-01-03  False  False  False  False  False   True
2013-01-04  False  False  False  False  False   True
```

5.5 Operations

See the *Basic section on Binary Ops*

5.5.1 Stats

Operations in general *exclude* missing data.

Performing a descriptive statistic

```
In [61]: df.mean()
Out[61]:
A   -0.004474
B   -0.383981
C   -0.687758
D    5.000000
F    3.000000
dtype: float64
```

Same operation on the other axis

```
In [62]: df.mean(1)
Out[62]:
2013-01-01    0.872735
2013-01-02    1.431621
2013-01-03    0.707731
2013-01-04    1.395042
2013-01-05    1.883656
2013-01-06    1.592306
Freq: D, dtype: float64
```

Operating with objects that have different dimensionality and need alignment. In addition, pandas automatically broadcasts along the specified dimension.

```
In [63]: s = pd.Series([1,3,5,np.nan,6,8], index=dates).shift(2)

In [64]: s
Out[64]:
2013-01-01    NaN
2013-01-02    NaN
2013-01-03    1.0
2013-01-04    3.0
2013-01-05    5.0
2013-01-06    NaN
Freq: D, dtype: float64

In [65]: df.sub(s, axis='index')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C    D    F
2013-01-01       NaN       NaN       NaN  NaN  NaN
```

```
2013-01-02       NaN       NaN       NaN  NaN  NaN
2013-01-03 -1.861849 -3.104569 -1.494929  4.0  1.0
2013-01-04 -2.278445 -3.706771 -4.039575  2.0  0.0
2013-01-05 -5.424972 -4.432980 -4.723768  0.0 -1.0
2013-01-06       NaN       NaN       NaN  NaN  NaN
```

5.5.2 Apply

Applying functions to the data

```
In [66]: df.apply(np.cumsum)
Out[66]:
                   A         B         C   D     F
2013-01-01  0.000000  0.000000 -1.509059   5   NaN
2013-01-02  1.212112 -0.173215 -1.389850  10   1.0
2013-01-03  0.350263 -2.277784 -1.884779  15   3.0
2013-01-04  1.071818 -2.984555 -2.924354  20   6.0
2013-01-05  0.646846 -2.417535 -2.648122  25  10.0
2013-01-06 -0.026844 -2.303886 -4.126549  30  15.0

In [67]: df.apply(lambda x: x.max() - x.min())
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    2.073961
B    2.671590
C    1.785291
D    0.000000
F    4.000000
dtype: float64
```

5.5.3 Histogramming

See more at *Histogramming and Discretization*

```
In [68]: s = pd.Series(np.random.randint(0, 7, size=10))

In [69]: s
Out[69]:
0    4
1    2
2    1
3    2
4    6
5    4
6    4
7    6
8    4
9    4
dtype: int64

In [70]: s.value_counts()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[70]
↪
4    5
6    2
```

```
2    2
1    1
dtype: int64
```

5.5.4 String Methods

Series is equipped with a set of string processing methods in the *str* attribute that make it easy to operate on each element of the array, as in the code snippet below. Note that pattern-matching in *str* generally uses regular expressions by default (and in some cases always uses them). See more at *Vectorized String Methods*.

```
In [71]: s = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog', 'cat'])

In [72]: s.str.lower()
Out[72]:
0       a
1       b
2       c
3    aaba
4    baca
5     NaN
6    caba
7     dog
8     cat
dtype: object
```

5.6 Merge

5.6.1 Concat

pandas provides various facilities for easily combining together Series, DataFrame, and Panel objects with various kinds of set logic for the indexes and relational algebra functionality in the case of join / merge-type operations.

See the *Merging section*

Concatenating pandas objects together with `concat()`:

```
In [73]: df = pd.DataFrame(np.random.randn(10, 4))

In [74]: df
Out[74]:
          0         1         2         3
0 -0.548702  1.467327 -1.015962 -0.483075
1  1.637550 -1.217659 -0.291519 -1.745505
2 -0.263952  0.991460 -0.919069  0.266046
3 -0.709661  1.669052  1.037882 -1.705775
4 -0.919854 -0.042379  1.247642 -0.009920
5  0.290213  0.495767  0.362949  1.548106
6 -1.131345 -0.089329  0.337863 -0.945867
7 -0.932132  1.956030  0.017587 -0.016692
8 -0.575247  0.254161 -1.143704  0.215897
9  1.193555 -0.077118 -0.408530 -0.862495

# break it into pieces
In [75]: pieces = [df[:3], df[3:7], df[7:]]
```

```
In [76]: pd.concat(pieces)
Out[76]:
          0         1         2         3
0 -0.548702  1.467327 -1.015962 -0.483075
1  1.637550 -1.217659 -0.291519 -1.745505
2 -0.263952  0.991460 -0.919069  0.266046
3 -0.709661  1.669052  1.037882 -1.705775
4 -0.919854 -0.042379  1.247642 -0.009920
5  0.290213  0.495767  0.362949  1.548106
6 -1.131345 -0.089329  0.337863 -0.945867
7 -0.932132  1.956030  0.017587 -0.016692
8 -0.575247  0.254161 -1.143704  0.215897
9  1.193555 -0.077118 -0.408530 -0.862495
```

5.6.2 Join

SQL style merges. See the *Database style joining*

```
In [77]: left = pd.DataFrame({'key': ['foo', 'foo'], 'lval': [1, 2]})

In [78]: right = pd.DataFrame({'key': ['foo', 'foo'], 'rval': [4, 5]})

In [79]: left
Out[79]:
   key  lval
0  foo     1
1  foo     2

In [80]: right
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[80]:
   key  rval
0  foo     4
1  foo     5

In [81]: pd.merge(left, right, on='key')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out
↪
   key  lval  rval
0  foo     1     4
1  foo     1     5
2  foo     2     4
3  foo     2     5
```

Another example that can be given is:

```
In [82]: left = pd.DataFrame({'key': ['foo', 'bar'], 'lval': [1, 2]})

In [83]: right = pd.DataFrame({'key': ['foo', 'bar'], 'rval': [4, 5]})

In [84]: left
Out[84]:
   key  lval
0  foo     1
1  bar     2
```

```
In [85]: right
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[85]:
   key  rval
0  foo     4
1  bar     5

In [86]: pd.merge(left, right, on='key')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out
↪
   key  lval  rval
0  foo     1     4
1  bar     2     5
```

5.6.3 Append

Append rows to a dataframe. See the *Appending*

```
In [87]: df = pd.DataFrame(np.random.randn(8, 4), columns=['A','B','C','D'])

In [88]: df
Out[88]:
          A         B         C         D
0  1.346061  1.511763  1.627081 -0.990582
1 -0.441652  1.211526  0.268520  0.024580
2 -1.577585  0.396823 -0.105381 -0.532532
3  1.453749  1.208843 -0.080952 -0.264610
4 -0.727965 -0.589346  0.339969 -0.693205
5 -0.339355  0.593616  0.884345  1.591431
6  0.141809  0.220390  0.435589  0.192451
7 -0.096701  0.803351  1.715071 -0.708758

In [89]: s = df.iloc[3]

In [90]: df.append(s, ignore_index=True)
Out[90]:
          A         B         C         D
0  1.346061  1.511763  1.627081 -0.990582
1 -0.441652  1.211526  0.268520  0.024580
2 -1.577585  0.396823 -0.105381 -0.532532
3  1.453749  1.208843 -0.080952 -0.264610
4 -0.727965 -0.589346  0.339969 -0.693205
5 -0.339355  0.593616  0.884345  1.591431
6  0.141809  0.220390  0.435589  0.192451
7 -0.096701  0.803351  1.715071 -0.708758
8  1.453749  1.208843 -0.080952 -0.264610
```

5.7 Grouping

By "group by" we are referring to a process involving one or more of the following steps

- **Splitting** the data into groups based on some criteria
- **Applying** a function to each group independently
- **Combining** the results into a data structure

See the *Grouping section*

```
In [91]: df = pd.DataFrame({'A' : ['foo', 'bar', 'foo', 'bar',
   ....:                           'foo', 'bar', 'foo', 'foo'],
   ....:                    'B' : ['one', 'one', 'two', 'three',
   ....:                           'two', 'two', 'one', 'three'],
   ....:                    'C' : np.random.randn(8),
   ....:                    'D' : np.random.randn(8)})
   ....:

In [92]: df
Out[92]:
     A      B         C         D
0  foo    one -1.202872 -0.055224
1  bar    one -1.814470  2.395985
2  foo    two  1.018601  1.552825
3  bar  three -0.595447  0.166599
4  foo    two  1.395433  0.047609
5  bar    two -0.392670 -0.136473
6  foo    one  0.007207 -0.561757
7  foo  three  1.928123 -1.623033
```

Grouping and then applying a function `sum` to the resulting groups.

```
In [93]: df.groupby('A').sum()
Out[93]:
            C        D
A
bar -2.802588  2.42611
foo  3.146492 -0.63958
```

Grouping by multiple columns forms a hierarchical index, which we then apply the function.

```
In [94]: df.groupby(['A','B']).sum()
Out[94]:
                  C         D
A   B
bar one   -1.814470  2.395985
    three -0.595447  0.166599
    two   -0.392670 -0.136473
foo one   -1.195665 -0.616981
    three  1.928123 -1.623033
    two    2.414034  1.600434
```

5.8 Reshaping

See the sections on *Hierarchical Indexing* and *Reshaping*.

5.8.1 Stack

```
In [95]: tuples = list(zip(*[['bar', 'bar', 'baz', 'baz',
   ....:                      'foo', 'foo', 'qux', 'qux'],
   ....:                     ['one', 'two', 'one', 'two',
   ....:                      'one', 'two', 'one', 'two']]))
```

```
   ....:

In [96]: index = pd.MultiIndex.from_tuples(tuples, names=['first', 'second'])

In [97]: df = pd.DataFrame(np.random.randn(8, 2), index=index, columns=['A', 'B'])

In [98]: df2 = df[:4]

In [99]: df2
Out[99]:
                     A         B
first second
bar   one     0.029399 -0.542108
      two     0.282696 -0.087302
baz   one    -1.575170  1.771208
      two     0.816482  1.100230
```

The *`stack()`* method "compresses" a level in the DataFrame's columns.

```
In [100]: stacked = df2.stack()

In [101]: stacked
Out[101]:
first  second
bar    one     A    0.029399
               B   -0.542108
       two     A    0.282696
               B   -0.087302
baz    one     A   -1.575170
               B    1.771208
       two     A    0.816482
               B    1.100230
dtype: float64
```

With a "stacked" DataFrame or Series (having a `MultiIndex` as the `index`), the inverse operation of *`stack()`* is *`unstack()`*, which by default unstacks the **last level**:

```
In [102]: stacked.unstack()
Out[102]:
                     A         B
first second
bar   one     0.029399 -0.542108
      two     0.282696 -0.087302
baz   one    -1.575170  1.771208
      two     0.816482  1.100230

In [103]: stacked.unstack(1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
second          one       two
first
bar    A  0.029399  0.282696
       B -0.542108 -0.087302
baz    A -1.575170  0.816482
       B  1.771208  1.100230

In [104]: stacked.unstack(0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
first          bar       baz
second
one    A  0.029399 -1.575170
       B -0.542108  1.771208
two    A  0.282696  0.816482
       B -0.087302  1.100230
```

5.8.2 Pivot Tables

See the section on *Pivot Tables*.

```
In [105]: df = pd.DataFrame({'A' : ['one', 'one', 'two', 'three'] * 3,
   .....:                    'B' : ['A', 'B', 'C'] * 4,
   .....:                    'C' : ['foo', 'foo', 'foo', 'bar', 'bar', 'bar'] * 2,
   .....:                    'D' : np.random.randn(12),
   .....:                    'E' : np.random.randn(12)})
   .....:

In [106]: df
Out[106]:
        A  B    C         D         E
0     one  A  foo  1.418757 -0.179666
1     one  B  foo -1.879024  1.291836
2     two  C  foo  0.536826 -0.009614
3   three  A  bar  1.006160  0.392149
4     one  B  bar -0.029716  0.264599
5     one  C  bar -1.146178 -0.057409
6     two  A  foo  0.100900 -1.425638
7   three  B  foo -1.035018  1.024098
8     one  C  foo  0.314665 -0.106062
9     one  A  bar -0.773723  1.824375
10    two  B  bar -1.170653  0.595974
11  three  C  bar  0.648740  1.167115
```

We can produce pivot tables from this data very easily:

```
In [107]: pd.pivot_table(df, values='D', index=['A', 'B'], columns=['C'])
Out[107]:
C             bar       foo
A     B
one   A -0.773723  1.418757
      B -0.029716 -1.879024
      C -1.146178  0.314665
three A  1.006160       NaN
      B       NaN -1.035018
      C  0.648740       NaN
two   A       NaN  0.100900
      B -1.170653       NaN
      C       NaN  0.536826
```

5.9 Time Series

pandas has simple, powerful, and efficient functionality for performing resampling operations during frequency conversion (e.g., converting secondly data into 5-minutely data). This is extremely common in, but not limited to, financial

applications. See the *Time Series section*

```
In [108]: rng = pd.date_range('1/1/2012', periods=100, freq='S')

In [109]: ts = pd.Series(np.random.randint(0, 500, len(rng)), index=rng)

In [110]: ts.resample('5Min').sum()
Out[110]:
2012-01-01    25083
Freq: 5T, dtype: int64
```

Time zone representation

```
In [111]: rng = pd.date_range('3/6/2012 00:00', periods=5, freq='D')

In [112]: ts = pd.Series(np.random.randn(len(rng)), rng)

In [113]: ts
Out[113]:
2012-03-06    0.464000
2012-03-07    0.227371
2012-03-08   -0.496922
2012-03-09    0.306389
2012-03-10   -2.290613
Freq: D, dtype: float64

In [114]: ts_utc = ts.tz_localize('UTC')

In [115]: ts_utc
Out[115]:
2012-03-06 00:00:00+00:00    0.464000
2012-03-07 00:00:00+00:00    0.227371
2012-03-08 00:00:00+00:00   -0.496922
2012-03-09 00:00:00+00:00    0.306389
2012-03-10 00:00:00+00:00   -2.290613
Freq: D, dtype: float64
```

Convert to another time zone

```
In [116]: ts_utc.tz_convert('US/Eastern')
Out[116]:
2012-03-05 19:00:00-05:00    0.464000
2012-03-06 19:00:00-05:00    0.227371
2012-03-07 19:00:00-05:00   -0.496922
2012-03-08 19:00:00-05:00    0.306389
2012-03-09 19:00:00-05:00   -2.290613
Freq: D, dtype: float64
```

Converting between time span representations

```
In [117]: rng = pd.date_range('1/1/2012', periods=5, freq='M')

In [118]: ts = pd.Series(np.random.randn(len(rng)), index=rng)

In [119]: ts
Out[119]:
2012-01-31   -1.134623
2012-02-29   -1.561819
2012-03-31   -0.260838
```

```
2012-04-30    0.281957
2012-05-31    1.523962
Freq: M, dtype: float64

In [120]: ps = ts.to_period()

In [121]: ps
Out[121]: 
2012-01   -1.134623
2012-02   -1.561819
2012-03   -0.260838
2012-04    0.281957
2012-05    1.523962
Freq: M, dtype: float64

In [122]: ps.to_timestamp()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-01-01   -1.134623
2012-02-01   -1.561819
2012-03-01   -0.260838
2012-04-01    0.281957
2012-05-01    1.523962
Freq: MS, dtype: float64
```

Converting between period and timestamp enables some convenient arithmetic functions to be used. In the following example, we convert a quarterly frequency with year ending in November to 9am of the end of the month following the quarter end:

```
In [123]: prng = pd.period_range('1990Q1', '2000Q4', freq='Q-NOV')

In [124]: ts = pd.Series(np.random.randn(len(prng)), prng)

In [125]: ts.index = (prng.asfreq('M', 'e') + 1).asfreq('H', 's') + 9

In [126]: ts.head()
Out[126]: 
1990-03-01 09:00   -0.902937
1990-06-01 09:00    0.068159
1990-09-01 09:00   -0.057873
1990-12-01 09:00   -0.368204
1991-03-01 09:00   -1.144073
Freq: H, dtype: float64
```

5.10 Categoricals

pandas can include categorical data in a `DataFrame`. For full docs, see the *categorical introduction* and the *API documentation*.

```
In [127]: df = pd.DataFrame({"id":[1,2,3,4,5,6], "raw_grade":['a', 'b', 'b', 'a', 'a',
↪ 'e']})
```

Convert the raw grades to a categorical data type.

```
In [128]: df["grade"] = df["raw_grade"].astype("category")

In [129]: df["grade"]
Out[129]:
0    a
1    b
2    b
3    a
4    a
5    e
Name: grade, dtype: category
Categories (3, object): [a, b, e]
```

Rename the categories to more meaningful names (assigning to `Series.cat.categories` is inplace!)

```
In [130]: df["grade"].cat.categories = ["very good", "good", "very bad"]
```

Reorder the categories and simultaneously add the missing categories (methods under `Series .cat` return a new `Series` per default).

```
In [131]: df["grade"] = df["grade"].cat.set_categories(["very bad", "bad", "medium",
↪"good", "very good"])

In [132]: df["grade"]
Out[132]:
0    very good
1         good
2         good
3    very good
4    very good
5     very bad
Name: grade, dtype: category
Categories (5, object): [very bad, bad, medium, good, very good]
```

Sorting is per order in the categories, not lexical order.

```
In [133]: df.sort_values(by="grade")
Out[133]:
   id raw_grade      grade
5   6         e   very bad
1   2         b       good
2   3         b       good
0   1         a  very good
3   4         a  very good
4   5         a  very good
```

Grouping by a categorical column shows also empty categories.

```
In [134]: df.groupby("grade").size()
Out[134]:
grade
very bad     1
bad          0
medium       0
good         2
very good    3
dtype: int64
```

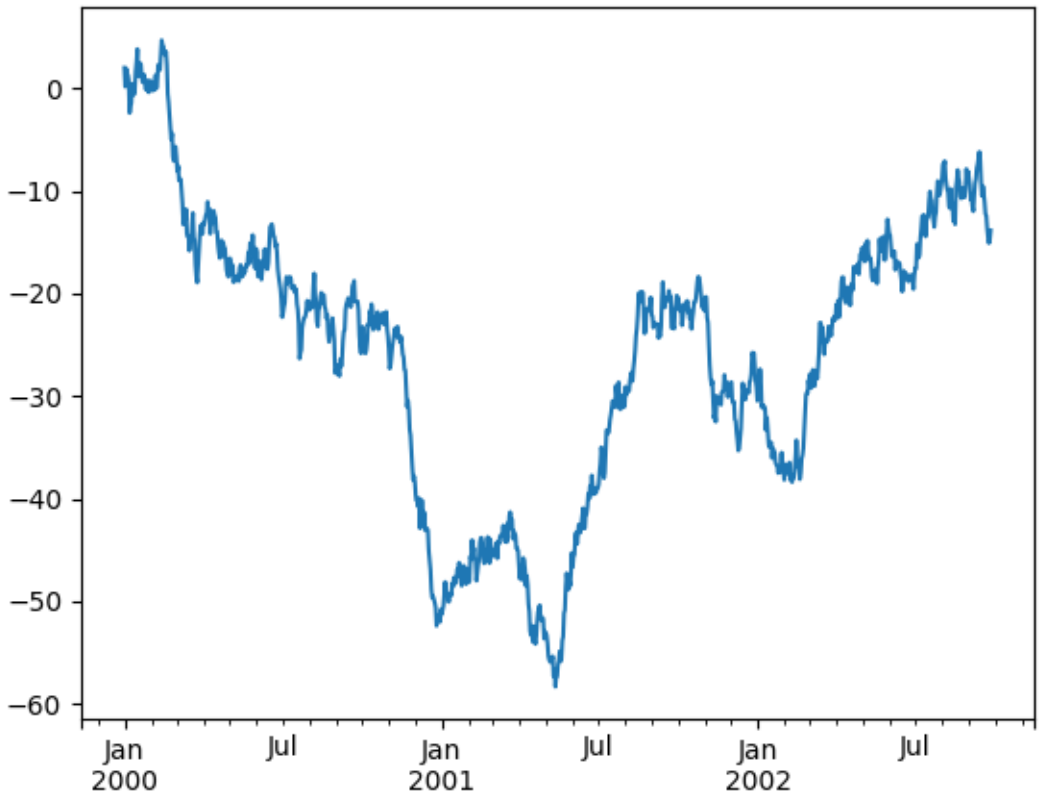
5.11 Plotting

Plotting docs.

```
In [135]: ts = pd.Series(np.random.randn(1000), index=pd.date_range('1/1/2000',␣
↪periods=1000))

In [136]: ts = ts.cumsum()

In [137]: ts.plot()
Out[137]: <matplotlib.axes._subplots.AxesSubplot at 0x1108045c0>
```

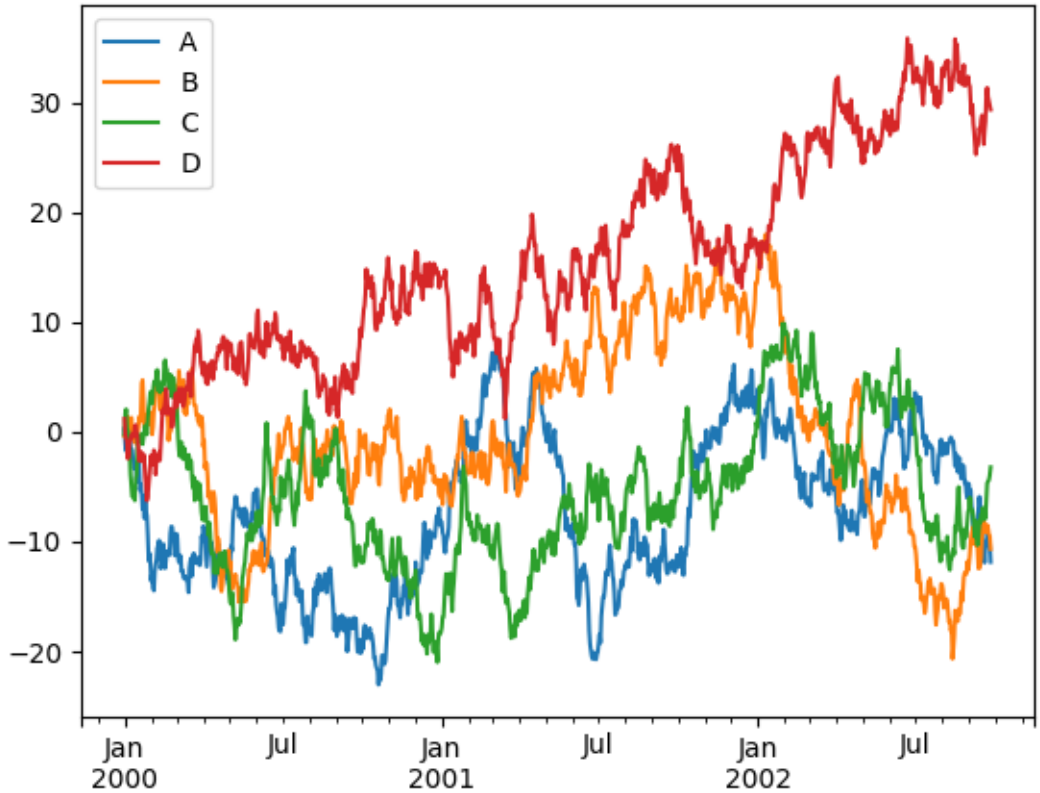


On DataFrame, `plot()` is a convenience to plot all of the columns with labels:

```
In [138]: df = pd.DataFrame(np.random.randn(1000, 4), index=ts.index,
   .....:                   columns=['A', 'B', 'C', 'D'])
   .....:

In [139]: df = df.cumsum()

In [140]: plt.figure(); df.plot(); plt.legend(loc='best')
Out[140]: <matplotlib.legend.Legend at 0x115427080>
```



5.12 Getting Data In/Out

5.12.1 CSV

Writing to a csv file

```
In [141]: df.to_csv('foo.csv')
```

Reading from a csv file

```
In [142]: pd.read_csv('foo.csv')
Out[142]:
     Unnamed: 0          A          B         C          D
0    2000-01-01   0.266457  -0.399641 -0.219582   1.186860
1    2000-01-02  -1.170732  -0.345873  1.653061  -0.282953
2    2000-01-03  -1.734933   0.530468  2.060811  -0.515536
3    2000-01-04  -1.555121   1.452620  0.239859  -1.156896
4    2000-01-05   0.578117   0.511371  0.103552  -2.428202
5    2000-01-06   0.478344   0.449933 -0.741620  -1.962409
6    2000-01-07   1.235339  -0.091757 -1.543861  -1.084753
..          ...        ...        ...       ...        ...
993  2002-09-20 -10.628548  -9.153563 -7.883146  28.313940
994  2002-09-21 -10.390377  -8.727491 -6.399645  30.914107
995  2002-09-22  -8.985362  -8.485624 -4.669462  31.367740
996  2002-09-23  -9.558560  -8.781216 -4.499815  30.518439
997  2002-09-24  -9.902058  -9.340490 -4.386639  30.105593
```

```
998  2002-09-25 -10.216020  -9.480682 -3.933802  29.758560
999  2002-09-26 -11.856774 -10.671012 -3.216025  29.369368

[1000 rows x 5 columns]
```

5.12.2 HDF5

Reading and writing to *HDFStores*

Writing to a HDF5 Store

```
In [143]: df.to_hdf('foo.h5','df')
```

Reading from a HDF5 Store

```
In [144]: pd.read_hdf('foo.h5','df')
Out[144]:
                    A          B         C          D
2000-01-01   0.266457  -0.399641 -0.219582   1.186860
2000-01-02  -1.170732  -0.345873  1.653061  -0.282953
2000-01-03  -1.734933   0.530468  2.060811  -0.515536
2000-01-04  -1.555121   1.452620  0.239859  -1.156896
2000-01-05   0.578117   0.511371  0.103552  -2.428202
2000-01-06   0.478344   0.449933 -0.741620  -1.962409
2000-01-07   1.235339  -0.091757 -1.543861  -1.084753
...               ...        ...       ...        ...
2002-09-20 -10.628548  -9.153563 -7.883146  28.313940
2002-09-21 -10.390377  -8.727491 -6.399645  30.914107
2002-09-22  -8.985362  -8.485624 -4.669462  31.367740
2002-09-23  -9.558560  -8.781216 -4.499815  30.518439
2002-09-24  -9.902058  -9.340490 -4.386639  30.105593
2002-09-25 -10.216020  -9.480682 -3.933802  29.758560
2002-09-26 -11.856774 -10.671012 -3.216025  29.369368

[1000 rows x 4 columns]
```

5.12.3 Excel

Reading and writing to *MS Excel*

Writing to an excel file

```
In [145]: df.to_excel('foo.xlsx', sheet_name='Sheet1')
```

Reading from an excel file

```
In [146]: pd.read_excel('foo.xlsx', 'Sheet1', index_col=None, na_values=['NA'])
Out[146]:
                    A          B         C          D
2000-01-01   0.266457  -0.399641 -0.219582   1.186860
2000-01-02  -1.170732  -0.345873  1.653061  -0.282953
2000-01-03  -1.734933   0.530468  2.060811  -0.515536
2000-01-04  -1.555121   1.452620  0.239859  -1.156896
2000-01-05   0.578117   0.511371  0.103552  -2.428202
2000-01-06   0.478344   0.449933 -0.741620  -1.962409
```

```
2000-01-07   1.235339  -0.091757 -1.543861  -1.084753
...               ...        ...       ...        ...
2002-09-20 -10.628548  -9.153563 -7.883146  28.313940
2002-09-21 -10.390377  -8.727491 -6.399645  30.914107
2002-09-22  -8.985362  -8.485624 -4.669462  31.367740
2002-09-23  -9.558560  -8.781216 -4.499815  30.518439
2002-09-24  -9.902058  -9.340490 -4.386639  30.105593
2002-09-25 -10.216020  -9.480682 -3.933802  29.758560
2002-09-26 -11.856774 -10.671012 -3.216025  29.369368

[1000 rows x 4 columns]
```

5.13 Gotchas

If you are trying an operation and you see an exception like:

```
>>> if pd.Series([False, True, False]):
    print("I was true")
Traceback
    ...
ValueError: The truth value of an array is ambiguous. Use a.empty, a.any() or a.all().
```

See *Comparisons* for an explanation and what to do.

See *Gotchas* as well.

CHAPTER

SIX

TUTORIALS

This is a guide to many pandas tutorials, geared mainly for new users.

6.1 Internal Guides

pandas own *10 Minutes to pandas*

More complex recipes are in the *Cookbook*

6.2 pandas Cookbook

The goal of this cookbook (by Julia Evans) is to give you some concrete examples for getting started with pandas. These are examples with real-world data, and all the bugs and weirdness that that entails.

Here are links to the v0.1 release. For an up-to-date table of contents, see the pandas-cookbook GitHub repository. To run the examples in this tutorial, you'll need to clone the GitHub repository and get IPython Notebook running. See How to use this cookbook.

- A quick tour of the IPython Notebook: Shows off IPython's awesome tab completion and magic functions.
- Chapter 1: Reading your data into pandas is pretty much the easiest thing. Even when the encoding is wrong!
- Chapter 2: It's not totally obvious how to select data from a pandas dataframe. Here we explain the basics (how to take slices and get columns)
- Chapter 3: Here we get into serious slicing and dicing and learn how to filter dataframes in complicated ways, really fast.
- Chapter 4: Groupby/aggregate is seriously my favorite thing about pandas and I use it all the time. You should probably read this.
- Chapter 5: Here you get to find out if it's cold in Montreal in the winter (spoiler: yes). Web scraping with pandas is fun! Here we combine dataframes.
- Chapter 6: Strings with pandas are great. It has all these vectorized string operations and they're the best. We will turn a bunch of strings containing "Snow" into vectors of numbers in a trice.
- Chapter 7: Cleaning up messy data is never a joy, but with pandas it's easier.
- Chapter 8: Parsing Unix timestamps is confusing at first but it turns out to be really easy.

6.3 Lessons for New pandas Users

For more resources, please visit the main repository.

- 01 - Lesson: - Importing libraries - Creating data sets - Creating data frames - Reading from CSV - Exporting to CSV - Finding maximums - Plotting data
- 02 - Lesson: - Reading from TXT - Exporting to TXT - Selecting top/bottom records - Descriptive statistics - Grouping/sorting data
- 03 - Lesson: - Creating functions - Reading from EXCEL - Exporting to EXCEL - Outliers - Lambda functions - Slice and dice data
- 04 - Lesson: - Adding/deleting columns - Index operations
- 05 - Lesson: - Stack/Unstack/Transpose functions
- 06 - Lesson: - GroupBy function
- 07 - Lesson: - Ways to calculate outliers
- 08 - Lesson: - Read from Microsoft SQL databases
- 09 - Lesson: - Export to CSV/EXCEL/TXT
- 10 - Lesson: - Converting between different kinds of formats
- 11 - Lesson: - Combining data from various sources

6.4 Practical data analysis with Python

This guide is a comprehensive introduction to the data analysis process using the Python data ecosystem and an interesting open dataset. There are four sections covering selected topics as follows:

- Munging Data
- Aggregating Data
- Visualizing Data
- Time Series

6.5 Exercises for New Users

Practice your skills with real data sets and exercises. For more resources, please visit the main repository.

- 01 - Getting & Knowing Your Data
- 02 - Filtering & Sorting
- 03 - Grouping
- 04 - Apply
- 05 - Merge
- 06 - Stats
- 07 - Visualization
- 08 - Creating Series and DataFrames

- 09 - Time Series
- 10 - Deleting

6.6 Modern Pandas

- Modern Pandas
- Method Chaining
- Indexes
- Performance
- Tidy Data
- Visualization

6.7 Excel charts with pandas, vincent and xlsxwriter

- Using Pandas and XlsxWriter to create Excel charts

6.8 Various Tutorials

- Wes McKinney's (pandas BDFL) blog
- Statistical analysis made easy in Python with SciPy and pandas DataFrames, by Randal Olson
- Statistical Data Analysis in Python, tutorial videos, by Christopher Fonnesbeck from SciPy 2013
- Financial analysis in python, by Thomas Wiecki
- Intro to pandas data structures, by Greg Reda
- Pandas and Python: Top 10, by Manish Amde
- Pandas Tutorial, by Mikhail Semeniuk
- Pandas DataFrames Tutorial, by Karlijn Willems
- A concise tutorial with real life examples

CHAPTER

SEVEN

COOKBOOK

This is a repository for *short and sweet* examples and links for useful pandas recipes. We encourage users to add to this documentation.

Adding interesting links and/or inline examples to this section is a great *First Pull Request*.

Simplified, condensed, new-user friendly, in-line examples have been inserted where possible to augment the Stack-Overflow and GitHub links. Many of the links contain expanded information, above what the in-line examples offer.

Pandas (pd) and Numpy (np) are the only two abbreviated imported modules. The rest are kept explicitly imported for newer users.

These examples are written for python 3.4. Minor tweaks might be necessary for earlier python versions.

7.1 Idioms

These are some neat pandas `idioms`

if-then/if-then-else on one column, and assignment to another one or more columns:

```
In [1]: df = pd.DataFrame(
   ...:      {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40],'CCC' : [100,50,-30,-50]}); df
   ...:
Out[1]:
   AAA  BBB  CCC
0    4   10  100
1    5   20   50
2    6   30  -30
3    7   40  -50
```

7.1.1 if-then...

An if-then on one column

```
In [2]: df.loc[df.AAA >= 5,'BBB'] = -1; df
Out[2]:
   AAA  BBB  CCC
0    4   10  100
1    5   -1   50
2    6   -1  -30
3    7   -1  -50
```

An if-then with assignment to 2 columns:

```
In [3]: df.loc[df.AAA >= 5,['BBB','CCC']] = 555; df
Out[3]:
   AAA  BBB  CCC
0    4   10  100
1    5  555  555
2    6  555  555
3    7  555  555
```

Add another line with different logic, to do the -else

```
In [4]: df.loc[df.AAA < 5,['BBB','CCC']] = 2000; df
Out[4]:
   AAA   BBB   CCC
0    4  2000  2000
1    5   555   555
2    6   555   555
3    7   555   555
```

Or use pandas where after you’ve set up a mask

```
In [5]: df_mask = pd.DataFrame({'AAA' : [True] * 4, 'BBB' : [False] * 4,'CCC' : [True,
↪False] * 2})

In [6]: df.where(df_mask,-1000)
Out[6]:
   AAA   BBB   CCC
0    4 -1000  2000
1    5 -1000 -1000
2    6 -1000   555
3    7 -1000 -1000
```

if-then-else using numpy’s where()

```
In [7]: df = pd.DataFrame(
   ...:      {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40],'CCC' : [100,50,-30,-50]}); df
   ...:
Out[7]:
   AAA  BBB  CCC
0    4   10  100
1    5   20   50
2    6   30  -30
3    7   40  -50

In [8]: df['logic'] = np.where(df['AAA'] > 5,'high','low'); df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[8]
↪
   AAA  BBB  CCC logic
0    4   10  100   low
1    5   20   50   low
2    6   30  -30  high
3    7   40  -50  high
```

7.1.2 Splitting

Split a frame with a boolean criterion

```
In [9]: df = pd.DataFrame(
   ...:      {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40],'CCC' : [100,50,-30,-50]}); df
   ...:
Out[9]:
   AAA  BBB  CCC
0    4   10  100
1    5   20   50
2    6   30  -30
3    7   40  -50

In [10]: dflow = df[df.AAA <= 5]; dflow
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[10]
↪
   AAA  BBB  CCC
0    4   10  100
1    5   20   50

In [11]: dfhigh = df[df.AAA > 5]; dfhigh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   AAA  BBB  CCC
2    6   30  -30
3    7   40  -50
```

7.1.3 Building Criteria

Select with multi-column criteria

```
In [12]: df = pd.DataFrame(
   ....:      {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40],'CCC' : [100,50,-30,-50]}); df
   ....:
Out[12]:
   AAA  BBB  CCC
0    4   10  100
1    5   20   50
2    6   30  -30
3    7   40  -50
```

...and (without assignment returns a Series)

```
In [13]: newseries = df.loc[(df['BBB'] < 25) & (df['CCC'] >= -40), 'AAA']; newseries
Out[13]:
0    4
1    5
Name: AAA, dtype: int64
```

...or (without assignment returns a Series)

```
In [14]: newseries = df.loc[(df['BBB'] > 25) | (df['CCC'] >= -40), 'AAA']; newseries;
```

...or (with assignment modifies the DataFrame.)

```
In [15]: df.loc[(df['BBB'] > 25) | (df['CCC'] >= 75), 'AAA'] = 0.1; df
Out[15]:
   AAA  BBB  CCC
0  0.1   10  100
```

```
1  5.0   20   50
2  0.1   30  -30
3  0.1   40  -50
```

Select rows with data closest to certain value using argsort

```
In [16]: df = pd.DataFrame(
   ....:      {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40],'CCC' : [100,50,-30,-50]}); df
   ....:
Out[16]:
   AAA  BBB  CCC
0    4   10  100
1    5   20   50
2    6   30  -30
3    7   40  -50

In [17]: aValue = 43.0

In [18]: df.loc[(df.CCC-aValue).abs().argsort()]
Out[18]:
   AAA  BBB  CCC
1    5   20   50
0    4   10  100
2    6   30  -30
3    7   40  -50
```

Dynamically reduce a list of criteria using a binary operators

```
In [19]: df = pd.DataFrame(
   ....:      {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40],'CCC' : [100,50,-30,-50]}); df
   ....:
Out[19]:
   AAA  BBB  CCC
0    4   10  100
1    5   20   50
2    6   30  -30
3    7   40  -50

In [20]: Crit1 = df.AAA <= 5.5

In [21]: Crit2 = df.BBB == 10.0

In [22]: Crit3 = df.CCC > -40.0
```

One could hard code:

```
In [23]: AllCrit = Crit1 & Crit2 & Crit3
```

...Or it can be done with a list of dynamically built criteria

```
In [24]: CritList = [Crit1,Crit2,Crit3]

In [25]: AllCrit = functools.reduce(lambda x,y: x & y, CritList)

In [26]: df[AllCrit]
Out[26]:
   AAA  BBB  CCC
0    4   10  100
```

7.2 Selection

7.2.1 DataFrames

The *indexing* docs.

Using both row labels and value conditionals

```
In [27]: df = pd.DataFrame(
   ....:      {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40],'CCC' : [100,50,-30,-50]}); df
   ....:
Out[27]:
   AAA  BBB  CCC
0    4   10  100
1    5   20   50
2    6   30  -30
3    7   40  -50

In [28]: df[(df.AAA <= 6) & (df.index.isin([0,2,4]))]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[28
↪
   AAA  BBB  CCC
0    4   10  100
2    6   30  -30
```

Use loc for label-oriented slicing and iloc positional slicing

```
In [29]: data = {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40],'CCC' : [100,50,-30,-50]}

In [30]: df = pd.DataFrame(data=data,index=['foo','bar','boo','kar']); df
Out[30]:
     AAA  BBB  CCC
foo    4   10  100
bar    5   20   50
boo    6   30  -30
kar    7   40  -50
```

There are 2 explicit slicing methods, with a third general case

1. Positional-oriented (Python slicing style : exclusive of end)
2. Label-oriented (Non-Python slicing style : inclusive of end)
3. General (Either slicing style : depends on if the slice contains labels or positions)

```
In [31]: df.loc['bar':'kar'] #Label
Out[31]:
     AAA  BBB  CCC
bar    5   20   50
boo    6   30  -30
kar    7   40  -50

# Generic
In [32]: df.iloc[0:3]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[32]:␣
↪
     AAA  BBB  CCC
foo    4   10  100
bar    5   20   50
```

```
boo    6   30  -30

In [33]: df.loc['bar':'kar']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     AAA  BBB  CCC
bar    5   20   50
boo    6   30  -30
kar    7   40  -50
```

Ambiguity arises when an index consists of integers with a non-zero start or non-unit increment.

```
In [34]: df2 = pd.DataFrame(data=data,index=[1,2,3,4]); #Note index starts at 1.

In [35]: df2.iloc[1:3] #Position-oriented
Out[35]:
   AAA  BBB  CCC
2    5   20   50
3    6   30  -30

In [36]: df2.loc[1:3] #Label-oriented
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[36]:
   AAA  BBB  CCC
1    4   10  100
2    5   20   50
3    6   30  -30
```

Using inverse operator (~) to take the complement of a mask

```
In [37]: df = pd.DataFrame(
   ....:      {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40], 'CCC' : [100,50,-30,-50]});␣
↪df
   ....:
Out[37]:
   AAA  BBB  CCC
0    4   10  100
1    5   20   50
2    6   30  -30
3    7   40  -50

In [38]: df[~((df.AAA <= 6) & (df.index.isin([0,2,4])))]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[38
↪
   AAA  BBB  CCC
1    5   20   50
3    7   40  -50
```

7.2.2 Panels

Extend a panel frame by transposing, adding a new dimension, and transposing back to the original dimensions

```
In [39]: rng = pd.date_range('1/1/2013',periods=100,freq='D')

In [40]: data = np.random.randn(100, 4)

In [41]: cols = ['A','B','C','D']
```

```
In [42]: df1, df2, df3 = pd.DataFrame(data, rng, cols), pd.DataFrame(data, rng, cols),
↪ pd.DataFrame(data, rng, cols)

In [43]: pf = pd.Panel({'df1':df1,'df2':df2,'df3':df3});pf
Out[43]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 100 (major_axis) x 4 (minor_axis)
Items axis: df1 to df3
Major_axis axis: 2013-01-01 00:00:00 to 2013-04-10 00:00:00
Minor_axis axis: A to D

In [44]: pf.loc[:,:,'F'] = pd.DataFrame(data, rng, cols);pf
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 100 (major_axis) x 5 (minor_axis)
Items axis: df1 to df3
Major_axis axis: 2013-01-01 00:00:00 to 2013-04-10 00:00:00
Minor_axis axis: A to F
```

Mask a panel by using np.where and then reconstructing the panel with the new masked values

7.2.3 New Columns

Efficiently and dynamically creating new columns using applymap

```
In [45]: df = pd.DataFrame(
   ....:      {'AAA' : [1,2,1,3], 'BBB' : [1,1,2,2], 'CCC' : [2,1,3,1]}); df
   ....:
Out[45]:
   AAA  BBB  CCC
0    1    1    2
1    2    1    1
2    1    2    3
3    3    2    1

In [46]: source_cols = df.columns # or some subset would work too.

In [47]: new_cols = [str(x) + "_cat" for x in source_cols]

In [48]: categories = {1 : 'Alpha', 2 : 'Beta', 3 : 'Charlie' }

In [49]: df[new_cols] = df[source_cols].applymap(categories.get);df
Out[49]:
   AAA  BBB  CCC  AAA_cat BBB_cat  CCC_cat
0    1    1    2    Alpha   Alpha     Beta
1    2    1    1     Beta   Alpha    Alpha
2    1    2    3    Alpha    Beta  Charlie
3    3    2    1  Charlie    Beta    Alpha
```

Keep other columns when using min() with groupby

```
In [50]: df = pd.DataFrame(
   ....:      {'AAA' : [1,1,1,2,2,2,3,3], 'BBB' : [2,1,3,4,5,1,2,3]}); df
   ....:
Out[50]:
```

```
   AAA  BBB
0    1    2
1    1    1
2    1    3
3    2    4
4    2    5
5    2    1
6    3    2
7    3    3
```

Method 1 : idxmin() to get the index of the mins

```
In [51]: df.loc[df.groupby("AAA")["BBB"].idxmin()]
Out[51]:
   AAA  BBB
1    1    1
5    2    1
6    3    2
```

Method 2 : sort then take first of each

```
In [52]: df.sort_values(by="BBB").groupby("AAA", as_index=False).first()
Out[52]:
   AAA  BBB
0    1    1
1    2    1
2    3    2
```

Notice the same results, with the exception of the index.

7.3 MultiIndexing

The *multindexing* docs.

Creating a multi-index from a labeled frame

```
In [53]: df = pd.DataFrame({'row' : [0,1,2],
   ....:                    'One_X' : [1.1,1.1,1.1],
   ....:                    'One_Y' : [1.2,1.2,1.2],
   ....:                    'Two_X' : [1.11,1.11,1.11],
   ....:                    'Two_Y' : [1.22,1.22,1.22]}); df
   ....:
Out[53]:
   One_X  One_Y  Two_X  Two_Y  row
0    1.1    1.2   1.11   1.22    0
1    1.1    1.2   1.11   1.22    1
2    1.1    1.2   1.11   1.22    2

# As Labelled Index
In [54]: df = df.set_index('row');df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     One_X  One_Y  Two_X  Two_Y
row
0      1.1    1.2   1.11   1.22
1      1.1    1.2   1.11   1.22
```

```
2      1.1    1.2   1.11   1.22

# With Hierarchical Columns
In [55]: df.columns = pd.MultiIndex.from_tuples([tuple(c.split('_')) for c in df.
↪columns]);df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     One        Two
       X    Y     X     Y
row
0    1.1  1.2  1.11  1.22
1    1.1  1.2  1.11  1.22
2    1.1  1.2  1.11  1.22

# Now stack & Reset
In [56]: df = df.stack(0).reset_index(1);df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
    level_1     X     Y
row
0       One  1.10  1.20
0       Two  1.11  1.22
1       One  1.10  1.20
1       Two  1.11  1.22
2       One  1.10  1.20
2       Two  1.11  1.22

# And fix the labels (Notice the label 'level_1' got added automatically)
In [57]: df.columns = ['Sample','All_X','All_Y'];df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
    Sample  All_X  All_Y
row
0      One   1.10   1.20
0      Two   1.11   1.22
1      One   1.10   1.20
1      Two   1.11   1.22
2      One   1.10   1.20
2      Two   1.11   1.22
```

7.3.1 Arithmetic

Performing arithmetic with a multi-index that needs broadcasting

```
In [58]: cols = pd.MultiIndex.from_tuples([ (x,y) for x in ['A','B','C'] for y in ['O
↪','I']])

In [59]: df = pd.DataFrame(np.random.randn(2,6),index=['n','m'],columns=cols); df
Out[59]:
          A                   B                   C
          O         I         O         I         O         I
n  1.920906 -0.388231 -2.314394  0.665508  0.402562  0.399555
m -1.765956  0.850423  0.388054  0.992312  0.744086 -0.739776

In [60]: df = df.div(df['C'],level=1); df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
          A                   B              C
          O         I         O         I    O    I
n  4.771702 -0.971660 -5.749162  1.665625  1.0  1.0
m -2.373321 -1.149568  0.521518 -1.341367  1.0  1.0
```

7.3.2 Slicing

Slicing a multi-index with xs

```
In [61]: coords = [('AA','one'),('AA','six'),('BB','one'),('BB','two'),('BB','six')]

In [62]: index = pd.MultiIndex.from_tuples(coords)

In [63]: df = pd.DataFrame([11,22,33,44,55],index,['MyData']); df
Out[63]:
        MyData
AA one      11
   six      22
BB one      33
   two      44
   six      55
```

To take the cross section of the 1st level and 1st axis the index:

```
In [64]: df.xs('BB',level=0,axis=0)  #Note : level and axis are optional, and default␣
↪to zero
Out[64]:
     MyData
one      33
two      44
six      55
```

...and now the 2nd level of the 1st axis.

```
In [65]: df.xs('six',level=1,axis=0)
Out[65]:
    MyData
AA      22
BB      55
```

Slicing a multi-index with xs, method #2

```
In [66]: index = list(itertools.product(['Ada','Quinn','Violet'],['Comp','Math','Sci
↪']))

In [67]: headr = list(itertools.product(['Exams','Labs'],['I','II']))

In [68]: indx = pd.MultiIndex.from_tuples(index,names=['Student','Course'])

In [69]: cols = pd.MultiIndex.from_tuples(headr) #Notice these are un-named

In [70]: data = [[70+x+y+(x*y)%3 for x in range(4)] for y in range(9)]

In [71]: df = pd.DataFrame(data,indx,cols); df
Out[71]:
               Exams     Labs
```

```
                   I  II    I  II
Student Course
Ada     Comp      70  71   72  73
        Math      71  73   75  74
        Sci       72  75   75  75
Quinn   Comp      73  74   75  76
        Math      74  76   78  77
        Sci       75  78   78  78
Violet  Comp      76  77   78  79
        Math      77  79   81  80
        Sci       78  81   81  81

In [72]: All = slice(None)

In [73]: df.loc['Violet']
Out[73]:
       Exams     Labs
           I  II    I  II
Course
Comp      76  77   78  79
Math      77  79   81  80
Sci       78  81   81  81

In [74]: df.loc[(All,'Math'),All]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
               Exams     Labs
                   I  II    I  II
Student Course
Ada     Math      71  73   75  74
Quinn   Math      74  76   78  77
Violet  Math      77  79   81  80

In [75]: df.loc[(slice('Ada','Quinn'),'Math'),All]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
               Exams     Labs
                   I  II    I  II
Student Course
Ada     Math      71  73   75  74
Quinn   Math      74  76   78  77

In [76]: df.loc[(All,'Math'),('Exams')]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
                 I  II
Student Course
Ada     Math    71  73
Quinn   Math    74  76
Violet  Math    77  79

In [77]: df.loc[(All,'Math'),(All,'II')]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
               Exams Labs
                  II   II
Student Course
Ada     Math      73   74
```

```
Quinn   Math      76   77
Violet  Math      79   80
```

Setting portions of a multi-index with xs

7.3.3 Sorting

Sort by specific column or an ordered list of columns, with a multi-index

```
In [78]: df.sort_values(by=('Labs', 'II'), ascending=False)
Out[78]:
               Exams     Labs
                   I  II    I  II
Student Course
Violet  Sci       78  81   81  81
        Math      77  79   81  80
        Comp      76  77   78  79
Quinn   Sci       75  78   78  78
        Math      74  76   78  77
        Comp      73  74   75  76
Ada     Sci       72  75   75  75
        Math      71  73   75  74
        Comp      70  71   72  73
```

Partial Selection, the need for sortedness;

7.3.4 Levels

Prepending a level to a multiindex

Flatten Hierarchical columns

7.3.5 panelnd

The *panelnd* docs.

Construct a 5D panelnd

7.4 Missing Data

The *missing data* docs.

Fill forward a reversed timeseries

```
In [79]: df = pd.DataFrame(np.random.randn(6,1), index=pd.date_range('2013-08-01',␣
↪periods=6, freq='B'), columns=list('A'))

In [80]: df.loc[df.index[3], 'A'] = np.nan

In [81]: df
Out[81]:
                   A
2013-08-01 -1.054874
```

```
2013-08-02 -0.179642
2013-08-05  0.639589
2013-08-06       NaN
2013-08-07  1.906684
2013-08-08  0.104050

In [82]: df.reindex(df.index[::-1]).ffill()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A
2013-08-08  0.104050
2013-08-07  1.906684
2013-08-06  1.906684
2013-08-05  0.639589
2013-08-02 -0.179642
2013-08-01 -1.054874
```

cumsum reset at NaN values

7.4.1 Replace

Using replace with backrefs

7.5 Grouping

The *grouping* docs.

Basic grouping with apply

Unlike agg, apply's callable is passed a sub-DataFrame which gives you access to all the columns

```
In [83]: df = pd.DataFrame({'animal': 'cat dog cat fish dog cat cat'.split(),
   ....:                    'size': list('SSMMMLL'),
   ....:                    'weight': [8, 10, 11, 1, 20, 12, 12],
   ....:                    'adult' : [False] * 5 + [True] * 2}); df
   ....:
Out[83]:
   adult animal size  weight
0  False    cat    S       8
1  False    dog    S      10
2  False    cat    M      11
3  False   fish    M       1
4  False    dog    M      20
5   True    cat    L      12
6   True    cat    L      12

#List the size of the animals with the highest weight.
In [84]: df.groupby('animal').apply(lambda subf: subf['size'][subf['weight'].
↪idxmax()])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
animal
cat      L
dog      M
```

```
fish    M
dtype: object
```

Using get_group

```
In [85]: gb = df.groupby(['animal'])

In [86]: gb.get_group('cat')
Out[86]:
   adult animal size  weight
0  False    cat    S       8
2  False    cat    M      11
5   True    cat    L      12
6   True    cat    L      12
```

Apply to different items in a group

```
In [87]: def GrowUp(x):
   ....:    avg_weight =  sum(x[x['size'] == 'S'].weight * 1.5)
   ....:    avg_weight += sum(x[x['size'] == 'M'].weight * 1.25)
   ....:    avg_weight += sum(x[x['size'] == 'L'].weight)
   ....:    avg_weight /= len(x)
   ....:    return pd.Series(['L',avg_weight,True], index=['size', 'weight', 'adult'])
   ....:

In [88]: expected_df = gb.apply(GrowUp)

In [89]: expected_df
Out[89]:
       size   weight  adult
animal
cat       L  12.4375   True
dog       L  20.0000   True
fish      L   1.2500   True
```

Expanding Apply

```
In [90]: S = pd.Series([i / 100.0 for i in range(1,11)])

In [91]: def CumRet(x,y):
   ....:    return x * (1 + y)
   ....:

In [92]: def Red(x):
   ....:    return functools.reduce(CumRet,x,1.0)
   ....:

In [93]: S.expanding().apply(Red)
Out[93]:
0    1.010000
1    1.030200
2    1.061106
3    1.103550
4    1.158728
5    1.228251
6    1.314229
7    1.419367
8    1.547110
```

```
9    1.701821
dtype: float64
```

Replacing some values with mean of the rest of a group

```
In [94]: df = pd.DataFrame({'A' : [1, 1, 2, 2], 'B' : [1, -1, 1, 2]})

In [95]: gb = df.groupby('A')

In [96]: def replace(g):
   ....:    mask = g < 0
   ....:    g.loc[mask] = g[~mask].mean()
   ....:    return g
   ....:

In [97]: gb.transform(replace)
Out[97]:
     B
0  1.0
1  1.0
2  1.0
3  2.0
```

Sort groups by aggregated data

```
In [98]: df = pd.DataFrame({'code': ['foo', 'bar', 'baz'] * 2,
   ....:                    'data': [0.16, -0.21, 0.33, 0.45, -0.59, 0.62],
   ....:                    'flag': [False, True] * 3})
   ....:

In [99]: code_groups = df.groupby('code')

In [100]: agg_n_sort_order = code_groups[['data']].transform(sum).sort_values(by='data
↪')

In [101]: sorted_df = df.loc[agg_n_sort_order.index]

In [102]: sorted_df
Out[102]:
  code  data   flag
1  bar -0.21   True
4  bar -0.59  False
0  foo  0.16  False
3  foo  0.45   True
2  baz  0.33  False
5  baz  0.62   True
```

Create multiple aggregated columns

```
In [103]: rng = pd.date_range(start="2014-10-07",periods=10,freq='2min')

In [104]: ts = pd.Series(data = list(range(10)), index = rng)

In [105]: def MyCust(x):
   .....:    if len(x) > 2:
   .....:       return x[1] * 1.234
   .....:    return pd.NaT
   .....:
```

```
In [106]: mhc = {'Mean' : np.mean, 'Max' : np.max, 'Custom' : MyCust}

In [107]: ts.resample("5min").apply(mhc)
Out[107]:
Custom  2014-10-07 00:00:00    1.234
        2014-10-07 00:05:00      NaT
        2014-10-07 00:10:00    7.404
        2014-10-07 00:15:00      NaT
Max     2014-10-07 00:00:00        2
        2014-10-07 00:05:00        4
        2014-10-07 00:10:00        7
        2014-10-07 00:15:00        9
Mean    2014-10-07 00:00:00        1
        2014-10-07 00:05:00      3.5
        2014-10-07 00:10:00        6
        2014-10-07 00:15:00      8.5
dtype: object

In [108]: ts
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
2014-10-07 00:00:00    0
2014-10-07 00:02:00    1
2014-10-07 00:04:00    2
2014-10-07 00:06:00    3
2014-10-07 00:08:00    4
2014-10-07 00:10:00    5
2014-10-07 00:12:00    6
2014-10-07 00:14:00    7
2014-10-07 00:16:00    8
2014-10-07 00:18:00    9
Freq: 2T, dtype: int64
```

Create a value counts column and reassign back to the DataFrame

```
In [109]: df = pd.DataFrame({'Color': 'Red Red Red Blue'.split(),
   .....:                    'Value': [100, 150, 50, 50]}); df
   .....:
Out[109]:
  Color  Value
0   Red    100
1   Red    150
2   Red     50
3  Blue     50

In [110]: df['Counts'] = df.groupby(['Color']).transform(len)

In [111]: df
Out[111]:
  Color  Value  Counts
0   Red    100       3
1   Red    150       3
2   Red     50       3
3  Blue     50       1
```

Shift groups of the values in a column based on the index

```
In [112]: df = pd.DataFrame(
   .....:    {u'line_race': [10, 10, 8, 10, 10, 8],
   .....:     u'beyer': [99, 102, 103, 103, 88, 100]},
   .....:     index=[u'Last Gunfighter', u'Last Gunfighter', u'Last Gunfighter',
   .....:            u'Paynter', u'Paynter', u'Paynter']); df
   .....:
Out[112]:
                 beyer  line_race
Last Gunfighter     99         10
Last Gunfighter    102         10
Last Gunfighter    103          8
Paynter            103         10
Paynter             88         10
Paynter            100          8

In [113]: df['beyer_shifted'] = df.groupby(level=0)['beyer'].shift(1)

In [114]: df
Out[114]:
                 beyer  line_race  beyer_shifted
Last Gunfighter     99         10            NaN
Last Gunfighter    102         10           99.0
Last Gunfighter    103          8          102.0
Paynter            103         10            NaN
Paynter             88         10          103.0
Paynter            100          8           88.0
```

Select row with maximum value from each group

```
In [115]: df = pd.DataFrame({'host':['other','other','that','this','this'],
   .....:                    'service':['mail','web','mail','mail','web'],
   .....:                    'no':[1, 2, 1, 2, 1]}).set_index(['host', 'service'])
   .....:

In [116]: mask = df.groupby(level=0).agg('idxmax')

In [117]: df_count = df.loc[mask['no']].reset_index()

In [118]: df_count
Out[118]:
    host service  no
0  other     web   2
1   that    mail   1
2   this    mail   2
```

Grouping like Python's itertools.groupby

```
In [119]: df = pd.DataFrame([0, 1, 0, 1, 1, 1, 0, 1, 1], columns=['A'])

In [120]: df.A.groupby((df.A != df.A.shift()).cumsum()).groups
Out[120]:
{1: Int64Index([0], dtype='int64'),
 2: Int64Index([1], dtype='int64'),
 3: Int64Index([2], dtype='int64'),
 4: Int64Index([3, 4, 5], dtype='int64'),
 5: Int64Index([6], dtype='int64'),
 6: Int64Index([7, 8], dtype='int64')}
```

```
In [121]: df.A.groupby((df.A != df.A.shift()).cumsum()).cumsum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    0
1    1
2    0
3    1
4    2
5    3
6    0
7    1
8    2
Name: A, dtype: int64
```

7.5.1 Expanding Data

Alignment and to-date

Rolling Computation window based on values instead of counts

Rolling Mean by Time Interval

7.5.2 Splitting

Splitting a frame

Create a list of dataframes, split using a delineation based on logic included in rows.

```
In [122]: df = pd.DataFrame(data={'Case' : ['A','A','A','B','A','A','B','A','A'],
   .....:                         'Data' : np.random.randn(9)})
   .....:

In [123]: dfs = list(zip(*df.groupby((1*(df['Case']=='B')).cumsum().rolling(window=3,
↪min_periods=1).median())))[-1]

In [124]: dfs[0]
Out[124]:
  Case      Data
0    A  0.174068
1    A -0.439461
2    A -0.741343
3    B -0.079673

In [125]: dfs[1]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[
↪
  Case      Data
4    A -0.922875
5    A  0.303638
6    B -0.917368

In [126]: dfs[2]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
  Case      Data
```

```
7    A -1.624062
8    A -0.758514
```

7.5.3 Pivot

The *Pivot* docs.

Partial sums and subtotals

```
In [127]: df = pd.DataFrame(data={'Province' : ['ON','QC','BC','AL','AL','MN','ON'],
   .....:                         'City' : ['Toronto','Montreal','Vancouver','Calgary
↪','Edmonton','Winnipeg','Windsor'],
   .....:                         'Sales' : [13,6,16,8,4,3,1]})
   .....:

In [128]: table = pd.pivot_table(df,values=['Sales'],index=['Province'],columns=['City
↪'],aggfunc=np.sum,margins=True)

In [129]: table.stack('City')
Out[129]:
                    Sales
Province City
AL       All         12.0
         Calgary      8.0
         Edmonton     4.0
BC       All         16.0
         Vancouver   16.0
MN       All          3.0
         Winnipeg     3.0
...                    ...
All      Calgary      8.0
         Edmonton     4.0
         Montreal     6.0
         Toronto     13.0
         Vancouver   16.0
         Windsor      1.0
         Winnipeg     3.0

[20 rows x 1 columns]
```

Frequency table like plyr in R

```
In [130]: grades = [48,99,75,80,42,80,72,68,36,78]

In [131]: df = pd.DataFrame( {'ID': ["x%d" % r for r in range(10)],
   .....:                     'Gender' : ['F', 'M', 'F', 'M', 'F', 'M', 'F', 'M', 'M',
↪ 'M'],
   .....:                     'ExamYear': ['2007','2007','2007','2008','2008','2008',
↪'2008','2009','2009','2009'],
   .....:                     'Class': ['algebra', 'stats', 'bio', 'algebra', 'algebra
↪', 'stats', 'stats', 'algebra', 'bio', 'bio'],
   .....:                     'Participated': ['yes','yes','yes','yes','no','yes','yes
↪','yes','yes','yes'],
   .....:                     'Passed': ['yes' if x > 50 else 'no' for x in grades],
   .....:                     'Employed': [True,True,True,False,False,False,False,
↪True,True,False],
   .....:                     'Grade': grades})
```

```
   .....:

In [132]: df.groupby('ExamYear').agg({'Participated': lambda x: x.value_counts()['yes
↪'],
   .....:                     'Passed': lambda x: sum(x == 'yes'),
   .....:                     'Employed' : lambda x : sum(x),
   .....:                     'Grade' : lambda x : sum(x) / len(x)})
   .....:
Out[132]:
          Participated  Passed  Employed      Grade
ExamYear
2007                 3       2         3  74.000000
2008                 3       3         0  68.500000
2009                 3       2         2  60.666667
```

Plot pandas DataFrame with year over year data

To create year and month crosstabulation:

```
In [133]: df = pd.DataFrame({'value': np.random.randn(36)},
   .....:                   index=pd.date_range('2011-01-01', freq='M', periods=36))
   .....:

In [134]: pd.pivot_table(df, index=df.index.month, columns=df.index.year,
   .....:                values='value', aggfunc='sum')
   .....:
Out[134]:
        2011      2012      2013
1  -0.560859  0.120930  0.516870
2  -0.589005 -0.210518  0.343125
3  -1.070678 -0.931184  2.137827
4  -1.681101  0.240647  0.452429
5   0.403776 -0.027462  0.483103
6   0.609862  0.033113  0.061495
7   0.387936 -0.658418  0.240767
8   1.815066  0.324102  0.782413
9   0.705200 -1.403048  0.628462
10 -0.668049 -0.581967 -0.880627
11  0.242501 -1.233862  0.777575
12  0.313421 -3.520876 -0.779367
```

7.5.4 Apply

Rolling Apply to Organize - Turning embedded lists into a multi-index frame

```
In [135]: df = pd.DataFrame(data={'A' : [[2,4,8,16],[100,200],[10,20,30]], 'B' : [['a
↪','b','c'],['jj','kk'],['ccc']]},index=['I','II','III'])

In [136]: def SeriesFromSubList(aList):
   .....:    return pd.Series(aList)
   .....:

In [137]: df_orgz = pd.concat(dict([ (ind,row.apply(SeriesFromSubList)) for ind,row␣
↪in df.iterrows() ]))
```

Rolling Apply with a DataFrame returning a Series

Rolling Apply to multiple columns where function calculates a Series before a Scalar from the Series is returned

```
In [138]: df = pd.DataFrame(data=np.random.randn(2000,2)/10000,
   .....:                   index=pd.date_range('2001-01-01',periods=2000),
   .....:                   columns=['A','B']); df
   .....:
Out[138]:
                   A         B
2001-01-01  0.000032 -0.000004
2001-01-02 -0.000001  0.000207
2001-01-03  0.000120 -0.000220
2001-01-04 -0.000083 -0.000165
2001-01-05 -0.000047  0.000156
2001-01-06  0.000027  0.000104
2001-01-07  0.000041 -0.000101
...              ...       ...
2006-06-17 -0.000034  0.000034
2006-06-18  0.000002  0.000166
2006-06-19  0.000023 -0.000081
2006-06-20 -0.000061  0.000012
2006-06-21 -0.000111  0.000027
2006-06-22 -0.000061 -0.000009
2006-06-23  0.000074 -0.000138

[2000 rows x 2 columns]

In [139]: def gm(aDF,Const):
   .....:     v = ((((aDF.A+aDF.B)+1).cumprod())-1)*Const
   .....:     return (aDF.index[0],v.iloc[-1])
   .....:

In [140]: S = pd.Series(dict([ gm(df.iloc[i:min(i+51,len(df)-1)],5) for i in␣
↪range(len(df)-50) ])); S
Out[140]:
2001-01-01   -0.001373
2001-01-02   -0.001705
2001-01-03   -0.002885
2001-01-04   -0.002987
2001-01-05   -0.002384
2001-01-06   -0.004700
2001-01-07   -0.005500
                ...
2006-04-28   -0.002682
2006-04-29   -0.002436
2006-04-30   -0.002602
2006-05-01   -0.001785
2006-05-02   -0.001799
2006-05-03   -0.000605
2006-05-04   -0.000541
Length: 1950, dtype: float64
```

Rolling apply with a DataFrame returning a Scalar

Rolling Apply to multiple columns where function returns a Scalar (Volume Weighted Average Price)

```
In [141]: rng = pd.date_range(start = '2014-01-01',periods = 100)

In [142]: df = pd.DataFrame({'Open' : np.random.randn(len(rng)),
   .....:                    'Close' : np.random.randn(len(rng)),
```

```
   .....:                     'Volume' : np.random.randint(100,2000,len(rng))},␣
↪index=rng); df
   .....:
Out[142]:
               Close      Open  Volume
2014-01-01 -0.653039  0.011174    1581
2014-01-02  1.314205  0.214258    1707
2014-01-03 -0.341915 -1.046922    1768
2014-01-04 -1.303586 -0.752902     836
2014-01-05  0.396288 -0.410793     694
2014-01-06 -0.548006  0.648401     796
2014-01-07  0.481380  0.737320     265
...              ...       ...     ...
2014-04-04 -2.548128  0.120378     564
2014-04-05  0.223346  0.231661    1908
2014-04-06  1.228841  0.952664    1090
2014-04-07  0.552784 -0.176090    1813
2014-04-08 -0.795389  1.781318    1103
2014-04-09 -0.018815 -0.753493    1456
2014-04-10  1.138197 -1.047997    1193

[100 rows x 3 columns]

In [143]: def vwap(bars): return ((bars.Close*bars.Volume).sum()/bars.Volume.sum())

In [144]: window = 5

In [145]: s = pd.concat([ (pd.Series(vwap(df.iloc[i:i+window]), index=[df.
↪index[i+window]])) for i in range(len(df)-window) ]);

In [146]: s.round(2)
Out[146]:
2014-01-06   -0.03
2014-01-07    0.07
2014-01-08   -0.40
2014-01-09   -0.81
2014-01-10   -0.63
2014-01-11   -0.86
2014-01-12   -0.36
              ...
2014-04-04   -1.27
2014-04-05   -1.36
2014-04-06   -0.73
2014-04-07    0.04
2014-04-08    0.21
2014-04-09    0.07
2014-04-10    0.25
Length: 95, dtype: float64
```

7.6 Timeseries

Between times

Using indexer between time

Constructing a datetime range that excludes weekends and includes only certain times

Vectorized Lookup

Aggregation and plotting time series

Turn a matrix with hours in columns and days in rows into a continuous row sequence in the form of a time series. How to rearrange a python pandas DataFrame?

Dealing with duplicates when reindexing a timeseries to a specified frequency

Calculate the first day of the month for each entry in a DatetimeIndex

```
In [147]: dates = pd.date_range('2000-01-01', periods=5)

In [148]: dates.to_period(freq='M').to_timestamp()
Out[148]:
DatetimeIndex(['2000-01-01', '2000-01-01', '2000-01-01', '2000-01-01',
               '2000-01-01'],
              dtype='datetime64[ns]', freq=None)
```

7.6.1 Resampling

The *Resample* docs.

Using Grouper instead of TimeGrouper for time grouping of values

Time grouping with some missing values

Valid frequency arguments to Grouper

Grouping using a MultiIndex

Using TimeGrouper and another grouping to create subgroups, then apply a custom function

Resampling with custom periods

Resample intraday frame without adding new days

Resample minute data

Resample with groupby

7.7 Merge

The *Concat* docs. The *Join* docs.

Append two dataframes with overlapping index (emulate R rbind)

```
In [149]: rng = pd.date_range('2000-01-01', periods=6)

In [150]: df1 = pd.DataFrame(np.random.randn(6, 3), index=rng, columns=['A', 'B', 'C
↪'])

In [151]: df2 = df1.copy()
```

Depending on df construction, `ignore_index` may be needed

```
In [152]: df = df1.append(df2,ignore_index=True); df
Out[152]:
           A         B         C
0  -0.480676 -1.305282 -0.212846
```

```
1   1.979901  0.363112 -0.275732
2  -1.433852  0.580237 -0.013672
3   1.776623 -0.803467  0.521517
4  -0.302508 -0.442948 -0.395768
5  -0.249024 -0.031510  2.413751
6  -0.480676 -1.305282 -0.212846
7   1.979901  0.363112 -0.275732
8  -1.433852  0.580237 -0.013672
9   1.776623 -0.803467  0.521517
10 -0.302508 -0.442948 -0.395768
11 -0.249024 -0.031510  2.413751
```

Self Join of a DataFrame

```
In [153]: df = pd.DataFrame(data={'Area' : ['A'] * 5 + ['C'] * 2,
   .....:                         'Bins' : [110] * 2 + [160] * 3 + [40] * 2,
   .....:                         'Test_0' : [0, 1, 0, 1, 2, 0, 1],
   .....:                         'Data' : np.random.randn(7)});df
   .....:
Out[153]:
  Area  Bins      Data  Test_0
0    A   110 -0.378914       0
1    A   110 -1.032527       1
2    A   160 -1.402816       0
3    A   160  0.715333       1
4    A   160 -0.091438       2
5    C    40  1.608418       0
6    C    40  0.753207       1

In [154]: df['Test_1'] = df['Test_0'] - 1

In [155]: pd.merge(df, df, left_on=['Bins', 'Area','Test_0'], right_on=['Bins', 'Area
↪','Test_1'],suffixes=('_L','_R'))
Out[155]:
  Area  Bins    Data_L  Test_0_L  Test_1_L    Data_R  Test_0_R  Test_1_R
0    A   110 -0.378914         0        -1 -1.032527         1         0
1    A   160 -1.402816         0        -1  0.715333         1         0
2    A   160  0.715333         1         0 -0.091438         2         1
3    C    40  1.608418         0        -1  0.753207         1         0
```

How to set the index and join

KDB like asof join

Join with a criteria based on the values

Using searchsorted to merge based on values inside a range

7.8 Plotting

The *Plotting* docs.

Make Matplotlib look like R

Setting x-axis major and minor labels

Plotting multiple charts in an ipython notebook

Creating a multi-line plot

Plotting a heatmap

Annotate a time-series plot

Annotate a time-series plot #2

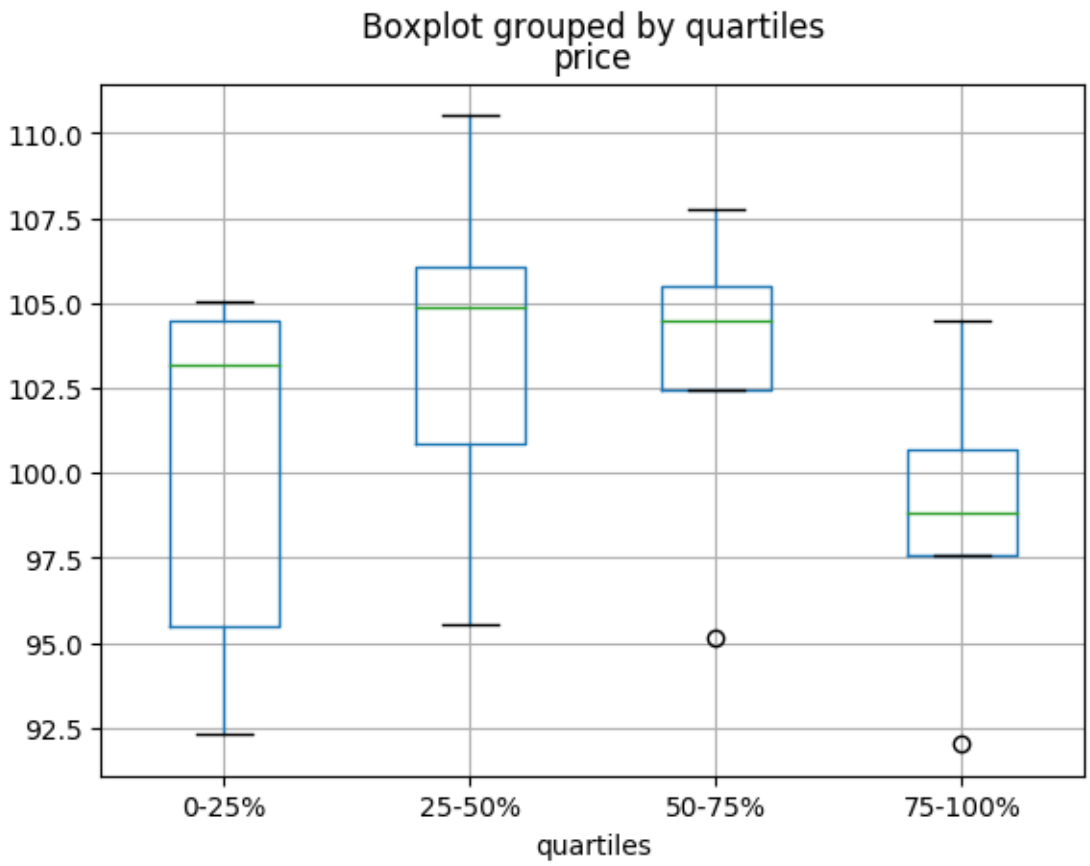
Generate Embedded plots in excel files using Pandas, Vincent and xlsxwriter

Boxplot for each quartile of a stratifying variable

```
In [156]: df = pd.DataFrame(
   .....:      {u'stratifying_var': np.random.uniform(0, 100, 20),
   .....:       u'price': np.random.normal(100, 5, 20)})
   .....:

In [157]: df[u'quartiles'] = pd.qcut(
   .....:     df[u'stratifying_var'],
   .....:     4,
   .....:     labels=[u'0-25%', u'25-50%', u'50-75%', u'75-100%'])
   .....:

In [158]: df.boxplot(column=u'price', by=u'quartiles')
Out[158]: <matplotlib.axes._subplots.AxesSubplot at 0x121bc60f0>
```



7.9 Data In/Out

Performance comparison of SQL vs HDF5

7.9.1 CSV

The *CSV* docs

read_csv in action

appending to a csv

Reading a csv chunk-by-chunk

Reading only certain rows of a csv chunk-by-chunk

Reading the first few lines of a frame

Reading a file that is compressed but not by `gzip/bz2` (the native compressed formats which `read_csv` understands). This example shows a `WinZipped` file, but is a general application of opening the file within a context manager and using that handle to read. See here

Inferring dtypes from a file

Dealing with bad lines

Dealing with bad lines II

Reading CSV with Unix timestamps and converting to local timezone

Write a multi-row index CSV without writing duplicates

7.9.1.1 Reading multiple files to create a single DataFrame

The best way to combine multiple files into a single DataFrame is to read the individual frames one by one, put all of the individual frames into a list, and then combine the frames in the list using `pd.concat()`:

```
In [159]: for i in range(3):
   .....:     data = pd.DataFrame(np.random.randn(10, 4))
   .....:     data.to_csv('file_{}.csv'.format(i))
   .....:

In [160]: files = ['file_0.csv', 'file_1.csv', 'file_2.csv']

In [161]: result = pd.concat([pd.read_csv(f) for f in files], ignore_index=True)
```

You can use the same approach to read all files matching a pattern. Here is an example using `glob`:

```
In [162]: import glob

In [163]: files = glob.glob('file_*.csv')

In [164]: result = pd.concat([pd.read_csv(f) for f in files], ignore_index=True)
```

Finally, this strategy will work with the other `pd.read_*(...)` functions described in the *io docs*.

7.9.1.2 Parsing date components in multi-columns

Parsing date components in multi-columns is faster with a format

```
In [30]: i = pd.date_range('20000101',periods=10000)

In [31]: df = pd.DataFrame(dict(year = i.year, month = i.month, day = i.day))

In [32]: df.head()
Out[32]:
   day  month  year
0    1      1  2000
1    2      1  2000
2    3      1  2000
3    4      1  2000
4    5      1  2000

In [33]: %timeit pd.to_datetime(df.year*10000+df.month*100+df.day,format='%Y%m%d')
100 loops, best of 3: 7.08 ms per loop

# simulate combinging into a string, then parsing
In [34]: ds = df.apply(lambda x: "%04d%02d%02d" % (x['year'],x['month'],x['day']),
↪axis=1)

In [35]: ds.head()
Out[35]:
0    20000101
1    20000102
2    20000103
3    20000104
4    20000105
dtype: object

In [36]: %timeit pd.to_datetime(ds)
1 loops, best of 3: 488 ms per loop
```

7.9.1.3 Skip row between header and data

```
In [165]: data = """;;;;
   .....:  ;;;;
   .....:  ;;;;
   .....:  ;;;;
   .....:  ;;;;
   .....:  ;;;;
   .....: ;;;;
   .....:  ;;;;
   .....:  ;;;;
   .....: ;;;;
   .....: date;Param1;Param2;Param4;Param5
   .....:     ;m²;°C;m²;m
   .....: ;;;;
   .....: 01.01.1990 00:00;1;1;2;3
   .....: 01.01.1990 01:00;5;3;4;5
   .....: 01.01.1990 02:00;9;5;6;7
   .....: 01.01.1990 03:00;13;7;8;9
   .....: 01.01.1990 04:00;17;9;10;11
   .....: 01.01.1990 05:00;21;11;12;13
```

```
   .....: """
   .....:
```

Option 1: pass rows explicitly to skiprows

```
In [166]: pd.read_csv(StringIO(data), sep=';', skiprows=[11,12],
   .....:         index_col=0, parse_dates=True, header=10)
   .....:
Out[166]:
                     Param1  Param2  Param4  Param5
date
1990-01-01 00:00:00       1       1       2       3
1990-01-01 01:00:00       5       3       4       5
1990-01-01 02:00:00       9       5       6       7
1990-01-01 03:00:00      13       7       8       9
1990-01-01 04:00:00      17       9      10      11
1990-01-01 05:00:00      21      11      12      13
```

Option 2: read column names and then data

```
In [167]: pd.read_csv(StringIO(data), sep=';', header=10, nrows=10).columns
Out[167]: Index(['date', 'Param1', 'Param2', 'Param4', 'Param5'], dtype='object')

In [168]: columns = pd.read_csv(StringIO(data), sep=';', header=10, nrows=10).columns

In [169]: pd.read_csv(StringIO(data), sep=';', index_col=0,
   .....:             header=12, parse_dates=True, names=columns)
   .....:
Out[169]:
                     Param1  Param2  Param4  Param5
date
1990-01-01 00:00:00       1       1       2       3
1990-01-01 01:00:00       5       3       4       5
1990-01-01 02:00:00       9       5       6       7
1990-01-01 03:00:00      13       7       8       9
1990-01-01 04:00:00      17       9      10      11
1990-01-01 05:00:00      21      11      12      13
```

7.9.2 SQL

The *SQL* docs

Reading from databases with SQL

7.9.3 Excel

The *Excel* docs

Reading from a filelike handle

Modifying formatting in XlsxWriter output

7.9.4 HTML

Reading HTML tables from a server that cannot handle the default request header

7.9.5 HDFStore

The *HDFStores* docs

Simple Queries with a Timestamp Index

Managing heterogeneous data using a linked multiple table hierarchy

Merging on-disk tables with millions of rows

Avoiding inconsistencies when writing to a store from multiple processes/threads

De-duplicating a large store by chunks, essentially a recursive reduction operation. Shows a function for taking in data from csv file and creating a store by chunks, with date parsing as well. See here

Creating a store chunk-by-chunk from a csv file

Appending to a store, while creating a unique index

Large Data work flows

Reading in a sequence of files, then providing a global unique index to a store while appending

Groupby on a HDFStore with low group density

Groupby on a HDFStore with high group density

Hierarchical queries on a HDFStore

Counting with a HDFStore

Troubleshoot HDFStore exceptions

Setting min_itemsize with strings

Using ptrepack to create a completely-sorted-index on a store

Storing Attributes to a group node

```
In [170]: df = pd.DataFrame(np.random.randn(8,3))

In [171]: store = pd.HDFStore('test.h5')

In [172]: store.put('df',df)

# you can store an arbitrary python object via pickle
In [173]: store.get_storer('df').attrs.my_attribute = dict(A = 10)

In [174]: store.get_storer('df').attrs.my_attribute
Out[174]: {'A': 10}
```

7.9.6 Binary Files

pandas readily accepts numpy record arrays, if you need to read in a binary file consisting of an array of C structs. For example, given this C program in a file called `main.c` compiled with `gcc main.c -std=gnu99` on a 64-bit machine,

```
#include <stdio.h>
#include <stdint.h>

typedef struct _Data
{
    int32_t count;
    double avg;
    float scale;
} Data;

int main(int argc, const char *argv[])
{
    size_t n = 10;
    Data d[n];

    for (int i = 0; i < n; ++i)
    {
        d[i].count = i;
        d[i].avg = i + 1.0;
        d[i].scale = (float) i + 2.0f;
    }

    FILE *file = fopen("binary.dat", "wb");
    fwrite(&d, sizeof(Data), n, file);
    fclose(file);

    return 0;
}
```

the following Python code will read the binary file `'binary.dat'` into a pandas `DataFrame`, where each element of the struct corresponds to a column in the frame:

```
names = 'count', 'avg', 'scale'

# note that the offsets are larger than the size of the type because of
# struct padding
offsets = 0, 8, 16
formats = 'i4', 'f8', 'f4'
dt = np.dtype({'names': names, 'offsets': offsets, 'formats': formats},
              align=True)
df = pd.DataFrame(np.fromfile('binary.dat', dt))
```

Note: The offsets of the structure elements may be different depending on the architecture of the machine on which the file was created. Using a raw binary file format like this for general data storage is not recommended, as it is not cross platform. We recommended either HDF5 or msgpack, both of which are supported by pandas' IO facilities.

7.10 Computation

Numerical integration (sample-based) of a time series

7.11 Timedeltas

The *Timedeltas* docs.

Using timedeltas

```
In [175]: s  = pd.Series(pd.date_range('2012-1-1', periods=3, freq='D'))

In [176]: s - s.max()
Out[176]:
0   -2 days
1   -1 days
2    0 days
dtype: timedelta64[ns]

In [177]: s.max() - s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[177]:
0   2 days
1   1 days
2   0 days
dtype: timedelta64[ns]

In [178]: s - datetime.datetime(2011,1,1,3,5)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   364 days 20:55:00
1   365 days 20:55:00
2   366 days 20:55:00
dtype: timedelta64[ns]

In [179]: s + datetime.timedelta(minutes=5)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2012-01-01 00:05:00
1   2012-01-02 00:05:00
2   2012-01-03 00:05:00
dtype: datetime64[ns]

In [180]: datetime.datetime(2011,1,1,3,5) - s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   -365 days +03:05:00
1   -366 days +03:05:00
2   -367 days +03:05:00
dtype: timedelta64[ns]

In [181]: datetime.timedelta(minutes=5) + s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2012-01-01 00:05:00
1   2012-01-02 00:05:00
2   2012-01-03 00:05:00
dtype: datetime64[ns]
```

Adding and subtracting deltas and dates

```
In [182]: deltas = pd.Series([ datetime.timedelta(days=i) for i in range(3) ])
```

```
In [183]: df = pd.DataFrame(dict(A = s, B = deltas)); df
Out[183]:
           A      B
0 2012-01-01 0 days
1 2012-01-02 1 days
2 2012-01-03 2 days

In [184]: df['New Dates'] = df['A'] + df['B'];

In [185]: df['Delta'] = df['A'] - df['New Dates']; df
Out[185]:
           A      B  New Dates   Delta
0 2012-01-01 0 days 2012-01-01  0 days
1 2012-01-02 1 days 2012-01-03 -1 days
2 2012-01-03 2 days 2012-01-05 -2 days

In [186]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A              datetime64[ns]
B             timedelta64[ns]
New Dates      datetime64[ns]
Delta         timedelta64[ns]
dtype: object
```

Another example

Values can be set to NaT using np.nan, similar to datetime

```
In [187]: y = s - s.shift(); y
Out[187]:
0      NaT
1   1 days
2   1 days
dtype: timedelta64[ns]

In [188]: y[1] = np.nan; y
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[188]:
0      NaT
1      NaT
2   1 days
dtype: timedelta64[ns]
```

7.12 Aliasing Axis Names

To globally provide aliases for axis names, one can define these 2 functions:

```
In [189]: def set_axis_alias(cls, axis, alias):
   .....:     if axis not in cls._AXIS_NUMBERS:
   .....:         raise Exception("invalid axis [%s] for alias [%s]" % (axis, alias))
   .....:     cls._AXIS_ALIASES[alias] = axis
   .....:
```

```
In [190]: def clear_axis_alias(cls, axis, alias):
   .....:     if axis not in cls._AXIS_NUMBERS:
```

```
   .....:        raise Exception("invalid axis [%s] for alias [%s]" % (axis, alias))
   .....:    cls._AXIS_ALIASES.pop(alias,None)
   .....:
```

```
In [191]: set_axis_alias(pd.DataFrame,'columns', 'myaxis2')

In [192]: df2 = pd.DataFrame(np.random.randn(3,2),columns=['c1','c2'],index=['i1','i2
↪','i3'])

In [193]: df2.sum(axis='myaxis2')
Out[193]:
i1    0.745167
i2   -0.176251
i3    0.014354
dtype: float64

In [194]: clear_axis_alias(pd.DataFrame,'columns', 'myaxis2')
```

7.13 Creating Example Data

To create a dataframe from every combination of some given values, like R's `expand.grid()` function, we can create a dict where the keys are column names and the values are lists of the data values:

```
In [195]: def expand_grid(data_dict):
   .....:    rows = itertools.product(*data_dict.values())
   .....:    return pd.DataFrame.from_records(rows, columns=data_dict.keys())
   .....:

In [196]: df = expand_grid(
   .....:    {'height': [60, 70],
   .....:     'weight': [100, 140, 180],
   .....:     'sex': ['Male', 'Female']})
   .....:

In [197]: df
Out[197]:
    height  weight     sex
0       60     100    Male
1       60     100  Female
2       60     140    Male
3       60     140  Female
4       60     180    Male
5       60     180  Female
6       70     100    Male
7       70     100  Female
8       70     140    Male
9       70     140  Female
10      70     180    Male
11      70     180  Female
```

CHAPTER

EIGHT

INTRO TO DATA STRUCTURES

We'll start with a quick, non-comprehensive overview of the fundamental data structures in pandas to get you started. The fundamental behavior about data types, indexing, and axis labeling / alignment apply across all of the objects. To get started, import numpy and load pandas into your namespace:

```
In [1]: import numpy as np

In [2]: import pandas as pd
```

Here is a basic tenet to keep in mind: **data alignment is intrinsic**. The link between labels and data will not be broken unless done so explicitly by you.

We'll give a brief intro to the data structures, then consider all of the broad categories of functionality and methods in separate sections.

8.1 Series

`Series` is a one-dimensional labeled array capable of holding any data type (integers, strings, floating point numbers, Python objects, etc.). The axis labels are collectively referred to as the **index**. The basic method to create a Series is to call:

```
>>> s = pd.Series(data, index=index)
```

Here, `data` can be many different things:

- a Python dict
- an ndarray
- a scalar value (like 5)

The passed **index** is a list of axis labels. Thus, this separates into a few cases depending on what **data is**:

From ndarray

If `data` is an ndarray, **index** must be the same length as **data**. If no index is passed, one will be created having values `[0, ..., len(data) - 1]`.

```
In [3]: s = pd.Series(np.random.randn(5), index=['a', 'b', 'c', 'd', 'e'])

In [4]: s
Out[4]:
a    0.4691
b   -0.2829
c   -1.5091
```

```
d   -1.1356
e    1.2121
dtype: float64

In [5]: s.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[5]:␣
↪Index(['a', 'b', 'c', 'd', 'e'], dtype='object')

In [6]: pd.Series(np.random.randn(5))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   -0.1732
1    0.1192
2   -1.0442
3   -0.8618
4   -2.1046
dtype: float64
```

Note: pandas supports non-unique index values. If an operation that does not support duplicate index values is attempted, an exception will be raised at that time. The reason for being lazy is nearly all performance-based (there are many instances in computations, like parts of GroupBy, where the index is not used).

From dict

If `data` is a dict, if **index** is passed the values in data corresponding to the labels in the index will be pulled out. Otherwise, an index will be constructed from the sorted keys of the dict, if possible.

```
In [7]: d = {'a' : 0., 'b' : 1., 'c' : 2.}

In [8]: pd.Series(d)
Out[8]:
a    0.0
b    1.0
c    2.0
dtype: float64

In [9]: pd.Series(d, index=['b', 'c', 'd', 'a'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[9]:
b    1.0
c    2.0
d    NaN
a    0.0
dtype: float64
```

Note: NaN (not a number) is the standard missing data marker used in pandas

---

From scalar value If `data` is a scalar value, an index must be provided. The value will be repeated to match the length of **index**

```
In [10]: pd.Series(5., index=['a', 'b', 'c', 'd', 'e'])
Out[10]:
a    5.0
b    5.0
c    5.0
```

```
d    5.0
e    5.0
dtype: float64
```

8.1.1 Series is ndarray-like

`Series` acts very similarly to a `ndarray`, and is a valid argument to most NumPy functions. However, things like slicing also slice the index.

```
In [11]: s[0]
Out[11]: 0.46911229990718628

In [12]: s[:3]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[12]:
a    0.4691
b   -0.2829
c   -1.5091
dtype: float64

In [13]: s[s > s.median()]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[13]:␣
↪
a    0.4691
e    1.2121
dtype: float64

In [14]: s[[4, 3, 1]]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
e    1.2121
d   -1.1356
b   -0.2829
dtype: float64

In [15]: np.exp(s)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a    1.5986
b    0.7536
c    0.2211
d    0.3212
e    3.3606
dtype: float64
```

We will address array-based indexing in a separate *section*.

8.1.2 Series is dict-like

A Series is like a fixed-size dict in that you can get and set values by index label:

```
In [16]: s['a']
Out[16]: 0.46911229990718628

In [17]: s['e'] = 12.
```

```
In [18]: s
Out[18]:
a     0.4691
b    -0.2829
c    -1.5091
d    -1.1356
e    12.0000
dtype: float64

In [19]: 'e' in s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[19]:␣
↪True

In [20]: 'f' in s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪False
```

If a label is not contained, an exception is raised:

```
>>> s['f']
KeyError: 'f'
```

Using the `get` method, a missing label will return None or specified default:

```
In [21]: s.get('f')

In [22]: s.get('f', np.nan)
Out[22]: nan
```

See also the *section on attribute access*.

8.1.3 Vectorized operations and label alignment with Series

When doing data analysis, as with raw NumPy arrays looping through Series value-by-value is usually not necessary. Series can also be passed into most NumPy methods expecting an ndarray.

```
In [23]: s + s
Out[23]:
a     0.9382
b    -0.5657
c    -3.0181
d    -2.2713
e    24.0000
dtype: float64

In [24]: s * 2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[24]:␣
↪
a     0.9382
b    -0.5657
c    -3.0181
d    -2.2713
e    24.0000
dtype: float64

In [25]: np.exp(s)
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a          1.5986
b          0.7536
c          0.2211
d          0.3212
e     162754.7914
dtype: float64
```

A key difference between Series and ndarray is that operations between Series automatically align the data based on label. Thus, you can write computations without giving consideration to whether the Series involved have the same labels.

```
In [26]: s[1:] + s[:-1]
Out[26]:
a       NaN
b   -0.5657
c   -3.0181
d   -2.2713
e       NaN
dtype: float64
```

The result of an operation between unaligned Series will have the **union** of the indexes involved. If a label is not found in one Series or the other, the result will be marked as missing `NaN`. Being able to write code without doing any explicit data alignment grants immense freedom and flexibility in interactive data analysis and research. The integrated data alignment features of the pandas data structures set pandas apart from the majority of related tools for working with labeled data.

Note: In general, we chose to make the default result of operations between differently indexed objects yield the **union** of the indexes in order to avoid loss of information. Having an index label, though the data is missing, is typically important information as part of a computation. You of course have the option of dropping labels with missing data via the **dropna** function.

8.1.4 Name attribute

Series can also have a `name` attribute:

```
In [27]: s = pd.Series(np.random.randn(5), name='something')

In [28]: s
Out[28]:
0   -0.4949
1    1.0718
2    0.7216
3   -0.7068
4   -1.0396
Name: something, dtype: float64

In [29]: s.name
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪'something'
```

The Series `name` will be assigned automatically in many cases, in particular when taking 1D slices of DataFrame as you will see below.

New in version 0.18.0.

You can rename a Series with the *pandas.Series.rename()* method.

```
In [30]: s2 = s.rename("different")

In [31]: s2.name
Out[31]: 'different'
```

Note that `s` and `s2` refer to different objects.

8.2 DataFrame

DataFrame is a 2-dimensional labeled data structure with columns of potentially different types. You can think of it like a spreadsheet or SQL table, or a dict of Series objects. It is generally the most commonly used pandas object. Like Series, DataFrame accepts many different kinds of input:

- Dict of 1D ndarrays, lists, dicts, or Series
- 2-D numpy.ndarray
- Structured or record ndarray
- A `Series`
- Another `DataFrame`

Along with the data, you can optionally pass **index** (row labels) and **columns** (column labels) arguments. If you pass an index and / or columns, you are guaranteeing the index and / or columns of the resulting DataFrame. Thus, a dict of Series plus a specific index will discard all data not matching up to the passed index.

If axis labels are not passed, they will be constructed from the input data based on common sense rules.

8.2.1 From dict of Series or dicts

The result **index** will be the **union** of the indexes of the various Series. If there are any nested dicts, these will be first converted to Series. If no columns are passed, the columns will be the sorted list of dict keys.

```
In [32]: d = {'one' : pd.Series([1., 2., 3.], index=['a', 'b', 'c']),
   ....:      'two' : pd.Series([1., 2., 3., 4.], index=['a', 'b', 'c', 'd'])}
   ....:

In [33]: df = pd.DataFrame(d)

In [34]: df
Out[34]:
   one  two
a  1.0  1.0
b  2.0  2.0
c  3.0  3.0
d  NaN  4.0

In [35]: pd.DataFrame(d, index=['d', 'b', 'a'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[35]:
   one  two
d  NaN  4.0
b  2.0  2.0
a  1.0  1.0
```

```
In [36]: pd.DataFrame(d, index=['d', 'b', 'a'], columns=['two', 'three'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   two three
d  4.0   NaN
b  2.0   NaN
a  1.0   NaN
```

The row and column labels can be accessed respectively by accessing the **index** and **columns** attributes:

Note: When a particular set of columns is passed along with a dict of data, the passed columns override the keys in the dict.

```
In [37]: df.index
Out[37]: Index(['a', 'b', 'c', 'd'], dtype='object')

In [38]: df.columns
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[38]: Index(['one', 'two'],␣
↪dtype='object')
```

8.2.2 From dict of ndarrays / lists

The ndarrays must all be the same length. If an index is passed, it must clearly also be the same length as the arrays. If no index is passed, the result will be `range(n)`, where `n` is the array length.

```
In [39]: d = {'one' : [1., 2., 3., 4.],
   ....:      'two' : [4., 3., 2., 1.]}
   ....:

In [40]: pd.DataFrame(d)
Out[40]:
   one  two
0  1.0  4.0
1  2.0  3.0
2  3.0  2.0
3  4.0  1.0

In [41]: pd.DataFrame(d, index=['a', 'b', 'c', 'd'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[41]:
   one  two
a  1.0  4.0
b  2.0  3.0
c  3.0  2.0
d  4.0  1.0
```

8.2.3 From structured or record array

This case is handled identically to a dict of arrays.

```
In [42]: data = np.zeros((2,), dtype=[('A', 'i4'),('B', 'f4'),('C', 'a10')])

In [43]: data[:] = [(1,2.,'Hello'), (2,3.,"World")]
```

```
In [44]: pd.DataFrame(data)
Out[44]:
   A    B         C
0  1  2.0  b'Hello'
1  2  3.0  b'World'

In [45]: pd.DataFrame(data, index=['first', 'second'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[45]:
        A    B         C
first   1  2.0  b'Hello'
second  2  3.0  b'World'

In [46]: pd.DataFrame(data, columns=['C', 'A', 'B'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          C  A    B
0  b'Hello'  1  2.0
1  b'World'  2  3.0
```

Note: DataFrame is not intended to work exactly like a 2-dimensional NumPy ndarray.

8.2.4 From a list of dicts

```
In [47]: data2 = [{'a': 1, 'b': 2}, {'a': 5, 'b': 10, 'c': 20}]

In [48]: pd.DataFrame(data2)
Out[48]:
   a   b     c
0  1   2   NaN
1  5  10  20.0

In [49]: pd.DataFrame(data2, index=['first', 'second'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[49]:
        a   b     c
first   1   2   NaN
second  5  10  20.0

In [50]: pd.DataFrame(data2, columns=['a', 'b'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a   b
0  1   2
1  5  10
```

8.2.5 From a dict of tuples

You can automatically create a multi-indexed frame by passing a tuples dictionary

```
In [51]: pd.DataFrame({('a', 'b'): {('A', 'B'): 1, ('A', 'C'): 2},
   ....:               ('a', 'a'): {('A', 'C'): 3, ('A', 'B'): 4},
   ....:               ('a', 'c'): {('A', 'B'): 5, ('A', 'C'): 6},
```

```
   ....:               ('b', 'a'): {('A', 'C'): 7, ('A', 'B'): 8},
   ....:               ('b', 'b'): {('A', 'D'): 9, ('A', 'B'): 10}})
   ....:
Out[51]:
       a              b
       a    b    c    a     b
A B  4.0  1.0  5.0  8.0  10.0
  C  3.0  2.0  6.0  7.0   NaN
  D  NaN  NaN  NaN  NaN   9.0
```

8.2.6 From a Series

The result will be a DataFrame with the same index as the input Series, and with one column whose name is the original name of the Series (only if no other column name provided).

Missing Data

Much more will be said on this topic in the *Missing data* section. To construct a DataFrame with missing data, use `np.nan` for those values which are missing. Alternatively, you may pass a `numpy.MaskedArray` as the data argument to the DataFrame constructor, and its masked entries will be considered missing.

8.2.7 Alternate Constructors

DataFrame.from_dict

`DataFrame.from_dict` takes a dict of dicts or a dict of array-like sequences and returns a DataFrame. It operates like the `DataFrame` constructor except for the `orient` parameter which is `'columns'` by default, but which can be set to `'index'` in order to use the dict keys as row labels. **DataFrame.from_records**

`DataFrame.from_records` takes a list of tuples or an ndarray with structured dtype. Works analogously to the normal `DataFrame` constructor, except that index maybe be a specific field of the structured dtype to use as the index. For example:

```
In [52]: data
Out[52]:
array([(1, 2., b'Hello'), (2, 3., b'World')],
      dtype=[('A', '<i4'), ('B', '<f4'), ('C', 'S10')])

In [53]: pd.DataFrame.from_records(data, index='C')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A    B
C
b'Hello'  1  2.0
b'World'  2  3.0
```

DataFrame.from_items

`DataFrame.from_items` works analogously to the form of the `dict` constructor that takes a sequence of `(key, value)` pairs, where the keys are column (or row, in the case of `orient='index'`) names, and the value are the column values (or row values). This can be useful for constructing a DataFrame with the columns in a particular order without having to pass an explicit list of columns:

```
In [54]: pd.DataFrame.from_items([('A', [1, 2, 3]), ('B', [4, 5, 6])])
Out[54]:
   A  B
```

```
0  1  4
1  2  5
2  3  6
```

If you pass `orient='index'`, the keys will be the row labels. But in this case you must also pass the desired column names:

```
In [55]: pd.DataFrame.from_items([('A', [1, 2, 3]), ('B', [4, 5, 6])],
   ....:                         orient='index', columns=['one', 'two', 'three'])
   ....:
Out[55]:
   one  two  three
A    1    2      3
B    4    5      6
```

8.2.8 Column selection, addition, deletion

You can treat a DataFrame semantically like a dict of like-indexed Series objects. Getting, setting, and deleting columns works with the same syntax as the analogous dict operations:

```
In [56]: df['one']
Out[56]:
a    1.0
b    2.0
c    3.0
d    NaN
Name: one, dtype: float64

In [57]: df['three'] = df['one'] * df['two']

In [58]: df['flag'] = df['one'] > 2

In [59]: df
Out[59]:
   one  two  three   flag
a  1.0  1.0    1.0  False
b  2.0  2.0    4.0  False
c  3.0  3.0    9.0   True
d  NaN  4.0    NaN  False
```

Columns can be deleted or popped like with a dict:

```
In [60]: del df['two']

In [61]: three = df.pop('three')

In [62]: df
Out[62]:
   one   flag
a  1.0  False
b  2.0  False
c  3.0   True
d  NaN  False
```

When inserting a scalar value, it will naturally be propagated to fill the column:

```
In [63]: df['foo'] = 'bar'

In [64]: df
Out[64]:
   one   flag  foo
a  1.0  False  bar
b  2.0  False  bar
c  3.0   True  bar
d  NaN  False  bar
```

When inserting a Series that does not have the same index as the DataFrame, it will be conformed to the DataFrame's index:

```
In [65]: df['one_trunc'] = df['one'][:2]

In [66]: df
Out[66]:
   one   flag  foo  one_trunc
a  1.0  False  bar        1.0
b  2.0  False  bar        2.0
c  3.0   True  bar        NaN
d  NaN  False  bar        NaN
```

You can insert raw ndarrays but their length must match the length of the DataFrame's index.

By default, columns get inserted at the end. The `insert` function is available to insert at a particular location in the columns:

```
In [67]: df.insert(1, 'bar', df['one'])

In [68]: df
Out[68]:
   one  bar   flag  foo  one_trunc
a  1.0  1.0  False  bar        1.0
b  2.0  2.0  False  bar        2.0
c  3.0  3.0   True  bar        NaN
d  NaN  NaN  False  bar        NaN
```

8.2.9 Assigning New Columns in Method Chains

Inspired by dplyr's `mutate` verb, DataFrame has an *`assign()`* method that allows you to easily create new columns that are potentially derived from existing columns.

```
In [69]: iris = pd.read_csv('data/iris.data')

In [70]: iris.head()
Out[70]:
   SepalLength  SepalWidth  PetalLength  PetalWidth         Name
0          5.1         3.5          1.4         0.2  Iris-setosa
1          4.9         3.0          1.4         0.2  Iris-setosa
2          4.7         3.2          1.3         0.2  Iris-setosa
3          4.6         3.1          1.5         0.2  Iris-setosa
4          5.0         3.6          1.4         0.2  Iris-setosa

In [71]: (iris.assign(sepal_ratio = iris['SepalWidth'] / iris['SepalLength'])
   ....:      .head())
```

```
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   SepalLength  SepalWidth  PetalLength  PetalWidth         Name  sepal_ratio
0          5.1         3.5          1.4         0.2  Iris-setosa       0.6863
1          4.9         3.0          1.4         0.2  Iris-setosa       0.6122
2          4.7         3.2          1.3         0.2  Iris-setosa       0.6809
3          4.6         3.1          1.5         0.2  Iris-setosa       0.6739
4          5.0         3.6          1.4         0.2  Iris-setosa       0.7200
```

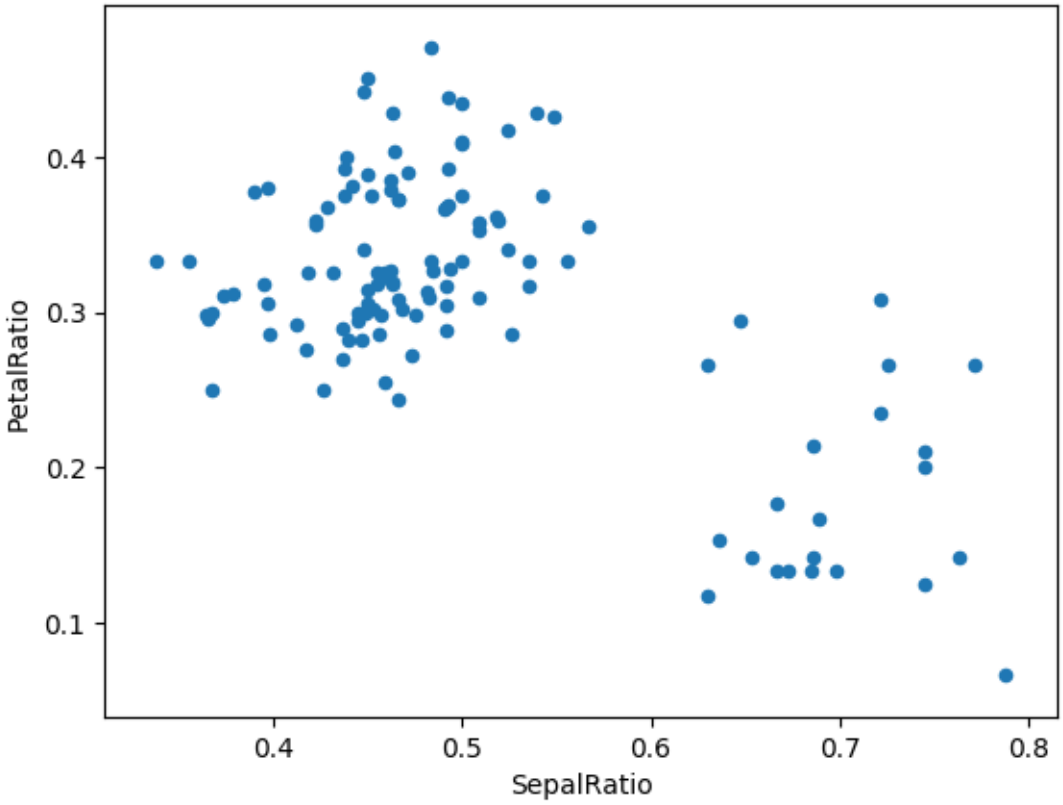
Above was an example of inserting a precomputed value. We can also pass in a function of one argument to be evalutated on the DataFrame being assigned to.

```
In [72]: iris.assign(sepal_ratio = lambda x: (x['SepalWidth'] /
   ....:                                      x['SepalLength'])).head()
   ....:
Out[72]:
   SepalLength  SepalWidth  PetalLength  PetalWidth         Name  sepal_ratio
0          5.1         3.5          1.4         0.2  Iris-setosa       0.6863
1          4.9         3.0          1.4         0.2  Iris-setosa       0.6122
2          4.7         3.2          1.3         0.2  Iris-setosa       0.6809
3          4.6         3.1          1.5         0.2  Iris-setosa       0.6739
4          5.0         3.6          1.4         0.2  Iris-setosa       0.7200
```

`assign` **always** returns a copy of the data, leaving the original DataFrame untouched.

Passing a callable, as opposed to an actual value to be inserted, is useful when you don't have a reference to the DataFrame at hand. This is common when using `assign` in chains of operations. For example, we can limit the DataFrame to just those observations with a Sepal Length greater than 5, calculate the ratio, and plot:

```
In [73]: (iris.query('SepalLength > 5')
   ....:      .assign(SepalRatio = lambda x: x.SepalWidth / x.SepalLength,
   ....:              PetalRatio = lambda x: x.PetalWidth / x.PetalLength)
   ....:      .plot(kind='scatter', x='SepalRatio', y='PetalRatio'))
   ....:
Out[73]: <matplotlib.axes._subplots.AxesSubplot at 0x122d7fba8>
```



Since a function is passed in, the function is computed on the DataFrame being assigned to. Importantly, this is the DataFrame that's been filtered to those rows with sepal length greater than 5. The filtering happens first, and then the ratio calculations. This is an example where we didn't have a reference to the *filtered* DataFrame available.

The function signature for `assign` is simply `**kwargs`. The keys are the column names for the new fields, and the values are either a value to be inserted (for example, a `Series` or NumPy array), or a function of one argument to be called on the `DataFrame`. A *copy* of the original DataFrame is returned, with the new values inserted.

Warning: Since the function signature of `assign` is `**kwargs`, a dictionary, the order of the new columns in the resulting DataFrame cannot be guaranteed to match the order you pass in. To make things predictable, items are inserted alphabetically (by key) at the end of the DataFrame.

All expressions are computed first, and then assigned. So you can't refer to another column being assigned in the same call to `assign`. For example:

```
In [74]: # Don't do this, bad reference to `C`
         df.assign(C = lambda x: x['A'] + x['B'],
                   D = lambda x: x['A'] + x['C'])
In [2]: # Instead, break it into two assigns
         (df.assign(C = lambda x: x['A'] + x['B'])
            .assign(D = lambda x: x['A'] + x['C']))
```

8.2.10 Indexing / Selection

The basics of indexing are as follows:

Operation	Syntax	Result
Select column	`df[col]`	Series
Select row by label	`df.loc[label]`	Series
Select row by integer location	`df.iloc[loc]`	Series
Slice rows	`df[5:10]`	DataFrame
Select rows by boolean vector	`df[bool_vec]`	DataFrame

Row selection, for example, returns a Series whose index is the columns of the DataFrame:

```
In [75]: df.loc['b']
Out[75]:
one              2
bar              2
flag         False
foo            bar
one_trunc        2
Name: b, dtype: object

In [76]: df.iloc[2]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
one             3
bar             3
flag         True
foo           bar
one_trunc     NaN
Name: c, dtype: object
```

For a more exhaustive treatment of more sophisticated label-based indexing and slicing, see the *section on indexing*. We will address the fundamentals of reindexing / conforming to new sets of labels in the *section on reindexing*.

8.2.11 Data alignment and arithmetic

Data alignment between DataFrame objects automatically align on **both the columns and the index (row labels)**. Again, the resulting object will have the union of the column and row labels.

```
In [77]: df = pd.DataFrame(np.random.randn(10, 4), columns=['A', 'B', 'C', 'D'])

In [78]: df2 = pd.DataFrame(np.random.randn(7, 3), columns=['A', 'B', 'C'])

In [79]: df + df2
Out[79]:
        A       B       C   D
0  0.0457 -0.0141  1.3809 NaN
1 -0.9554 -1.5010  0.0372 NaN
2 -0.6627  1.5348 -0.8597 NaN
3 -2.4529  1.2373 -0.1337 NaN
4  1.4145  1.9517 -2.3204 NaN
5 -0.4949 -1.6497 -1.0846 NaN
6 -1.0476 -0.7486 -0.8055 NaN
7     NaN     NaN     NaN NaN
8     NaN     NaN     NaN NaN
9     NaN     NaN     NaN NaN
```

When doing an operation between DataFrame and Series, the default behavior is to align the Series **index** on the DataFrame **columns**, thus broadcasting row-wise. For example:

```
In [80]: df - df.iloc[0]
Out[80]:
        A       B       C       D
0  0.0000  0.0000  0.0000  0.0000
1 -1.3593 -0.2487 -0.4534 -1.7547
2  0.2531  0.8297  0.0100 -1.9912
3 -1.3111  0.0543 -1.7249 -1.6205
4  0.5730  1.5007 -0.6761  1.3673
5 -1.7412  0.7820 -1.2416 -2.0531
6 -1.2408 -0.8696 -0.1533  0.0004
7 -0.7439  0.4110 -0.9296 -0.2824
8 -1.1949  1.3207  0.2382 -1.4826
9  2.2938  1.8562  0.7733 -1.4465
```

In the special case of working with time series data, and the DataFrame index also contains dates, the broadcasting will be column-wise:

```
In [81]: index = pd.date_range('1/1/2000', periods=8)

In [82]: df = pd.DataFrame(np.random.randn(8, 3), index=index, columns=list('ABC'))

In [83]: df
Out[83]:
                 A       B       C
2000-01-01 -1.2268  0.7698 -1.2812
2000-01-02 -0.7277 -0.1213 -0.0979
2000-01-03  0.6958  0.3417  0.9597
2000-01-04 -1.1103 -0.6200  0.1497
2000-01-05 -0.7323  0.6877  0.1764
2000-01-06  0.4033 -0.1550  0.3016
2000-01-07 -2.1799 -1.3698 -0.9542
2000-01-08  1.4627 -1.7432 -0.8266

In [84]: type(df['A'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪pandas.core.series.Series

In [85]: df - df['A']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
            2000-01-01 00:00:00  2000-01-02 00:00:00  2000-01-03 00:00:00  \
2000-01-01                  NaN                  NaN                  NaN
2000-01-02                  NaN                  NaN                  NaN
2000-01-03                  NaN                  NaN                  NaN
2000-01-04                  NaN                  NaN                  NaN
2000-01-05                  NaN                  NaN                  NaN
2000-01-06                  NaN                  NaN                  NaN
2000-01-07                  NaN                  NaN                  NaN
2000-01-08                  NaN                  NaN                  NaN

            2000-01-04 00:00:00 ...  2000-01-08 00:00:00   A   B   C
2000-01-01                  NaN ...                  NaN NaN NaN NaN
2000-01-02                  NaN ...                  NaN NaN NaN NaN
2000-01-03                  NaN ...                  NaN NaN NaN NaN
2000-01-04                  NaN ...                  NaN NaN NaN NaN
2000-01-05                  NaN ...                  NaN NaN NaN NaN
2000-01-06                  NaN ...                  NaN NaN NaN NaN
2000-01-07                  NaN ...                  NaN NaN NaN NaN
```

```
2000-01-08                     NaN ...                         NaN NaN NaN NaN

[8 rows x 11 columns]
```

Warning:

```
df - df['A']
```

is now deprecated and will be removed in a future release. The preferred way to replicate this behavior is

```
df.sub(df['A'], axis=0)
```

For explicit control over the matching and broadcasting behavior, see the section on *flexible binary operations*.

Operations with scalars are just as you would expect:

```
In [86]: df * 5 + 2
Out[86]:
                 A       B       C
2000-01-01 -4.1341  5.8490 -4.4062
2000-01-02 -1.6385  1.3935  1.5106
2000-01-03  5.4789  3.7087  6.7986
2000-01-04 -3.5517 -1.0999  2.7487
2000-01-05 -1.6617  5.4387  2.8822
2000-01-06  4.0165  1.2252  3.5081
2000-01-07 -8.8993 -4.8492 -2.7710
2000-01-08  9.3135 -6.7158 -2.1330

In [87]: 1 / df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                 A       B        C
2000-01-01 -0.8151  1.2990  -0.7805
2000-01-02 -1.3742 -8.2436 -10.2163
2000-01-03  1.4372  2.9262   1.0420
2000-01-04 -0.9006 -1.6130   6.6779
2000-01-05 -1.3655  1.4540   5.6675
2000-01-06  2.4795 -6.4537   3.3154
2000-01-07 -0.4587 -0.7300  -1.0480
2000-01-08  0.6837 -0.5737  -1.2098

In [88]: df ** 4
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                  A       B           C
2000-01-01   2.2653  0.3512  2.6948e+00
2000-01-02   0.2804  0.0002  9.1796e-05
2000-01-03   0.2344  0.0136  8.4838e-01
2000-01-04   1.5199  0.1477  5.0286e-04
2000-01-05   0.2876  0.2237  9.6924e-04
2000-01-06   0.0265  0.0006  8.2769e-03
2000-01-07  22.5795  3.5212  8.2903e-01
2000-01-08   4.5774  9.2332  4.6683e-01
```

Boolean operators work as well:

```
In [89]: df1 = pd.DataFrame({'a' : [1, 0, 1], 'b' : [0, 1, 1] }, dtype=bool)

In [90]: df2 = pd.DataFrame({'a' : [0, 1, 1], 'b' : [1, 1, 0] }, dtype=bool)

In [91]: df1 & df2
Out[91]: 
       a      b
0  False  False
1  False   True
2   True  False

In [92]: df1 | df2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[92]: 
      a     b
0  True  True
1  True  True
2  True  True

In [93]: df1 ^ df2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
       a      b
0   True   True
1   True  False
2  False   True

In [94]: -df1
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
       a      b
0  False   True
1   True  False
2  False  False
```

8.2.12 Transposing

To transpose, access the `T` attribute (also the `transpose` function), similar to an ndarray:

```
# only show the first 5 rows
In [95]: df[:5].T
Out[95]: 
   2000-01-01  2000-01-02  2000-01-03  2000-01-04  2000-01-05
A     -1.2268     -0.7277      0.6958     -1.1103     -0.7323
B      0.7698     -0.1213      0.3417     -0.6200      0.6877
C     -1.2812     -0.0979      0.9597      0.1497      0.1764
```

8.2.13 DataFrame interoperability with NumPy functions

Elementwise NumPy ufuncs (log, exp, sqrt, ...) and various other NumPy functions can be used with no issues on DataFrame, assuming the data within are numeric:

```
In [96]: np.exp(df)
Out[96]: 
                 A        B        C
```

```
2000-01-01  0.2932  2.1593  0.2777
2000-01-02  0.4830  0.8858  0.9068
2000-01-03  2.0053  1.4074  2.6110
2000-01-04  0.3294  0.5380  1.1615
2000-01-05  0.4808  1.9892  1.1930
2000-01-06  1.4968  0.8565  1.3521
2000-01-07  0.1131  0.2541  0.3851
2000-01-08  4.3176  0.1750  0.4375

In [97]: np.asarray(df)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
array([[-1.2268,  0.7698, -1.2812],
       [-0.7277, -0.1213, -0.0979],
       [ 0.6958,  0.3417,  0.9597],
       [-1.1103, -0.62  ,  0.1497],
       [-0.7323,  0.6877,  0.1764],
       [ 0.4033, -0.155 ,  0.3016],
       [-2.1799, -1.3698, -0.9542],
       [ 1.4627, -1.7432, -0.8266]])
```

The dot method on DataFrame implements matrix multiplication:

```
In [98]: df.T.dot(df)
Out[98]:
         A       B       C
A  11.3419 -0.0598  3.0080
B  -0.0598  6.5206  2.0833
C   3.0080  2.0833  4.3105
```

Similarly, the dot method on Series implements dot product:

```
In [99]: s1 = pd.Series(np.arange(5,10))

In [100]: s1.dot(s1)
Out[100]: 255
```

DataFrame is not intended to be a drop-in replacement for ndarray as its indexing semantics are quite different in places from a matrix.

8.2.14 Console display

Very large DataFrames will be truncated to display them in the console. You can also get a summary using *info()*. (Here I am reading a CSV version of the **baseball** dataset from the **plyr** R package):

```
In [101]: baseball = pd.read_csv('data/baseball.csv')

In [102]: print(baseball)
       id     player  year  stint  ...   hbp   sh   sf  gidp
0   88641  womacto01  2006      2  ...   0.0  3.0  0.0   0.0
1   88643  schilcu01  2006      1  ...   0.0  0.0  0.0   0.0
..    ...        ...   ...    ...  ...   ...  ...  ...   ...
98  89533   aloumo01  2007      1  ...   2.0  0.0  3.0  13.0
99  89534  alomasa02  2007      1  ...   0.0  0.0  0.0   0.0

[100 rows x 23 columns]
```

```
In [103]: baseball.info()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100 entries, 0 to 99
Data columns (total 23 columns):
id        100 non-null int64
player    100 non-null object
year      100 non-null int64
stint     100 non-null int64
team      100 non-null object
lg        100 non-null object
g         100 non-null int64
ab        100 non-null int64
r         100 non-null int64
h         100 non-null int64
X2b       100 non-null int64
X3b       100 non-null int64
hr        100 non-null int64
rbi       100 non-null float64
sb        100 non-null float64
cs        100 non-null float64
bb        100 non-null int64
so        100 non-null float64
ibb       100 non-null float64
hbp       100 non-null float64
sh        100 non-null float64
sf        100 non-null float64
gidp      100 non-null float64
dtypes: float64(9), int64(11), object(3)
memory usage: 18.0+ KB
```

However, using `to_string` will return a string representation of the DataFrame in tabular form, though it won't always fit the console width:

```
In [104]: print(baseball.iloc[-20:, :12].to_string())
       id     player  year  stint team  lg    g   ab   r    h  X2b  X3b
80  89474  finlest01  2007      1  COL  NL   43   94   9   17    3    0
81  89480  embreal01  2007      1  OAK  AL    4    0   0    0    0    0
82  89481  edmonji01  2007      1  SLN  NL  117  365  39   92   15    2
83  89482  easleda01  2007      1  NYN  NL   76  193  24   54    6    0
84  89489  delgaca01  2007      1  NYN  NL  139  538  71  139   30    0
85  89493  cormirh01  2007      1  CIN  NL    6    0   0    0    0    0
86  89494  coninje01  2007      2  NYN  NL   21   41   2    8    2    0
87  89495  coninje01  2007      1  CIN  NL   80  215  23   57   11    1
88  89497  clemero02  2007      1  NYA  AL    2    2   0    1    0    0
89  89498  claytro01  2007      2  BOS  AL    8    6   1    0    0    0
90  89499  claytro01  2007      1  TOR  AL   69  189  23   48   14    0
91  89501  cirilje01  2007      2  ARI  NL   28   40   6    8    4    0
92  89502  cirilje01  2007      1  MIN  AL   50  153  18   40    9    2
93  89521  bondsba01  2007      1  SFN  NL  126  340  75   94   14    0
94  89523  biggicr01  2007      1  HOU  NL  141  517  68  130   31    3
95  89525  benitar01  2007      2  FLO  NL   34    0   0    0    0    0
96  89526  benitar01  2007      1  SFN  NL   19    0   0    0    0    0
97  89530  ausmubr01  2007      1  HOU  NL  117  349  38   82   16    3
98  89533   aloumo01  2007      1  NYN  NL   87  328  51  112   19    1
99  89534  alomasa02  2007      1  NYN  NL    8   22   1    3    1    0
```

Wide DataFrames will be printed across multiple rows by default:

```
In [105]: pd.DataFrame(np.random.randn(3, 12))
Out[105]:
         0         1         2         3         4         5         6   \
0 -0.345352  1.314232  0.690579  0.995761  2.396780  0.014871  3.357427
1 -2.182937  0.380396  0.084844  0.432390  1.519970 -0.493662  0.600178
2  0.206053 -0.251905 -2.213588  1.063327  1.266143  0.299368 -0.863838

         7         8         9         10        11
0 -0.317441 -1.236269  0.896171 -0.487602 -0.082240
1  0.274230  0.132885 -0.023688  2.410179  1.450520
2  0.408204 -1.048089 -0.025747 -0.988387  0.094055
```

You can change how much to print on a single row by setting the `display.width` option:

```
In [106]: pd.set_option('display.width', 40) # default is 80

In [107]: pd.DataFrame(np.random.randn(3, 12))
Out[107]:
         0         1         2   \
0  1.262731  1.289997  0.082423
1  1.126203 -0.977349  1.474071
2  0.758527  1.729689 -0.964980

         3         4         5   \
0 -0.055758  0.536580 -0.489682
1 -0.064034 -1.282782  0.781836
2 -0.845696 -1.340896  1.846883

         6         7         8   \
0  0.369374 -0.034571 -2.484478
1 -1.071357  0.441153  2.353925
2 -1.328865  1.682706 -1.717693

         9         10        11
0 -0.281461  0.030711  0.109121
1  0.583787  0.221471 -0.744471
2  0.888782  0.228440  0.901805
```

You can adjust the max width of the individual columns by setting `display.max_colwidth`

```
In [108]: datafile={'filename': ['filename_01','filename_02'],
   .....:           'path': ["media/user_name/storage/folder_01/filename_01",
   .....:                    "media/user_name/storage/folder_02/filename_02"]}
   .....:

In [109]: pd.set_option('display.max_colwidth',30)

In [110]: pd.DataFrame(datafile)
Out[110]:
      filename  \
0  filename_01
1  filename_02

                            path
0  media/user_name/storage/fo...
1  media/user_name/storage/fo...
```

```
In [111]: pd.set_option('display.max_colwidth',100)

In [112]: pd.DataFrame(datafile)
Out[112]:
      filename  \
0  filename_01
1  filename_02

                                          path
0  media/user_name/storage/folder_01/filename_01
1  media/user_name/storage/folder_02/filename_02
```

You can also disable this feature via the `expand_frame_repr` option. This will print the table in one block.

8.2.15 DataFrame column attribute access and IPython completion

If a DataFrame column label is a valid Python variable name, the column can be accessed like attributes:

```
In [113]: df = pd.DataFrame({'foo1' : np.random.randn(5),
   .....:                    'foo2' : np.random.randn(5)})
   .....:

In [114]: df
Out[114]:
       foo1      foo2
0  1.171216 -0.858447
1  0.520260  0.306996
2 -1.197071 -0.028665
3 -1.066969  0.384316
4 -0.303421  1.574159

In [115]: df.foo1
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1.171216
1    0.520260
2   -1.197071
3   -1.066969
4   -0.303421
Name: foo1, dtype: float64
```

The columns are also connected to the IPython completion mechanism so they can be tab-completed:

```
In [5]: df.fo<TAB>
df.foo1  df.foo2
```

8.3 Panel

Warning: In 0.20.0, `Panel` is deprecated and will be removed in a future version. See the section *Deprecate Panel*.

Panel is a somewhat less-used, but still important container for 3-dimensional data. The term panel data is derived from econometrics and is partially responsible for the name pandas: pan(el)-da(ta)-s. The names for the 3 axes are intended to give some semantic meaning to describing operations involving panel data and, in particular, econometric analysis of panel data. However, for the strict purposes of slicing and dicing a collection of DataFrame objects, you may find the axis names slightly arbitrary:

- **items**: axis 0, each item corresponds to a DataFrame contained inside
- **major_axis**: axis 1, it is the **index** (rows) of each of the DataFrames
- **minor_axis**: axis 2, it is the **columns** of each of the DataFrames

Construction of Panels works about like you would expect:

8.3.1 From 3D ndarray with optional axis labels

```
In [116]: wp = pd.Panel(np.random.randn(2, 5, 4), items=['Item1', 'Item2'],
   .....:               major_axis=pd.date_range('1/1/2000', periods=5),
   .....:               minor_axis=['A', 'B', 'C', 'D'])
   .....:

In [117]: wp
Out[117]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to D
```

8.3.2 From dict of DataFrame objects

```
In [118]: data = {'Item1' : pd.DataFrame(np.random.randn(4, 3)),
   .....:         'Item2' : pd.DataFrame(np.random.randn(4, 2))}
   .....:

In [119]: pd.Panel(data)
Out[119]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 4 (major_axis) x 3 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 0 to 3
Minor_axis axis: 0 to 2
```

Note that the values in the dict need only be **convertible to DataFrame**. Thus, they can be any of the other valid inputs to DataFrame as per above.

One helpful factory method is `Panel.from_dict`, which takes a dictionary of DataFrames as above, and the following named parameters:

Parameter	Default	Description
intersect	`False`	drops elements whose indices do not align
orient	`items`	use `minor` to use DataFrames' columns as panel items

For example, compare to the construction above:

```
In [120]: pd.Panel.from_dict(data, orient='minor')
Out[120]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 4 (major_axis) x 2 (minor_axis)
Items axis: 0 to 2
Major_axis axis: 0 to 3
Minor_axis axis: Item1 to Item2
```

Orient is especially useful for mixed-type DataFrames. If you pass a dict of DataFrame objects with mixed-type columns, all of the data will get upcasted to `dtype=object` unless you pass `orient='minor'`:

```
In [121]: df = pd.DataFrame({'a': ['foo', 'bar', 'baz'],
   .....:                    'b': np.random.randn(3)})
   .....:

In [122]: df
Out[122]:
     a         b
0  foo -0.308853
1  bar -0.681087
2  baz  0.377953

In [123]: data = {'item1': df, 'item2': df}

In [124]: panel = pd.Panel.from_dict(data, orient='minor')

In [125]: panel['a']
Out[125]:
  item1 item2
0   foo   foo
1   bar   bar
2   baz   baz

In [126]: panel['b']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[126]:
      item1     item2
0 -0.308853 -0.308853
1 -0.681087 -0.681087
2  0.377953  0.377953

In [127]: panel['b'].dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
item1    float64
item2    float64
dtype: object
```

Note: Panel, being less commonly used than Series and DataFrame, has been slightly neglected feature-wise. A number of methods and options available in DataFrame are not available in Panel.

8.3.3 From DataFrame using `to_panel` method

`to_panel` converts a DataFrame with a two-level index to a Panel.

```
In [128]: midx = pd.MultiIndex(levels=[['one', 'two'], ['x','y']], labels=[[1,1,0,0],
↪[1,0,1,0]])

In [129]: df = pd.DataFrame({'A' : [1, 2, 3, 4], 'B': [5, 6, 7, 8]}, index=midx)

In [130]: df.to_panel()
Out[130]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 2 (major_axis) x 2 (minor_axis)
Items axis: A to B
Major_axis axis: one to two
Minor_axis axis: x to y
```

8.3.4 Item selection / addition / deletion

Similar to DataFrame functioning as a dict of Series, Panel is like a dict of DataFrames:

```
In [131]: wp['Item1']
Out[131]:
                   A         B         C         D
2000-01-01  1.588931  0.476720  0.473424 -0.242861
2000-01-02 -0.014805 -0.284319  0.650776 -1.461665
2000-01-03 -1.137707 -0.891060 -0.693921  1.613616
2000-01-04  0.464000  0.227371 -0.496922  0.306389
2000-01-05 -2.290613 -1.134623 -1.561819 -0.260838

In [132]: wp['Item3'] = wp['Item1'] / wp['Item2']
```

The API for insertion and deletion is the same as for DataFrame. And as with DataFrame, if the item is a valid python identifier, you can access it as an attribute and tab-complete it in IPython.

8.3.5 Transposing

A Panel can be rearranged using its `transpose` method (which does not make a copy by default unless the data are heterogeneous):

```
In [133]: wp.transpose(2, 0, 1)
Out[133]:
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 3 (major_axis) x 5 (minor_axis)
Items axis: A to D
Major_axis axis: Item1 to Item3
Minor_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
```

8.3.6 Indexing / Selection

Operation	Syntax	Result
Select item	`wp[item]`	DataFrame
Get slice at major_axis label	`wp.major_xs(val)`	DataFrame
Get slice at minor_axis label	`wp.minor_xs(val)`	DataFrame

For example, using the earlier example data, we could do:

```
In [134]: wp['Item1']
Out[134]:
                   A         B         C         D
2000-01-01  1.588931  0.476720  0.473424 -0.242861
2000-01-02 -0.014805 -0.284319  0.650776 -1.461665
2000-01-03 -1.137707 -0.891060 -0.693921  1.613616
2000-01-04  0.464000  0.227371 -0.496922  0.306389
2000-01-05 -2.290613 -1.134623 -1.561819 -0.260838

In [135]: wp.major_xs(wp.major_axis[2])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      Item1     Item2     Item3
A -1.137707  0.800193 -1.421791
B -0.891060  0.782098 -1.139320
C -0.693921 -1.069094  0.649074
D  1.613616 -1.099248 -1.467927

In [136]: wp.minor_axis
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Index(['A', 'B', 'C', 'D'], dtype='object')

In [137]: wp.minor_xs('C')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
               Item1     Item2     Item3
2000-01-01  0.473424 -0.902937 -0.524316
2000-01-02  0.650776 -1.144073 -0.568824
2000-01-03 -0.693921 -1.069094  0.649074
2000-01-04 -0.496922  0.661084 -0.751678
2000-01-05 -1.561819 -1.056652  1.478083
```

8.3.7 Squeezing

Another way to change the dimensionality of an object is to `squeeze` a 1-len object, similar to `wp['Item1']`

```
In [138]: wp.reindex(items=['Item1']).squeeze()
Out[138]:
                   A         B         C         D
2000-01-01  1.588931  0.476720  0.473424 -0.242861
2000-01-02 -0.014805 -0.284319  0.650776 -1.461665
2000-01-03 -1.137707 -0.891060 -0.693921  1.613616
2000-01-04  0.464000  0.227371 -0.496922  0.306389
2000-01-05 -2.290613 -1.134623 -1.561819 -0.260838

In [139]: wp.reindex(items=['Item1'], minor=['B']).squeeze()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-01    0.476720
2000-01-02   -0.284319
2000-01-03   -0.891060
2000-01-04    0.227371
2000-01-05   -1.134623
Freq: D, Name: B, dtype: float64
```

8.3.8 Conversion to DataFrame

A Panel can be represented in 2D form as a hierarchically indexed DataFrame. See the section *hierarchical indexing* for more on this. To convert a Panel to a DataFrame, use the `to_frame` method:

```
In [140]: panel = pd.Panel(np.random.randn(3, 5, 4), items=['one', 'two', 'three'],
   .....:                  major_axis=pd.date_range('1/1/2000', periods=5),
   .....:                  minor_axis=['a', 'b', 'c', 'd'])
   .....:

In [141]: panel.to_frame()
Out[141]:
                       one       two     three
major      minor
2000-01-01 a      0.493672  1.219492 -1.290493
           b     -2.461467  0.062297  0.787872
           c     -1.553902 -0.110388  1.515707
           d      2.015523 -1.184357 -0.276487
2000-01-02 a     -1.833722 -0.558081 -0.223762
           b      1.771740  0.077849  1.397431
           c     -0.670027  0.629498  1.503874
           d      0.049307 -1.035260 -0.478905
2000-01-03 a     -0.521493 -0.438229 -0.135950
           b     -3.201750  0.503703 -0.730327
           c      0.792716  0.413086 -0.033277
           d      0.146111 -1.139050  0.281151
2000-01-04 a      1.903247  0.660342 -1.298915
           b     -0.747169  0.464794 -2.819487
           c     -0.309038 -0.309337 -0.851985
           d      0.393876 -0.649593 -1.106952
2000-01-05 a      1.861468  0.683758 -0.937731
           b      0.936527 -0.643834 -1.537770
           c      1.255746  0.421287  0.555759
           d     -2.655452  1.032814 -2.277282
```

8.4 Deprecate Panel

Over the last few years, pandas has increased in both breadth and depth, with new features, datatype support, and manipulation routines. As a result, supporting efficient indexing and functional routines for `Series`, `DataFrame` and `Panel` has contributed to an increasingly fragmented and difficult-to-understand codebase.

The 3-D structure of a `Panel` is much less common for many types of data analysis, than the 1-D of the `Series` or the 2-D of the `DataFrame`. Going forward it makes sense for pandas to focus on these areas exclusively.

Oftentimes, one can simply use a MultiIndex `DataFrame` for easily working with higher dimensional data.

In additon, the `xarray` package was built from the ground up, specifically in order to support the multi-dimensional analysis that is one of `Panel` s main usecases. Here is a link to the xarray panel-transition documentation.

```
In [142]: p = tm.makePanel()

In [143]: p
Out[143]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 30 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
```

```
Major_axis axis: 2000-01-03 00:00:00 to 2000-02-11 00:00:00
Minor_axis axis: A to D
```

Convert to a MultiIndex DataFrame

```
In [144]: p.to_frame()
Out[144]:
                     ItemA     ItemB     ItemC
major      minor
2000-01-03 A     -0.390201 -1.624062 -0.605044
           B      1.562443  0.483103  0.583129
           C     -1.085663  0.768159 -0.273458
           D      0.136235 -0.021763 -0.700648
2000-01-04 A      1.207122 -0.758514  0.878404
           B      0.763264  0.061495 -0.876690
           C     -1.114738  0.225441 -0.335117
           D      0.886313 -0.047152 -1.166607
2000-01-05 A      0.178690 -0.560859 -0.921485
           B      0.162027  0.240767 -1.919354
           C     -0.058216  0.543294 -0.476268
           D     -1.350722  0.088472 -0.367236
2000-01-06 A     -1.004168 -0.589005 -0.200312
           B     -0.902704  0.782413 -0.572707
           C     -0.486768  0.771931 -1.765602
           D     -0.886348 -0.857435  1.296674
2000-01-07 A     -1.377627 -1.070678  0.522423
           B      1.106010  0.628462 -1.736484
           C      1.685148 -0.968145  0.578223
           D     -1.013316 -2.503786  0.641385
2000-01-10 A      0.499281 -1.681101  0.722511
           B     -0.199234 -0.880627 -1.335113
           C      0.112572 -1.176383  0.242697
           D      1.920906 -1.058041 -0.779432
2000-01-11 A     -1.405256  0.403776 -1.702486
           B      0.458265  0.777575 -1.244471
           C     -1.495309 -3.192716  0.208129
           D     -0.388231 -0.657981  0.602456
2000-01-12 A      0.162565  0.609862 -0.709535
           B      0.491048 -0.779367  0.347339
...                    ...       ...       ...
2000-02-02 C     -0.303961 -0.463752 -0.288962
           D      0.104050  1.116086  0.506445
2000-02-03 A     -2.338595 -0.581967 -0.801820
           B     -0.557697 -0.033731 -0.176382
           C      0.625555 -0.055289  0.875359
           D      0.174068 -0.443915  1.626369
2000-02-04 A     -0.374279 -1.233862 -0.915751
           B      0.381353 -1.108761 -1.970108
           C     -0.059268 -0.360853 -0.614618
           D     -0.439461 -0.200491  0.429518
2000-02-07 A     -2.359958 -3.520876 -0.288156
           B      1.337122 -0.314399 -1.044208
           C      0.249698  0.728197  0.565375
           D     -0.741343  1.092633  0.013910
2000-02-08 A     -1.157886  0.516870 -1.199945
           B     -1.531095 -0.860626 -0.821179
           C      1.103949  1.326768  0.068184
           D     -0.079673 -1.675194 -0.458272
```

```
2000-02-09 A     -0.551865  0.343125 -0.072869
           B      1.331458  0.370397 -1.914267
           C     -1.087532  0.208927  0.788871
           D     -0.922875  0.437234 -1.531004
2000-02-10 A      1.592673  2.137827 -1.828740
           B     -0.571329 -1.761442 -0.826439
           C      1.998044  0.292058 -0.280343
           D      0.303638  0.388254 -0.500569
2000-02-11 A      1.559318  0.452429 -1.716981
           B     -0.026671 -0.899454  0.124808
           C     -0.244548 -2.019610  0.931536
           D     -0.917368  0.479630  0.870690

[120 rows x 3 columns]
```

Alternatively, one can convert to an xarray `DataArray`.

```
In [145]: p.to_xarray()
Out[145]:
<xarray.DataArray (items: 3, major_axis: 30, minor_axis: 4)>
array([[[-0.390201,  1.562443, -1.085663,  0.136235],
        [ 1.207122,  0.763264, -1.114738,  0.886313],
        ...,
        [ 1.592673, -0.571329,  1.998044,  0.303638],
        [ 1.559318, -0.026671, -0.244548, -0.917368]],

       [[-1.624062,  0.483103,  0.768159, -0.021763],
        [-0.758514,  0.061495,  0.225441, -0.047152],
        ...,
        [ 2.137827, -1.761442,  0.292058,  0.388254],
        [ 0.452429, -0.899454, -2.01961 ,  0.47963 ]],

       [[-0.605044,  0.583129, -0.273458, -0.700648],
        [ 0.878404, -0.87669 , -0.335117, -1.166607],
        ...,
        [-1.82874 , -0.826439, -0.280343, -0.500569],
        [-1.716981,  0.124808,  0.931536,  0.87069 ]]])
Coordinates:
  * items       (items) object 'ItemA' 'ItemB' 'ItemC'
  * major_axis  (major_axis) datetime64[ns] 2000-01-03 2000-01-04 2000-01-05 ...
  * minor_axis  (minor_axis) object 'A' 'B' 'C' 'D'
```

You can see the full-documentation for the xarray package.

8.5 Panel4D and PanelND (Deprecated)

Warning: In 0.19.0 `Panel4D` and `PanelND` are deprecated and will be removed in a future version. The recommended way to represent these types of n-dimensional data are with the xarray package. Pandas provides a `to_xarray()` method to automate this conversion.

See the docs of a previous version for documentation on these objects.

CHAPTER

NINE

ESSENTIAL BASIC FUNCTIONALITY

Here we discuss a lot of the essential functionality common to the pandas data structures. Here's how to create some of the objects used in the examples from the previous section:

```
In [1]: index = pd.date_range('1/1/2000', periods=8)

In [2]: s = pd.Series(np.random.randn(5), index=['a', 'b', 'c', 'd', 'e'])

In [3]: df = pd.DataFrame(np.random.randn(8, 3), index=index,
   ...:                   columns=['A', 'B', 'C'])
   ...:

In [4]: wp = pd.Panel(np.random.randn(2, 5, 4), items=['Item1', 'Item2'],
   ...:               major_axis=pd.date_range('1/1/2000', periods=5),
   ...:               minor_axis=['A', 'B', 'C', 'D'])
   ...:
```

9.1 Head and Tail

To view a small sample of a Series or DataFrame object, use the `head()` and `tail()` methods. The default number of elements to display is five, but you may pass a custom number.

```
In [5]: long_series = pd.Series(np.random.randn(1000))

In [6]: long_series.head()
Out[6]:
0    0.229453
1    0.304418
2    0.736135
3   -0.859631
4   -0.424100
dtype: float64

In [7]: long_series.tail(3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[7]
↪
997   -0.351587
998    1.136249
999   -0.448789
dtype: float64
```

9.2 Attributes and the raw ndarray(s)

pandas objects have a number of attributes enabling you to access the metadata

- **shape**: gives the axis dimensions of the object, consistent with ndarray
- Axis labels
    - **Series**: *index* (only axis)
    - **DataFrame**: *index* (rows) and *columns*
    - **Panel**: *items*, *major_axis*, and *minor_axis*

Note, **these attributes can be safely assigned to**!

```
In [8]: df[:2]
Out[8]:
                   A         B        C
2000-01-01  0.048869 -1.360687 -0.47901
2000-01-02 -0.859661 -0.231595 -0.52775

In [9]: df.columns = [x.lower() for x in df.columns]

In [10]: df
Out[10]:
                   a         b         c
2000-01-01  0.048869 -1.360687 -0.479010
2000-01-02 -0.859661 -0.231595 -0.527750
2000-01-03 -1.296337  0.150680  0.123836
2000-01-04  0.571764  1.555563 -0.823761
2000-01-05  0.535420 -1.032853  1.469725
2000-01-06  1.304124  1.449735  0.203109
2000-01-07 -1.032011  0.969818 -0.962723
2000-01-08  1.382083 -0.938794  0.669142
```

To get the actual data inside a data structure, one need only access the **values** property:

```
In [11]: s.values
Out[11]: array([-1.9339,  0.3773,  0.7341,  2.1416, -0.0112])

In [12]: df.values
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[12]:
array([[ 0.0489, -1.3607, -0.479 ],
       [-0.8597, -0.2316, -0.5278],
       [-1.2963,  0.1507,  0.1238],
       [ 0.5718,  1.5556, -0.8238],
       [ 0.5354, -1.0329,  1.4697],
       [ 1.3041,  1.4497,  0.2031],
       [-1.032 ,  0.9698, -0.9627],
       [ 1.3821, -0.9388,  0.6691]])

In [13]: wp.values
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
array([[[-0.4336, -0.2736,  0.6804, -0.3084],
        [-0.2761, -1.8212, -1.9936, -1.9274],
        [-2.0279,  1.625 ,  0.5511,  3.0593],
        [ 0.4553, -0.0307,  0.9357,  1.0612],
        [-2.1079,  0.1999,  0.3236, -0.6416]],
```

```
       [[-0.5875,  0.0539,  0.1949, -0.382 ],
        [ 0.3186,  2.0891, -0.7283, -0.0903],
        [-0.7482,  1.3189, -2.0298,  0.7927],
        [ 0.461 , -0.5427, -0.3054, -0.4792],
        [ 0.095 , -0.2701, -0.7071, -0.7739]]])
```

If a DataFrame or Panel contains homogeneously-typed data, the ndarray can actually be modified in-place, and the changes will be reflected in the data structure. For heterogeneous data (e.g. some of the DataFrame's columns are not all the same dtype), this will not be the case. The values attribute itself, unlike the axis labels, cannot be assigned to.

Note: When working with heterogeneous data, the dtype of the resulting ndarray will be chosen to accommodate all of the data involved. For example, if strings are involved, the result will be of object dtype. If there are only floats and integers, the resulting array will be of float dtype.

9.3 Accelerated operations

pandas has support for accelerating certain types of binary numerical and boolean operations using the `numexpr` library and the `bottleneck` libraries.

These libraries are especially useful when dealing with large data sets, and provide large speedups. `numexpr` uses smart chunking, caching, and multiple cores. `bottleneck` is a set of specialized cython routines that are especially fast when dealing with arrays that have `nans`.

Here is a sample (using 100 column x 100,000 row `DataFrames`):

Operation	0.11.0 (ms)	Prior Version (ms)	Ratio to Prior
`df1 > df2`	13.32	125.35	0.1063
`df1 * df2`	21.71	36.63	0.5928
`df1 + df2`	22.04	36.50	0.6039

You are highly encouraged to install both libraries. See the section *Recommended Dependencies* for more installation info.

These are both enabled to be used by default, you can control this by setting the options:

New in version 0.20.0.

```
pd.set_option('compute.use_bottleneck', False)
pd.set_option('compute.use_numexpr', False)
```

9.4 Flexible binary operations

With binary operations between pandas data structures, there are two key points of interest:

- Broadcasting behavior between higher- (e.g. DataFrame) and lower-dimensional (e.g. Series) objects.
- Missing data in computations

We will demonstrate how to manage these issues independently, though they can be handled simultaneously.

9.4.1 Matching / broadcasting behavior

DataFrame has the methods `add()`, `sub()`, `mul()`, `div()` and related functions `radd()`, `rsub()`, ... for carrying out binary operations. For broadcasting behavior, Series input is of primary interest. Using these functions, you can use to either match on the *index* or *columns* via the **axis** keyword:

```
In [14]: df = pd.DataFrame({'one' : pd.Series(np.random.randn(3), index=['a', 'b', 'c
↪']),
   ....:                    'two' : pd.Series(np.random.randn(4), index=['a', 'b', 'c
↪', 'd']),
   ....:                    'three' : pd.Series(np.random.randn(3), index=['b', 'c',
↪'d'])})
   ....:

In [15]: df
Out[15]:
        one     three       two
a -1.101558       NaN  1.124472
b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.486066
d       NaN -1.222918 -0.456288

In [16]: row = df.iloc[1]

In [17]: column = df['two']

In [18]: df.sub(row, axis='columns')
Out[18]:
        one     three       two
a -0.924269       NaN -1.362632
b  0.000000  0.000000  0.000000
c  0.639504  2.565487 -2.973170
d       NaN -0.588625 -2.943392

In [19]: df.sub(row, axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one     three       two
a -0.924269       NaN -1.362632
b  0.000000  0.000000  0.000000
c  0.639504  2.565487 -2.973170
d       NaN -0.588625 -2.943392

In [20]: df.sub(column, axis='index')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one     three  two
a -2.226031       NaN  0.0
b -2.664393 -3.121397  0.0
c  0.948280  2.417260  0.0
d       NaN -0.766631  0.0

In [21]: df.sub(column, axis=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one     three  two
a -2.226031       NaN  0.0
b -2.664393 -3.121397  0.0
```

```
c  0.948280  2.417260  0.0
d       NaN -0.766631  0.0
```

Furthermore you can align a level of a multi-indexed DataFrame with a Series.

```
In [22]: dfmi = df.copy()

In [23]: dfmi.index = pd.MultiIndex.from_tuples([(1,'a'),(1,'b'),(1,'c'),(2,'a')],
   ....:                                        names=['first','second'])
   ....:

In [24]: dfmi.sub(column, axis=0, level='second')
Out[24]:
                   one     three      two
first second
1     a      -2.226031       NaN  0.00000
      b      -2.664393 -3.121397  0.00000
      c       0.948280  2.417260  0.00000
2     a            NaN -2.347391 -1.58076
```

With Panel, describing the matching behavior is a bit more difficult, so the arithmetic methods instead (and perhaps confusingly?) give you the option to specify the *broadcast axis*. For example, suppose we wished to demean the data over a particular axis. This can be accomplished by taking the mean over an axis and broadcasting over the same axis:

```
In [25]: major_mean = wp.mean(axis='major')

In [26]: major_mean
Out[26]:
      Item1     Item2
A -0.878036 -0.092218
B -0.060128  0.529811
C  0.099453 -0.715139
D  0.248599 -0.186535

In [27]: wp.sub(major_mean, axis='major')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to D
```

And similarly for `axis="items"` and `axis="minor"`.

Note: I could be convinced to make the **axis** argument in the DataFrame methods match the broadcasting behavior of Panel. Though it would require a transition period so users can change their code...

Series and Index also support the `divmod()` builtin. This function takes the floor division and modulo operation at the same time returning a two-tuple of the same type as the left hand side. For example:

```
In [28]: s = pd.Series(np.arange(10))

In [29]: s
Out[29]:
0    0
```

```
1    1
2    2
3    3
4    4
5    5
6    6
7    7
8    8
9    9
dtype: int64

In [30]: div, rem = divmod(s, 3)

In [31]: div
Out[31]: 
0    0
1    0
2    0
3    1
4    1
5    1
6    2
7    2
8    2
9    3
dtype: int64

In [32]: rem
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[32]
↪
0    0
1    1
2    2
3    0
4    1
5    2
6    0
7    1
8    2
9    0
dtype: int64

In [33]: idx = pd.Index(np.arange(10))

In [34]: idx
Out[34]: Int64Index([0, 1, 2, 3, 4, 5, 6, 7, 8, 9], dtype='int64')

In [35]: div, rem = divmod(idx, 3)

In [36]: div
Out[36]: Int64Index([0, 0, 0, 1, 1, 1, 2, 2, 2, 3], dtype='int64')

In [37]: rem
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[37]:␣
↪Int64Index([0, 1, 2, 0, 1, 2, 0, 1, 2, 0], dtype='int64')
```

We can also do elementwise `divmod()`:

```
In [38]: div, rem = divmod(s, [2, 2, 3, 3, 4, 4, 5, 5, 6, 6])

In [39]: div
Out[39]:
0    0
1    0
2    0
3    1
4    1
5    1
6    1
7    1
8    1
9    1
dtype: int64

In [40]: rem
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[40]
↪
0    0
1    1
2    2
3    0
4    0
5    1
6    1
7    2
8    2
9    3
dtype: int64
```

9.4.2 Missing data / operations with fill values

In Series and DataFrame (though not yet in Panel), the arithmetic functions have the option of inputting a *fill_value*, namely a value to substitute when at most one of the values at a location are missing. For example, when adding two DataFrame objects, you may wish to treat NaN as 0 unless both DataFrames are missing that value, in which case the result will be NaN (you can later replace NaN with some other value using `fillna` if you wish).

```
In [41]: df
Out[41]:
        one     three       two
a -1.101558       NaN  1.124472
b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.486066
d       NaN -1.222918 -0.456288

In [42]: df2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one     three       two
a -1.101558  1.000000  1.124472
b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.486066
d       NaN -1.222918 -0.456288

In [43]: df + df2
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one     three       two
a -2.203116       NaN  2.248945
b -0.354579 -1.268586  4.974208
c  0.924429  3.862388 -0.972131
d       NaN -2.445837 -0.912575

In [44]: df.add(df2, fill_value=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one     three       two
a -2.203116  1.000000  2.248945
b -0.354579 -1.268586  4.974208
c  0.924429  3.862388 -0.972131
d       NaN -2.445837 -0.912575
```

9.4.3 Flexible Comparisons

Series and DataFrame have the binary comparison methods `eq`, `ne`, `lt`, `gt`, `le`, and `ge` whose behavior is analogous to the binary arithmetic operations described above:

```
In [45]: df.gt(df2)
Out[45]:
     one  three    two
a  False  False  False
b  False  False  False
c  False  False  False
d  False  False  False

In [46]: df2.ne(df)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     one  three    two
a  False   True  False
b  False  False  False
c  False  False  False
d   True  False  False
```

These operations produce a pandas object the same type as the left-hand-side input that if of dtype `bool`. These `boolean` objects can be used in indexing operations, see *here*

9.4.4 Boolean Reductions

You can apply the reductions: *`empty`*, *`any()`*, *`all()`*, and *`bool()`* to provide a way to summarize a boolean result.

```
In [47]: (df > 0).all()
Out[47]:
one      False
three    False
two      False
dtype: bool

In [48]: (df > 0).any()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[48]:
```

```
one      True
three    True
two      True
dtype: bool
```

You can reduce to a final boolean value.

```
In [49]: (df > 0).any().any()
Out[49]: True
```

You can test if a pandas object is empty, via the *empty* property.

```
In [50]: df.empty
Out[50]: False

In [51]: pd.DataFrame(columns=list('ABC')).empty
\\\\\\\\\\\\\\Out[51]: True
```

To evaluate single-element pandas objects in a boolean context, use the method *bool()*:

```
In [52]: pd.Series([True]).bool()
Out[52]: True

In [53]: pd.Series([False]).bool()
\\\\\\\\\\\\\Out[53]: False

In [54]: pd.DataFrame([[True]]).bool()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[54]: True

In [55]: pd.DataFrame([[False]]).bool()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[55]: False
```

Warning: You might be tempted to do the following:

```
>>> if df:
     ...
```

Or

```
>>> df and df2
```

These both will raise as you are trying to compare multiple values.

```
ValueError: The truth value of an array is ambiguous. Use a.empty, a.any() or a.
↪all().
```

See *gotchas* for a more detailed discussion.

9.4.5 Comparing if objects are equivalent

Often you may find there is more than one way to compute the same result. As a simple example, consider `df+df` and `df*2`. To test that these two computations produce the same result, given the tools shown above, you might imagine using `(df+df == df*2).all()`. But in fact, this expression is False:

```
In [56]: df+df == df*2
Out[56]:
     one  three   two
a   True  False  True
b   True   True  True
c   True   True  True
d  False   True  True

In [57]: (df+df == df*2).all()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
one      False
three    False
two       True
dtype: bool
```

Notice that the boolean DataFrame `df+df == df*2` contains some False values! That is because NaNs do not compare as equals:

```
In [58]: np.nan == np.nan
Out[58]: False
```

So, NDFrames (such as Series, DataFrames, and Panels) have an `equals()` method for testing equality, with NaNs in corresponding locations treated as equal.

```
In [59]: (df+df).equals(df*2)
Out[59]: True
```

Note that the Series or DataFrame index needs to be in the same order for equality to be True:

```
In [60]: df1 = pd.DataFrame({'col':['foo', 0, np.nan]})

In [61]: df2 = pd.DataFrame({'col':[np.nan, 0, 'foo']}, index=[2,1,0])

In [62]: df1.equals(df2)
Out[62]: False

In [63]: df1.equals(df2.sort_index())
\\\\\\\\\\\\\\\Out[63]: True
```

9.4.6 Comparing array-like objects

You can conveniently do element-wise comparisons when comparing a pandas data structure with a scalar value:

```
In [64]: pd.Series(['foo', 'bar', 'baz']) == 'foo'
Out[64]:
0     True
1    False
2    False
dtype: bool

In [65]: pd.Index(['foo', 'bar', 'baz']) == 'foo'
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[65]: array([ True, False,␣
↪False], dtype=bool)
```

Pandas also handles element-wise comparisons between different array-like objects of the same length:

```
In [66]: pd.Series(['foo', 'bar', 'baz']) == pd.Index(['foo', 'bar', 'qux'])
Out[66]:
0     True
1     True
2    False
dtype: bool

In [67]: pd.Series(['foo', 'bar', 'baz']) == np.array(['foo', 'bar', 'qux'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[67]:
0     True
1     True
2    False
dtype: bool
```

Trying to compare `Index` or `Series` objects of different lengths will raise a ValueError:

```
In [55]: pd.Series(['foo', 'bar', 'baz']) == pd.Series(['foo', 'bar'])
ValueError: Series lengths must match to compare

In [56]: pd.Series(['foo', 'bar', 'baz']) == pd.Series(['foo'])
ValueError: Series lengths must match to compare
```

Note that this is different from the numpy behavior where a comparison can be broadcast:

```
In [68]: np.array([1, 2, 3]) == np.array([2])
Out[68]: array([False,  True, False], dtype=bool)
```

or it can return False if broadcasting can not be done:

```
In [69]: np.array([1, 2, 3]) == np.array([1, 2])
Out[69]: False
```

9.4.7 Combining overlapping data sets

A problem occasionally arising is the combination of two similar data sets where values in one are preferred over the other. An example would be two data series representing a particular economic indicator where one is considered to be of "higher quality". However, the lower quality series might extend further back in history or have more complete data coverage. As such, we would like to combine two DataFrame objects where missing values in one DataFrame are conditionally filled with like-labeled values from the other DataFrame. The function implementing this operation is *`combine_first()`*, which we illustrate:

```
In [70]: df1 = pd.DataFrame({'A' : [1., np.nan, 3., 5., np.nan],
   ....:                     'B' : [np.nan, 2., 3., np.nan, 6.]})
   ....:

In [71]: df2 = pd.DataFrame({'A' : [5., 2., 4., np.nan, 3., 7.],
   ....:                     'B' : [np.nan, np.nan, 3., 4., 6., 8.]})
   ....:

In [72]: df1
Out[72]:
     A    B
0  1.0  NaN
1  NaN  2.0
2  3.0  3.0
3  5.0  NaN
```

```
4   NaN   6.0

In [73]: df2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[73]:␣
↪
     A    B
0  5.0  NaN
1  2.0  NaN
2  4.0  3.0
3  NaN  4.0
4  3.0  6.0
5  7.0  8.0

In [74]: df1.combine_first(df2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     A    B
0  1.0  NaN
1  2.0  2.0
2  3.0  3.0
3  5.0  4.0
4  3.0  6.0
5  7.0  8.0
```

9.4.8 General DataFrame Combine

The `combine_first()` method above calls the more general DataFrame method `combine()`. This method takes another DataFrame and a combiner function, aligns the input DataFrame and then passes the combiner function pairs of Series (i.e., columns whose names are the same).

So, for instance, to reproduce `combine_first()` as above:

```
In [75]: combiner = lambda x, y: np.where(pd.isna(x), y, x)

In [76]: df1.combine(df2, combiner)
Out[76]:
     A    B
0  1.0  NaN
1  2.0  2.0
2  3.0  3.0
3  5.0  4.0
4  3.0  6.0
5  7.0  8.0
```

9.5 Descriptive statistics

A large number of methods for computing descriptive statistics and other related operations on *Series*, *DataFrame*, and *Panel*. Most of these are aggregations (hence producing a lower-dimensional result) like `sum()`, `mean()`, and `quantile()`, but some of them, like `cumsum()` and `cumprod()`, produce an object of the same size. Generally speaking, these methods take an **axis** argument, just like *ndarray.{sum, std, ...}*, but the axis can be specified by name or integer:

- **Series**: no axis argument needed

- **DataFrame**: “index” (axis=0, default), “columns” (axis=1)
- **Panel**: “items” (axis=0), “major” (axis=1, default), “minor” (axis=2)

For example:

```
In [77]: df
Out[77]:
        one     three       two
a -1.101558       NaN  1.124472
b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.486066
d       NaN -1.222918 -0.456288

In [78]: df.mean(0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
one     -0.272211
three    0.024661
two      0.667306
dtype: float64

In [79]: df.mean(1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a    0.011457
b    0.558507
c    0.635781
d   -0.839603
dtype: float64
```

All such methods have a `skipna` option signaling whether to exclude missing data (`True` by default):

```
In [80]: df.sum(0, skipna=False)
Out[80]:
one           NaN
three         NaN
two      2.669223
dtype: float64

In [81]: df.sum(axis=1, skipna=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[81]:␣
↪
a    0.022914
b    1.675522
c    1.907343
d   -1.679206
dtype: float64
```

Combined with the broadcasting / arithmetic behavior, one can describe various statistical procedures, like standardization (rendering data zero mean and standard deviation 1), very concisely:

```
In [82]: ts_stand = (df - df.mean()) / df.std()

In [83]: ts_stand.std()
Out[83]:
one      1.0
three    1.0
two      1.0
```

```
dtype: float64

In [84]: xs_stand = df.sub(df.mean(1), axis=0).div(df.std(1), axis=0)

In [85]: xs_stand.std(1)
Out[85]:
a    1.0
b    1.0
c    1.0
d    1.0
dtype: float64
```

Note that methods like *cumsum()* and *cumprod()* preserve the location of NaN values. This is somewhat different from *expanding()* and *rolling()*. For more details please see *this note*.

```
In [86]: df.cumsum()
Out[86]:
        one     three       two
a -1.101558       NaN  1.124472
b -1.278848 -0.634293  3.611576
c -0.816633  1.296901  3.125511
d       NaN  0.073983  2.669223
```

Here is a quick reference summary table of common functions. Each also takes an optional `level` parameter which applies only if the object has a *hierarchical index*.

Function	Description
count	Number of non-NA observations
sum	Sum of values
mean	Mean of values
mad	Mean absolute deviation
median	Arithmetic median of values
min	Minimum
max	Maximum
mode	Mode
abs	Absolute Value
prod	Product of values
std	Bessel-corrected sample standard deviation
var	Unbiased variance
sem	Standard error of the mean
skew	Sample skewness (3rd moment)
kurt	Sample kurtosis (4th moment)
quantile	Sample quantile (value at %)
cumsum	Cumulative sum
cumprod	Cumulative product
cummax	Cumulative maximum
cummin	Cumulative minimum

Note that by chance some NumPy methods, like `mean`, `std`, and `sum`, will exclude NAs on Series input by default:

```
In [87]: np.mean(df['one'])
Out[87]: -0.27221094480450114

In [88]: np.mean(df['one'].values)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[88]: nan
```

`Series` also has a method *`nunique()`* which will return the number of unique non-NA values:

```
In [89]: series = pd.Series(np.random.randn(500))

In [90]: series[20:500] = np.nan

In [91]: series[10:20]  = 5

In [92]: series.nunique()
Out[92]: 11
```

9.5.1 Summarizing data: describe

There is a convenient *`describe()`* function which computes a variety of summary statistics about a Series or the columns of a DataFrame (excluding NAs of course):

```
In [93]: series = pd.Series(np.random.randn(1000))

In [94]: series[::2] = np.nan

In [95]: series.describe()
Out[95]:
count    500.000000
mean      -0.032127
std        1.067484
min       -3.463789
25%       -0.725523
50%       -0.053230
75%        0.679790
max        3.120271
dtype: float64

In [96]: frame = pd.DataFrame(np.random.randn(1000, 5), columns=['a', 'b', 'c', 'd',
↪'e'])

In [97]: frame.iloc[::2] = np.nan

In [98]: frame.describe()
Out[98]:
                a           b           c           d           e
count  500.000000  500.000000  500.000000  500.000000  500.000000
mean    -0.045109   -0.052045    0.024520    0.006117    0.001141
std      1.029268    1.002320    1.042793    1.040134    1.005207
min     -2.915767   -3.294023   -3.610499   -2.907036   -3.010899
25%     -0.763783   -0.720389   -0.609600   -0.665896   -0.682900
50%     -0.086033   -0.048843    0.006093    0.043191   -0.001651
75%      0.663399    0.620980    0.728382    0.735973    0.656439
max      3.400646    2.925597    3.416896    3.331522    3.007143
```

You can select specific percentiles to include in the output:

```
In [99]: series.describe(percentiles=[.05, .25, .75, .95])
Out[99]:
count    500.000000
mean      -0.032127
std        1.067484
min       -3.463789
```

```
5%        -1.733545
25%       -0.725523
50%       -0.053230
75%        0.679790
95%        1.854383
max        3.120271
dtype: float64
```

By default, the median is always included.

For a non-numerical Series object, *describe()* will give a simple summary of the number of unique values and most frequently occurring values:

```
In [100]: s = pd.Series(['a', 'a', 'b', 'b', 'a', 'a', np.nan, 'c', 'd', 'a'])

In [101]: s.describe()
Out[101]: 
count       9
unique      4
top         a
freq        5
dtype: object
```

Note that on a mixed-type DataFrame object, *describe()* will restrict the summary to include only numerical columns or, if none are, only categorical columns:

```
In [102]: frame = pd.DataFrame({'a': ['Yes', 'Yes', 'No', 'No'], 'b': range(4)})

In [103]: frame.describe()
Out[103]: 
              b
count  4.000000
mean   1.500000
std    1.290994
min    0.000000
25%    0.750000
50%    1.500000
75%    2.250000
max    3.000000
```

This behaviour can be controlled by providing a list of types as `include`/`exclude` arguments. The special value `all` can also be used:

```
In [104]: frame.describe(include=['object'])
Out[104]: 
          a
count     4
unique    2
top     Yes
freq      2

In [105]: frame.describe(include=['number'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[105]: 
              b
count  4.000000
mean   1.500000
std    1.290994
min    0.000000
```

```
25%     0.750000
50%     1.500000
75%     2.250000
max     3.000000

In [106]: frame.describe(include='all')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          a         b
count     4  4.000000
unique    2       NaN
top     Yes       NaN
freq      2       NaN
mean    NaN  1.500000
std     NaN  1.290994
min     NaN  0.000000
25%     NaN  0.750000
50%     NaN  1.500000
75%     NaN  2.250000
max     NaN  3.000000
```

That feature relies on *select_dtypes*. Refer to there for details about accepted inputs.

9.5.2 Index of Min/Max Values

The `idxmin()` and `idxmax()` functions on Series and DataFrame compute the index labels with the minimum and maximum corresponding values:

```
In [107]: s1 = pd.Series(np.random.randn(5))

In [108]: s1
Out[108]:
0   -1.649461
1    0.169660
2    1.246181
3    0.131682
4   -2.001988
dtype: float64

In [109]: s1.idxmin(), s1.idxmax()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[
↪(4, 2)

In [110]: df1 = pd.DataFrame(np.random.randn(5,3), columns=['A','B','C'])

In [111]: df1
Out[111]:
          A         B         C
0 -1.273023  0.870502  0.214583
1  0.088452 -0.173364  1.207466
2  0.546121  0.409515 -0.310515
3  0.585014 -0.490528 -0.054639
4 -0.239226  0.701089  0.228656

In [112]: df1.idxmin(axis=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
A    0
B    3
C    2
dtype: int64

In [113]: df1.idxmax(axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    B
1    C
2    A
3    A
4    B
dtype: object
```

When there are multiple rows (or columns) matching the minimum or maximum value, `idxmin()` and `idxmax()` return the first matching index:

```
In [114]: df3 = pd.DataFrame([2, 1, 1, 3, np.nan], columns=['A'], index=list('edcba'))

In [115]: df3
Out[115]:
     A
e  2.0
d  1.0
c  1.0
b  3.0
a  NaN

In [116]: df3['A'].idxmin()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[116]: 'd'
```

Note: `idxmin` and `idxmax` are called `argmin` and `argmax` in NumPy.

9.5.3 Value counts (histogramming) / Mode

The `value_counts()` Series method and top-level function computes a histogram of a 1D array of values. It can also be used as a function on regular arrays:

```
In [117]: data = np.random.randint(0, 7, size=50)

In [118]: data
Out[118]:
array([3, 3, 0, 2, 1, 0, 5, 5, 3, 6, 1, 5, 6, 2, 0, 0, 6, 3, 3, 5, 0, 4, 3,
       3, 3, 0, 6, 1, 3, 5, 5, 0, 4, 0, 6, 3, 6, 5, 4, 3, 2, 1, 5, 0, 1, 1,
       6, 4, 1, 4])

In [119]: s = pd.Series(data)

In [120]: s.value_counts()
Out[120]:
3    11
0     9
5     8
```

```
6     7
1     7
4     5
2     3
dtype: int64

In [121]: pd.value_counts(data)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[121]:␣
↪
3    11
0     9
5     8
6     7
1     7
4     5
2     3
dtype: int64
```

Similarly, you can get the most frequently occurring value(s) (the mode) of the values in a Series or DataFrame:

```
In [122]: s5 = pd.Series([1, 1, 3, 3, 3, 5, 5, 7, 7, 7])

In [123]: s5.mode()
Out[123]:
0    3
1    7
dtype: int64

In [124]: df5 = pd.DataFrame({"A": np.random.randint(0, 7, size=50),
   .....:                     "B": np.random.randint(-10, 15, size=50)})
   .....:

In [125]: df5.mode()
Out[125]:
   A  B
0  2 -5
```

9.5.4 Discretization and quantiling

Continuous values can be discretized using the *cut()* (bins based on values) and *qcut()* (bins based on sample quantiles) functions:

```
In [126]: arr = np.random.randn(20)

In [127]: factor = pd.cut(arr, 4)

In [128]: factor
Out[128]:
[(-2.611, -1.58], (0.473, 1.499], (-2.611, -1.58], (-1.58, -0.554], (-0.554, 0.473], .
↪.., (0.473, 1.499], (0.473, 1.499], (-0.554, 0.473], (-0.554, 0.473], (-0.554, 0.
↪473]]
Length: 20
Categories (4, interval[float64]): [(-2.611, -1.58] < (-1.58, -0.554] < (-0.554, 0.
↪473] <
                                    (0.473, 1.499]]
```

```
In [129]: factor = pd.cut(arr, [-5, -1, 0, 1, 5])

In [130]: factor
Out[130]: 
[(-5, -1], (0, 1], (-5, -1], (-1, 0], (-1, 0], ..., (1, 5], (1, 5], (-1, 0], (-1, 0],␣
↪(-1, 0]]
Length: 20
Categories (4, interval[int64]): [(-5, -1] < (-1, 0] < (0, 1] < (1, 5]]
```

`qcut()` computes sample quantiles. For example, we could slice up some normally distributed data into equal-size quartiles like so:

```
In [131]: arr = np.random.randn(30)

In [132]: factor = pd.qcut(arr, [0, .25, .5, .75, 1])

In [133]: factor
Out[133]: 
[(0.544, 1.976], (0.544, 1.976], (-1.255, -0.375], (0.544, 1.976], (-0.103, 0.544], ..
↪., (-0.103, 0.544], (0.544, 1.976], (-0.103, 0.544], (-1.255, -0.375], (-0.375, -0.
↪103]]
Length: 30
Categories (4, interval[float64]): [(-1.255, -0.375] < (-0.375, -0.103] < (-0.103, 0.
↪544] <
                                    (0.544, 1.976]]

In [134]: pd.value_counts(factor)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
(0.544, 1.976]      8
(-1.255, -0.375]    8
(-0.103, 0.544]     7
(-0.375, -0.103]    7
dtype: int64
```

We can also pass infinite values to define the bins:

```
In [135]: arr = np.random.randn(20)

In [136]: factor = pd.cut(arr, [-np.inf, 0, np.inf])

In [137]: factor
Out[137]: 
[(0.0, inf], (0.0, inf], (0.0, inf], (0.0, inf], (-inf, 0.0], ..., (-inf, 0.0], (-inf,
↪ 0.0], (0.0, inf], (-inf, 0.0], (0.0, inf]]
Length: 20
Categories (2, interval[float64]): [(-inf, 0.0] < (0.0, inf]]
```

9.6 Function application

To apply your own or another library's functions to pandas objects, you should be aware of the three methods below. The appropriate method to use depends on whether your function expects to operate on an entire `DataFrame` or `Series`, row- or column-wise, or elementwise.

1. *Tablewise Function Application*: `pipe()`

2. *Row or Column-wise Function Application*: `apply()`
3. *Aggregation API*: `agg()` and `transform()`
4. *Applying Elementwise Functions*: `applymap()`

9.6.1 Tablewise Function Application

`DataFrames` and `Series` can of course just be passed into functions. However, if the function needs to be called in a chain, consider using the `pipe()` method. Compare the following

```
# f, g, and h are functions taking and returning ``DataFrames``
>>> f(g(h(df), arg1=1), arg2=2, arg3=3)
```

with the equivalent

```
>>> (df.pipe(h)
       .pipe(g, arg1=1)
       .pipe(f, arg2=2, arg3=3)
    )
```

Pandas encourages the second style, which is known as method chaining. `pipe` makes it easy to use your own or another library's functions in method chains, alongside pandas' methods.

In the example above, the functions `f`, `g`, and `h` each expected the `DataFrame` as the first positional argument. What if the function you wish to apply takes its data as, say, the second argument? In this case, provide `pipe` with a tuple of `(callable, data_keyword)`. `.pipe` will route the `DataFrame` to the argument specified in the tuple.

For example, we can fit a regression using statsmodels. Their API expects a formula first and a `DataFrame` as the second argument, `data`. We pass in the function, keyword pair `(sm.poisson, 'data')` to `pipe`:

```
In [138]: import statsmodels.formula.api as sm

In [139]: bb = pd.read_csv('data/baseball.csv', index_col='id')

In [140]: (bb.query('h > 0')
   .....:    .assign(ln_h = lambda df: np.log(df.h))
   .....:    .pipe((sm.poisson, 'data'), 'hr ~ ln_h + year + g + C(lg)')
   .....:    .fit()
   .....:    .summary()
   .....: )
   .....:
Optimization terminated successfully.
         Current function value: 2.116284
         Iterations 24
Out[140]:
<class 'statsmodels.iolib.summary.Summary'>
"""
                          Poisson Regression Results
==============================================================================
Dep. Variable:                     hr   No. Observations:                   68
Model:                        Poisson   Df Residuals:                       63
Method:                           MLE   Df Model:                            4
Date:                Fri, 27 Oct 2017   Pseudo R-squ.:                  0.6878
Time:                        10:34:06   Log-Likelihood:                -143.91
converged:                       True   LL-Null:                       -460.91
                                        LLR p-value:                 6.774e-136
==============================================================================
```

```
                  coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------
Intercept   -1267.3636    457.867     -2.768      0.006   -2164.767    -369.960
C(lg)[T.NL]    -0.2057      0.101     -2.044      0.041      -0.403      -0.008
ln_h            0.9280      0.191      4.866      0.000       0.554       1.302
year            0.6301      0.228      2.762      0.006       0.183       1.077
g               0.0099      0.004      2.754      0.006       0.003       0.017
===============================================================================
"""
```

The pipe method is inspired by unix pipes and more recently dplyr and magrittr, which have introduced the popular `(%>%)` (read pipe) operator for R. The implementation of `pipe` here is quite clean and feels right at home in python. We encourage you to view the source code (`pd.DataFrame.pipe??` in IPython).

9.6.2 Row or Column-wise Function Application

Arbitrary functions can be applied along the axes of a DataFrame or Panel using the `apply()` method, which, like the descriptive statistics methods, take an optional `axis` argument:

```
In [141]: df.apply(np.mean)
Out[141]:
one     -0.272211
three    0.024661
two      0.667306
dtype: float64

In [142]: df.apply(np.mean, axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[142]:␣
↪
a    0.011457
b    0.558507
c    0.635781
d   -0.839603
dtype: float64

In [143]: df.apply(lambda x: x.max() - x.min())
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
one      1.563773
three    3.154112
two      2.973170
dtype: float64

In [144]: df.apply(np.cumsum)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one     three       two
a -1.101558       NaN  1.124472
b -1.278848 -0.634293  3.611576
c -0.816633  1.296901  3.125511
d       NaN  0.073983  2.669223

In [145]: df.apply(np.exp)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one    three        two
```

```
a  0.332353       NaN   3.078592
b  0.837537  0.53031  12.026397
c  1.587586  6.89774   0.615041
d       NaN  0.29437   0.633631
```

`.apply()` will also dispatch on a string method name.

```
In [146]: df.apply('mean')
Out[146]:
one     -0.272211
three    0.024661
two      0.667306
dtype: float64

In [147]: df.apply('mean', axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[147]: ␣
↪
a    0.011457
b    0.558507
c    0.635781
d   -0.839603
dtype: float64
```

Depending on the return type of the function passed to `apply()`, the result will either be of lower dimension or the same dimension.

`apply()` combined with some cleverness can be used to answer many questions about a data set. For example, suppose we wanted to extract the date where the maximum value for each column occurred:

```
In [148]: tsdf = pd.DataFrame(np.random.randn(1000, 3), columns=['A', 'B', 'C'],
   .....:                     index=pd.date_range('1/1/2000', periods=1000))
   .....:

In [149]: tsdf.apply(lambda x: x.idxmax())
Out[149]:
A   2001-04-25
B   2002-05-31
C   2002-09-25
dtype: datetime64[ns]
```

You may also pass additional arguments and keyword arguments to the `apply()` method. For instance, consider the following function you would like to apply:

```
def subtract_and_divide(x, sub, divide=1):
    return (x - sub) / divide
```

You may then apply this function as follows:

```
df.apply(subtract_and_divide, args=(5,), divide=3)
```

Another useful feature is the ability to pass Series methods to carry out some Series operation on each column or row:

```
In [150]: tsdf
Out[150]:
                   A         B         C
2000-01-01 -0.720299  0.546303 -0.082042
2000-01-02  0.200295 -0.577554 -0.908402
2000-01-03  0.102533  1.653614  0.303319
```

```
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08  0.532566  0.341548  0.150493
2000-01-09  0.330418  1.761200  0.567133
2000-01-10 -0.251020  1.020099  1.893177

In [151]: tsdf.apply(pd.Series.interpolate)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C
2000-01-01 -0.720299  0.546303 -0.082042
2000-01-02  0.200295 -0.577554 -0.908402
2000-01-03  0.102533  1.653614  0.303319
2000-01-04  0.188539  1.391201  0.272754
2000-01-05  0.274546  1.128788  0.242189
2000-01-06  0.360553  0.866374  0.211624
2000-01-07  0.446559  0.603961  0.181059
2000-01-08  0.532566  0.341548  0.150493
2000-01-09  0.330418  1.761200  0.567133
2000-01-10 -0.251020  1.020099  1.893177
```

Finally, `apply()` takes an argument `raw` which is False by default, which converts each row or column into a Series before applying the function. When set to True, the passed function will instead receive an ndarray object, which has positive performance implications if you do not need the indexing functionality.

9.6.3 Aggregation API

New in version 0.20.0.

The aggregation API allows one to express possibly multiple aggregation operations in a single concise way. This API is similar across pandas objects, see *groupby API*, the *window functions API*, and the *resample API*. The entry point for aggregation is the method `aggregate()`, or the alias `agg()`.

We will use a similar starting frame from above:

```
In [152]: tsdf = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
   .....:                     index=pd.date_range('1/1/2000', periods=10))
   .....:

In [153]: tsdf.iloc[3:7] = np.nan

In [154]: tsdf
Out[154]:
                   A         B         C
2000-01-01  0.170247 -0.916844  0.835024
2000-01-02  1.259919  0.801111  0.445614
2000-01-03  1.453046  2.430373  0.653093
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08 -1.874526  0.569822 -0.609644
2000-01-09  0.812462  0.565894 -1.461363
2000-01-10 -0.985475  1.388154 -0.078747
```

Using a single function is equivalent to *`apply()`*; You can also pass named methods as strings. These will return a `Series` of the aggregated output:

```
In [155]: tsdf.agg(np.sum)
Out[155]:
A    0.835673
B    4.838510
C   -0.216025
dtype: float64

In [156]: tsdf.agg('sum')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[156]:
A    0.835673
B    4.838510
C   -0.216025
dtype: float64

# these are equivalent to a ``.sum()`` because we are aggregating on a single function
In [157]: tsdf.sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    0.835673
B    4.838510
C   -0.216025
dtype: float64
```

Single aggregations on a `Series` this will result in a scalar value:

```
In [158]: tsdf.A.agg('sum')
Out[158]: 0.83567297915820504
```

9.6.3.1 Aggregating with multiple functions

You can pass multiple aggregation arguments as a list. The results of each of the passed functions will be a row in the resultant `DataFrame`. These are naturally named from the aggregation function.

```
In [159]: tsdf.agg(['sum'])
Out[159]:
            A        B         C
sum  0.835673  4.83851 -0.216025
```

Multiple functions yield multiple rows:

```
In [160]: tsdf.agg(['sum', 'mean'])
Out[160]:
             A         B         C
sum   0.835673  4.838510 -0.216025
mean  0.139279  0.806418 -0.036004
```

On a `Series`, multiple functions return a `Series`, indexed by the function names:

```
In [161]: tsdf.A.agg(['sum', 'mean'])
Out[161]:
sum     0.835673
mean    0.139279
Name: A, dtype: float64
```

Passing a `lambda` function will yield a `<lambda>` named row:

```
In [162]: tsdf.A.agg(['sum', lambda x: x.mean()])
Out[162]:
sum         0.835673
<lambda>    0.139279
Name: A, dtype: float64
```

Passing a named function will yield that name for the row:

```
In [163]: def mymean(x):
   .....:     return x.mean()
   .....:

In [164]: tsdf.A.agg(['sum', mymean])
Out[164]:
sum       0.835673
mymean    0.139279
Name: A, dtype: float64
```

9.6.3.2 Aggregating with a dict

Passing a dictionary of column names to a scalar or a list of scalars, to `DataFrame.agg` allows you to customize which functions are applied to which columns. Note that the results are not in any particular order, you can use an `OrderedDict` instead to guarantee ordering.

```
In [165]: tsdf.agg({'A': 'mean', 'B': 'sum'})
Out[165]:
A    0.139279
B    4.838510
dtype: float64
```

Passing a list-like will generate a `DataFrame` output. You will get a matrix-like output of all of the aggregators. The output will consist of all unique functions. Those that are not noted for a particular column will be `NaN`:

```
In [166]: tsdf.agg({'A': ['mean', 'min'], 'B': 'sum'})
Out[166]:
              A        B
mean   0.139279      NaN
min   -1.874526      NaN
sum        NaN  4.83851
```

9.6.3.3 Mixed Dtypes

When presented with mixed dtypes that cannot aggregate, `.agg` will only take the valid aggregations. This is similiar to how groupby `.agg` works.

```
In [167]: mdf = pd.DataFrame({'A': [1, 2, 3],
   .....:                     'B': [1., 2., 3.],
   .....:                     'C': ['foo', 'bar', 'baz'],
   .....:                     'D': pd.date_range('20130101', periods=3)})
   .....:

In [168]: mdf.dtypes
Out[168]:
```

```
A             int64
B           float64
C            object
D    datetime64[ns]
dtype: object
```

```
In [169]: mdf.agg(['min', 'sum'])
Out[169]:
     A    B          C          D
min  1  1.0        bar 2013-01-01
sum  6  6.0  foobarbaz        NaT
```

9.6.3.4 Custom describe

With `.agg()` is it possible to easily create a custom describe function, similar to the built in *describe function*.

```
In [170]: from functools import partial

In [171]: q_25 = partial(pd.Series.quantile, q=0.25)

In [172]: q_25.__name__ = '25%'

In [173]: q_75 = partial(pd.Series.quantile, q=0.75)

In [174]: q_75.__name__ = '75%'

In [175]: tsdf.agg(['count', 'mean', 'std', 'min', q_25, 'median', q_75, 'max'])
Out[175]:
                A         B         C
count    6.000000  6.000000  6.000000
mean     0.139279  0.806418 -0.036004
std      1.323362  1.100830  0.874990
min     -1.874526 -0.916844 -1.461363
25%     -0.696544  0.566876 -0.476920
median   0.491354  0.685467  0.183433
75%      1.148055  1.241393  0.601223
max      1.453046  2.430373  0.835024
```

9.6.4 Transform API

New in version 0.20.0.

The `transform()` method returns an object that is indexed the same (same size) as the original. This API allows you to provide *multiple* operations at the same time rather than one-by-one. Its API is quite similar to the `.agg` API.

Use a similar frame to the above sections.

```
In [176]: tsdf = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
   .....:                     index=pd.date_range('1/1/2000', periods=10))
   .....:

In [177]: tsdf.iloc[3:7] = np.nan

In [178]: tsdf
Out[178]:
```

```
                   A         B         C
2000-01-01 -0.578465 -0.503335 -0.987140
2000-01-02 -0.767147 -0.266046  1.083797
2000-01-03  0.195348  0.722247 -0.894537
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08 -0.556397  0.542165 -0.308675
2000-01-09 -1.010924 -0.672504 -1.139222
2000-01-10  0.354653  0.563622 -0.365106
```

Transform the entire frame. `.transform()` allows input functions as: a numpy function, a string function name or a user defined function.

```
In [179]: tsdf.transform(np.abs)
Out[179]:
                   A         B         C
2000-01-01  0.578465  0.503335  0.987140
2000-01-02  0.767147  0.266046  1.083797
2000-01-03  0.195348  0.722247  0.894537
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08  0.556397  0.542165  0.308675
2000-01-09  1.010924  0.672504  1.139222
2000-01-10  0.354653  0.563622  0.365106

In [180]: tsdf.transform('abs')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C
2000-01-01  0.578465  0.503335  0.987140
2000-01-02  0.767147  0.266046  1.083797
2000-01-03  0.195348  0.722247  0.894537
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08  0.556397  0.542165  0.308675
2000-01-09  1.010924  0.672504  1.139222
2000-01-10  0.354653  0.563622  0.365106

In [181]: tsdf.transform(lambda x: x.abs())
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C
2000-01-01  0.578465  0.503335  0.987140
2000-01-02  0.767147  0.266046  1.083797
2000-01-03  0.195348  0.722247  0.894537
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08  0.556397  0.542165  0.308675
2000-01-09  1.010924  0.672504  1.139222
2000-01-10  0.354653  0.563622  0.365106
```

Here `.transform()` received a single function; this is equivalent to a ufunc application

```
In [182]: np.abs(tsdf)
Out[182]:
                   A         B         C
2000-01-01  0.578465  0.503335  0.987140
2000-01-02  0.767147  0.266046  1.083797
2000-01-03  0.195348  0.722247  0.894537
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08  0.556397  0.542165  0.308675
2000-01-09  1.010924  0.672504  1.139222
2000-01-10  0.354653  0.563622  0.365106
```

Passing a single function to `.transform()` with a `Series` will yield a single `Series` in return.

```
In [183]: tsdf.A.transform(np.abs)
Out[183]:
2000-01-01    0.578465
2000-01-02    0.767147
2000-01-03    0.195348
2000-01-04         NaN
2000-01-05         NaN
2000-01-06         NaN
2000-01-07         NaN
2000-01-08    0.556397
2000-01-09    1.010924
2000-01-10    0.354653
Freq: D, Name: A, dtype: float64
```

9.6.4.1 Transform with multiple functions

Passing multiple functions will yield a column multi-indexed DataFrame. The first level will be the original frame column names; the second level will be the names of the transforming functions.

```
In [184]: tsdf.transform([np.abs, lambda x: x+1])
Out[184]:
                   A                   B                   C
            absolute  <lambda>  absolute  <lambda>  absolute  <lambda>
2000-01-01  0.578465  0.421535  0.503335  0.496665  0.987140  0.012860
2000-01-02  0.767147  0.232853  0.266046  0.733954  1.083797  2.083797
2000-01-03  0.195348  1.195348  0.722247  1.722247  0.894537  0.105463
2000-01-04       NaN       NaN       NaN       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN       NaN       NaN       NaN
2000-01-08  0.556397  0.443603  0.542165  1.542165  0.308675  0.691325
2000-01-09  1.010924 -0.010924  0.672504  0.327496  1.139222 -0.139222
2000-01-10  0.354653  1.354653  0.563622  1.563622  0.365106  0.634894
```

Passing multiple functions to a Series will yield a DataFrame. The resulting column names will be the transforming functions.

```
In [185]: tsdf.A.transform([np.abs, lambda x: x+1])
Out[185]:
```

```
            absolute  <lambda>
2000-01-01  0.578465  0.421535
2000-01-02  0.767147  0.232853
2000-01-03  0.195348  1.195348
2000-01-04       NaN       NaN
2000-01-05       NaN       NaN
2000-01-06       NaN       NaN
2000-01-07       NaN       NaN
2000-01-08  0.556397  0.443603
2000-01-09  1.010924 -0.010924
2000-01-10  0.354653  1.354653
```

9.6.4.2 Transforming with a dict

Passing a dict of functions will will allow selective transforming per column.

```
In [186]: tsdf.transform({'A': np.abs, 'B': lambda x: x+1})
Out[186]:
                   A         B
2000-01-01  0.578465  0.496665
2000-01-02  0.767147  0.733954
2000-01-03  0.195348  1.722247
2000-01-04       NaN       NaN
2000-01-05       NaN       NaN
2000-01-06       NaN       NaN
2000-01-07       NaN       NaN
2000-01-08  0.556397  1.542165
2000-01-09  1.010924  0.327496
2000-01-10  0.354653  1.563622
```

Passing a dict of lists will generate a multi-indexed DataFrame with these selective transforms.

```
In [187]: tsdf.transform({'A': np.abs, 'B': [lambda x: x+1, 'sqrt']})
Out[187]:
                   A         B
            absolute  <lambda>      sqrt
2000-01-01  0.578465  0.496665       NaN
2000-01-02  0.767147  0.733954       NaN
2000-01-03  0.195348  1.722247  0.849851
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08  0.556397  1.542165  0.736318
2000-01-09  1.010924  0.327496       NaN
2000-01-10  0.354653  1.563622  0.750748
```

9.6.5 Applying Elementwise Functions

Since not all functions can be vectorized (accept NumPy arrays and return another array or value), the methods `applymap()` on DataFrame and analogously `map()` on Series accept any Python function taking a single value and returning a single value. For example:

```
In [188]: df4
Out[188]:
```

```
        one     three       two
a -1.101558       NaN  1.124472
b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.486066
d       NaN -1.222918 -0.456288

In [189]: f = lambda x: len(str(x))

In [190]: df4['one'].map(f)
Out[190]:
a    19
b    20
c    18
d     3
Name: one, dtype: int64

In [191]: df4.applymap(f)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[191]:
   one  three  two
a   19      3   18
b   20     19   18
c   18     18   20
d    3     19   19
```

Series.map() has an additional feature which is that it can be used to easily "link" or "map" values defined by a secondary series. This is closely related to *merging/joining functionality*:

```
In [192]: s = pd.Series(['six', 'seven', 'six', 'seven', 'six'],
   .....:                index=['a', 'b', 'c', 'd', 'e'])
   .....:

In [193]: t = pd.Series({'six' : 6., 'seven' : 7.})

In [194]: s
Out[194]:
a      six
b    seven
c      six
d    seven
e      six
dtype: object

In [195]: s.map(t)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[195]:␣
↪
a    6.0
b    7.0
c    6.0
d    7.0
e    6.0
dtype: float64
```

9.6.6 Applying with a Panel

Applying with a `Panel` will pass a `Series` to the applied function. If the applied function returns a `Series`, the result of the application will be a `Panel`. If the applied function reduces to a scalar, the result of the application will

be a `DataFrame`.

```
In [196]: import pandas.util.testing as tm

In [197]: panel = tm.makePanel(5)

In [198]: panel
Out[198]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D

In [199]: panel['ItemA']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-03  1.092702  0.604244 -2.927808  0.339642
2000-01-04 -1.481449 -0.487265  0.082065  1.499953
2000-01-05  1.781190  1.990533  0.456554 -0.317818
2000-01-06 -0.031543  0.327007 -1.757911  0.447371
2000-01-07  0.480993  1.053639  0.982407 -1.315799
```

A transformational apply.

```
In [200]: result = panel.apply(lambda x: x*2, axis='items')

In [201]: result
Out[201]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D

In [202]: result['ItemA']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-03  2.185405  1.208489 -5.855616  0.679285
2000-01-04 -2.962899 -0.974530  0.164130  2.999905
2000-01-05  3.562379  3.981066  0.913107 -0.635635
2000-01-06 -0.063086  0.654013 -3.515821  0.894742
2000-01-07  0.961986  2.107278  1.964815 -2.631598
```

A reduction operation.

```
In [203]: panel.apply(lambda x: x.dtype, axis='items')
Out[203]:
                  A        B        C        D
2000-01-03  float64  float64  float64  float64
2000-01-04  float64  float64  float64  float64
2000-01-05  float64  float64  float64  float64
2000-01-06  float64  float64  float64  float64
2000-01-07  float64  float64  float64  float64
```

A similar reduction type operation

```
In [204]: panel.apply(lambda x: x.sum(), axis='major_axis')
Out[204]:
      ItemA     ItemB     ItemC
A  1.841893  0.918017 -1.160547
B  3.488158 -2.629773  0.603397
C -3.164692  0.805970  0.806501
D  0.653349 -0.152299  0.252577
```

This last reduction is equivalent to

```
In [205]: panel.sum('major_axis')
Out[205]:
      ItemA     ItemB     ItemC
A  1.841893  0.918017 -1.160547
B  3.488158 -2.629773  0.603397
C -3.164692  0.805970  0.806501
D  0.653349 -0.152299  0.252577
```

A transformation operation that returns a `Panel`, but is computing the z-score across the `major_axis`.

```
In [206]: result = panel.apply(
   .....:             lambda x: (x-x.mean())/x.std(),
   .....:             axis='major_axis')
   .....:

In [207]: result
Out[207]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D

In [208]: result['ItemA']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-03  0.585813 -0.102070 -1.394063  0.201263
2000-01-04 -1.496089 -1.295066  0.434343  1.318766
2000-01-05  1.142642  1.413112  0.661833 -0.431942
2000-01-06 -0.323445 -0.405085 -0.683386  0.305017
2000-01-07  0.091079  0.389108  0.981273 -1.393105
```

Apply can also accept multiple axes in the `axis` argument. This will pass a `DataFrame` of the cross-section to the applied function.

```
In [209]: f = lambda x: ((x.T-x.mean(1))/x.std(1)).T

In [210]: result = panel.apply(f, axis = ['items','major_axis'])

In [211]: result
Out[211]:
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 5 (major_axis) x 3 (minor_axis)
Items axis: A to D
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: ItemA to ItemC
```

```
In [212]: result.loc[:,:,'ItemA']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-03  0.859304  0.448509 -1.109374  0.397237
2000-01-04 -1.053319 -1.063370  0.986639  1.152266
2000-01-05  1.106511  1.143185 -0.093917 -0.583083
2000-01-06  0.561619 -0.835608 -1.075936  0.194525
2000-01-07 -0.339514  1.097901  0.747522 -1.147605
```

This is equivalent to the following

```
In [213]: result = pd.Panel(dict([ (ax, f(panel.loc[:,:,ax]))
   .....:                         for ax in panel.minor_axis ]))
   .....:

In [214]: result
Out[214]:
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 5 (major_axis) x 3 (minor_axis)
Items axis: A to D
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: ItemA to ItemC

In [215]: result.loc[:,:,'ItemA']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-03  0.859304  0.448509 -1.109374  0.397237
2000-01-04 -1.053319 -1.063370  0.986639  1.152266
2000-01-05  1.106511  1.143185 -0.093917 -0.583083
2000-01-06  0.561619 -0.835608 -1.075936  0.194525
2000-01-07 -0.339514  1.097901  0.747522 -1.147605
```

9.7 Reindexing and altering labels

`reindex()` is the fundamental data alignment method in pandas. It is used to implement nearly all other features relying on label-alignment functionality. To *reindex* means to conform the data to match a given set of labels along a particular axis. This accomplishes several things:

- Reorders the existing data to match a new set of labels
- Inserts missing value (NA) markers in label locations where no data for that label existed
- If specified, **fill** data for missing labels using logic (highly relevant to working with time series data)

Here is a simple example:

```
In [216]: s = pd.Series(np.random.randn(5), index=['a', 'b', 'c', 'd', 'e'])

In [217]: s
Out[217]:
a   -0.454087
b   -0.360309
c   -0.951631
d   -0.535459
e    0.835231
```

```
dtype: float64

In [218]: s.reindex(['e', 'b', 'f', 'd'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[2
↪
e    0.835231
b   -0.360309
f         NaN
d   -0.535459
dtype: float64
```

Here, the `f` label was not contained in the Series and hence appears as `NaN` in the result.

With a DataFrame, you can simultaneously reindex the index and columns:

```
In [219]: df
Out[219]:
        one     three       two
a -1.101558       NaN  1.124472
b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.486066
d       NaN -1.222918 -0.456288

In [220]: df.reindex(index=['c', 'f', 'b'], columns=['three', 'two', 'one'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      three       two       one
c  1.931194 -0.486066  0.462215
f       NaN       NaN       NaN
b -0.634293  2.487104 -0.177289
```

You may also use `reindex` with an `axis` keyword:

```
In [221]: df.reindex(['c', 'f', 'b'], axis='index')
Out[221]:
        one     three       two
c  0.462215  1.931194 -0.486066
f       NaN       NaN       NaN
b -0.177289 -0.634293  2.487104
```

Note that the `Index` objects containing the actual axis labels can be **shared** between objects. So if we have a Series and a DataFrame, the following can be done:

```
In [222]: rs = s.reindex(df.index)

In [223]: rs
Out[223]:
a   -0.454087
b   -0.360309
c   -0.951631
d   -0.535459
dtype: float64

In [224]: rs.index is df.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[224]:␣
↪True
```

This means that the reindexed Series's index is the same Python object as the DataFrame's index.

New in version 0.21.0.

`DataFrame.reindex()` also supports an “axis-style” calling convention, where you specify a single `labels` argument and the `axis` it applies to.

```
In [225]: df.reindex(['c', 'f', 'b'], axis='index')
Out[225]:
        one     three       two
c  0.462215  1.931194 -0.486066
f       NaN       NaN       NaN
b -0.177289 -0.634293  2.487104

In [226]: df.reindex(['three', 'two', 'one'], axis='columns')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      three       two       one
a       NaN  1.124472 -1.101558
b -0.634293  2.487104 -0.177289
c  1.931194 -0.486066  0.462215
d -1.222918 -0.456288       NaN
```

See also:

MultiIndex / Advanced Indexing is an even more concise way of doing reindexing.

Note: When writing performance-sensitive code, there is a good reason to spend some time becoming a reindexing ninja: **many operations are faster on pre-aligned data**. Adding two unaligned DataFrames internally triggers a reindexing step. For exploratory analysis you will hardly notice the difference (because `reindex` has been heavily optimized), but when CPU cycles matter sprinkling a few explicit `reindex` calls here and there can have an impact.

9.7.1 Reindexing to align with another object

You may wish to take an object and reindex its axes to be labeled the same as another object. While the syntax for this is straightforward albeit verbose, it is a common enough operation that the *`reindex_like()`* method is available to make this simpler:

```
In [227]: df2
Out[227]:
        one       two
a -1.101558  1.124472
b -0.177289  2.487104
c  0.462215 -0.486066

In [228]: df3
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Ou
↪
        one       two
a -0.829347  0.082635
b  0.094922  1.445267
c  0.734426 -1.527903

In [229]: df.reindex_like(df2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one       two
a -1.101558  1.124472
```

```
b -0.177289  2.487104
c  0.462215 -0.486066
```

9.7.2 Aligning objects with each other with `align`

The *`align()`* method is the fastest way to simultaneously align two objects. It supports a `join` argument (related to *joining and merging*):

- `join='outer'`: take the union of the indexes (default)
- `join='left'`: use the calling object’s index
- `join='right'`: use the passed object’s index
- `join='inner'`: intersect the indexes

It returns a tuple with both of the reindexed Series:

```
In [230]: s = pd.Series(np.random.randn(5), index=['a', 'b', 'c', 'd', 'e'])

In [231]: s1 = s[:4]

In [232]: s2 = s[1:]

In [233]: s1.align(s2)
Out[233]: 
(a    0.505453
 b    1.788110
 c   -0.405908
 d   -0.801912
 e         NaN
 dtype: float64, a         NaN
 b    1.788110
 c   -0.405908
 d   -0.801912
 e    0.768460
 dtype: float64)

In [234]: s1.align(s2, join='inner')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
(b    1.788110
 c   -0.405908
 d   -0.801912
 dtype: float64, b    1.788110
 c   -0.405908
 d   -0.801912
 dtype: float64)

In [235]: s1.align(s2, join='left')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
(a    0.505453
 b    1.788110
 c   -0.405908
 d   -0.801912
 dtype: float64, a         NaN
 b    1.788110
```

```
c   -0.405908
d   -0.801912
dtype: float64)
```

For DataFrames, the join method will be applied to both the index and the columns by default:

```
In [236]: df.align(df2, join='inner')
Out[236]:
(        one       two
 a -1.101558  1.124472
 b -0.177289  2.487104
 c  0.462215 -0.486066,         one       two
 a -1.101558  1.124472
 b -0.177289  2.487104
 c  0.462215 -0.486066)
```

You can also pass an `axis` option to only align on the specified axis:

```
In [237]: df.align(df2, join='inner', axis=0)
Out[237]:
(        one     three       two
 a -1.101558       NaN  1.124472
 b -0.177289 -0.634293  2.487104
 c  0.462215  1.931194 -0.486066,         one       two
 a -1.101558  1.124472
 b -0.177289  2.487104
 c  0.462215 -0.486066)
```

If you pass a Series to *`DataFrame.align()`*, you can choose to align both objects either on the DataFrame's index or columns using the `axis` argument:

```
In [238]: df.align(df2.iloc[0], axis=1)
Out[238]:
(        one     three       two
 a -1.101558       NaN  1.124472
 b -0.177289 -0.634293  2.487104
 c  0.462215  1.931194 -0.486066
 d       NaN -1.222918 -0.456288, one     -1.101558
 three         NaN
 two      1.124472
 Name: a, dtype: float64)
```

9.7.3 Filling while reindexing

`reindex()` takes an optional parameter `method` which is a filling method chosen from the following table:

Method	Action
pad / ffill	Fill values forward
bfill / backfill	Fill values backward
nearest	Fill from the nearest index value

We illustrate these fill methods on a simple Series:

```
In [239]: rng = pd.date_range('1/3/2000', periods=8)

In [240]: ts = pd.Series(np.random.randn(8), index=rng)
```

```
In [241]: ts2 = ts[[0, 3, 6]]

In [242]: ts
Out[242]:
2000-01-03    0.466284
2000-01-04   -0.457411
2000-01-05   -0.364060
2000-01-06    0.785367
2000-01-07   -1.463093
2000-01-08    1.187315
2000-01-09   -0.493153
2000-01-10   -1.323445
Freq: D, dtype: float64

In [243]: ts2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-03    0.466284
2000-01-06    0.785367
2000-01-09   -0.493153
dtype: float64

In [244]: ts2.reindex(ts.index)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-03    0.466284
2000-01-04         NaN
2000-01-05         NaN
2000-01-06    0.785367
2000-01-07         NaN
2000-01-08         NaN
2000-01-09   -0.493153
2000-01-10         NaN
Freq: D, dtype: float64

In [245]: ts2.reindex(ts.index, method='ffill')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-03    0.466284
2000-01-04    0.466284
2000-01-05    0.466284
2000-01-06    0.785367
2000-01-07    0.785367
2000-01-08    0.785367
2000-01-09   -0.493153
2000-01-10   -0.493153
Freq: D, dtype: float64

In [246]: ts2.reindex(ts.index, method='bfill')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-03    0.466284
2000-01-04    0.785367
2000-01-05    0.785367
2000-01-06    0.785367
2000-01-07   -0.493153
2000-01-08   -0.493153
```

```
2000-01-09   -0.493153
2000-01-10         NaN
Freq: D, dtype: float64

In [247]: ts2.reindex(ts.index, method='nearest')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-03    0.466284
2000-01-04    0.466284
2000-01-05    0.785367
2000-01-06    0.785367
2000-01-07    0.785367
2000-01-08   -0.493153
2000-01-09   -0.493153
2000-01-10   -0.493153
Freq: D, dtype: float64
```

These methods require that the indexes are **ordered** increasing or decreasing.

Note that the same result could have been achieved using *fillna* (except for `method='nearest'`) or *interpolate*:

```
In [248]: ts2.reindex(ts.index).fillna(method='ffill')
Out[248]:
2000-01-03    0.466284
2000-01-04    0.466284
2000-01-05    0.466284
2000-01-06    0.785367
2000-01-07    0.785367
2000-01-08    0.785367
2000-01-09   -0.493153
2000-01-10   -0.493153
Freq: D, dtype: float64
```

`reindex()` will raise a ValueError if the index is not monotonic increasing or decreasing. `fillna()` and `interpolate()` will not make any checks on the order of the index.

9.7.4 Limits on filling while reindexing

The `limit` and `tolerance` arguments provide additional control over filling while reindexing. Limit specifies the maximum count of consecutive matches:

```
In [249]: ts2.reindex(ts.index, method='ffill', limit=1)
Out[249]:
2000-01-03    0.466284
2000-01-04    0.466284
2000-01-05         NaN
2000-01-06    0.785367
2000-01-07    0.785367
2000-01-08         NaN
2000-01-09   -0.493153
2000-01-10   -0.493153
Freq: D, dtype: float64
```

In contrast, tolerance specifies the maximum distance between the index and indexer values:

```
In [250]: ts2.reindex(ts.index, method='ffill', tolerance='1 day')
Out[250]:
```

```
2000-01-03    0.466284
2000-01-04    0.466284
2000-01-05         NaN
2000-01-06    0.785367
2000-01-07    0.785367
2000-01-08         NaN
2000-01-09   -0.493153
2000-01-10   -0.493153
Freq: D, dtype: float64
```

Notice that when used on a `DatetimeIndex`, `TimedeltaIndex` or `PeriodIndex`, `tolerance` will coerced into a `Timedelta` if possible. This allows you to specify tolerance with appropriate strings.

9.7.5 Dropping labels from an axis

A method closely related to `reindex` is the *`drop()`* function. It removes a set of labels from an axis:

```
In [251]: df
Out[251]:
        one     three       two
a -1.101558       NaN  1.124472
b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.486066
d       NaN -1.222918 -0.456288

In [252]: df.drop(['a', 'd'], axis=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one     three       two
b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.486066

In [253]: df.drop(['one'], axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      three       two
a       NaN  1.124472
b -0.634293  2.487104
c  1.931194 -0.486066
d -1.222918 -0.456288
```

Note that the following also works, but is a bit less obvious / clean:

```
In [254]: df.reindex(df.index.difference(['a', 'd']))
Out[254]:
        one     three       two
b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.486066
```

9.7.6 Renaming / mapping labels

The *`rename()`* method allows you to relabel an axis based on some mapping (a dict or Series) or an arbitrary function.

```
In [255]: s
Out[255]:
```

```
a    0.505453
b    1.788110
c   -0.405908
d   -0.801912
e    0.768460
dtype: float64

In [256]: s.rename(str.upper)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[2
↪
A    0.505453
B    1.788110
C   -0.405908
D   -0.801912
E    0.768460
dtype: float64
```

If you pass a function, it must return a value when called with any of the labels (and must produce a set of unique values). A dict or Series can also be used:

```
In [257]: df.rename(columns={'one': 'foo', 'two': 'bar'},
   .....:           index={'a': 'apple', 'b': 'banana', 'd': 'durian'})
   .....:
Out[257]:
             foo     three       bar
apple  -1.101558       NaN  1.124472
banana -0.177289 -0.634293  2.487104
c       0.462215  1.931194 -0.486066
durian       NaN -1.222918 -0.456288
```

If the mapping doesn't include a column/index label, it isn't renamed. Also extra labels in the mapping don't throw an error.

New in version 0.21.0.

`DataFrame.rename()` also supports an "axis-style" calling convention, where you specify a single `mapper` and the `axis` to apply that mapping to.

```
In [258]: df.rename({'one': 'foo', 'two': 'bar'}, axis='columns'})
   .....: df.rename({'a': 'apple', 'b': 'banana', 'd': 'durian'}, axis='columns'})
   .....:
  File "<ipython-input-258-d5b8afcaa5ce>", line 1
    df.rename({'one': 'foo', 'two': 'bar'}, axis='columns'})
                                                          ^
SyntaxError: invalid syntax

  File "<ipython-input-259-f42b3f5a87b8>", line 1
    df.rename({'a': 'apple', 'b': 'banana', 'd': 'durian'}, axis='columns'})
                                                                          ^
SyntaxError: invalid syntax
```

The *`rename()`* method also provides an `inplace` named parameter that is by default `False` and copies the underlying data. Pass `inplace=True` to rename the data in place.

New in version 0.18.0.

Finally, *`rename()`* also accepts a scalar or list-like for altering the `Series.name` attribute.

```
In [260]: s.rename("scalar-name")
Out[260]:
a    0.505453
b    1.788110
c   -0.405908
d   -0.801912
e    0.768460
Name: scalar-name, dtype: float64
```

The Panel class has a related `rename_axis()` class which can rename any of its three axes.

9.8 Iteration

The behavior of basic iteration over pandas objects depends on the type. When iterating over a Series, it is regarded as array-like, and basic iteration produces the values. Other data structures, like DataFrame and Panel, follow the dict-like convention of iterating over the "keys" of the objects.

In short, basic iteration (`for i in object`) produces:

- **Series**: values
- **DataFrame**: column labels
- **Panel**: item labels

Thus, for example, iterating over a DataFrame gives you the column names:

```
In [261]: df = pd.DataFrame({'col1' : np.random.randn(3), 'col2' : np.random.randn(3)}
↪,
   .....:                   index=['a', 'b', 'c'])
   .....:

In [262]: for col in df:
   .....:     print(col)
   .....:
col1
col2
```

Pandas objects also have the dict-like `iteritems()` method to iterate over the (key, value) pairs.

To iterate over the rows of a DataFrame, you can use the following methods:

- `iterrows()`: Iterate over the rows of a DataFrame as (index, Series) pairs. This converts the rows to Series objects, which can change the dtypes and has some performance implications.
- `itertuples()`: Iterate over the rows of a DataFrame as namedtuples of the values. This is a lot faster than `iterrows()`, and is in most cases preferable to use to iterate over the values of a DataFrame.

> **Warning:** Iterating through pandas objects is generally **slow**. In many cases, iterating manually over the rows is not needed and can be avoided with one of the following approaches:
>
> - Look for a *vectorized* solution: many operations can be performed using built-in methods or numpy functions, (boolean) indexing, ...
> - When you have a function that cannot work on the full DataFrame/Series at once, it is better to use `apply()` instead of iterating over the values. See the docs on *function application*.

- If you need to do iterative manipulations on the values but performance is important, consider writing the inner loop using e.g. cython or numba. See the *enhancing performance* section for some examples of this approach.

Warning: You should **never modify** something you are iterating over. This is not guaranteed to work in all cases. Depending on the data types, the iterator returns a copy and not a view, and writing to it will have no effect!

For example, in the following case setting the value has no effect:

```
In [263]: df = pd.DataFrame({'a': [1, 2, 3], 'b': ['a', 'b', 'c']})

In [264]: for index, row in df.iterrows():
   .....:     row['a'] = 10
   .....:

In [265]: df
Out[265]:
   a  b
0  1  a
1  2  b
2  3  c
```

9.8.1 iteritems

Consistent with the dict-like interface, `iteritems()` iterates through key-value pairs:

- **Series**: (index, scalar value) pairs
- **DataFrame**: (column, Series) pairs
- **Panel**: (item, DataFrame) pairs

For example:

```
In [266]: for item, frame in wp.iteritems():
   .....:     print(item)
   .....:     print(frame)
   .....:
Item1
                   A         B         C         D
2000-01-01 -0.433567 -0.273610  0.680433 -0.308450
2000-01-02 -0.276099 -1.821168 -1.993606 -1.927385
2000-01-03 -2.027924  1.624972  0.551135  3.059267
2000-01-04  0.455264 -0.030740  0.935716  1.061192
2000-01-05 -2.107852  0.199905  0.323586 -0.641630
Item2
                   A         B         C         D
2000-01-01 -0.587514  0.053897  0.194889 -0.381994
2000-01-02  0.318587  2.089075 -0.728293 -0.090255
2000-01-03 -0.748199  1.318931 -2.029766  0.792652
2000-01-04  0.461007 -0.542749 -0.305384 -0.479195
2000-01-05  0.095031 -0.270099 -0.707140 -0.773882
```

9.8.2 iterrows

iterrows() allows you to iterate through the rows of a DataFrame as Series objects. It returns an iterator yielding each index value along with a Series containing the data in each row:

```
In [267]: for row_index, row in df.iterrows():
   .....:     print('%s\n%s' % (row_index, row))
   .....:
0
a    1
b    a
Name: 0, dtype: object
1
a    2
b    b
Name: 1, dtype: object
2
a    3
b    c
Name: 2, dtype: object
```

Note: Because *iterrows()* returns a Series for each row, it does **not** preserve dtypes across the rows (dtypes are preserved across columns for DataFrames). For example,

```
In [268]: df_orig = pd.DataFrame([[1, 1.5]], columns=['int', 'float'])

In [269]: df_orig.dtypes
Out[269]:
int        int64
float    float64
dtype: object

In [270]: row = next(df_orig.iterrows())[1]

In [271]: row
Out[271]:
int      1.0
float    1.5
Name: 0, dtype: float64
```

All values in `row`, returned as a Series, are now upcasted to floats, also the original integer value in column *x*:

```
In [272]: row['int'].dtype
Out[272]: dtype('float64')

In [273]: df_orig['int'].dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[273]: dtype('int64')
```

To preserve dtypes while iterating over the rows, it is better to use *itertuples()* which returns namedtuples of the values and which is generally much faster as `iterrows`.

For instance, a contrived way to transpose the DataFrame would be:

```
In [274]: df2 = pd.DataFrame({'x': [1, 2, 3], 'y': [4, 5, 6]})

In [275]: print(df2)
```

```
   x  y
0  1  4
1  2  5
2  3  6

In [276]: print(df2.T)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\   0  1  2
x  1  2  3
y  4  5  6

In [277]: df2_t = pd.DataFrame(dict((idx,values) for idx, values in df2.iterrows()))

In [278]: print(df2_t)
   0  1  2
x  1  2  3
y  4  5  6
```

9.8.3 itertuples

The *`itertuples()`* method will return an iterator yielding a namedtuple for each row in the DataFrame. The first element of the tuple will be the row's corresponding index value, while the remaining values are the row values.

For instance,

```
In [279]: for row in df.itertuples():
   .....:     print(row)
   .....:
Pandas(Index=0, a=1, b='a')
Pandas(Index=1, a=2, b='b')
Pandas(Index=2, a=3, b='c')
```

This method does not convert the row to a Series object but just returns the values inside a namedtuple. Therefore, *`itertuples()`* preserves the data type of the values and is generally faster as *`iterrows()`*.

Note: The column names will be renamed to positional names if they are invalid Python identifiers, repeated, or start with an underscore. With a large number of columns (>255), regular tuples are returned.

9.9 .dt accessor

`Series` has an accessor to succinctly return datetime like properties for the *values* of the Series, if it is a datetime/period like Series. This will return a Series, indexed like the existing Series.

```
# datetime
In [280]: s = pd.Series(pd.date_range('20130101 09:10:12', periods=4))

In [281]: s
Out[281]:
0   2013-01-01 09:10:12
1   2013-01-02 09:10:12
2   2013-01-03 09:10:12
3   2013-01-04 09:10:12
dtype: datetime64[ns]
```

```
In [282]: s.dt.hour
\\\
```

```
3   2013-01-04 04:10:12-05:00
dtype: datetime64[ns, US/Eastern]
```

You can also format datetime values as strings with *`Series.dt.strftime()`* which supports the same format as the standard `strftime()`.

```
# DatetimeIndex
In [290]: s = pd.Series(pd.date_range('20130101', periods=4))

In [291]: s
Out[291]:
0   2013-01-01
1   2013-01-02
2   2013-01-03
3   2013-01-04
dtype: datetime64[ns]

In [292]: s.dt.strftime('%Y/%m/%d')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[292]
↪
0    2013/01/01
1    2013/01/02
2    2013/01/03
3    2013/01/04
dtype: object
```

```
# PeriodIndex
In [293]: s = pd.Series(pd.period_range('20130101', periods=4))

In [294]: s
Out[294]:
0   2013-01-01
1   2013-01-02
2   2013-01-03
3   2013-01-04
dtype: object

In [295]: s.dt.strftime('%Y/%m/%d')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[295]:␣
↪
0    2013/01/01
1    2013/01/02
2    2013/01/03
3    2013/01/04
dtype: object
```

The `.dt` accessor works for period and timedelta dtypes.

```
# period
In [296]: s = pd.Series(pd.period_range('20130101', periods=4, freq='D'))

In [297]: s
Out[297]:
0   2013-01-01
1   2013-01-02
2   2013-01-03
3   2013-01-04
```

```
dtype: object

In [298]: s.dt.year
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[298]:␣
↪
0    2013
1    2013
2    2013
3    2013
dtype: int64

In [299]: s.dt.day
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    2
2    3
3    4
dtype: int64
```

```
# timedelta
In [300]: s = pd.Series(pd.timedelta_range('1 day 00:00:05', periods=4, freq='s'))

In [301]: s
Out[301]:
0   1 days 00:00:05
1   1 days 00:00:06
2   1 days 00:00:07
3   1 days 00:00:08
dtype: timedelta64[ns]

In [302]: s.dt.days
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    1
2    1
3    1
dtype: int64

In [303]: s.dt.seconds
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    5
1    6
2    7
3    8
dtype: int64

In [304]: s.dt.components
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   days  hours  minutes  seconds  milliseconds  microseconds  nanoseconds
0     1      0        0        5             0             0            0
1     1      0        0        6             0             0            0
2     1      0        0        7             0             0            0
3     1      0        0        8             0             0            0
```

Note: `Series.dt` will raise a `TypeError` if you access with a non-datetimelike values

9.10 Vectorized string methods

Series is equipped with a set of string processing methods that make it easy to operate on each element of the array. Perhaps most importantly, these methods exclude missing/NA values automatically. These are accessed via the Series's `str` attribute and generally have names matching the equivalent (scalar) built-in string methods. For example:

```
In [305]: s = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog
↪', 'cat'])

In [306]: s.str.lower()
Out[306]:
0       a
1       b
2       c
3    aaba
4    baca
5     NaN
6    caba
7     dog
8     cat
dtype: object
```

Powerful pattern-matching methods are provided as well, but note that pattern-matching generally uses regular expressions by default (and in some cases always uses them).

Please see *Vectorized String Methods* for a complete description.

9.11 Sorting

Warning: The sorting API is substantially changed in 0.17.0, see *here* for these changes. In particular, all sorting methods now return a new object by default, and **DO NOT** operate in-place (except by passing `inplace=True`).

There are two obvious kinds of sorting that you may be interested in: sorting by label and sorting by actual values.

9.11.1 By Index

The primary method for sorting axis labels (indexes) are the `Series.sort_index()` and the `DataFrame.sort_index()` methods.

```
In [307]: unsorted_df = df.reindex(index=['a', 'd', 'c', 'b'],
   .....:                          columns=['three', 'two', 'one'])
   .....:

# DataFrame
In [308]: unsorted_df.sort_index()
Out[308]:
   three  two  one
```

```
a    NaN  NaN  NaN
b    NaN  NaN  NaN
c    NaN  NaN  NaN
d    NaN  NaN  NaN

In [309]: unsorted_df.sort_index(ascending=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   three  two  one
d    NaN  NaN  NaN
c    NaN  NaN  NaN
b    NaN  NaN  NaN
a    NaN  NaN  NaN

In [310]: unsorted_df.sort_index(axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   one  three  two
a  NaN    NaN  NaN
d  NaN    NaN  NaN
c  NaN    NaN  NaN
b  NaN    NaN  NaN

# Series
In [311]: unsorted_df['three'].sort_index()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a   NaN
b   NaN
c   NaN
d   NaN
Name: three, dtype: float64
```

9.11.2 By Values

The *Series.sort_values()* and *DataFrame.sort_values()* are the entry points for **value** sorting (that is the values in a column or row). *DataFrame.sort_values()* can accept an optional `by` argument for `axis=0` which will use an arbitrary vector or a column name of the DataFrame to determine the sort order:

```
In [312]: df1 = pd.DataFrame({'one':[2,1,1,1],'two':[1,3,2,4],'three':[5,4,3,2]})

In [313]: df1.sort_values(by='two')
Out[313]:
   one  three  two
0    2      5    1
2    1      3    2
1    1      4    3
3    1      2    4
```

The `by` argument can take a list of column names, e.g.:

```
In [314]: df1[['one', 'two', 'three']].sort_values(by=['one','two'])
Out[314]:
   one  two  three
2    1    2      3
1    1    3      4
```

```
3    1    4      2
0    2    1      5
```

These methods have special treatment of NA values via the `na_position` argument:

```
In [315]: s[2] = np.nan

In [316]: s.sort_values()
Out[316]:
0       A
3    Aaba
1       B
4    Baca
6    CABA
8     cat
7     dog
2     NaN
5     NaN
dtype: object

In [317]: s.sort_values(na_position='first')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2     NaN
5     NaN
0       A
3    Aaba
1       B
4    Baca
6    CABA
8     cat
7     dog
dtype: object
```

9.11.3 searchsorted

Series has the *`searchsorted()`* method, which works similar to `numpy.ndarray.searchsorted()`.

```
In [318]: ser = pd.Series([1, 2, 3])

In [319]: ser.searchsorted([0, 3])
Out[319]: array([0, 2])

In [320]: ser.searchsorted([0, 4])
\\\\\\\\\\\\\\\\\\\\\\\\Out[320]: array([0, 3])

In [321]: ser.searchsorted([1, 3], side='right')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[321]: array([1, 3])

In [322]: ser.searchsorted([1, 3], side='left')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[322]:␣
↪array([0, 2])

In [323]: ser = pd.Series([3, 1, 2])

In [324]: ser.searchsorted([0, 3], sorter=np.argsort(ser))
```

```
Out[324]: array([0, 2])
```

9.11.4 smallest / largest values

`Series` has the *`nsmallest()`* and *`nlargest()`* methods which return the smallest or largest n values. For a large `Series` this can be much faster than sorting the entire Series and calling `head(n)` on the result.

```
In [325]: s = pd.Series(np.random.permutation(10))

In [326]: s
Out[326]:
0    3
1    1
2    9
3    6
4    0
5    8
6    5
7    2
8    7
9    4
dtype: int64

In [327]: s.sort_values()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[32
↪
4    0
1    1
7    2
0    3
9    4
6    5
3    6
8    7
5    8
2    9
dtype: int64

In [328]: s.nsmallest(3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
4    0
1    1
7    2
dtype: int64

In [329]: s.nlargest(3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2    9
5    8
8    7
dtype: int64
```

New in version 0.17.0.

`DataFrame` also has the `nlargest` and `nsmallest` methods.

```
In [330]: df = pd.DataFrame({'a': [-2, -1, 1, 10, 8, 11, -1],
   .....:                    'b': list('abdceff'),
   .....:                    'c': [1.0, 2.0, 4.0, 3.2, np.nan, 3.0, 4.0]})
   .....:

In [331]: df.nlargest(3, 'a')
Out[331]:
    a  b    c
5  11  f  3.0
3  10  c  3.2
4   8  e  NaN

In [332]: df.nlargest(5, ['a', 'c'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[332]:
    a  b    c
6  -1  f  4.0
5  11  f  3.0
3  10  c  3.2
4   8  e  NaN
2   1  d  4.0

In [333]: df.nsmallest(3, 'a')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  b    c
0 -2  a  1.0
1 -1  b  2.0
6 -1  f  4.0

In [334]: df.nsmallest(5, ['a', 'c'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  b    c
0 -2  a  1.0
2  1  d  4.0
4  8  e  NaN
1 -1  b  2.0
6 -1  f  4.0
```

9.11.5 Sorting by a multi-index column

You must be explicit about sorting when the column is a multi-index, and fully specify all levels to `by`.

```
In [335]: df1.columns = pd.MultiIndex.from_tuples([('a','one'),('a','two'),('b','three
↪')])

In [336]: df1.sort_values(by=('a','two'))
Out[336]:
    a         b
  one two three
3   1   2     4
2   1   3     2
1   1   4     3
0   2   5     1
```

9.12 Copying

The `copy()` method on pandas objects copies the underlying data (though not the axis indexes, since they are immutable) and returns a new object. Note that **it is seldom necessary to copy objects**. For example, there are only a handful of ways to alter a DataFrame *in-place*:

- Inserting, deleting, or modifying a column
- Assigning to the `index` or `columns` attributes
- For homogeneous data, directly modifying the values via the `values` attribute or advanced indexing

To be clear, no pandas methods have the side effect of modifying your data; almost all methods return new objects, leaving the original object untouched. If data is modified, it is because you did so explicitly.

9.13 dtypes

The main types stored in pandas objects are `float`, `int`, `bool`, `datetime64[ns]` and `datetime64[ns, tz]` (in >= 0.17.0), `timedelta[ns]`, `category` and `object`. In addition these dtypes have item sizes, e.g. `int64` and `int32`. See *Series with TZ* for more detail on `datetime64[ns, tz]` dtypes.

A convenient `dtypes` attribute for DataFrames returns a Series with the data type of each column.

```
In [337]: dft = pd.DataFrame(dict(A = np.random.rand(3),
   .....:                         B = 1,
   .....:                         C = 'foo',
   .....:                         D = pd.Timestamp('20010102'),
   .....:                         E = pd.Series([1.0]*3).astype('float32'),
   .....:                                     F = False,
   .....:                                     G = pd.Series([1]*3,dtype='int8')))
   .....:

In [338]: dft
Out[338]:
          A  B    C          D    E      F  G
0  0.534749  1  foo 2001-01-02  1.0  False  1
1  0.688452  1  foo 2001-01-02  1.0  False  1
2  0.777842  1  foo 2001-01-02  1.0  False  1

In [339]: dft.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
A            float64
B              int64
C             object
D     datetime64[ns]
E            float32
F               bool
G               int8
dtype: object
```

On a `Series` use the `dtype` attribute.

```
In [340]: dft['A'].dtype
Out[340]: dtype('float64')
```

If a pandas object contains data multiple dtypes *IN A SINGLE COLUMN*, the dtype of the column will be chosen to accommodate all of the data types (`object` is the most general).

```
# these ints are coerced to floats
In [341]: pd.Series([1, 2, 3, 4, 5, 6.])
Out[341]:
0    1.0
1    2.0
2    3.0
3    4.0
4    5.0
5    6.0
dtype: float64

# string data forces an ``object`` dtype
In [342]: pd.Series([1, 2, 3, 6., 'foo'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[342]:␣
↪
0      1
1      2
2      3
3      6
4    foo
dtype: object
```

The method *`get_dtype_counts()`* will return the number of columns of each type in a `DataFrame`:

```
In [343]: dft.get_dtype_counts()
Out[343]:
bool              1
datetime64[ns]    1
float32           1
float64           1
int64             1
int8              1
object            1
dtype: int64
```

Numeric dtypes will propagate and can coexist in DataFrames. If a dtype is passed (either directly via the `dtype` keyword, a passed `ndarray`, or a passed `Series`, then it will be preserved in DataFrame operations. Furthermore, different numeric dtypes will **NOT** be combined. The following example will give you a taste.

```
In [344]: df1 = pd.DataFrame(np.random.randn(8, 1), columns=['A'], dtype='float32')

In [345]: df1
Out[345]:
          A
0 -2.038777
1  1.121731
2  0.586626
3 -0.282532
4  0.410238
5 -0.540166
6  1.400679
7 -0.255975

In [346]: df1.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
A    float32
dtype: object

In [347]: df2 = pd.DataFrame(dict( A = pd.Series(np.random.randn(8), dtype='float16'),
   .....:                         B = pd.Series(np.random.randn(8)),
   .....:                         C = pd.Series(np.array(np.random.randn(8), dtype=
↪'uint8')) ))
   .....:

In [348]: df2
Out[348]: 
          A         B    C
0 -0.624512 -1.397492    0
1  0.022354  1.338115    0
2 -0.433594  0.781169  255
3 -0.405762 -0.791687    0
4 -0.149658 -0.764810  255
5  0.644531 -2.000933    0
6 -1.260742 -0.345662    0
7  0.365967  0.393915    0

In [349]: df2.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    float16
B    float64
C      uint8
dtype: object
```

9.13.1 defaults

By default integer types are `int64` and float types are `float64`, *REGARDLESS* of platform (32-bit or 64-bit). The following will all result in `int64` dtypes.

```
In [350]: pd.DataFrame([1, 2], columns=['a']).dtypes
Out[350]: 
a    int64
dtype: object

In [351]: pd.DataFrame({'a': [1, 2]}).dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[351]: 
a    int64
dtype: object

In [352]: pd.DataFrame({'a': 1 }, index=list(range(2))).dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[352]: 
a    int64
dtype: object
```

Numpy, however will choose *platform-dependent* types when creating arrays. The following **WILL** result in `int32` on 32-bit platform.

```
In [353]: frame = pd.DataFrame(np.array([1, 2]))
```

9.13.2 upcasting

Types can potentially be *upcasted* when combined with other types, meaning they are promoted from the current type (say `int` to `float`)

```
In [354]: df3 = df1.reindex_like(df2).fillna(value=0.0) + df2

In [355]: df3
Out[355]: 
          A         B      C
0 -2.663288 -1.397492    0.0
1  1.144085  1.338115    0.0
2  0.153032  0.781169  255.0
3 -0.688294 -0.791687    0.0
4  0.260580 -0.764810  255.0
5  0.104365 -2.000933    0.0
6  0.139937 -0.345662    0.0
7  0.109992  0.393915    0.0

In [356]: df3.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A     float32
B     float64
C     float64
dtype: object
```

The `values` attribute on a DataFrame return the *lower-common-denominator* of the dtypes, meaning the dtype that can accommodate **ALL** of the types in the resulting homogeneous dtyped numpy array. This can force some *upcasting*.

```
In [357]: df3.values.dtype
Out[357]: dtype('float64')
```

9.13.3 astype

You can use the *`astype()`* method to explicitly convert dtypes from one to another. These will by default return a copy, even if the dtype was unchanged (pass `copy=False` to change this behavior). In addition, they will raise an exception if the astype operation is invalid.

Upcasting is always according to the **numpy** rules. If two different dtypes are involved in an operation, then the more *general* one will be used as the result of the operation.

```
In [358]: df3
Out[358]: 
          A         B      C
0 -2.663288 -1.397492    0.0
1  1.144085  1.338115    0.0
2  0.153032  0.781169  255.0
3 -0.688294 -0.791687    0.0
4  0.260580 -0.764810  255.0
5  0.104365 -2.000933    0.0
6  0.139937 -0.345662    0.0
7  0.109992  0.393915    0.0

In [359]: df3.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
A    float32
B    float64
C    float64
dtype: object

# conversion of dtypes
In [360]: df3.astype('float32').dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    float32
B    float32
C    float32
dtype: object
```

Convert a subset of columns to a specified type using `astype()`

```
In [361]: dft = pd.DataFrame({'a': [1,2,3], 'b': [4,5,6], 'c': [7, 8, 9]})

In [362]: dft[['a','b']] = dft[['a','b']].astype(np.uint8)

In [363]: dft
Out[363]:
   a  b  c
0  1  4  7
1  2  5  8
2  3  6  9

In [364]: dft.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[364]:
a    uint8
b    uint8
c    int64
dtype: object
```

New in version 0.19.0.

Convert certain columns to a specific dtype by passing a dict to `astype()`

```
In [365]: dft1 = pd.DataFrame({'a': [1,0,1], 'b': [4,5,6], 'c': [7, 8, 9]})

In [366]: dft1 = dft1.astype({'a': np.bool, 'c': np.float64})

In [367]: dft1
Out[367]:
       a  b    c
0   True  4  7.0
1  False  5  8.0
2   True  6  9.0

In [368]: dft1.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[368]:␣
↪
a       bool
b      int64
c    float64
dtype: object
```

Note: When trying to convert a subset of columns to a specified type using `astype()` and `loc()`, upcasting occurs.

`loc()` tries to fit in what we are assigning to the current dtypes, while `[]` will overwrite them taking the dtype from the right hand side. Therefore the following piece of code produces the unintended result.

```
In [369]: dft = pd.DataFrame({'a': [1,2,3], 'b': [4,5,6], 'c': [7, 8, 9]})

In [370]: dft.loc[:, ['a', 'b']].astype(np.uint8).dtypes
Out[370]: 
a    uint8
b    uint8
dtype: object

In [371]: dft.loc[:, ['a', 'b']] = dft.loc[:, ['a', 'b']].astype(np.uint8)

In [372]: dft.dtypes
Out[372]: 
a    int64
b    int64
c    int64
dtype: object
```

9.13.4 object conversion

pandas offers various functions to try to force conversion of types from the `object` dtype to other types. In cases where the data is already of the correct type, but stored in an `object` array, the `DataFrame.infer_objects()` and `Series.infer_objects()` methods can be used to soft convert to the correct type.

```
In [373]: import datetime

In [374]: df = pd.DataFrame([[1, 2],
   .....:                    ['a', 'b'],
   .....:                    [datetime.datetime(2016, 3, 2), datetime.
↪datetime(2016, 3, 2)]])
   .....: 

In [375]: df = df.T

In [376]: df
Out[376]: 
   0  1                    2
0  1  a  2016-03-02 00:00:00
1  2  b  2016-03-02 00:00:00

In [377]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    object
1    object
2    object
dtype: object
```

Because the data was transposed the original inference stored all columns as object, which `infer_objects` will correct.

```
In [378]: df.infer_objects().dtypes
Out[378]:
0              int64
1             object
2    datetime64[ns]
dtype: object
```

The following functions are available for one dimensional object arrays or scalars to perform hard conversion of objects to a specified type:

- *to_numeric()* (conversion to numeric dtypes)

```
In [379]: m = ['1.1', 2, 3]

In [380]: pd.to_numeric(m)
Out[380]: array([1.1, 2. , 3. ])
```

- *to_datetime()* (conversion to datetime objects)

```
In [381]: import datetime

In [382]: m = ['2016-07-09', datetime.datetime(2016, 3, 2)]

In [383]: pd.to_datetime(m)
Out[383]: DatetimeIndex(['2016-07-09', '2016-03-02'], dtype='datetime64[ns]',␣
↪freq=None)
```

- *to_timedelta()* (conversion to timedelta objects)

```
In [384]: m = ['5us', pd.Timedelta('1day')]

In [385]: pd.to_timedelta(m)
Out[385]: TimedeltaIndex(['0 days 00:00:00.000005', '1 days 00:00:00'], dtype=
↪'timedelta64[ns]', freq=None)
```

To force a conversion, we can pass in an `errors` argument, which specifies how pandas should deal with elements that cannot be converted to desired dtype or object. By default, `errors='raise'`, meaning that any errors encountered will be raised during the conversion process. However, if `errors='coerce'`, these errors will be ignored and pandas will convert problematic elements to `pd.NaT` (for datetime and timedelta) or `np.nan` (for numeric). This might be useful if you are reading in data which is mostly of the desired dtype (e.g. numeric, datetime), but occasionally has non-conforming elements intermixed that you want to represent as missing:

```
In [386]: import datetime

In [387]: m = ['apple', datetime.datetime(2016, 3, 2)]

In [388]: pd.to_datetime(m, errors='coerce')
Out[388]: DatetimeIndex(['NaT', '2016-03-02'], dtype='datetime64[ns]', freq=None)

In [389]: m = ['apple', 2, 3]

In [390]: pd.to_numeric(m, errors='coerce')
Out[390]: array([nan,  2.,  3.])

In [391]: m = ['apple', pd.Timedelta('1day')]

In [392]: pd.to_timedelta(m, errors='coerce')
Out[392]: TimedeltaIndex([NaT, '1 days'], dtype='timedelta64[ns]', freq=None)
```

The `errors` parameter has a third option of `errors='ignore'`, which will simply return the passed in data if it encounters any errors with the conversion to a desired data type:

```
In [393]: import datetime

In [394]: m = ['apple', datetime.datetime(2016, 3, 2)]

In [395]: pd.to_datetime(m, errors='ignore')
Out[395]: array(['apple', datetime.datetime(2016, 3, 2, 0, 0)], dtype=object)

In [396]: m = ['apple', 2, 3]

In [397]: pd.to_numeric(m, errors='ignore')
Out[397]: array(['apple', 2, 3], dtype=object)

In [398]: m = ['apple', pd.Timedelta('1day')]

In [399]: pd.to_timedelta(m, errors='ignore')
Out[399]: array(['apple', Timedelta('1 days 00:00:00')], dtype=object)
```

In addition to object conversion, *`to_numeric()`* provides another argument `downcast`, which gives the option of downcasting the newly (or already) numeric data to a smaller dtype, which can conserve memory:

```
In [400]: m = ['1', 2, 3]

In [401]: pd.to_numeric(m, downcast='integer')   # smallest signed int dtype
Out[401]: array([1, 2, 3], dtype=int8)

In [402]: pd.to_numeric(m, downcast='signed')    # same as 'integer'
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[402]: array([1, 2, 3], dtype=int8)

In [403]: pd.to_numeric(m, downcast='unsigned')  # smallest unsigned int dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[403]:␣
↪array([1, 2, 3], dtype=uint8)

In [404]: pd.to_numeric(m, downcast='float')     # smallest float dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪array([1., 2., 3.], dtype=float32)
```

As these methods apply only to one-dimensional arrays, lists or scalars; they cannot be used directly on multi-dimensional objects such as DataFrames. However, with *`apply()`*, we can "apply" the function over each column efficiently:

```
In [405]: import datetime

In [406]: df = pd.DataFrame([['2016-07-09', datetime.datetime(2016, 3, 2)]] * 2,␣
↪dtype='O')

In [407]: df
Out[407]: 
            0                    1
0  2016-07-09  2016-03-02 00:00:00
1  2016-07-09  2016-03-02 00:00:00

In [408]: df.apply(pd.to_datetime)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
           0          1
0 2016-07-09 2016-03-02
1 2016-07-09 2016-03-02

In [409]: df = pd.DataFrame([['1.1', 2, 3]] * 2, dtype='O')

In [410]: df
Out[410]: 
     0  1  2
0  1.1  2  3
1  1.1  2  3

In [411]: df.apply(pd.to_numeric)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[411]: 
     0  1  2
0  1.1  2  3
1  1.1  2  3

In [412]: df = pd.DataFrame([['5us', pd.Timedelta('1day')]] * 2, dtype='O')

In [413]: df
Out[413]: 
     0                1
0  5us  1 days 00:00:00
1  5us  1 days 00:00:00

In [414]: df.apply(pd.to_timedelta)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[414]:␣
↪
                0      1
0 00:00:00.000005 1 days
1 00:00:00.000005 1 days
```

9.13.5 gotchas

Performing selection operations on `integer` type data can easily upcast the data to `floating`. The dtype of the input data will be preserved in cases where `nans` are not introduced. See also *Support for integer NA*

```
In [415]: dfi = df3.astype('int32')

In [416]: dfi['E'] = 1

In [417]: dfi
Out[417]: 
   A  B    C  E
0 -2 -1    0  1
1  1  1    0  1
2  0  0  255  1
3  0  0    0  1
4  0  0  255  1
5  0 -2    0  1
6  0  0    0  1
7  0  0    0  1

In [418]: dfi.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
A    int32
B    int32
C    int32
E    int64
dtype: object

In [419]: casted = dfi[dfi>0]

In [420]: casted
Out[420]:
     A    B      C  E
0  NaN  NaN    NaN  1
1  1.0  1.0    NaN  1
2  NaN  NaN  255.0  1
3  NaN  NaN    NaN  1
4  NaN  NaN  255.0  1
5  NaN  NaN    NaN  1
6  NaN  NaN    NaN  1
7  NaN  NaN    NaN  1

In [421]: casted.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
A    float64
B    float64
C    float64
E      int64
dtype: object
```

While float dtypes are unchanged.

```
In [422]: dfa = df3.copy()

In [423]: dfa['A'] = dfa['A'].astype('float32')

In [424]: dfa.dtypes
Out[424]:
A    float32
B    float64
C    float64
dtype: object

In [425]: casted = dfa[df2>0]

In [426]: casted
Out[426]:
          A         B      C
0       NaN       NaN    NaN
1  1.144085  1.338115    NaN
2       NaN  0.781169  255.0
3       NaN       NaN    NaN
4       NaN       NaN  255.0
5  0.104365       NaN    NaN
6       NaN       NaN    NaN
7  0.109992  0.393915    NaN

In [427]: casted.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
```

```
A    float32
B    float64
C    float64
dtype: object
```

9.14 Selecting columns based on `dtype`

The *select_dtypes()* method implements subsetting of columns based on their `dtype`.

First, let's create a *DataFrame* with a slew of different dtypes:

```
In [428]: df = pd.DataFrame({'string': list('abc'),
   .....:                    'int64': list(range(1, 4)),
   .....:                    'uint8': np.arange(3, 6).astype('u1'),
   .....:                    'float64': np.arange(4.0, 7.0),
   .....:                    'bool1': [True, False, True],
   .....:                    'bool2': [False, True, False],
   .....:                    'dates': pd.date_range('now', periods=3).values,
   .....:                    'category': pd.Series(list("ABC")).astype('category')})
   .....:

In [429]: df['tdeltas'] = df.dates.diff()

In [430]: df['uint64'] = np.arange(3, 6).astype('u8')

In [431]: df['other_dates'] = pd.date_range('20130101', periods=3).values

In [432]: df['tz_aware_dates'] = pd.date_range('20130101', periods=3, tz='US/Eastern')

In [433]: df
Out[433]:
   bool1  bool2 category                     dates  float64  int64 string  \
0   True  False        A 2017-10-27 10:34:07.934179      4.0      1      a
1  False   True        B 2017-10-28 10:34:07.934179      5.0      2      b
2   True  False        C 2017-10-29 10:34:07.934179      6.0      3      c

   uint8 tdeltas  uint64 other_dates            tz_aware_dates
0      3     NaT       3  2013-01-01 2013-01-01 00:00:00-05:00
1      4  1 days       4  2013-01-02 2013-01-02 00:00:00-05:00
2      5  1 days       5  2013-01-03 2013-01-03 00:00:00-05:00
```

And the dtypes

```
In [434]: df.dtypes
Out[434]:
bool1                                   bool
bool2                                   bool
category                            category
dates                        datetime64[ns]
float64                             float64
int64                                 int64
string                               object
uint8                                 uint8
tdeltas                     timedelta64[ns]
uint64                               uint64
other_dates                  datetime64[ns]
```

```
tz_aware_dates    datetime64[ns, US/Eastern]
dtype: object
```

select_dtypes() has two parameters `include` and `exclude` that allow you to say "give me the columns WITH these dtypes" (`include`) and/or "give the columns WITHOUT these dtypes" (`exclude`).

For example, to select `bool` columns

```
In [435]: df.select_dtypes(include=[bool])
Out[435]:
   bool1  bool2
0   True  False
1  False   True
2   True  False
```

You can also pass the name of a dtype in the numpy dtype hierarchy:

```
In [436]: df.select_dtypes(include=['bool'])
Out[436]:
   bool1  bool2
0   True  False
1  False   True
2   True  False
```

select_dtypes() also works with generic dtypes as well.

For example, to select all numeric and boolean columns while excluding unsigned integers

```
In [437]: df.select_dtypes(include=['number', 'bool'], exclude=['unsignedinteger'])
Out[437]:
   bool1  bool2  float64  int64 tdeltas
0   True  False      4.0      1     NaT
1  False   True      5.0      2  1 days
2   True  False      6.0      3  1 days
```

To select string columns you must use the `object` dtype:

```
In [438]: df.select_dtypes(include=['object'])
Out[438]:
  string
0      a
1      b
2      c
```

To see all the child dtypes of a generic `dtype` like `numpy.number` you can define a function that returns a tree of child dtypes:

```
In [439]: def subdtypes(dtype):
   .....:     subs = dtype.__subclasses__()
   .....:     if not subs:
   .....:         return dtype
   .....:     return [dtype, [subdtypes(dt) for dt in subs]]
   .....:
```

All numpy dtypes are subclasses of `numpy.generic`:

```
In [440]: subdtypes(np.generic)
Out[440]:
```

```
[numpy.generic,
 [[numpy.number,
   [[numpy.integer,
     [[numpy.signedinteger,
       [numpy.int8,
        numpy.int16,
        numpy.int32,
        numpy.int64,
        numpy.int64,
        numpy.timedelta64]],
      [numpy.unsignedinteger,
       [numpy.uint8,
        numpy.uint16,
        numpy.uint32,
        numpy.uint64,
        numpy.uint64]]]],
    [numpy.inexact,
     [[numpy.floating,
       [numpy.float16, numpy.float32, numpy.float64, numpy.float128]],
      [numpy.complexfloating,
       [numpy.complex64, numpy.complex128, numpy.complex256]]]]]],
  [numpy.flexible,
   [[numpy.character, [numpy.bytes_, numpy.str_]],
    [numpy.void, [numpy.record]]]],
  numpy.bool_,
  numpy.datetime64,
  numpy.object_]]
```

Note: Pandas also defines the types `category`, and `datetime64[ns, tz]`, which are not integrated into the normal numpy hierarchy and wont show up with the above function.

CHAPTER

TEN

WORKING WITH TEXT DATA

Series and Index are equipped with a set of string processing methods that make it easy to operate on each element of the array. Perhaps most importantly, these methods exclude missing/NA values automatically. These are accessed via the `str` attribute and generally have names matching the equivalent (scalar) built-in string methods:

```
In [1]: s = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog', 'cat'])

In [2]: s.str.lower()
Out[2]:
0       a
1       b
2       c
3    aaba
4    baca
5     NaN
6    caba
7     dog
8     cat
dtype: object

In [3]: s.str.upper()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0       A
1       B
2       C
3    AABA
4    BACA
5     NaN
6    CABA
7     DOG
8     CAT
dtype: object

In [4]: s.str.len()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1.0
1    1.0
2    1.0
3    4.0
4    4.0
5    NaN
6    4.0
7    3.0
```

```
8    3.0
dtype: float64
```

```
In [5]: idx = pd.Index([' jack', 'jill ', ' jesse ', 'frank'])

In [6]: idx.str.strip()
Out[6]: Index(['jack', 'jill', 'jesse', 'frank'], dtype='object')

In [7]: idx.str.lstrip()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[7]: Index(['jack
↪', 'jill ', 'jesse ', 'frank'], dtype='object')

In [8]: idx.str.rstrip()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Index([' jack', 'jill', ' jesse', 'frank'], dtype='object')
```

The string methods on Index are especially useful for cleaning up or transforming DataFrame columns. For instance, you may have columns with leading or trailing whitespace:

```
In [9]: df = pd.DataFrame(randn(3, 2), columns=[' Column A ', ' Column B '],
   ...:                   index=range(3))
   ...:

In [10]: df
Out[10]:
    Column A    Column B
0   -1.425575   -1.336299
1    0.740933    1.032121
2   -1.585660    0.913812
```

Since `df.columns` is an Index object, we can use the `.str` accessor

```
In [11]: df.columns.str.strip()
Out[11]: Index(['Column A', 'Column B'], dtype='object')

In [12]: df.columns.str.lower()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[12]: Index([' column a ',
↪ ' column b '], dtype='object')
```

These string methods can then be used to clean up the columns as needed. Here we are removing leading and trailing whitespaces, lowercasing all names, and replacing any remaining whitespaces with underscores:

```
In [13]: df.columns = df.columns.str.strip().str.lower().str.replace(' ', '_')

In [14]: df
Out[14]:
   column_a  column_b
0 -1.425575 -1.336299
1  0.740933  1.032121
2 -1.585660  0.913812
```

Note: If you have a `Series` where lots of elements are repeated (i.e. the number of unique elements in the `Series` is a lot smaller than the length of the `Series`), it can be faster to convert the original `Series` to one of type `category` and then use `.str.<method>` or `.dt.<property>` on that. The performance difference comes from the fact that, for `Series` of type `category`, the string operations are done on the `.categories` and not on each element of the `Series`.

Please note that a `Series` of type `category` with string `.categories` has some limitations in comparison of `Series` of type string (e.g. you can't add strings to each other: `s + " " + s` won't work if `s` is a `Series` of type `category`). Also, `.str` methods which operate on elements of type `list` are not available on such a `Series`.

10.1 Splitting and Replacing Strings

Methods like `split` return a Series of lists:

```
In [15]: s2 = pd.Series(['a_b_c', 'c_d_e', np.nan, 'f_g_h'])

In [16]: s2.str.split('_')
Out[16]:
0    [a, b, c]
1    [c, d, e]
2          NaN
3    [f, g, h]
dtype: object
```

Elements in the split lists can be accessed using `get` or `[]` notation:

```
In [17]: s2.str.split('_').str.get(1)
Out[17]:
0      b
1      d
2    NaN
3      g
dtype: object

In [18]: s2.str.split('_').str[1]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[18]:
0      b
1      d
2    NaN
3      g
dtype: object
```

Easy to expand this to return a DataFrame using `expand`.

```
In [19]: s2.str.split('_', expand=True)
Out[19]:
     0     1     2
0    a     b     c
1    c     d     e
2  NaN  None  None
3    f     g     h
```

It is also possible to limit the number of splits:

```
In [20]: s2.str.split('_', expand=True, n=1)
Out[20]:
     0     1
0    a   b_c
1    c   d_e
2  NaN  None
3    f   g_h
```

`rsplit` is similar to `split` except it works in the reverse direction, i.e., from the end of the string to the beginning of the string:

```
In [21]: s2.str.rsplit('_', expand=True, n=1)
Out[21]:
     0     1
0  a_b     c
1  c_d     e
2  NaN  None
3  f_g     h
```

Methods like `replace` and `findall` take regular expressions, too:

```
In [22]: s3 = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca',
   ....:                 '', np.nan, 'CABA', 'dog', 'cat'])
   ....:

In [23]: s3
Out[23]:
0       A
1       B
2       C
3    Aaba
4    Baca
5
6     NaN
7    CABA
8     dog
9     cat
dtype: object

In [24]: s3.str.replace('^.a|dog', 'XX-XX ', case=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0           A
1           B
2           C
3    XX-XX ba
4    XX-XX ca
5
6         NaN
7    XX-XX BA
8      XX-XX
9     XX-XX t
dtype: object
```

Some caution must be taken to keep regular expressions in mind! For example, the following code will cause trouble because of the regular expression meaning of *$*:

```
# Consider the following badly formatted financial data
In [25]: dollars = pd.Series(['12', '-$10', '$10,000'])

# This does what you'd naively expect:
In [26]: dollars.str.replace('$', '')
Out[26]:
0        12
1       -10
2    10,000
```

```
dtype: object

# But this doesn't:
In [27]: dollars.str.replace('-$', '-')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[27]:
0         12
1       -$10
2    $10,000
dtype: object

# We need to escape the special character (for >1 len patterns)
In [28]: dollars.str.replace(r'-\$', '-')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0         12
1        -10
2    $10,000
dtype: object
```

The `replace` method can also take a callable as replacement. It is called on every `pat` using `re.sub()`. The callable should expect one positional argument (a regex object) and return a string.

New in version 0.20.0.

```
# Reverse every lowercase alphabetic word
In [29]: pat = r'[a-z]+'

In [30]: repl = lambda m: m.group(0)[::-1]

In [31]: pd.Series(['foo 123', 'bar baz', np.nan]).str.replace(pat, repl)
Out[31]:
0    oof 123
1    rab zab
2        NaN
dtype: object

# Using regex groups
In [32]: pat = r"(?P<one>\w+) (?P<two>\w+) (?P<three>\w+)"

In [33]: repl = lambda m: m.group('two').swapcase()

In [34]: pd.Series(['Foo Bar Baz', np.nan]).str.replace(pat, repl)
Out[34]:
0    bAR
1    NaN
dtype: object
```

The `replace` method also accepts a compiled regular expression object from `re.compile()` as a pattern. All flags should be included in the compiled regular expression object.

New in version 0.20.0.

```
In [35]: import re

In [36]: regex_pat = re.compile(r'^.a|dog', flags=re.IGNORECASE)

In [37]: s3.str.replace(regex_pat, 'XX-XX ')
Out[37]:
```

```
0           A
1           B
2           C
3    XX-XX ba
4    XX-XX ca
5
6         NaN
7    XX-XX BA
8      XX-XX
9     XX-XX t
dtype: object
```

Including a `flags` argument when calling `replace` with a compiled regular expression object will raise a `ValueError`.

```
In [38]: s3.str.replace(regex_pat, 'XX-XX ', flags=re.IGNORECASE)
---------------------------------------------------------------------------
ValueError: case and flags cannot be set when pat is a compiled regex
```

10.2 Indexing with `.str`

You can use `[]` notation to directly index by position locations. If you index past the end of the string, the result will be a `NaN`.

```
In [39]: s = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan,
   ....:                 'CABA', 'dog', 'cat'])
   ....:

In [40]: s.str[0]
Out[40]:
0      A
1      B
2      C
3      A
4      B
5    NaN
6      C
7      d
8      c
dtype: object

In [41]: s.str[1]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
0    NaN
1    NaN
2    NaN
3      a
4      a
5    NaN
6      A
7      o
8      a
dtype: object
```

10.3 Extracting Substrings

10.3.1 Extract first match in each subject (extract)

Warning: In version 0.18.0, `extract` gained the `expand` argument. When `expand=False` it returns a `Series`, `Index`, or `DataFrame`, depending on the subject and regular expression pattern (same behavior as pre-0.18.0). When `expand=True` it always returns a `DataFrame`, which is more consistent and less confusing from the perspective of a user.

The `extract` method accepts a regular expression with at least one capture group.

Extracting a regular expression with more than one group returns a DataFrame with one column per group.

```
In [42]: pd.Series(['a1', 'b2', 'c3']).str.extract('([ab])(\d)', expand=False)
Out[42]:
     0    1
0    a    1
1    b    2
2  NaN  NaN
```

Elements that do not match return a row filled with `NaN`. Thus, a Series of messy strings can be "converted" into a like-indexed Series or DataFrame of cleaned-up or more useful strings, without necessitating `get()` to access tuples or `re.match` objects. The dtype of the result is always object, even if no match is found and the result only contains `NaN`.

Named groups like

```
In [43]: pd.Series(['a1', 'b2', 'c3']).str.extract('(?P<letter>[ab])(?P<digit>\d)',␣
↪expand=False)
Out[43]:
  letter digit
0      a     1
1      b     2
2    NaN   NaN
```

and optional groups like

```
In [44]: pd.Series(['a1', 'b2', '3']).str.extract('([ab])?(\d)', expand=False)
Out[44]:
     0  1
0    a  1
1    b  2
2  NaN  3
```

can also be used. Note that any capture group names in the regular expression will be used for column names; otherwise capture group numbers will be used.

Extracting a regular expression with one group returns a `DataFrame` with one column if `expand=True`.

```
In [45]: pd.Series(['a1', 'b2', 'c3']).str.extract('[ab](\d)', expand=True)
Out[45]:
     0
0    1
1    2
2  NaN
```

It returns a Series if `expand=False`.

```
In [46]: pd.Series(['a1', 'b2', 'c3']).str.extract('[ab](\d)', expand=False)
Out[46]:
0      1
1      2
2    NaN
dtype: object
```

Calling on an `Index` with a regex with exactly one capture group returns a `DataFrame` with one column if `expand=True`,

```
In [47]: s = pd.Series(["a1", "b2", "c3"], ["A11", "B22", "C33"])

In [48]: s
Out[48]:
A11    a1
B22    b2
C33    c3
dtype: object

In [49]: s.index.str.extract("(?P<letter>[a-zA-Z])", expand=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[49]:
  letter
0      A
1      B
2      C
```

It returns an `Index` if `expand=False`.

```
In [50]: s.index.str.extract("(?P<letter>[a-zA-Z])", expand=False)
Out[50]: Index(['A', 'B', 'C'], dtype='object', name='letter')
```

Calling on an `Index` with a regex with more than one capture group returns a `DataFrame` if `expand=True`.

```
In [51]: s.index.str.extract("(?P<letter>[a-zA-Z])([0-9]+)", expand=True)
Out[51]:
  letter   1
0      A  11
1      B  22
2      C  33
```

It raises `ValueError` if `expand=False`.

```
>>> s.index.str.extract("(?P<letter>[a-zA-Z])([0-9]+)", expand=False)
ValueError: only one regex group is supported with Index
```

The table below summarizes the behavior of `extract(expand=False)` (input subject in first column, number of groups in regex in first row)

	1 group	>1 group
Index	Index	ValueError
Series	Series	DataFrame

10.3.2 Extract all matches in each subject (extractall)

New in version 0.18.0.

Unlike `extract` (which returns only the first match),

```
In [52]: s = pd.Series(["a1a2", "b1", "c1"], index=["A", "B", "C"])

In [53]: s
Out[53]:
A    a1a2
B      b1
C      c1
dtype: object

In [54]: two_groups = '(?P<letter>[a-z])(?P<digit>[0-9])'

In [55]: s.str.extract(two_groups, expand=True)
Out[55]:
  letter digit
A      a     1
B      b     1
C      c     1
```

the `extractall` method returns every match. The result of `extractall` is always a `DataFrame` with a `MultiIndex` on its rows. The last level of the `MultiIndex` is named `match` and indicates the order in the subject.

```
In [56]: s.str.extractall(two_groups)
Out[56]:
        letter digit
  match
A 0          a     1
  1          a     2
B 0          b     1
C 0          c     1
```

When each subject string in the Series has exactly one match,

```
In [57]: s = pd.Series(['a3', 'b3', 'c2'])

In [58]: s
Out[58]:
0    a3
1    b3
2    c2
dtype: object
```

then `extractall(pat).xs(0, level='match')` gives the same result as `extract(pat)`.

```
In [59]: extract_result = s.str.extract(two_groups, expand=True)

In [60]: extract_result
Out[60]:
  letter digit
0      a     3
1      b     3
2      c     2

In [61]: extractall_result = s.str.extractall(two_groups)

In [62]: extractall_result
```

```
Out[62]:
        letter digit
  match
0 0          a     3
1 0          b     3
2 0          c     2

In [63]: extractall_result.xs(0, level="match")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
  letter digit
0      a     3
1      b     3
2      c     2
```

`Index` also supports `.str.extractall`. It returns a `DataFrame` which has the same result as a `Series.str.extractall` with a default index (starts from 0).

New in version 0.19.0.

```
In [64]: pd.Index(["a1a2", "b1", "c1"]).str.extractall(two_groups)
Out[64]:
        letter digit
  match
0 0          a     1
  1          a     2
1 0          b     1
2 0          c     1

In [65]: pd.Series(["a1a2", "b1", "c1"]).str.extractall(two_groups)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        letter digit
  match
0 0          a     1
  1          a     2
1 0          b     1
2 0          c     1
```

10.4 Testing for Strings that Match or Contain a Pattern

You can check whether elements contain a pattern:

```
In [66]: pattern = r'[0-9][a-z]'

In [67]: pd.Series(['1', '2', '3a', '3b', '03c']).str.contains(pattern)
Out[67]:
0    False
1    False
2     True
3     True
4     True
dtype: bool
```

or match a pattern:

```
In [68]: pd.Series(['1', '2', '3a', '3b', '03c']).str.match(pattern)
Out[68]:
0    False
1    False
2     True
3     True
4    False
dtype: bool
```

The distinction between `match` and `contains` is strictness: `match` relies on strict `re.match`, while `contains` relies on `re.search`.

Methods like `match`, `contains`, `startswith`, and `endswith` take an extra `na` argument so missing values can be considered True or False:

```
In [69]: s4 = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog', 'cat'])

In [70]: s4.str.contains('A', na=False)
Out[70]:
0     True
1    False
2    False
3     True
4    False
5    False
6     True
7    False
8    False
dtype: bool
```

10.5 Creating Indicator Variables

You can extract dummy variables from string columns. For example if they are separated by a `'|'`:

```
In [71]: s = pd.Series(['a', 'a|b', np.nan, 'a|c'])

In [72]: s.str.get_dummies(sep='|')
Out[72]:
   a  b  c
0  1  0  0
1  1  1  0
2  0  0  0
3  1  0  1
```

String `Index` also supports `get_dummies` which returns a `MultiIndex`.

New in version 0.18.1.

```
In [73]: idx = pd.Index(['a', 'a|b', np.nan, 'a|c'])

In [74]: idx.str.get_dummies(sep='|')
Out[74]:
MultiIndex(levels=[[0, 1], [0, 1], [0, 1]],
           labels=[[1, 1, 0, 1], [0, 1, 0, 0], [0, 0, 0, 1]],
           names=['a', 'b', 'c'])
```

See also *get_dummies()*.

10.6 Method Summary

Method	Description
cat()	Concatenate strings
split()	Split strings on delimiter
rsplit()	Split strings on delimiter working from the end of the string
get()	Index into each element (retrieve i-th element)
join()	Join strings in each element of the Series with passed separator
get_dummies()	Split strings on the delimiter returning DataFrame of dummy variables
contains()	Return boolean array if each string contains pattern/regex
replace()	Replace occurrences of pattern/regex with some other string or the return value of a callable given the occur
repeat()	Duplicate values (`s.str.repeat(3)` equivalent to `x * 3`)
pad()	Add whitespace to left, right, or both sides of strings
center()	Equivalent to `str.center`
ljust()	Equivalent to `str.ljust`
rjust()	Equivalent to `str.rjust`
zfill()	Equivalent to `str.zfill`
wrap()	Split long strings into lines with length less than a given width
slice()	Slice each string in the Series
slice_replace()	Replace slice in each string with passed value
count()	Count occurrences of pattern
startswith()	Equivalent to `str.startswith(pat)` for each element
endswith()	Equivalent to `str.endswith(pat)` for each element
findall()	Compute list of all occurrences of pattern/regex for each string
match()	Call `re.match` on each element, returning matched groups as list
extract()	Call `re.search` on each element, returning DataFrame with one row for each element and one column for
extractall()	Call `re.findall` on each element, returning DataFrame with one row for each match and one column for
len()	Compute string lengths
strip()	Equivalent to `str.strip`
rstrip()	Equivalent to `str.rstrip`
lstrip()	Equivalent to `str.lstrip`
partition()	Equivalent to `str.partition`
rpartition()	Equivalent to `str.rpartition`
lower()	Equivalent to `str.lower`
upper()	Equivalent to `str.upper`
find()	Equivalent to `str.find`
rfind()	Equivalent to `str.rfind`
index()	Equivalent to `str.index`
rindex()	Equivalent to `str.rindex`
capitalize()	Equivalent to `str.capitalize`
swapcase()	Equivalent to `str.swapcase`
normalize()	Return Unicode normal form. Equivalent to `unicodedata.normalize`
translate()	Equivalent to `str.translate`
isalnum()	Equivalent to `str.isalnum`
isalpha()	Equivalent to `str.isalpha`
isdigit()	Equivalent to `str.isdigit`
isspace()	Equivalent to `str.isspace`

Table 10.1 – continued from previous page

Method	Description
islower()	Equivalent to `str.islower`
isupper()	Equivalent to `str.isupper`
istitle()	Equivalent to `str.istitle`
isnumeric()	Equivalent to `str.isnumeric`
isdecimal()	Equivalent to `str.isdecimal`

CHAPTER

ELEVEN

OPTIONS AND SETTINGS

11.1 Overview

pandas has an options system that lets you customize some aspects of its behaviour, display-related options being those the user is most likely to adjust.

Options have a full "dotted-style", case-insensitive name (e.g. `display.max_rows`). You can get/set options directly as attributes of the top-level `options` attribute:

```
In [1]: import pandas as pd

In [2]: pd.options.display.max_rows
Out[2]: 15

In [3]: pd.options.display.max_rows = 999

In [4]: pd.options.display.max_rows
Out[4]: 999
```

The API is composed of 5 relevant functions, available directly from the `pandas` namespace:

- *`get_option()`* / *`set_option()`* - get/set the value of a single option.
- *`reset_option()`* - reset one or more options to their default value.
- *`describe_option()`* - print the descriptions of one or more options.
- *`option_context()`* - execute a codeblock with a set of options that revert to prior settings after execution.

Note: developers can check out pandas/core/config.py for more info.

All of the functions above accept a regexp pattern (`re.search` style) as an argument, and so passing in a substring will work - as long as it is unambiguous:

```
In [5]: pd.get_option("display.max_rows")
Out[5]: 999

In [6]: pd.set_option("display.max_rows",101)

In [7]: pd.get_option("display.max_rows")
Out[7]: 101

In [8]: pd.set_option("max_r",102)

In [9]: pd.get_option("display.max_rows")
Out[9]: 102
```

The following will **not work** because it matches multiple option names, e.g. `display.max_colwidth`, `display.max_rows`, `display.max_columns`:

```
In [10]: try:
   ....:     pd.get_option("column")
   ....: except KeyError as e:
   ....:     print(e)
   ....:
'Pattern matched multiple keys'
```

Note: Using this form of shorthand may cause your code to break if new options with similar names are added in future versions.

You can get a list of available options and their descriptions with `describe_option`. When called with no argument `describe_option` will print out the descriptions for all available options.

11.2 Getting and Setting Options

As described above, `get_option()` and `set_option()` are available from the pandas namespace. To change an option, call `set_option('option regex', new_value)`

```
In [11]: pd.get_option('mode.sim_interactive')
Out[11]: False

In [12]: pd.set_option('mode.sim_interactive', True)

In [13]: pd.get_option('mode.sim_interactive')
Out[13]: True
```

Note: that the option 'mode.sim_interactive' is mostly used for debugging purposes.

All options also have a default value, and you can use `reset_option` to do just that:

```
In [14]: pd.get_option("display.max_rows")
Out[14]: 60

In [15]: pd.set_option("display.max_rows",999)

In [16]: pd.get_option("display.max_rows")
Out[16]: 999

In [17]: pd.reset_option("display.max_rows")

In [18]: pd.get_option("display.max_rows")
Out[18]: 60
```

It's also possible to reset multiple options at once (using a regex):

```
In [19]: pd.reset_option("^display")
```

`option_context` context manager has been exposed through the top-level API, allowing you to execute code with given option values. Option values are restored automatically when you exit the *with* block:

```
In [20]: with pd.option_context("display.max_rows",10,"display.max_columns", 5):
   ....:     print(pd.get_option("display.max_rows"))
   ....:     print(pd.get_option("display.max_columns"))
   ....:
```

```
10
5

In [21]: print(pd.get_option("display.max_rows"))
\\\\\60

In [22]: print(pd.get_option("display.max_columns"))
\\\\\\\\20
```

11.3 Setting Startup Options in python/ipython Environment

Using startup scripts for the python/ipython environment to import pandas and set options makes working with pandas more efficient. To do this, create a .py or .ipy script in the startup directory of the desired profile. An example where the startup folder is in a default ipython profile can be found at:

```
$IPYTHONDIR/profile_default/startup
```

More information can be found in the ipython documentation. An example startup script for pandas is displayed below:

```
import pandas as pd
pd.set_option('display.max_rows', 999)
pd.set_option('precision', 5)
```

11.4 Frequently Used Options

The following is a walkthrough of the more frequently used display options.

`display.max_rows` and `display.max_columns` sets the maximum number of rows and columns displayed when a frame is pretty-printed. Truncated lines are replaced by an ellipsis.

```
In [23]: df = pd.DataFrame(np.random.randn(7,2))

In [24]: pd.set_option('max_rows', 7)

In [25]: df
Out[25]:
          0         1
0  0.469112 -0.282863
1 -1.509059 -1.135632
2  1.212112 -0.173215
3  0.119209 -1.044236
4 -0.861849 -2.104569
5 -0.494929  1.071804
6  0.721555 -0.706771

In [26]: pd.set_option('max_rows', 5)

In [27]: df
Out[27]:
           0         1
0   0.469112 -0.282863
1  -1.509059 -1.135632
```

```
..       ...       ...
5  -0.494929  1.071804
6   0.721555 -0.706771

[7 rows x 2 columns]

In [28]: pd.reset_option('max_rows')
```

`display.expand_frame_repr` allows for the the representation of dataframes to stretch across pages, wrapped over the full column vs row-wise.

```
In [29]: df = pd.DataFrame(np.random.randn(5,10))

In [30]: pd.set_option('expand_frame_repr', True)

In [31]: df
Out[31]:
          0         1         2         3         4         5         6  \
0 -1.039575  0.271860 -0.424972  0.567020  0.276232 -1.087401 -0.673690
1  0.404705  0.577046 -1.715002 -1.039268 -0.370647 -1.157892 -1.344312
2  1.643563 -1.469388  0.357021 -0.674600 -1.776904 -0.968914 -1.294524
3 -0.013960 -0.362543 -0.006154 -0.923061  0.895717  0.805244 -1.206412
4 -1.170299 -0.226169  0.410835  0.813850  0.132003 -0.827317 -0.076467

          7         8         9
0  0.113648 -1.478427  0.524988
1  0.844885  1.075770 -0.109050
2  0.413738  0.276662 -0.472035
3  2.565646  1.431256  1.340309
4 -1.187678  1.130127 -1.436737

In [32]: pd.set_option('expand_frame_repr', False)

In [33]: df
Out[33]:
          0         1         2         3         4         5         6         7
↪    8         9
0 -1.039575  0.271860 -0.424972  0.567020  0.276232 -1.087401 -0.673690  0.113648 -1.
↪478427  0.524988
1  0.404705  0.577046 -1.715002 -1.039268 -0.370647 -1.157892 -1.344312  0.844885  1.
↪075770 -0.109050
2  1.643563 -1.469388  0.357021 -0.674600 -1.776904 -0.968914 -1.294524  0.413738  0.
↪276662 -0.472035
3 -0.013960 -0.362543 -0.006154 -0.923061  0.895717  0.805244 -1.206412  2.565646  1.
↪431256  1.340309
4 -1.170299 -0.226169  0.410835  0.813850  0.132003 -0.827317 -0.076467 -1.187678  1.
↪130127 -1.436737

In [34]: pd.reset_option('expand_frame_repr')
```

`display.large_repr` lets you select whether to display dataframes that exceed `max_columns` or `max_rows` as a truncated frame, or as a summary.

```
In [35]: df = pd.DataFrame(np.random.randn(10,10))

In [36]: pd.set_option('max_rows', 5)

In [37]: pd.set_option('large_repr', 'truncate')
```

```
In [38]: df
Out[38]:
           0         1         2         3         4         5         6  \
0  -1.413681  1.607920  1.024180  0.569605  0.875906 -2.211372  0.974466
1   0.545952 -1.219217 -1.226825  0.769804 -1.281247 -0.727707 -0.121306
..       ...       ...       ...       ...       ...       ...       ...
8  -2.484478 -0.281461  0.030711  0.109121  1.126203 -0.977349  1.474071
9  -1.071357  0.441153  2.353925  0.583787  0.221471 -0.744471  0.758527

           7         8         9
0  -2.006747 -0.410001 -0.078638
1  -0.097883  0.695775  0.341734
..       ...       ...       ...
8  -0.064034 -1.282782  0.781836
9   1.729689 -0.964980 -0.845696

[10 rows x 10 columns]

In [39]: pd.set_option('large_repr', 'info')

In [40]: df
Out[40]:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 10 columns):
0    10 non-null float64
1    10 non-null float64
2    10 non-null float64
3    10 non-null float64
4    10 non-null float64
5    10 non-null float64
6    10 non-null float64
7    10 non-null float64
8    10 non-null float64
9    10 non-null float64
dtypes: float64(10)
memory usage: 880.0 bytes

In [41]: pd.reset_option('large_repr')

In [42]: pd.reset_option('max_rows')
```

`display.max_colwidth` sets the maximum width of columns. Cells of this length or longer will be truncated with an ellipsis.

```
In [43]: df = pd.DataFrame(np.array([['foo', 'bar', 'bim', 'uncomfortably long string
↪'],
   ....:                              ['horse', 'cow', 'banana', 'apple']]))
   ....:

In [44]: pd.set_option('max_colwidth',40)

In [45]: df
Out[45]:
       0    1       2                          3
0    foo  bar     bim  uncomfortably long string
1  horse  cow  banana                      apple
```

```
In [46]: pd.set_option('max_colwidth', 6)

In [47]: df
Out[47]:
       0    1      2      3
0    foo  bar    bim  un...
1  horse  cow  ba...  apple

In [48]: pd.reset_option('max_colwidth')
```

`display.max_info_columns` sets a threshold for when by-column info will be given.

```
In [49]: df = pd.DataFrame(np.random.randn(10,10))

In [50]: pd.set_option('max_info_columns', 11)

In [51]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 10 columns):
0    10 non-null float64
1    10 non-null float64
2    10 non-null float64
3    10 non-null float64
4    10 non-null float64
5    10 non-null float64
6    10 non-null float64
7    10 non-null float64
8    10 non-null float64
9    10 non-null float64
dtypes: float64(10)
memory usage: 880.0 bytes

In [52]: pd.set_option('max_info_columns', 5)

In [53]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Columns: 10 entries, 0 to 9
dtypes: float64(10)
memory usage: 880.0 bytes

In [54]: pd.reset_option('max_info_columns')
```

`display.max_info_rows`: `df.info()` will usually show null-counts for each column. For large frames this can be quite slow. `max_info_rows` and `max_info_cols` limit this null check only to frames with smaller dimensions then specified. Note that you can specify the option `df.info(null_counts=True)` to override on showing a particular frame.

```
In [55]: df  =pd.DataFrame(np.random.choice([0,1,np.nan], size=(10,10)))

In [56]: df
Out[56]:
     0    1    2    3    4    5    6    7    8    9
0  0.0  1.0  1.0  0.0  1.0  1.0  0.0  NaN  1.0  NaN
1  1.0  NaN  0.0  0.0  1.0  1.0  NaN  1.0  0.0  1.0
2  NaN  NaN  NaN  1.0  1.0  0.0  NaN  0.0  1.0  NaN
```

```
3  0.0  1.0  1.0  NaN  0.0  NaN  1.0  NaN  NaN  0.0
4  0.0  1.0  0.0  0.0  1.0  0.0  0.0  NaN  0.0  0.0
5  0.0  NaN  1.0  NaN  NaN  NaN  NaN  0.0  1.0  NaN
6  0.0  1.0  0.0  0.0  NaN  1.0  NaN  NaN  0.0  NaN
7  0.0  NaN  1.0  1.0  NaN  1.0  1.0  1.0  1.0  NaN
8  0.0  0.0  NaN  0.0  NaN  1.0  0.0  0.0  NaN  NaN
9  NaN  NaN  0.0  NaN  NaN  NaN  0.0  1.0  1.0  NaN

In [57]: pd.set_option('max_info_rows', 11)

In [58]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 10 columns):
0    8 non-null float64
1    5 non-null float64
2    8 non-null float64
3    7 non-null float64
4    5 non-null float64
5    7 non-null float64
6    6 non-null float64
7    6 non-null float64
8    8 non-null float64
9    3 non-null float64
dtypes: float64(10)
memory usage: 880.0 bytes

In [59]: pd.set_option('max_info_rows', 5)

In [60]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 10 columns):
0    float64
1    float64
2    float64
3    float64
4    float64
5    float64
6    float64
7    float64
8    float64
9    float64
dtypes: float64(10)
memory usage: 880.0 bytes

In [61]: pd.reset_option('max_info_rows')
```

`display.precision` sets the output display precision in terms of decimal places. This is only a suggestion.

```
In [62]: df = pd.DataFrame(np.random.randn(5,5))

In [63]: pd.set_option('precision',7)

In [64]: df
Out[64]:
           0          1          2          3          4
0 -2.0490276  2.8466122 -1.2080493 -0.4503923  2.4239054
```

```
1  0.1211080  0.2669165  0.8438259 -0.2225400  2.0219807
2 -0.7167894 -2.2244851 -1.0611370 -0.2328247  0.4307933
3 -0.6654779  1.8298075 -1.4065093  1.0782481  0.3227741
4  0.2003243  0.8900241  0.1948132  0.3516326  0.4488815

In [65]: pd.set_option('precision',4)

In [66]: df
Out[66]:
        0       1       2       3       4
0 -2.0490  2.8466 -1.2080 -0.4504  2.4239
1  0.1211  0.2669  0.8438 -0.2225  2.0220
2 -0.7168 -2.2245 -1.0611 -0.2328  0.4308
3 -0.6655  1.8298 -1.4065  1.0782  0.3228
4  0.2003  0.8900  0.1948  0.3516  0.4489
```

`display.chop_threshold` sets at what level pandas rounds to zero when it displays a Series of DataFrame. Note, this does not effect the precision at which the number is stored.

```
In [67]: df = pd.DataFrame(np.random.randn(6,6))

In [68]: pd.set_option('chop_threshold', 0)

In [69]: df
Out[69]:
        0       1       2       3       4       5
0 -0.1979  0.9657 -1.5229 -0.1166  0.2956 -1.0477
1  1.6406  1.9058  2.7721  0.0888 -1.1442 -0.6334
2  0.9254 -0.0064 -0.8204 -0.6009 -1.0393  0.8248
3 -0.8241 -0.3377 -0.9278 -0.8401  0.2485 -0.1093
4  0.4320 -0.4607  0.3365 -3.2076 -1.5359  0.4098
5 -0.6731 -0.7411 -0.1109 -2.6729  0.8645  0.0609

In [70]: pd.set_option('chop_threshold', .5)

In [71]: df
Out[71]:
        0       1       2       3       4       5
0  0.0000  0.9657 -1.5229  0.0000  0.0000 -1.0477
1  1.6406  1.9058  2.7721  0.0000 -1.1442 -0.6334
2  0.9254  0.0000 -0.8204 -0.6009 -1.0393  0.8248
3 -0.8241  0.0000 -0.9278 -0.8401  0.0000  0.0000
4  0.0000  0.0000  0.0000 -3.2076 -1.5359  0.0000
5 -0.6731 -0.7411  0.0000 -2.6729  0.8645  0.0000

In [72]: pd.reset_option('chop_threshold')
```

`display.colheader_justify` controls the justification of the headers. Options are 'right', and 'left'.

```
In [73]: df = pd.DataFrame(np.array([np.random.randn(6), np.random.randint(1,9,6)*.1,␣
↪np.zeros(6)]).T,
   ....:                   columns=['A', 'B', 'C'], dtype='float')
   ....:

In [74]: pd.set_option('colheader_justify', 'right')

In [75]: df
Out[75]:
```

```
        A    B    C
0  0.9331  0.3  0.0
1  0.2888  0.2  0.0
2  1.3250  0.2  0.0
3  0.5892  0.7  0.0
4  0.5314  0.1  0.0
5 -1.1987  0.7  0.0

In [76]: pd.set_option('colheader_justify', 'left')

In [77]: df
Out[77]:
   A       B    C
0  0.9331  0.3  0.0
1  0.2888  0.2  0.0
2  1.3250  0.2  0.0
3  0.5892  0.7  0.0
4  0.5314  0.1  0.0
5 -1.1987  0.7  0.0

In [78]: pd.reset_option('colheader_justify')
```

11.5 Available Options

Option	Default	Function
display.chop_threshold	None	If set to a float value, all float values smaller then the given threshold will be displaye
display.colheader_justify	right	Controls the justification of column headers. used by DataFrameFormatter.
display.column_space	12	No description available.
display.date_dayfirst	False	When True, prints and parses dates with the day first, eg 20/01/2005
display.date_yearfirst	False	When True, prints and parses dates with the year first, eg 2005/01/20
display.encoding	UTF-8	Defaults to the detected encoding of the console. Specifies the encoding to be used fo
display.expand_frame_repr	True	Whether to print out the full DataFrame repr for wide DataFrames across multiple lin
display.float_format	None	The callable should accept a floating point number and return a string with the desire
display.large_repr	truncate	For DataFrames exceeding max_rows/max_cols, the repr (and HTML repr) can show
display.latex.repr	False	Whether to produce a latex DataFrame representation for jupyter frontends that supp
display.latex.escape	True	Escapes special characters in DataFrames, when using the to_latex method.
display.latex.longtable	False	Specifies if the to_latex method of a DataFrame uses the longtable format.
display.latex.multicolumn	True	Combines columns when using a MultiIndex
display.latex.multicolumn_format	'l'	Alignment of multicolumn labels
display.latex.multirow	False	Combines rows when using a MultiIndex. Centered instead of top-aligned, separated
display.max_columns	20	max_rows and max_columns are used in __repr__() methods to decide if to_string()
display.max_colwidth	50	The maximum width in characters of a column in the repr of a pandas data structure.
display.max_info_columns	100	max_info_columns is used in DataFrame.info method to decide if per column inform
display.max_info_rows	1690785	df.info() will usually show null-counts for each column. For large frames this can be
display.max_rows	60	This sets the maximum number of rows pandas should output when printing out vari
display.max_seq_items	100	when pretty-printing a long sequence, no more then *max_seq_items* will be printed. I
display.memory_usage	True	This specifies if the memory usage of a DataFrame should be displayed when the df.
display.multi_sparse	True	"Sparsify" MultiIndex display (don't display repeated elements in outer levels within
display.notebook_repr_html	True	When True, IPython notebook will use html representation for pandas objects (if it is
display.pprint_nest_depth	3	Controls the number of nested levels to process when pretty-printing

Option	Default	Function
display.precision	6	Floating point output precision in terms of number of places after the decimal, for re
display.show_dimensions	truncate	Whether to print out dimensions at the end of DataFrame repr. If 'truncate' is specifi
display.width	80	Width of the display in characters. In case python/IPython is running in a terminal th
display.html.table_schema	False	Whether to publish a Table Schema representation for frontends that support it.
display.html.border	1	A `border=value` attribute is inserted in the `<table>` tag for the DataFrame HT
io.excel.xls.writer	xlwt	The default Excel writer engine for 'xls' files.
io.excel.xlsm.writer	openpyxl	The default Excel writer engine for 'xlsm' files. Available options: 'openpyxl' (the d
io.excel.xlsx.writer	openpyxl	The default Excel writer engine for 'xlsx' files.
io.hdf.default_format	None	default format writing format, if None, then put will default to 'fixed' and append wi
io.hdf.dropna_table	True	drop ALL nan rows when appending to a table
io.parquet.engine	None	The engine to use as a default for parquet reading and writing. If None then try 'pyar
mode.chained_assignment	warn	Raise an exception, warn, or no action if trying to use chained assignment, The defau
mode.sim_interactive	False	Whether to simulate interactive mode for purposes of testing.
mode.use_inf_as_na	False	True means treat None, NaN, -INF, INF as NA (old way), False means None and Na
compute.use_bottleneck	True	Use the bottleneck library to accelerate computation if it is installed.
compute.use_numexpr	True	Use the numexpr library to accelerate computation if it is installed.

11.6 Number Formatting

pandas also allows you to set how numbers are displayed in the console. This option is not set through the `set_options` API.

Use the `set_eng_float_format` function to alter the floating-point formatting of pandas objects to produce a particular format.

For instance:

```
In [79]: import numpy as np

In [80]: pd.set_eng_float_format(accuracy=3, use_eng_prefix=True)

In [81]: s = pd.Series(np.random.randn(5), index=['a', 'b', 'c', 'd', 'e'])

In [82]: s/1.e3
Out[82]:
a   -236.866u
b    846.974u
c   -685.597u
d    609.099u
e   -303.961u
dtype: float64

In [83]: s/1.e6
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[8
↪
a   -236.866n
b    846.974n
c   -685.597n
d    609.099n
e   -303.961n
dtype: float64
```

To round floats on a case-by-case basis, you can also use *`round()`* and *`round()`*.

11.7 Unicode Formatting

Warning: Enabling this option will affect the performance for printing of DataFrame and Series (about 2 times slower). Use only when it is actually required.

Some East Asian countries use Unicode characters whose width corresponds to two Latin characters. If a DataFrame or Series contains these characters, the default output mode may not align them properly.

Note: Screen captures are attached for each output to show the actual results.

```
In [84]: df = pd.DataFrame({u'': ['UK', u''], u'': ['Alice', u'']})

In [85]: df;
```

```
>>> df = pd.DataFrame({u'国籍': ['UK', u'日本'], u'名前': ['Alice', u'しのぶ']})
>>> df
      名前  国籍
0  Alice  UK
1    しのぶ  日本
```

Enabling `display.unicode.east_asian_width` allows pandas to check each character's "East Asian Width" property. These characters can be aligned properly by setting this option to `True`. However, this will result in longer render times than the standard `len` function.

```
In [86]: pd.set_option('display.unicode.east_asian_width', True)

In [87]: df;
```

```
>>> pd.set_option('display.unicode.east_asian_width', True)
>>> df
     名前  国籍
0   Alice    UK
1  しのぶ  日本
```

In addition, Unicode characters whose width is "Ambiguous" can either be 1 or 2 characters wide depending on the terminal setting or encoding. The option `display.unicode.ambiguous_as_wide` can be used to handle the ambiguity.

By default, an "Ambiguous" character's width, such as "¡" (inverted exclamation) in the example below, is taken to be 1.

```
In [88]: df = pd.DataFrame({'a': ['xxx', u'¡¡'], 'b': ['yyy', u'¡¡']})

In [89]: df;
```

```
>>> df = pd.DataFrame({'a': ['xxx', u'¡¡'], 'b': ['yyy', u'¡¡']})
>>> df
     a    b
0  xxx  yyy
1   ¡¡   ¡¡
```

Enabling `display.unicode.ambiguous_as_wide` makes pandas interpret these characters' widths to be 2. (Note that this option will only be effective when `display.unicode.east_asian_width` is enabled.)

However, setting this option incorrectly for your terminal will cause these characters to be aligned incorrectly:

```
In [90]: pd.set_option('display.unicode.ambiguous_as_wide', True)

In [91]: df;
```

```
>>> pd.set_option('display.unicode.ambiguous_as_wide', True)
>>> df
      a     b
0   xxx   yyy
1  ¡¡  ¡¡
```

11.8 Table Schema Display

New in version 0.20.0.

`DataFrame` and `Series` will publish a Table Schema representation by default. False by default, this can be enabled globally with the `display.html.table_schema` option:

```
In [92]: pd.set_option('display.html.table_schema', True)
```

Only `'display.max_rows'` are serialized and published.

CHAPTER

TWELVE

INDEXING AND SELECTING DATA

The axis labeling information in pandas objects serves many purposes:

- Identifies data (i.e. provides *metadata*) using known indicators, important for analysis, visualization, and interactive console display
- Enables automatic and explicit data alignment
- Allows intuitive getting and setting of subsets of the data set

In this section, we will focus on the final point: namely, how to slice, dice, and generally get and set subsets of pandas objects. The primary focus will be on Series and DataFrame as they have received more development attention in this area. Expect more work to be invested in higher-dimensional data structures (including `Panel`) in the future, especially in label-based advanced indexing.

Note: The Python and NumPy indexing operators `[]` and attribute operator `.` provide quick and easy access to pandas data structures across a wide range of use cases. This makes interactive work intuitive, as there's little new to learn if you already know how to deal with Python dictionaries and NumPy arrays. However, since the type of the data to be accessed isn't known in advance, directly using standard operators has some optimization limits. For production code, we recommended that you take advantage of the optimized pandas data access methods exposed in this chapter.

Warning: Whether a copy or a reference is returned for a setting operation, may depend on the context. This is sometimes called `chained assignment` and should be avoided. See *Returning a View versus Copy*

Warning: Indexing on an integer-based Index with floats has been clarified in 0.18.0, for a summary of the changes, see *here*.

See the *MultiIndex / Advanced Indexing* for `MultiIndex` and more advanced indexing documentation.

See the *cookbook* for some advanced strategies

12.1 Different Choices for Indexing

Object selection has had a number of user-requested additions in order to support more explicit location based indexing. Pandas now supports three types of multi-axis indexing.

- `.loc` is primarily label based, but may also be used with a boolean array. `.loc` will raise `KeyError` when the items are not found. Allowed inputs are:

  - A single label, e.g. `5` or `'a'`, (note that `5` is interpreted as a *label* of the index. This use is **not** an integer position along the index)
  - A list or array of labels `['a', 'b', 'c']`
  - A slice object with labels `'a':'f'` (note that contrary to usual python slices, **both** the start and the stop are included, when present in the index! - also see *Slicing with labels*)
  - A boolean array
  - A `callable` function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

    New in version 0.18.1.

  See more at *Selection by Label*

- `.iloc` is primarily integer position based (from `0` to `length-1` of the axis), but may also be used with a boolean array. `.iloc` will raise `IndexError` if a requested indexer is out-of-bounds, except *slice* indexers which allow out-of-bounds indexing. (this conforms with python/numpy *slice* semantics). Allowed inputs are:
  - An integer e.g. `5`
  - A list or array of integers `[4, 3, 0]`
  - A slice object with ints `1:7`
  - A boolean array
  - A `callable` function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

    New in version 0.18.1.

  See more at *Selection by Position*

  See more at *Advanced Indexing* and *Advanced Hierarchical*.

- `.loc`, `.iloc`, and also `[]` indexing can accept a `callable` as indexer. See more at *Selection By Callable*.

Getting values from an object with multi-axes selection uses the following notation (using `.loc` as an example, but applies to `.iloc` as well). Any of the axes accessors may be the null slice `:`. Axes left out of the specification are assumed to be `:`. (e.g. `p.loc['a']` is equiv to `p.loc['a', :, :]`)

Object Type	Indexers
Series	`s.loc[indexer]`
DataFrame	`df.loc[row_indexer,column_indexer]`
Panel	`p.loc[item_indexer,major_indexer,minor_indexer]`

12.2 Basics

As mentioned when introducing the data structures in the *last section*, the primary function of indexing with `[]` (a.k.a. `__getitem__` for those familiar with implementing class behavior in Python) is selecting out lower-dimensional slices. Thus,

Object Type	Selection	Return Value Type
Series	`series[label]`	scalar value
DataFrame	`frame[colname]`	`Series` corresponding to colname
Panel	`panel[itemname]`	`DataFrame` corresponding to the itemname

Here we construct a simple time series data set to use for illustrating the indexing functionality:

```
In [1]: dates = pd.date_range('1/1/2000', periods=8)

In [2]: df = pd.DataFrame(np.random.randn(8, 4), index=dates, columns=['A', 'B', 'C',
↪'D'])

In [3]: df
Out[3]:
                   A         B         C         D
2000-01-01  0.469112 -0.282863 -1.509059 -1.135632
2000-01-02  1.212112 -0.173215  0.119209 -1.044236
2000-01-03 -0.861849 -2.104569 -0.494929  1.071804
2000-01-04  0.721555 -0.706771 -1.039575  0.271860
2000-01-05 -0.424972  0.567020  0.276232 -1.087401
2000-01-06 -0.673690  0.113648 -1.478427  0.524988
2000-01-07  0.404705  0.577046 -1.715002 -1.039268
2000-01-08 -0.370647 -1.157892 -1.344312  0.844885

In [4]: panel = pd.Panel({'one' : df, 'two' : df - df.mean()})

In [5]: panel
Out[5]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 8 (major_axis) x 4 (minor_axis)
Items axis: one to two
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-08 00:00:00
Minor_axis axis: A to D
```

Note: None of the indexing functionality is time series specific unless specifically stated.

Thus, as per above, we have the most basic indexing using `[]`:

```
In [6]: s = df['A']

In [7]: s[dates[5]]
Out[7]: -0.67368970808837059

In [8]: panel['two']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[8]:
                   A         B         C         D
2000-01-01  0.409571  0.113086 -0.610826 -0.936507
2000-01-02  1.152571  0.222735  1.017442 -0.845111
2000-01-03 -0.921390 -1.708620  0.403304  1.270929
2000-01-04  0.662014 -0.310822 -0.141342  0.470985
2000-01-05 -0.484513  0.962970  1.174465 -0.888276
2000-01-06 -0.733231  0.509598 -0.580194  0.724113
2000-01-07  0.345164  0.972995 -0.816769 -0.840143
2000-01-08 -0.430188 -0.761943 -0.446079  1.044010
```

You can pass a list of columns to `[]` to select columns in that order. If a column is not contained in the DataFrame, an exception will be raised. Multiple columns can also be set in this manner:

```
In [9]: df
Out[9]:
                   A         B         C         D
2000-01-01  0.469112 -0.282863 -1.509059 -1.135632
2000-01-02  1.212112 -0.173215  0.119209 -1.044236
```

```
2000-01-03 -0.861849 -2.104569 -0.494929  1.071804
2000-01-04  0.721555 -0.706771 -1.039575  0.271860
2000-01-05 -0.424972  0.567020  0.276232 -1.087401
2000-01-06 -0.673690  0.113648 -1.478427  0.524988
2000-01-07  0.404705  0.577046 -1.715002 -1.039268
2000-01-08 -0.370647 -1.157892 -1.344312  0.844885

In [10]: df[['B', 'A']] = df[['A', 'B']]

In [11]: df
Out[11]:
                   A         B         C         D
2000-01-01 -0.282863  0.469112 -1.509059 -1.135632
2000-01-02 -0.173215  1.212112  0.119209 -1.044236
2000-01-03 -2.104569 -0.861849 -0.494929  1.071804
2000-01-04 -0.706771  0.721555 -1.039575  0.271860
2000-01-05  0.567020 -0.424972  0.276232 -1.087401
2000-01-06  0.113648 -0.673690 -1.478427  0.524988
2000-01-07  0.577046  0.404705 -1.715002 -1.039268
2000-01-08 -1.157892 -0.370647 -1.344312  0.844885
```

You may find this useful for applying a transform (in-place) to a subset of the columns.

Warning: pandas aligns all AXES when setting `Series` and `DataFrame` from `.loc`, and `.iloc`.

This will **not** modify `df` because the column alignment is before value assignment.

```
In [12]: df[['A', 'B']]
Out[12]:
                   A         B
2000-01-01 -0.282863  0.469112
2000-01-02 -0.173215  1.212112
2000-01-03 -2.104569 -0.861849
2000-01-04 -0.706771  0.721555
2000-01-05  0.567020 -0.424972
2000-01-06  0.113648 -0.673690
2000-01-07  0.577046  0.404705
2000-01-08 -1.157892 -0.370647

In [13]: df.loc[:,['B', 'A']] = df[['A', 'B']]

In [14]: df[['A', 'B']]
Out[14]:
                   A         B
2000-01-01 -0.282863  0.469112
2000-01-02 -0.173215  1.212112
2000-01-03 -2.104569 -0.861849
2000-01-04 -0.706771  0.721555
2000-01-05  0.567020 -0.424972
2000-01-06  0.113648 -0.673690
2000-01-07  0.577046  0.404705
2000-01-08 -1.157892 -0.370647
```

The correct way is to use raw values

```
In [15]: df.loc[:,['B', 'A']] = df[['A', 'B']].values

In [16]: df[['A', 'B']]
Out[16]: 
                   A         B
2000-01-01  0.469112 -0.282863
2000-01-02  1.212112 -0.173215
2000-01-03 -0.861849 -2.104569
2000-01-04  0.721555 -0.706771
2000-01-05 -0.424972  0.567020
2000-01-06 -0.673690  0.113648
2000-01-07  0.404705  0.577046
2000-01-08 -0.370647 -1.157892
```

12.3 Attribute Access

You may access an index on a `Series`, column on a `DataFrame`, and an item on a `Panel` directly as an attribute:

```
In [17]: sa = pd.Series([1,2,3],index=list('abc'))

In [18]: dfa = df.copy()
```

```
In [19]: sa.b
Out[19]: 2

In [20]: dfa.A
\\\\\\\\\\\Out[20]: 
2000-01-01    0.469112
2000-01-02    1.212112
2000-01-03   -0.861849
2000-01-04    0.721555
2000-01-05   -0.424972
2000-01-06   -0.673690
2000-01-07    0.404705
2000-01-08   -0.370647
Freq: D, Name: A, dtype: float64

In [21]: panel.one
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-01  0.469112 -0.282863 -1.509059 -1.135632
2000-01-02  1.212112 -0.173215  0.119209 -1.044236
2000-01-03 -0.861849 -2.104569 -0.494929  1.071804
2000-01-04  0.721555 -0.706771 -1.039575  0.271860
2000-01-05 -0.424972  0.567020  0.276232 -1.087401
2000-01-06 -0.673690  0.113648 -1.478427  0.524988
2000-01-07  0.404705  0.577046 -1.715002 -1.039268
2000-01-08 -0.370647 -1.157892 -1.344312  0.844885
```

```
In [22]: sa.a = 5

In [23]: sa
```

```
Out[23]:
a    5
b    2
c    3
dtype: int64

In [24]: dfa.A = list(range(len(dfa.index)))  # ok if A already exists

In [25]: dfa
Out[25]:
            A         B         C         D
2000-01-01  0 -0.282863 -1.509059 -1.135632
2000-01-02  1 -0.173215  0.119209 -1.044236
2000-01-03  2 -2.104569 -0.494929  1.071804
2000-01-04  3 -0.706771 -1.039575  0.271860
2000-01-05  4  0.567020  0.276232 -1.087401
2000-01-06  5  0.113648 -1.478427  0.524988
2000-01-07  6  0.577046 -1.715002 -1.039268
2000-01-08  7 -1.157892 -1.344312  0.844885

In [26]: dfa['A'] = list(range(len(dfa.index)))  # use this form to create a new␣
↪column

In [27]: dfa
Out[27]:
            A         B         C         D
2000-01-01  0 -0.282863 -1.509059 -1.135632
2000-01-02  1 -0.173215  0.119209 -1.044236
2000-01-03  2 -2.104569 -0.494929  1.071804
2000-01-04  3 -0.706771 -1.039575  0.271860
2000-01-05  4  0.567020  0.276232 -1.087401
2000-01-06  5  0.113648 -1.478427  0.524988
2000-01-07  6  0.577046 -1.715002 -1.039268
2000-01-08  7 -1.157892 -1.344312  0.844885
```

Warning:

- You can use this access only if the index element is a valid python identifier, e.g. `s.1` is not allowed. See here for an explanation of valid identifiers.
- The attribute will not be available if it conflicts with an existing method name, e.g. `s.min` is not allowed.
- Similarly, the attribute will not be available if it conflicts with any of the following list: `index`, `major_axis`, `minor_axis`, `items`, `labels`.
- In any of these cases, standard indexing will still work, e.g. `s['1']`, `s['min']`, and `s['index']` will access the corresponding element or column.

If you are using the IPython environment, you may also use tab-completion to see these accessible attributes.

You can also assign a `dict` to a row of a `DataFrame`:

```
In [28]: x = pd.DataFrame({'x': [1, 2, 3], 'y': [3, 4, 5]})

In [29]: x.iloc[1] = dict(x=9, y=99)

In [30]: x
```

```
Out[30]:
   x   y
0  1   3
1  9  99
2  3   5
```

You can use attribute access to modify an existing element of a Series or column of a DataFrame, but be careful; if you try to use attribute access to create a new column, it creates a new attribute rather than a new column. In 0.21.0 and later, this will raise a `UserWarning`:

```
In[1]: df = pd.DataFrame({'one': [1., 2., 3.]})
In[2]: df.two = [4, 5, 6]
UserWarning: Pandas doesn't allow Series to be assigned into nonexistent columns -␣
↪see https://pandas.pydata.org/pandas-docs/stable/indexing.html#attribute_access
In[3]: df
Out[3]:
   one
0  1.0
1  2.0
2  3.0
```

12.4 Slicing ranges

The most robust and consistent way of slicing ranges along arbitrary axes is described in the *Selection by Position* section detailing the `.iloc` method. For now, we explain the semantics of slicing using the `[]` operator.

With Series, the syntax works exactly as with an ndarray, returning a slice of the values and the corresponding labels:

```
In [31]: s[:5]
Out[31]:
2000-01-01    0.469112
2000-01-02    1.212112
2000-01-03   -0.861849
2000-01-04    0.721555
2000-01-05   -0.424972
Freq: D, Name: A, dtype: float64

In [32]: s[::2]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-01    0.469112
2000-01-03   -0.861849
2000-01-05   -0.424972
2000-01-07    0.404705
Freq: 2D, Name: A, dtype: float64

In [33]: s[::-1]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-08   -0.370647
2000-01-07    0.404705
2000-01-06   -0.673690
2000-01-05   -0.424972
2000-01-04    0.721555
2000-01-03   -0.861849
```

```
2000-01-02    1.212112
2000-01-01    0.469112
Freq: -1D, Name: A, dtype: float64
```

Note that setting works as well:

```
In [34]: s2 = s.copy()

In [35]: s2[:5] = 0

In [36]: s2
Out[36]:
2000-01-01    0.000000
2000-01-02    0.000000
2000-01-03    0.000000
2000-01-04    0.000000
2000-01-05    0.000000
2000-01-06   -0.673690
2000-01-07    0.404705
2000-01-08   -0.370647
Freq: D, Name: A, dtype: float64
```

With DataFrame, slicing inside of `[]` **slices the rows**. This is provided largely as a convenience since it is such a common operation.

```
In [37]: df[:3]
Out[37]:
                   A         B         C         D
2000-01-01  0.469112 -0.282863 -1.509059 -1.135632
2000-01-02  1.212112 -0.173215  0.119209 -1.044236
2000-01-03 -0.861849 -2.104569 -0.494929  1.071804

In [38]: df[::-1]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-08 -0.370647 -1.157892 -1.344312  0.844885
2000-01-07  0.404705  0.577046 -1.715002 -1.039268
2000-01-06 -0.673690  0.113648 -1.478427  0.524988
2000-01-05 -0.424972  0.567020  0.276232 -1.087401
2000-01-04  0.721555 -0.706771 -1.039575  0.271860
2000-01-03 -0.861849 -2.104569 -0.494929  1.071804
2000-01-02  1.212112 -0.173215  0.119209 -1.044236
2000-01-01  0.469112 -0.282863 -1.509059 -1.135632
```

12.5 Selection By Label

Warning: Whether a copy or a reference is returned for a setting operation, may depend on the context. This is sometimes called `chained assignment` and should be avoided. See *Returning a View versus Copy*

Warning:

`.loc` is strict when you present slicers that are not compatible (or convertible) with the index type. For example using integers in a `DatetimeIndex`. These will raise a `TypeError`.

```
In [39]: dfl = pd.DataFrame(np.random.randn(5,4), columns=list('ABCD'), index=pd.
↪date_range('20130101',periods=5))

In [40]: dfl
Out[40]:
                   A         B         C         D
2013-01-01  1.075770 -0.109050  1.643563 -1.469388
2013-01-02  0.357021 -0.674600 -1.776904 -0.968914
2013-01-03 -1.294524  0.413738  0.276662 -0.472035
2013-01-04 -0.013960 -0.362543 -0.006154 -0.923061
2013-01-05  0.895717  0.805244 -1.206412  2.565646
```

```
In [4]: dfl.loc[2:3]
TypeError: cannot do slice indexing on <class 'pandas.tseries.index.DatetimeIndex'>␣
↪with these indexers [2] of <type 'int'>
```

String likes in slicing *can* be convertible to the type of the index and lead to natural slicing.

```
In [41]: dfl.loc['20130102':'20130104']
Out[41]:
                   A         B         C         D
2013-01-02  0.357021 -0.674600 -1.776904 -0.968914
2013-01-03 -1.294524  0.413738  0.276662 -0.472035
2013-01-04 -0.013960 -0.362543 -0.006154 -0.923061
```

Warning: Starting in 0.21.0, pandas will show a `FutureWarning` if indexing with a list with missing labels. In the future this will raise a `KeyError`. See *list-like Using loc with missing keys in a list is Deprecated*

pandas provides a suite of methods in order to have **purely label based indexing**. This is a strict inclusion based protocol. All of the labels for which you ask, must be in the index or a `KeyError` will be raised! When slicing, both the start bound **AND** the stop bound are *included*, if present in the index. Integers are valid labels, but they refer to the label **and not the position**.

The `.loc` attribute is the primary access method. The following are valid inputs:

- A single label, e.g. `5` or `'a'`, (note that `5` is interpreted as a *label* of the index. This use is **not** an integer position along the index)
- A list or array of labels `['a', 'b', 'c']`
- A slice object with labels `'a':'f'` (note that contrary to usual python slices, **both** the start and the stop are included, when present in the index! - also See *Slicing with labels*)
- A boolean array
- A `callable`, see *Selection By Callable*

```
In [42]: s1 = pd.Series(np.random.randn(6),index=list('abcdef'))

In [43]: s1
Out[43]:
a    1.431256
```

```
b    1.340309
c   -1.170299
d   -0.226169
e    0.410835
f    0.813850
dtype: float64

In [44]: s1.loc['c':]
\\\
```

Accessing via label slices

```
In [51]: df1.loc['d':, 'A':'C']
Out[51]:
          A         B         C
d  0.974466 -2.006747 -0.410001
e  0.545952 -1.219217 -1.226825
f -1.281247 -0.727707 -0.121306
```

For getting a cross section using a label (equiv to `df.xs('a')`)

```
In [52]: df1.loc['a']
Out[52]:
A    0.132003
B   -0.827317
C   -0.076467
D   -1.187678
Name: a, dtype: float64
```

For getting values with a boolean array

```
In [53]: df1.loc['a'] > 0
Out[53]:
A     True
B    False
C    False
D    False
Name: a, dtype: bool

In [54]: df1.loc[:, df1.loc['a'] > 0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[54]:
          A
a  0.132003
b  1.130127
c  1.024180
d  0.974466
e  0.545952
f -1.281247
```

For getting a value explicitly (equiv to deprecated `df.get_value('a','A')`)

```
# this is also equivalent to ``df1.at['a','A']``
In [55]: df1.loc['a', 'A']
Out[55]: 0.13200317033032932
```

12.5.1 Slicing with labels

When using `.loc` with slices, if both the start and the stop labels are present in the index, then elements *located* between the two (including them) are returned:

```
In [56]: s = pd.Series(list('abcde'), index=[0,3,2,5,4])

In [57]: s.loc[3:5]
Out[57]:
3    b
2    c
```

```
5    d
dtype: object
```

If at least one of the two is absent, but the index is sorted, and can be compared against start and stop labels, then slicing will still work as expected, by selecting labels which *rank* between the two:

```
In [58]: s.sort_index()
Out[58]:
0    a
2    c
3    b
4    e
5    d
dtype: object

In [59]: s.sort_index().loc[1:6]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[59]:
2    c
3    b
4    e
5    d
dtype: object
```

However, if at least one of the two is absent *and* the index is not sorted, an error will be raised (since doing otherwise would be computationally expensive, as well as potentially ambiguous for mixed type indexes). For instance, in the above example, `s.loc[1:6]` would raise `KeyError`.

12.6 Selection By Position

Warning: Whether a copy or a reference is returned for a setting operation, may depend on the context. This is sometimes called `chained assignment` and should be avoided. See *Returning a View versus Copy*

Pandas provides a suite of methods in order to get **purely integer based indexing**. The semantics follow closely python and numpy slicing. These are `0-based` indexing. When slicing, the start bounds is *included*, while the upper bound is *excluded*. Trying to use a non-integer, even a **valid** label will raise an `IndexError`.

The `.iloc` attribute is the primary access method. The following are valid inputs:

- An integer e.g. `5`
- A list or array of integers `[4, 3, 0]`
- A slice object with ints `1:7`
- A boolean array
- A `callable`, see *Selection By Callable*

```
In [60]: s1 = pd.Series(np.random.randn(5), index=list(range(0,10,2)))

In [61]: s1
Out[61]:
0    0.695775
2    0.341734
4    0.959726
```

```
6   -1.110336
8   -0.619976
dtype: float64

In [62]: s1.iloc[:3]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[62
↪
0    0.695775
2    0.341734
4    0.959726
dtype: float64

In [63]: s1.iloc[3]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪-1.1103361028911669
```

Note that setting works as well:

```
In [64]: s1.iloc[:3] = 0

In [65]: s1
Out[65]:
0    0.000000
2    0.000000
4    0.000000
6   -1.110336
8   -0.619976
dtype: float64
```

With a DataFrame

```
In [66]: df1 = pd.DataFrame(np.random.randn(6,4),
   ....:                    index=list(range(0,12,2)),
   ....:                    columns=list(range(0,8,2)))
   ....:

In [67]: df1
Out[67]:
           0         2         4         6
0   0.149748 -0.732339  0.687738  0.176444
2   0.403310 -0.154951  0.301624 -2.179861
4  -1.369849 -0.954208  1.462696 -1.743161
6  -0.826591 -0.345352  1.314232  0.690579
8   0.995761  2.396780  0.014871  3.357427
10 -0.317441 -1.236269  0.896171 -0.487602
```

Select via integer slicing

```
In [68]: df1.iloc[:3]
Out[68]:
          0         2         4         6
0  0.149748 -0.732339  0.687738  0.176444
2  0.403310 -0.154951  0.301624 -2.179861
4 -1.369849 -0.954208  1.462696 -1.743161

In [69]: df1.iloc[1:5, 2:4]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
          4         6
2  0.301624 -2.179861
4  1.462696 -1.743161
6  1.314232  0.690579
8  0.014871  3.357427
```

Select via integer list

```
In [70]: df1.iloc[[1, 3, 5], [1, 3]]
Out[70]:
           2         6
2  -0.154951 -2.179861
6  -0.345352  0.690579
10 -1.236269 -0.487602
```

```
In [71]: df1.iloc[1:3, :]
Out[71]:
          0         2         4         6
2  0.403310 -0.154951  0.301624 -2.179861
4 -1.369849 -0.954208  1.462696 -1.743161
```

```
In [72]: df1.iloc[:, 1:3]
Out[72]:
           2         4
0  -0.732339  0.687738
2  -0.154951  0.301624
4  -0.954208  1.462696
6  -0.345352  1.314232
8   2.396780  0.014871
10 -1.236269  0.896171
```

```
# this is also equivalent to ``df1.iat[1,1]``
In [73]: df1.iloc[1, 1]
Out[73]: -0.15495077442490321
```

For getting a cross section using an integer position (equiv to `df.xs(1)`)

```
In [74]: df1.iloc[1]
Out[74]:
0    0.403310
2   -0.154951
4    0.301624
6   -2.179861
Name: 2, dtype: float64
```

Out of range slice indexes are handled gracefully just as in Python/Numpy.

```
# these are allowed in python/numpy.
In [75]: x = list('abcdef')

In [76]: x
Out[76]: ['a', 'b', 'c', 'd', 'e', 'f']

In [77]: x[4:10]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[77]: ['e', 'f']

In [78]: x[8:10]
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[78]: []

In [79]: s = pd.Series(x)

In [80]: s
Out[80]:
0    a
1    b
2    c
3    d
4    e
5    f
dtype: object

In [81]: s.iloc[4:10]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[81]:
4    e
5    f
dtype: object

In [82]: s.iloc[8:10]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Series([], dtype: object)
```

Note that using slices that go out of bounds can result in an empty axis (e.g. an empty DataFrame being returned)

```
In [83]: dfl = pd.DataFrame(np.random.randn(5,2), columns=list('AB'))

In [84]: dfl
Out[84]:
          A         B
0 -0.082240 -2.182937
1  0.380396  0.084844
2  0.432390  1.519970
3 -0.493662  0.600178
4  0.274230  0.132885

In [85]: dfl.iloc[:, 2:3]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
Empty DataFrame
Columns: []
Index: [0, 1, 2, 3, 4]

In [86]: dfl.iloc[:, 1:3]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          B
0 -2.182937
1  0.084844
2  1.519970
3  0.600178
4  0.132885

In [87]: dfl.iloc[4:6]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
         A         B
```

```
4  0.27423  0.132885
```

A single indexer that is out of bounds will raise an `IndexError`. A list of indexers where any element is out of bounds will raise an `IndexError`

```
dfl.iloc[[4, 5, 6]]
IndexError: positional indexers are out-of-bounds

dfl.iloc[:, 4]
IndexError: single positional indexer is out-of-bounds
```

12.7 Selection By Callable

New in version 0.18.1.

`.loc`, `.iloc`, and also `[]` indexing can accept a `callable` as indexer. The `callable` must be a function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing.

```
In [88]: df1 = pd.DataFrame(np.random.randn(6, 4),
   ....:                    index=list('abcdef'),
   ....:                    columns=list('ABCD'))
   ....:

In [89]: df1
Out[89]: 
          A         B         C         D
a -0.023688  2.410179  1.450520  0.206053
b -0.251905 -2.213588  1.063327  1.266143
c  0.299368 -0.863838  0.408204 -1.048089
d -0.025747 -0.988387  0.094055  1.262731
e  1.289997  0.082423 -0.055758  0.536580
f -0.489682  0.369374 -0.034571 -2.484478

In [90]: df1.loc[lambda df: df.A > 0, :]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B         C         D
c  0.299368 -0.863838  0.408204 -1.048089
e  1.289997  0.082423 -0.055758  0.536580

In [91]: df1.loc[:, lambda df: ['A', 'B']]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B
a -0.023688  2.410179
b -0.251905 -2.213588
c  0.299368 -0.863838
d -0.025747 -0.988387
e  1.289997  0.082423
f -0.489682  0.369374

In [92]: df1.iloc[:, lambda df: [0, 1]]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B
a -0.023688  2.410179
```

```
b -0.251905 -2.213588
c  0.299368 -0.863838
d -0.025747 -0.988387
e  1.289997  0.082423
f -0.489682  0.369374

In [93]: df1[lambda df: df.columns[0]]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
a   -0.023688
b   -0.251905
c    0.299368
d   -0.025747
e    1.289997
f   -0.489682
Name: A, dtype: float64
```

You can use callable indexing in `Series`.

```
In [94]: df1.A.loc[lambda s: s > 0]
Out[94]:
c    0.299368
e    1.289997
Name: A, dtype: float64
```

Using these methods / indexers, you can chain data selection operations without using temporary variable.

```
In [95]: bb = pd.read_csv('data/baseball.csv', index_col='id')

In [96]: (bb.groupby(['year', 'team']).sum()
   ....:    .loc[lambda df: df.r > 100])
   ....:
Out[96]:
           stint    g    ab    r    h  X2b  X3b  hr    rbi    sb   cs   bb  \
year team
2007 CIN       6  379   745  101  203   35    2  36  125.0  10.0  1.0  105
     DET       5  301  1062  162  283   54    4  37  144.0  24.0  7.0   97
     HOU       4  311   926  109  218   47    6  14   77.0  10.0  4.0   60
     LAN      11  413  1021  153  293   61    3  36  154.0   7.0  5.0  114
     NYN      13  622  1854  240  509  101    3  61  243.0  22.0  4.0  174
     SFN       5  482  1305  198  337   67    6  40  171.0  26.0  7.0  235
     TEX       2  198   729  115  200   40    4  28  115.0  21.0  4.0   73
     TOR       4  459  1408  187  378   96    2  58  223.0   4.0  2.0  190

              so   ibb   hbp    sh    sf  gidp
year team
2007 CIN   127.0  14.0   1.0   1.0  15.0  18.0
     DET   176.0   3.0  10.0   4.0   8.0  28.0
     HOU   212.0   3.0   9.0  16.0   6.0  17.0
     LAN   141.0   8.0   9.0   3.0   8.0  29.0
     NYN   310.0  24.0  23.0  18.0  15.0  48.0
     SFN   188.0  51.0   8.0  16.0   6.0  41.0
     TEX   140.0   4.0   5.0   2.0   8.0  16.0
     TOR   265.0  16.0  12.0   4.0  16.0  38.0
```

12.8 IX Indexer is Deprecated

Warning: Starting in 0.20.0, the `.ix` indexer is deprecated, in favor of the more strict `.iloc` and `.loc` indexers.

`.ix` offers a lot of magic on the inference of what the user wants to do. To wit, `.ix` can decide to index *positionally* OR via *labels* depending on the data type of the index. This has caused quite a bit of user confusion over the years.

The recommended methods of indexing are:

- `.loc` if you want to *label* index
- `.iloc` if you want to *positionally* index.

```
In [97]: dfd = pd.DataFrame({'A': [1, 2, 3],
   ....:                     'B': [4, 5, 6]},
   ....:                    index=list('abc'))
   ....:

In [98]: dfd
Out[98]:
   A  B
a  1  4
b  2  5
c  3  6
```

Previous Behavior, where you wish to get the 0th and the 2nd elements from the index in the 'A' column.

```
In [3]: dfd.ix[[0, 2], 'A']
Out[3]:
a    1
c    3
Name: A, dtype: int64
```

Using `.loc`. Here we will select the appropriate indexes from the index, then use *label* indexing.

```
In [99]: dfd.loc[dfd.index[[0, 2]], 'A']
Out[99]:
a    1
c    3
Name: A, dtype: int64
```

This can also be expressed using `.iloc`, by explicitly getting locations on the indexers, and using *positional* indexing to select things.

```
In [100]: dfd.iloc[[0, 2], dfd.columns.get_loc('A')]
Out[100]:
a    1
c    3
Name: A, dtype: int64
```

For getting *multiple* indexers, using `.get_indexer`

```
In [101]: dfd.iloc[[0, 2], dfd.columns.get_indexer(['A', 'B'])]
Out[101]:
   A  B
a  1  4
c  3  6
```

12.9 Indexing with list with missing labels is Deprecated

Warning: Starting in 0.21.0, using `.loc` or `[]` with a list with one or more missing labels, is deprecated, in favor of `.reindex`.

In prior versions, using `.loc[list-of-labels]` would work as long as *at least 1* of the keys was found (otherwise it would raise a `KeyError`). This behavior is deprecated and will show a warning message pointing to this section. The recommeded alternative is to use `.reindex()`.

For example.

```
In [102]: s = pd.Series([1, 2, 3])

In [103]: s
Out[103]:
0    1
1    2
2    3
dtype: int64
```

Selection with all keys found is unchanged.

```
In [104]: s.loc[[1, 2]]
Out[104]:
1    2
2    3
dtype: int64
```

Previous Behavior

```
In [4]: s.loc[[1, 2, 3]]
Out[4]:
1    2.0
2    3.0
3    NaN
dtype: float64
```

Current Behavior

```
In [4]: s.loc[[1, 2, 3]]
Passing list-likes to .loc with any non-matching elements will raise
KeyError in the future, you can use .reindex() as an alternative.

See the documentation here:
http://pandas.pydata.org/pandas-docs/stable/indexing.html#deprecate-loc-reindex-
↪listlike

Out[4]:
1    2.0
2    3.0
3    NaN
dtype: float64
```

12.9.1 Reindexing

The idiomatic way to achieve selecting potentially not-found elmenents is via `.reindex()`. See also the section on *reindexing*.

```
In [105]: s.reindex([1, 2, 3])
Out[105]:
1    2.0
2    3.0
3    NaN
dtype: float64
```

Alternatively, if you want to select only *valid* keys, the following is idiomatic and efficient; it is guaranteed to preserve the dtype of the selection.

```
In [106]: labels = [1, 2, 3]

In [107]: s.loc[s.index.intersection(labels)]
Out[107]:
1    2
2    3
dtype: int64
```

Having a duplicated index will raise for a `.reindex()`:

```
In [108]: s = pd.Series(np.arange(4), index=['a', 'a', 'b', 'c'])

In [109]: labels = ['c', 'd']
```

```
In [17]: s.reindex(labels)
ValueError: cannot reindex from a duplicate axis
```

Generally, you can interesect the desired labels with the current axis, and then reindex.

```
In [110]: s.loc[s.index.intersection(labels)].reindex(labels)
Out[110]:
c    3.0
d    NaN
dtype: float64
```

However, this would *still* raise if your resulting index is duplicated.

```
In [41]: labels = ['a', 'd']

In [42]: s.loc[s.index.intersection(labels)].reindex(labels)
ValueError: cannot reindex from a duplicate axis
```

12.10 Selecting Random Samples

A random selection of rows or columns from a Series, DataFrame, or Panel with the `sample()` method. The method will sample rows by default, and accepts a specific number of rows/columns to return, or a fraction of rows.

```
In [111]: s = pd.Series([0,1,2,3,4,5])

# When no arguments are passed, returns 1 row.
```

```
In [112]: s.sample()
Out[112]:
4    4
dtype: int64

# One may specify either a number of rows:
In [113]: s.sample(n=3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[113]:
0    0
4    4
1    1
dtype: int64

# Or a fraction of the rows:
In [114]: s.sample(frac=0.5)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[114]:
5    5
3    3
1    1
dtype: int64
```

By default, `sample` will return each row at most once, but one can also sample with replacement using the `replace` option:

```
In [115]: s = pd.Series([0,1,2,3,4,5])

 # Without replacement (default):
In [116]: s.sample(n=6, replace=False)
Out[116]:
0    0
1    1
5    5
3    3
2    2
4    4
dtype: int64

 # With replacement:
In [117]: s.sample(n=6, replace=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[117]:
0    0
4    4
3    3
2    2
4    4
4    4
dtype: int64
```

By default, each row has an equal probability of being selected, but if you want rows to have different probabilities, you can pass the `sample` function sampling weights as `weights`. These weights can be a list, a numpy array, or a Series, but they must be of the same length as the object you are sampling. Missing values will be treated as a weight of zero, and inf values are not allowed. If weights do not sum to 1, they will be re-normalized by dividing all weights by the sum of the weights. For example:

```
In [118]: s = pd.Series([0,1,2,3,4,5])

In [119]: example_weights = [0, 0, 0.2, 0.2, 0.2, 0.4]
```

```
In [120]: s.sample(n=3, weights=example_weights)
Out[120]:
5    5
4    4
3    3
dtype: int64

# Weights will be re-normalized automatically
In [121]: example_weights2 = [0.5, 0, 0, 0, 0, 0]

In [122]: s.sample(n=1, weights=example_weights2)
Out[122]:
0    0
dtype: int64
```

When applied to a DataFrame, you can use a column of the DataFrame as sampling weights (provided you are sampling rows and not columns) by simply passing the name of the column as a string.

```
In [123]: df2 = pd.DataFrame({'col1':[9,8,7,6], 'weight_column':[0.5, 0.4, 0.1, 0]})

In [124]: df2.sample(n = 3, weights = 'weight_column')
Out[124]:
   col1  weight_column
1     8            0.4
0     9            0.5
2     7            0.1
```

`sample` also allows users to sample columns instead of rows using the `axis` argument.

```
In [125]: df3 = pd.DataFrame({'col1':[1,2,3], 'col2':[2,3,4]})

In [126]: df3.sample(n=1, axis=1)
Out[126]:
   col1
0     1
1     2
2     3
```

Finally, one can also set a seed for `sample`'s random number generator using the `random_state` argument, which will accept either an integer (as a seed) or a numpy RandomState object.

```
In [127]: df4 = pd.DataFrame({'col1':[1,2,3], 'col2':[2,3,4]})

# With a given seed, the sample will always draw the same rows.
In [128]: df4.sample(n=2, random_state=2)
Out[128]:
   col1  col2
2     3     4
1     2     3

In [129]: df4.sample(n=2, random_state=2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[129]:
   col1  col2
2     3     4
1     2     3
```

12.11 Setting With Enlargement

The `.loc/[]` operations can perform enlargement when setting a non-existent key for that axis.

In the `Series` case this is effectively an appending operation

```
In [130]: se = pd.Series([1,2,3])

In [131]: se
Out[131]:
0    1
1    2
2    3
dtype: int64

In [132]: se[5] = 5.

In [133]: se
Out[133]:
0    1.0
1    2.0
2    3.0
5    5.0
dtype: float64
```

A `DataFrame` can be enlarged on either axis via `.loc`

```
In [134]: dfi = pd.DataFrame(np.arange(6).reshape(3,2),
   .....:                    columns=['A','B'])
   .....:

In [135]: dfi
Out[135]:
   A  B
0  0  1
1  2  3
2  4  5

In [136]: dfi.loc[:,'C'] = dfi.loc[:,'A']

In [137]: dfi
Out[137]:
   A  B  C
0  0  1  0
1  2  3  2
2  4  5  4
```

This is like an `append` operation on the `DataFrame`.

```
In [138]: dfi.loc[3] = 5

In [139]: dfi
Out[139]:
   A  B  C
0  0  1  0
1  2  3  2
2  4  5  4
3  5  5  5
```

12.12 Fast scalar value getting and setting

Since indexing with `[]` must handle a lot of cases (single-label access, slicing, boolean indexing, etc.), it has a bit of overhead in order to figure out what you're asking for. If you only want to access a scalar value, the fastest way is to use the `at` and `iat` methods, which are implemented on all of the data structures.

Similarly to `loc`, `at` provides **label** based scalar lookups, while, `iat` provides **integer** based lookups analogously to `iloc`

```
In [140]: s.iat[5]
Out[140]: 5

In [141]: df.at[dates[5], 'A']
\\\\\\\\\\\\Out[141]: -0.67368970808837059

In [142]: df.iat[3, 0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[142]: 0.7215551622443669
```

You can also set using these same indexers.

```
In [143]: df.at[dates[5], 'E'] = 7

In [144]: df.iat[3, 0] = 7
```

`at` may enlarge the object in-place as above if the indexer is missing.

```
In [145]: df.at[dates[-1]+1, 0] = 7

In [146]: df
Out[146]:
                   A         B         C         D    E    0
2000-01-01  0.469112 -0.282863 -1.509059 -1.135632  NaN  NaN
2000-01-02  1.212112 -0.173215  0.119209 -1.044236  NaN  NaN
2000-01-03 -0.861849 -2.104569 -0.494929  1.071804  NaN  NaN
2000-01-04  7.000000 -0.706771 -1.039575  0.271860  NaN  NaN
2000-01-05 -0.424972  0.567020  0.276232 -1.087401  NaN  NaN
2000-01-06 -0.673690  0.113648 -1.478427  0.524988  7.0  NaN
2000-01-07  0.404705  0.577046 -1.715002 -1.039268  NaN  NaN
2000-01-08 -0.370647 -1.157892 -1.344312  0.844885  NaN  NaN
2000-01-09       NaN       NaN       NaN       NaN  NaN  7.0
```

12.13 Boolean indexing

Another common operation is the use of boolean vectors to filter the data. The operators are: `|` for `or`, `&` for `and`, and `~` for `not`. These **must** be grouped by using parentheses.

Using a boolean vector to index a Series works exactly as in a numpy ndarray:

```
In [147]: s = pd.Series(range(-3, 4))

In [148]: s
Out[148]:
0   -3
1   -2
2   -1
```

```
3    0
4    1
5    2
6    3
dtype: int64

In [149]: s[s > 0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[149]:
4    1
5    2
6    3
dtype: int64

In [150]: s[(s < -1) | (s > 0.5)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   -3
1   -2
4    1
5    2
6    3
dtype: int64

In [151]: s[~(s < 0)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
3    0
4    1
5    2
6    3
dtype: int64
```

You may select rows from a DataFrame using a boolean vector the same length as the DataFrame's index (for example, something derived from one of the columns of the DataFrame):

```
In [152]: df[df['A'] > 0]
Out[152]:
                   A         B         C         D   E   0
2000-01-01  0.469112 -0.282863 -1.509059 -1.135632 NaN NaN
2000-01-02  1.212112 -0.173215  0.119209 -1.044236 NaN NaN
2000-01-04  7.000000 -0.706771 -1.039575  0.271860 NaN NaN
2000-01-07  0.404705  0.577046 -1.715002 -1.039268 NaN NaN
```

List comprehensions and `map` method of Series can also be used to produce more complex criteria:

```
In [153]: df2 = pd.DataFrame({'a' : ['one', 'one', 'two', 'three', 'two', 'one', 'six
↪'],
   .....:                     'b' : ['x', 'y', 'y', 'x', 'y', 'x', 'x'],
   .....:                     'c' : np.random.randn(7)})
   .....:

# only want 'two' or 'three'
In [154]: criterion = df2['a'].map(lambda x: x.startswith('t'))

In [155]: df2[criterion]
Out[155]:
       a  b         c
2    two  y  0.041290
```

```
3  three  x  0.361719
4    two  y -0.238075

# equivalent but slower
In [156]: df2[[x.startswith('t') for x in df2['a']]]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Ou
↪
       a  b         c
2    two  y  0.041290
3  three  x  0.361719
4    two  y -0.238075

# Multiple criteria
In [157]: df2[criterion & (df2['b'] == 'x')]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
       a  b         c
3  three  x  0.361719
```

Note, with the choice methods *Selection by Label*, *Selection by Position*, and *Advanced Indexing* you may select along more than one axis using boolean vectors combined with other indexing expressions.

```
In [158]: df2.loc[criterion & (df2['b'] == 'x'),'b':'c']
Out[158]:
   b         c
3  x  0.361719
```

12.14 Indexing with isin

Consider the `isin` method of Series, which returns a boolean vector that is true wherever the Series elements exist in the passed list. This allows you to select rows where one or more columns have values you want:

```
In [159]: s = pd.Series(np.arange(5), index=np.arange(5)[::-1], dtype='int64')

In [160]: s
Out[160]:
4    0
3    1
2    2
1    3
0    4
dtype: int64

In [161]: s.isin([2, 4, 6])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[161]:
4    False
3    False
2     True
1    False
0     True
dtype: bool

In [162]: s[s.isin([2, 4, 6])]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
2    2
0    4
dtype: int64
```

The same method is available for `Index` objects and is useful for the cases when you don't know which of the sought labels are in fact present:

```
In [163]: s[s.index.isin([2, 4, 6])]
Out[163]:
4    0
2    2
dtype: int64

# compare it to the following
In [164]: s.reindex([2, 4, 6])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[164]:
2    2.0
4    0.0
6    NaN
dtype: float64
```

In addition to that, `MultiIndex` allows selecting a separate level to use in the membership check:

```
In [165]: s_mi = pd.Series(np.arange(6),
   .....:                  index=pd.MultiIndex.from_product([[0, 1], ['a', 'b', 'c
↪']]))
   .....:

In [166]: s_mi
Out[166]:
0  a    0
   b    1
   c    2
1  a    3
   b    4
   c    5
dtype: int64

In [167]: s_mi.iloc[s_mi.index.isin([(1, 'a'), (2, 'b'), (0, 'c')])]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[167]:␣
↪
0  c    2
1  a    3
dtype: int64

In [168]: s_mi.iloc[s_mi.index.isin(['a', 'c', 'e'], level=1)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0  a    0
   c    2
1  a    3
   c    5
dtype: int64
```

DataFrame also has an `isin` method. When calling `isin`, pass a set of values as either an array or dict. If values is an array, `isin` returns a DataFrame of booleans that is the same shape as the original DataFrame, with True wherever the element is in the sequence of values.

```
In [169]: df = pd.DataFrame({'vals': [1, 2, 3, 4], 'ids': ['a', 'b', 'f', 'n'],
   .....:                    'ids2': ['a', 'n', 'c', 'n']})
   .....:

In [170]: values = ['a', 'b', 1, 3]

In [171]: df.isin(values)
Out[171]:
     ids   ids2   vals
0   True   True   True
1   True  False  False
2  False  False   True
3  False  False  False
```

Oftentimes you'll want to match certain values with certain columns. Just make values a `dict` where the key is the column, and the value is a list of items you want to check for.

```
In [172]: values = {'ids': ['a', 'b'], 'vals': [1, 3]}

In [173]: df.isin(values)
Out[173]:
     ids   ids2   vals
0   True  False   True
1   True  False  False
2  False  False   True
3  False  False  False
```

Combine DataFrame's `isin` with the `any()` and `all()` methods to quickly select subsets of your data that meet a given criteria. To select a row where each column meets its own criterion:

```
In [174]: values = {'ids': ['a', 'b'], 'ids2': ['a', 'c'], 'vals': [1, 3]}

In [175]: row_mask = df.isin(values).all(1)

In [176]: df[row_mask]
Out[176]:
  ids ids2  vals
0   a    a     1
```

12.15 The `where()` Method and Masking

Selecting values from a Series with a boolean vector generally returns a subset of the data. To guarantee that selection output has the same shape as the original data, you can use the `where` method in `Series` and `DataFrame`.

To return only the selected rows

```
In [177]: s[s > 0]
Out[177]:
3    1
2    2
1    3
0    4
dtype: int64
```

To return a Series of the same shape as the original

```
In [178]: s.where(s > 0)
Out[178]:
4    NaN
3    1.0
2    2.0
1    3.0
0    4.0
dtype: float64
```

Selecting values from a DataFrame with a boolean criterion now also preserves input data shape. `where` is used under the hood as the implementation. Equivalent is `df.where(df < 0)`

```
In [179]: df[df < 0]
Out[179]:
                   A         B         C         D
2000-01-01 -2.104139 -1.309525       NaN       NaN
2000-01-02 -0.352480       NaN -1.192319       NaN
2000-01-03 -0.864883       NaN -0.227870       NaN
2000-01-04       NaN -1.222082       NaN -1.233203
2000-01-05       NaN -0.605656 -1.169184       NaN
2000-01-06       NaN -0.948458       NaN -0.684718
2000-01-07 -2.670153 -0.114722       NaN -0.048048
2000-01-08       NaN       NaN -0.048788 -0.808838
```

In addition, `where` takes an optional `other` argument for replacement of values where the condition is False, in the returned copy.

```
In [180]: df.where(df < 0, -df)
Out[180]:
                   A         B         C         D
2000-01-01 -2.104139 -1.309525 -0.485855 -0.245166
2000-01-02 -0.352480 -0.390389 -1.192319 -1.655824
2000-01-03 -0.864883 -0.299674 -0.227870 -0.281059
2000-01-04 -0.846958 -1.222082 -0.600705 -1.233203
2000-01-05 -0.669692 -0.605656 -1.169184 -0.342416
2000-01-06 -0.868584 -0.948458 -2.297780 -0.684718
2000-01-07 -2.670153 -0.114722 -0.168904 -0.048048
2000-01-08 -0.801196 -1.392071 -0.048788 -0.808838
```

You may wish to set values based on some boolean criteria. This can be done intuitively like so:

```
In [181]: s2 = s.copy()

In [182]: s2[s2 < 0] = 0

In [183]: s2
Out[183]:
4    0
3    1
2    2
1    3
0    4
dtype: int64

In [184]: df2 = df.copy()

In [185]: df2[df2 < 0] = 0
```

```
In [186]: df2
Out[186]:
                   A         B         C         D
2000-01-01  0.000000  0.000000  0.485855  0.245166
2000-01-02  0.000000  0.390389  0.000000  1.655824
2000-01-03  0.000000  0.299674  0.000000  0.281059
2000-01-04  0.846958  0.000000  0.600705  0.000000
2000-01-05  0.669692  0.000000  0.000000  0.342416
2000-01-06  0.868584  0.000000  2.297780  0.000000
2000-01-07  0.000000  0.000000  0.168904  0.000000
2000-01-08  0.801196  1.392071  0.000000  0.000000
```

By default, `where` returns a modified copy of the data. There is an optional parameter `inplace` so that the original data can be modified without creating a copy:

```
In [187]: df_orig = df.copy()

In [188]: df_orig.where(df > 0, -df, inplace=True);

In [189]: df_orig
Out[189]:
                   A         B         C         D
2000-01-01  2.104139  1.309525  0.485855  0.245166
2000-01-02  0.352480  0.390389  1.192319  1.655824
2000-01-03  0.864883  0.299674  0.227870  0.281059
2000-01-04  0.846958  1.222082  0.600705  1.233203
2000-01-05  0.669692  0.605656  1.169184  0.342416
2000-01-06  0.868584  0.948458  2.297780  0.684718
2000-01-07  2.670153  0.114722  0.168904  0.048048
2000-01-08  0.801196  1.392071  0.048788  0.808838
```

Note: The signature for *`DataFrame.where()`* differs from `numpy.where()`. Roughly `df1.where(m, df2)` is equivalent to `np.where(m, df1, df2)`.

```
In [190]: df.where(df < 0, -df) == np.where(df < 0, df, -df)
Out[190]:
               A     B     C     D
2000-01-01  True  True  True  True
2000-01-02  True  True  True  True
2000-01-03  True  True  True  True
2000-01-04  True  True  True  True
2000-01-05  True  True  True  True
2000-01-06  True  True  True  True
2000-01-07  True  True  True  True
2000-01-08  True  True  True  True
```

alignment

Furthermore, `where` aligns the input boolean condition (ndarray or DataFrame), such that partial selection with setting is possible. This is analogous to partial setting via `.loc` (but on the contents rather than the axis labels)

```
In [191]: df2 = df.copy()

In [192]: df2[ df2[1:4] > 0 ] = 3

In [193]: df2
```

```
Out[193]:
                   A         B         C         D
2000-01-01 -2.104139 -1.309525  0.485855  0.245166
2000-01-02 -0.352480  3.000000 -1.192319  3.000000
2000-01-03 -0.864883  3.000000 -0.227870  3.000000
2000-01-04  3.000000 -1.222082  3.000000 -1.233203
2000-01-05  0.669692 -0.605656 -1.169184  0.342416
2000-01-06  0.868584 -0.948458  2.297780 -0.684718
2000-01-07 -2.670153 -0.114722  0.168904 -0.048048
2000-01-08  0.801196  1.392071 -0.048788 -0.808838
```

Where can also accept `axis` and `level` parameters to align the input when performing the `where`.

```
In [194]: df2 = df.copy()

In [195]: df2.where(df2>0,df2['A'],axis='index')
Out[195]:
                   A         B         C         D
2000-01-01 -2.104139 -2.104139  0.485855  0.245166
2000-01-02 -0.352480  0.390389 -0.352480  1.655824
2000-01-03 -0.864883  0.299674 -0.864883  0.281059
2000-01-04  0.846958  0.846958  0.600705  0.846958
2000-01-05  0.669692  0.669692  0.669692  0.342416
2000-01-06  0.868584  0.868584  2.297780  0.868584
2000-01-07 -2.670153 -2.670153  0.168904 -2.670153
2000-01-08  0.801196  1.392071  0.801196  0.801196
```

This is equivalent (but faster than) the following.

```
In [196]: df2 = df.copy()

In [197]: df.apply(lambda x, y: x.where(x>0,y), y=df['A'])
Out[197]:
                   A         B         C         D
2000-01-01 -2.104139 -2.104139  0.485855  0.245166
2000-01-02 -0.352480  0.390389 -0.352480  1.655824
2000-01-03 -0.864883  0.299674 -0.864883  0.281059
2000-01-04  0.846958  0.846958  0.600705  0.846958
2000-01-05  0.669692  0.669692  0.669692  0.342416
2000-01-06  0.868584  0.868584  2.297780  0.868584
2000-01-07 -2.670153 -2.670153  0.168904 -2.670153
2000-01-08  0.801196  1.392071  0.801196  0.801196
```

New in version 0.18.1.

Where can accept a callable as condition and `other` arguments. The function must be with one argument (the calling Series or DataFrame) and that returns valid output as condition and `other` argument.

```
In [198]: df3 = pd.DataFrame({'A': [1, 2, 3],
   .....:                     'B': [4, 5, 6],
   .....:                     'C': [7, 8, 9]})
   .....:

In [199]: df3.where(lambda x: x > 4, lambda x: x + 10)
Out[199]:
    A   B  C
0  11  14  7
1  12   5  8
```

```
2  13   6  9
```

mask

`mask` is the inverse boolean operation of `where`.

```
In [200]: s.mask(s >= 0)
Out[200]:
4   NaN
3   NaN
2   NaN
1   NaN
0   NaN
dtype: float64

In [201]: df.mask(df >= 0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[201]:
                   A         B         C         D
2000-01-01 -2.104139 -1.309525       NaN       NaN
2000-01-02 -0.352480       NaN -1.192319       NaN
2000-01-03 -0.864883       NaN -0.227870       NaN
2000-01-04       NaN -1.222082       NaN -1.233203
2000-01-05       NaN -0.605656 -1.169184       NaN
2000-01-06       NaN -0.948458       NaN -0.684718
2000-01-07 -2.670153 -0.114722       NaN -0.048048
2000-01-08       NaN       NaN -0.048788 -0.808838
```

12.16 The `query()` Method (Experimental)

`DataFrame` objects have a *`query()`* method that allows selection using an expression.

You can get the value of the frame where column `b` has values between the values of columns `a` and `c`. For example:

```
In [202]: n = 10

In [203]: df = pd.DataFrame(np.random.rand(n, 3), columns=list('abc'))

In [204]: df
Out[204]:
          a         b         c
0  0.438921  0.118680  0.863670
1  0.138138  0.577363  0.686602
2  0.595307  0.564592  0.520630
3  0.913052  0.926075  0.616184
4  0.078718  0.854477  0.898725
5  0.076404  0.523211  0.591538
6  0.792342  0.216974  0.564056
7  0.397890  0.454131  0.915716
8  0.074315  0.437913  0.019794
9  0.559209  0.502065  0.026437

# pure python
In [205]: df[(df.a < df.b) & (df.b < df.c)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          a         b         c
```

```
1  0.138138  0.577363  0.686602
4  0.078718  0.854477  0.898725
5  0.076404  0.523211  0.591538
7  0.397890  0.454131  0.915716

# query
In [206]: df.query('(a < b) & (b < c)')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          a         b         c
1  0.138138  0.577363  0.686602
4  0.078718  0.854477  0.898725
5  0.076404  0.523211  0.591538
7  0.397890  0.454131  0.915716
```

Do the same thing but fall back on a named index if there is no column with the name `a`.

```
In [207]: df = pd.DataFrame(np.random.randint(n / 2, size=(n, 2)), columns=list('bc'))

In [208]: df.index.name = 'a'

In [209]: df
Out[209]:
   b  c
a
0  0  4
1  0  1
2  3  4
3  4  3
4  1  4
5  0  3
6  0  1
7  3  4
8  2  3
9  1  1

In [210]: df.query('a < b and b < c')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   b  c
a
2  3  4
```

If instead you don't want to or cannot name your index, you can use the name `index` in your query expression:

```
In [211]: df = pd.DataFrame(np.random.randint(n, size=(n, 2)), columns=list('bc'))

In [212]: df
Out[212]:
   b  c
0  3  1
1  3  0
2  5  6
3  5  2
4  7  4
5  0  1
6  2  5
7  0  1
```

```
8   6   0
9   7   9

In [213]: df.query('index < b < c')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Ou
↪
   b  c
2  5  6
```

Note: If the name of your index overlaps with a column name, the column name is given precedence. For example,

```
In [214]: df = pd.DataFrame({'a': np.random.randint(5, size=5)})

In [215]: df.index.name = 'a'

In [216]: df.query('a > 2') # uses the column 'a', not the index
Out[216]:
   a
a
1  3
3  3
```

You can still use the index in a query expression by using the special identifier 'index':

```
In [217]: df.query('index > 2')
Out[217]:
   a
a
3  3
4  2
```

If for some reason you have a column named `index`, then you can refer to the index as `ilevel_0` as well, but at this point you should consider renaming your columns to something less ambiguous.

12.16.1 `MultiIndex` `query()` Syntax

You can also use the levels of a `DataFrame` with a *`MultiIndex`* as if they were columns in the frame:

```
In [218]: n = 10

In [219]: colors = np.random.choice(['red', 'green'], size=n)

In [220]: foods = np.random.choice(['eggs', 'ham'], size=n)

In [221]: colors
Out[221]:
array(['red', 'red', 'red', 'green', 'green', 'green', 'green', 'green',
       'green', 'green'],
      dtype='<U5')

In [222]: foods
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
array(['ham', 'ham', 'eggs', 'eggs', 'eggs', 'ham', 'ham', 'eggs', 'eggs',
```

```
       'eggs'],
      dtype='<U4')

In [223]: index = pd.MultiIndex.from_arrays([colors, foods], names=['color', 'food'])

In [224]: df = pd.DataFrame(np.random.randn(n, 2), index=index)

In [225]: df
Out[225]:
                   0         1
color food
red   ham   0.194889 -0.381994
      ham   0.318587  2.089075
      eggs -0.728293 -0.090255
green eggs -0.748199  1.318931
      eggs -2.029766  0.792652
      ham   0.461007 -0.542749
      ham  -0.305384 -0.479195
      eggs  0.095031 -0.270099
      eggs -0.707140 -0.773882
      eggs  0.229453  0.304418

In [226]: df.query('color == "red"')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   0         1
color food
red   ham   0.194889 -0.381994
      ham   0.318587  2.089075
      eggs -0.728293 -0.090255
```

If the levels of the `MultiIndex` are unnamed, you can refer to them using special names:

```
In [227]: df.index.names = [None, None]

In [228]: df
Out[228]:
                   0         1
red   ham   0.194889 -0.381994
      ham   0.318587  2.089075
      eggs -0.728293 -0.090255
green eggs -0.748199  1.318931
      eggs -2.029766  0.792652
      ham   0.461007 -0.542749
      ham  -0.305384 -0.479195
      eggs  0.095031 -0.270099
      eggs -0.707140 -0.773882
      eggs  0.229453  0.304418

In [229]: df.query('ilevel_0 == "red"')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                 0         1
red ham   0.194889 -0.381994
    ham   0.318587  2.089075
    eggs -0.728293 -0.090255
```

The convention is `ilevel_0`, which means "index level 0" for the 0th level of the `index`.

12.16.2 `query()` Use Cases

A use case for `query()` is when you have a collection of `DataFrame` objects that have a subset of column names (or index levels/names) in common. You can pass the same query to both frames *without* having to specify which frame you're interested in querying

```
In [230]: df = pd.DataFrame(np.random.rand(n, 3), columns=list('abc'))

In [231]: df
Out[231]:
          a         b         c
0  0.224283  0.736107  0.139168
1  0.302827  0.657803  0.713897
2  0.611185  0.136624  0.984960
3  0.195246  0.123436  0.627712
4  0.618673  0.371660  0.047902
5  0.480088  0.062993  0.185760
6  0.568018  0.483467  0.445289
7  0.309040  0.274580  0.587101
8  0.258993  0.477769  0.370255
9  0.550459  0.840870  0.304611

In [232]: df2 = pd.DataFrame(np.random.rand(n + 2, 3), columns=df.columns)

In [233]: df2
Out[233]:
           a         b         c
0   0.357579  0.229800  0.596001
1   0.309059  0.957923  0.965663
2   0.123102  0.336914  0.318616
3   0.526506  0.323321  0.860813
4   0.518736  0.486514  0.384724
5   0.190804  0.505723  0.614533
6   0.891939  0.623977  0.676639
7   0.480559  0.378528  0.460858
8   0.420223  0.136404  0.141295
9   0.732206  0.419540  0.604675
10  0.604466  0.848974  0.896165
11  0.589168  0.920046  0.732716

In [234]: expr = '0.0 <= a <= c <= 0.5'

In [235]: map(lambda frame: frame.query(expr), [df, df2])
Out[235]: <map at 0x12cb5cc18>
```

12.16.3 `query()` Python versus pandas Syntax Comparison

Full numpy-like syntax

```
In [236]: df = pd.DataFrame(np.random.randint(n, size=(n, 3)), columns=list('abc'))

In [237]: df
Out[237]:
   a  b  c
0  7  8  9
1  1  0  7
2  2  7  2
```

```
3  6  2  2
4  2  6  3
5  3  8  2
6  1  7  2
7  5  1  5
8  9  8  0
9  1  5  0

In [238]: df.query('(a < b) & (b < c)')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  b  c
0  7  8  9

In [239]: df[(df.a < df.b) & (df.b < df.c)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  b  c
0  7  8  9
```

Slightly nicer by removing the parentheses (by binding making comparison operators bind tighter than `&`/`|`)

```
In [240]: df.query('a < b & b < c')
Out[240]:
   a  b  c
0  7  8  9
```

Use English instead of symbols

```
In [241]: df.query('a < b and b < c')
Out[241]:
   a  b  c
0  7  8  9
```

Pretty close to how you might write it on paper

```
In [242]: df.query('a < b < c')
Out[242]:
   a  b  c
0  7  8  9
```

12.16.4 The `in` and `not in` operators

`query()` also supports special use of Python's `in` and `not in` comparison operators, providing a succinct syntax for calling the `isin` method of a `Series` or `DataFrame`.

```
# get all rows where columns "a" and "b" have overlapping values
In [243]: df = pd.DataFrame({'a': list('aabbccddeeff'), 'b': list('aaaabbbbcccc'),
   .....:                    'c': np.random.randint(5, size=12),
   .....:                    'd': np.random.randint(9, size=12)})
   .....:

In [244]: df
Out[244]:
    a  b  c  d
0   a  a  2  6
```

```
1   a  a  4  7
2   b  a  1  6
3   b  a  2  1
4   c  b  3  6
5   c  b  0  2
6   d  b  3  3
7   d  b  2  1
8   e  c  4  3
9   e  c  2  0
10  f  c  0  6
11  f  c  1  2

In [245]: df.query('a in b')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  b  c  d
0  a  a  2  6
1  a  a  4  7
2  b  a  1  6
3  b  a  2  1
4  c  b  3  6
5  c  b  0  2

# How you'd do it in pure Python
In [246]: df[df.a.isin(df.b)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  b  c  d
0  a  a  2  6
1  a  a  4  7
2  b  a  1  6
3  b  a  2  1
4  c  b  3  6
5  c  b  0  2

In [247]: df.query('a not in b')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
    a  b  c  d
6   d  b  3  3
7   d  b  2  1
8   e  c  4  3
9   e  c  2  0
10  f  c  0  6
11  f  c  1  2

# pure Python
In [248]: df[~df.a.isin(df.b)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
    a  b  c  d
6   d  b  3  3
7   d  b  2  1
8   e  c  4  3
9   e  c  2  0
10  f  c  0  6
11  f  c  1  2
```

You can combine this with other expressions for very succinct queries:

```
# rows where cols a and b have overlapping values and col c's values are less than␣
↪col d's
In [249]: df.query('a in b and c < d')
Out[249]:
   a  b  c  d
0  a  a  2  6
1  a  a  4  7
2  b  a  1  6
4  c  b  3  6
5  c  b  0  2

# pure Python
In [250]: df[df.b.isin(df.a) & (df.c < df.d)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[25
↪
    a  b  c  d
0   a  a  2  6
1   a  a  4  7
2   b  a  1  6
4   c  b  3  6
5   c  b  0  2
10  f  c  0  6
11  f  c  1  2
```

Note: Note that `in` and `not in` are evaluated in Python, since `numexpr` has no equivalent of this operation. However, **only the** `in`/`not in` **expression itself** is evaluated in vanilla Python. For example, in the expression

```
df.query('a in b + c + d')
```

`(b + c + d)` is evaluated by `numexpr` and *then* the `in` operation is evaluated in plain Python. In general, any operations that can be evaluated using `numexpr` will be.

12.16.5 Special use of the == operator with `list` objects

Comparing a `list` of values to a column using ==/!= works similarly to `in`/`not in`

```
In [251]: df.query('b == ["a", "b", "c"]')
Out[251]:
    a  b  c  d
0   a  a  2  6
1   a  a  4  7
2   b  a  1  6
3   b  a  2  1
4   c  b  3  6
5   c  b  0  2
6   d  b  3  3
7   d  b  2  1
8   e  c  4  3
9   e  c  2  0
10  f  c  0  6
11  f  c  1  2

# pure Python
```

```
In [252]: df[df.b.isin(["a", "b", "c"])]
\\\
```

```
6   d  b  3  3
8   e  c  4  3
10  f  c  0  6

# pure Python
In [257]: df[df.c.isin([1, 2])]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
    a  b  c  d
0   a  a  2  6
2   b  a  1  6
3   b  a  2  1
7   d  b  2  1
9   e  c  2  0
11  f  c  1  2
```

12.16.6 Boolean Operators

You can negate boolean expressions with the word `not` or the ~ operator.

```
In [258]: df = pd.DataFrame(np.random.rand(n, 3), columns=list('abc'))

In [259]: df['bools'] = np.random.rand(len(df)) > 0.5

In [260]: df.query('~bools')
Out[260]:
          a         b         c  bools
2  0.697753  0.212799  0.329209  False
7  0.275396  0.691034  0.826619  False
8  0.190649  0.558748  0.262467  False

In [261]: df.query('not bools')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          a         b         c  bools
2  0.697753  0.212799  0.329209  False
7  0.275396  0.691034  0.826619  False
8  0.190649  0.558748  0.262467  False

In [262]: df.query('not bools') == df[~df.bools]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      a     b     c  bools
2  True  True  True   True
7  True  True  True   True
8  True  True  True   True
```

Of course, expressions can be arbitrarily complex too

```
# short query syntax
In [263]: shorter = df.query('a < b < c and (not bools) or bools > 2')

# equivalent in pure Python
In [264]: longer = df[(df.a < df.b) & (df.b < df.c) & (~df.bools) | (df.bools > 2)]

In [265]: shorter
```

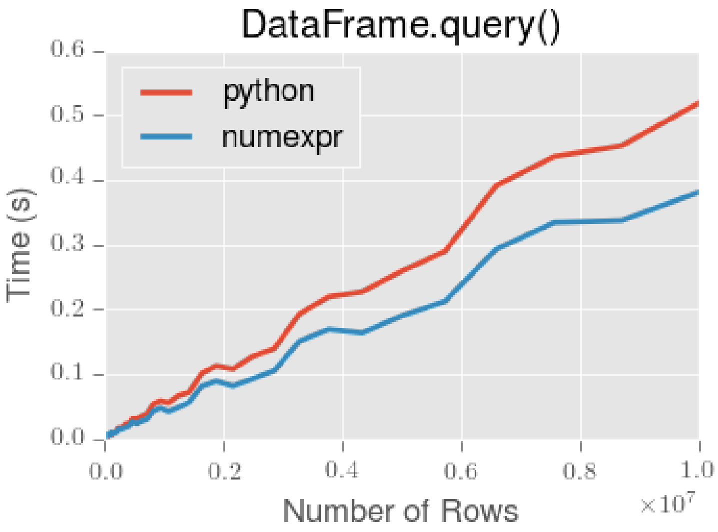
```
Out[265]:
          a         b         c  bools
7  0.275396  0.691034  0.826619  False

In [266]: longer
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[266]:␣
↪
          a         b         c  bools
7  0.275396  0.691034  0.826619  False

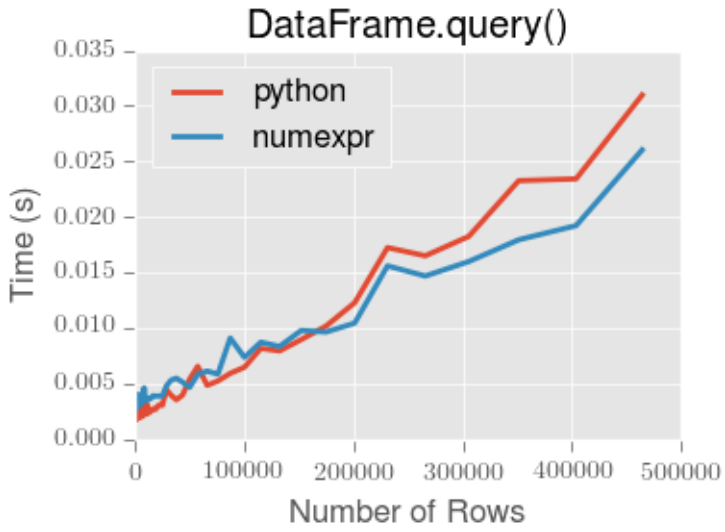
In [267]: shorter == longer
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      a     b     c  bools
7  True  True  True   True
```

12.16.7 Performance of `query()`

`DataFrame.query()` using `numexpr` is slightly faster than Python for large frames



Note: You will only see the performance benefits of using the `numexpr` engine with `DataFrame.query()` if your frame has more than approximately 200,000 rows



This plot was created using a `DataFrame` with 3 columns each containing floating point values generated using `numpy.random.randn()`.

12.17 Duplicate Data

If you want to identify and remove duplicate rows in a DataFrame, there are two methods that will help: `duplicated` and `drop_duplicates`. Each takes as an argument the columns to use to identify duplicated rows.

- `duplicated` returns a boolean vector whose length is the number of rows, and which indicates whether a row is duplicated.
- `drop_duplicates` removes duplicate rows.

By default, the first observed row of a duplicate set is considered unique, but each method has a `keep` parameter to specify targets to be kept.

- `keep='first'` (default): mark / drop duplicates except for the first occurrence.
- `keep='last'`: mark / drop duplicates except for the last occurrence.
- `keep=False`: mark / drop all duplicates.

```
In [268]: df2 = pd.DataFrame({'a': ['one', 'one', 'two', 'two', 'two', 'three', 'four
↪'],
   .....:                     'b': ['x', 'y', 'x', 'y', 'x', 'x', 'x'],
   .....:                     'c': np.random.randn(7)})
   .....:

In [269]: df2
Out[269]:
       a  b         c
0    one  x -1.067137
1    one  y  0.309500
2    two  x -0.211056
3    two  y -1.842023
4    two  x -0.390820
5  three  x -1.964475
```

```
6   four  x  1.298329

In [270]: df2.duplicated('a')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    False
1     True
2    False
3     True
4     True
5    False
6    False
dtype: bool

In [271]: df2.duplicated('a', keep='last')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0     True
1    False
2     True
3     True
4    False
5    False
6    False
dtype: bool

In [272]: df2.duplicated('a', keep=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0     True
1     True
2     True
3     True
4     True
5    False
6    False
dtype: bool

In [273]: df2.drop_duplicates('a')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
       a  b         c
0    one  x -1.067137
2    two  x -0.211056
5  three  x -1.964475
6   four  x  1.298329

In [274]: df2.drop_duplicates('a', keep='last')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
       a  b         c
1    one  y  0.309500
4    two  x -0.390820
5  three  x -1.964475
6   four  x  1.298329

In [275]: df2.drop_duplicates('a', keep=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
       a  b         c
5  three  x -1.964475
6   four  x  1.298329
```

Also, you can pass a list of columns to identify duplications.

```
In [276]: df2.duplicated(['a', 'b'])
Out[276]: 
0    False
1    False
2    False
3    False
4     True
5    False
6    False
dtype: bool

In [277]: df2.drop_duplicates(['a', 'b'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
       a  b         c
0    one  x -1.067137
1    one  y  0.309500
2    two  x -0.211056
3    two  y -1.842023
5  three  x -1.964475
6   four  x  1.298329
```

To drop duplicates by index value, use `Index.duplicated` then perform slicing. Same options are available in `keep` parameter.

```
In [278]: df3 = pd.DataFrame({'a': np.arange(6),
   .....:                     'b': np.random.randn(6)},
   .....:                    index=['a', 'a', 'b', 'c', 'b', 'a'])
   .....: 

In [279]: df3
Out[279]: 
   a         b
a  0  1.440455
a  1  2.456086
b  2  1.038402
c  3 -0.894409
b  4  0.683536
a  5  3.082764

In [280]: df3.index.duplicated()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪array([False,  True, False, False,  True,  True], dtype=bool)

In [281]: df3[~df3.index.duplicated()]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a         b
a  0  1.440455
b  2  1.038402
c  3 -0.894409
```

```
In [282]: df3[~df3.index.duplicated(keep='last')]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
   a         b
c  3 -0.894409
b  4  0.683536
a  5  3.082764

In [283]: df3[~df3.index.duplicated(keep=False)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
   a         b
c  3 -0.894409
```

12.18 Dictionary-like `get()` method

Each of Series, DataFrame, and Panel have a `get` method which can return a default value.

```
In [284]: s = pd.Series([1,2,3], index=['a','b','c'])

In [285]: s.get('a')               # equivalent to s['a']
Out[285]: 1

In [286]: s.get('x', default=-1)
\\\\\\\\\\\\Out[286]: -1
```

12.19 The `lookup()` Method

Sometimes you want to extract a set of values given a sequence of row labels and column labels, and the `lookup` method allows for this and returns a numpy array. For instance,

```
In [287]: dflookup = pd.DataFrame(np.random.rand(20,4), columns = ['A','B','C','D'])

In [288]: dflookup.lookup(list(range(0,10,2)), ['B','C','A','B','D'])
Out[288]: array([0.3506, 0.4779, 0.4825, 0.9197, 0.5019])
```

12.20 Index objects

The pandas *`Index`* class and its subclasses can be viewed as implementing an *ordered multiset*. Duplicates are allowed. However, if you try to convert an *`Index`* object with duplicate entries into a `set`, an exception will be raised.

`Index` also provides the infrastructure necessary for lookups, data alignment, and reindexing. The easiest way to create an *`Index`* directly is to pass a `list` or other sequence to *`Index`*:

```
In [289]: index = pd.Index(['e', 'd', 'a', 'b'])

In [290]: index
Out[290]: Index(['e', 'd', 'a', 'b'], dtype='object')
```

```
In [291]: 'd' in index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[291]: True
```

You can also pass a `name` to be stored in the index:

```
In [292]: index = pd.Index(['e', 'd', 'a', 'b'], name='something')

In [293]: index.name
Out[293]: 'something'
```

The name, if set, will be shown in the console display:

```
In [294]: index = pd.Index(list(range(5)), name='rows')

In [295]: columns = pd.Index(['A', 'B', 'C'], name='cols')

In [296]: df = pd.DataFrame(np.random.randn(5, 3), index=index, columns=columns)

In [297]: df
Out[297]:
cols         A         B         C
rows
0     1.295989  0.185778  0.436259
1     0.678101  0.311369 -0.528378
2    -0.674808 -1.103529 -0.656157
3     1.889957  2.076651 -1.102192
4    -1.211795 -0.791746  0.634724

In [298]: df['A']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
rows
0    1.295989
1    0.678101
2   -0.674808
3    1.889957
4   -1.211795
Name: A, dtype: float64
```

12.20.1 Setting metadata

Indexes are “mostly immutable”, but it is possible to set and change their metadata, like the index `name` (or, for `MultiIndex`, `levels` and `labels`).

You can use the `rename`, `set_names`, `set_levels`, and `set_labels` to set these attributes directly. They default to returning a copy; however, you can specify `inplace=True` to have the data change in place.

See *Advanced Indexing* for usage of MultiIndexes.

```
In [299]: ind = pd.Index([1, 2, 3])

In [300]: ind.rename("apple")
Out[300]: Int64Index([1, 2, 3], dtype='int64', name='apple')

In [301]: ind
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[301]: Int64Index([1,␣
↪2, 3], dtype='int64')
```

```
In [302]: ind.set_names(["apple"], inplace=True)

In [303]: ind.name = "bob"

In [304]: ind
Out[304]: Int64Index([1, 2, 3], dtype='int64', name='bob')
```

`set_names`, `set_levels`, and `set_labels` also take an optional *level*‘ argument

```
In [305]: index = pd.MultiIndex.from_product([range(3), ['one', 'two']], names=['first
↪', 'second'])

In [306]: index
Out[306]: 
MultiIndex(levels=[[0, 1, 2], ['one', 'two']],
           labels=[[0, 0, 1, 1, 2, 2], [0, 1, 0, 1, 0, 1]],
           names=['first', 'second'])

In [307]: index.levels[1]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Index(['one', 'two'], dtype='object', name='second')

In [308]: index.set_levels(["a", "b"], level=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
MultiIndex(levels=[[0, 1, 2], ['a', 'b']],
           labels=[[0, 0, 1, 1, 2, 2], [0, 1, 0, 1, 0, 1]],
           names=['first', 'second'])
```

12.20.2 Set operations on Index objects

The two main operations are `union (|)`, `intersection (&)` These can be directly called as instance methods or used via overloaded operators. Difference is provided via the `.difference()` method.

```
In [309]: a = pd.Index(['c', 'b', 'a'])

In [310]: b = pd.Index(['c', 'e', 'd'])

In [311]: a | b
Out[311]: Index(['a', 'b', 'c', 'd', 'e'], dtype='object')

In [312]: a & b
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[312]: Index(['c'],␣
↪dtype='object')

In [313]: a.difference(b)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out
↪Index(['a', 'b'], dtype='object')
```

Also available is the `symmetric_difference (^)` operation, which returns elements that appear in either `idx1` or `idx2` but not both. This is equivalent to the Index created by `idx1.difference(idx2).union(idx2.difference(idx1))`, with duplicates dropped.

```
In [314]: idx1 = pd.Index([1, 2, 3, 4])
```

```
In [315]: idx2 = pd.Index([2, 3, 4, 5])

In [316]: idx1.symmetric_difference(idx2)
Out[316]: Int64Index([1, 5], dtype='int64')

In [317]: idx1 ^ idx2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[317]: Int64Index([1, 5], dtype='int64
↪')
```

Note: The resulting index from a set operation will be sorted in ascending order.

12.20.3 Missing values

New in version 0.17.1.

Important: Even though `Index` can hold missing values (`NaN`), it should be avoided if you do not want any unexpected results. For example, some operations exclude missing values implicitly.

`Index.fillna` fills missing values with specified scalar value.

```
In [318]: idx1 = pd.Index([1, np.nan, 3, 4])

In [319]: idx1
Out[319]: Float64Index([1.0, nan, 3.0, 4.0], dtype='float64')

In [320]: idx1.fillna(2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[320]:␣
↪Float64Index([1.0, 2.0, 3.0, 4.0], dtype='float64')

In [321]: idx2 = pd.DatetimeIndex([pd.Timestamp('2011-01-01'), pd.NaT, pd.Timestamp(
↪'2011-01-03')])

In [322]: idx2
Out[322]: DatetimeIndex(['2011-01-01', 'NaT', '2011-01-03'], dtype='datetime64[ns]',␣
↪freq=None)

In [323]: idx2.fillna(pd.Timestamp('2011-01-02'))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[
↪DatetimeIndex(['2011-01-01', '2011-01-02', '2011-01-03'], dtype='datetime64[ns]',␣
↪freq=None)
```

12.21 Set / Reset Index

Occasionally you will load or create a data set into a DataFrame and want to add an index after you've already done so. There are a couple of different ways.

12.21.1 Set an index

DataFrame has a `set_index` method which takes a column name (for a regular `Index`) or a list of column names (for a `MultiIndex`), to create a new, indexed DataFrame:

```
In [324]: data
Out[324]:
     a    b  c    d
0  bar  one  z  1.0
1  bar  two  y  2.0
2  foo  one  x  3.0
3  foo  two  w  4.0

In [325]: indexed1 = data.set_index('c')

In [326]: indexed1
Out[326]:
     a    b    d
c
z  bar  one  1.0
y  bar  two  2.0
x  foo  one  3.0
w  foo  two  4.0

In [327]: indexed2 = data.set_index(['a', 'b'])

In [328]: indexed2
Out[328]:
          c    d
a   b
bar one   z  1.0
    two   y  2.0
foo one   x  3.0
    two   w  4.0
```

The `append` keyword option allow you to keep the existing index and append the given columns to a MultiIndex:

```
In [329]: frame = data.set_index('c', drop=False)

In [330]: frame = frame.set_index(['a', 'b'], append=True)

In [331]: frame
Out[331]:
            c    d
c a   b
z bar one   z  1.0
y bar two   y  2.0
x foo one   x  3.0
w foo two   w  4.0
```

Other options in `set_index` allow you not drop the index columns or to add the index in-place (without creating a new object):

```
In [332]: data.set_index('c', drop=False)
Out[332]:
     a    b  c    d
c
z  bar  one  z  1.0
```

```
y  bar  two  y  2.0
x  foo  one  x  3.0
w  foo  two  w  4.0

In [333]: data.set_index(['a', 'b'], inplace=True)

In [334]: data
Out[334]:
         c    d
a   b
bar one  z  1.0
    two  y  2.0
foo one  x  3.0
    two  w  4.0
```

12.21.2 Reset the index

As a convenience, there is a new function on DataFrame called `reset_index` which transfers the index values into the DataFrame's columns and sets a simple integer index. This is the inverse operation to `set_index`

```
In [335]: data
Out[335]:
         c    d
a   b
bar one  z  1.0
    two  y  2.0
foo one  x  3.0
    two  w  4.0

In [336]: data.reset_index()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     a    b  c    d
0  bar  one  z  1.0
1  bar  two  y  2.0
2  foo  one  x  3.0
3  foo  two  w  4.0
```

The output is more similar to a SQL table or a record array. The names for the columns derived from the index are the ones stored in the `names` attribute.

You can use the `level` keyword to remove only a portion of the index:

```
In [337]: frame
Out[337]:
           c    d
c a   b
z bar one  z  1.0
y bar two  y  2.0
x foo one  x  3.0
w foo two  w  4.0

In [338]: frame.reset_index(level=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
         a  c    d
```

```
c b
z one  bar  z  1.0
y two  bar  y  2.0
x one  foo  x  3.0
w two  foo  w  4.0
```

`reset_index` takes an optional parameter `drop` which if true simply discards the index, instead of putting index values in the DataFrame's columns.

Note: The `reset_index` method used to be called `delevel` which is now deprecated.

12.21.3 Adding an ad hoc index

If you create an index yourself, you can just assign it to the `index` field:

```
data.index = index
```

12.22 Returning a view versus a copy

When setting values in a pandas object, care must be taken to avoid what is called `chained indexing`. Here is an example.

```
In [339]: dfmi = pd.DataFrame([list('abcd'),
   .....:                      list('efgh'),
   .....:                      list('ijkl'),
   .....:                      list('mnop')],
   .....:                     columns=pd.MultiIndex.from_product([['one','two'],
   .....:                                                         ['first','second
↪']]))
   .....:

In [340]: dfmi
Out[340]:
    one          two
  first second first second
0     a      b     c      d
1     e      f     g      h
2     i      j     k      l
3     m      n     o      p
```

Compare these two access methods:

```
In [341]: dfmi['one']['second']
Out[341]:
0    b
1    f
2    j
3    n
Name: second, dtype: object
```

```
In [342]: dfmi.loc[:,('one','second')]
Out[342]:
0    b
1    f
2    j
3    n
Name: (one, second), dtype: object
```

These both yield the same results, so which should you use? It is instructive to understand the order of operations on these and why method 2 (`.loc`) is much preferred over method 1 (chained `[]`)

`dfmi['one']` selects the first level of the columns and returns a DataFrame that is singly-indexed. Then another python operation `dfmi_with_one['second']` selects the series indexed by `'second'` happens. This is indicated by the variable `dfmi_with_one` because pandas sees these operations as separate events. e.g. separate calls to `__getitem__`, so it has to treat them as linear operations, they happen one after another.

Contrast this to `df.loc[:,('one','second')]` which passes a nested tuple of `(slice(None),('one', 'second'))` to a single call to `__getitem__`. This allows pandas to deal with this as a single entity. Furthermore this order of operations *can* be significantly faster, and allows one to index *both* axes if so desired.

12.22.1 Why does assignment fail when using chained indexing?

The problem in the previous section is just a performance issue. What's up with the `SettingWithCopy` warning? We don't **usually** throw warnings around when you do something that might cost a few extra milliseconds!

But it turns out that assigning to the product of chained indexing has inherently unpredictable results. To see this, think about how the Python interpreter executes this code:

```
dfmi.loc[:,('one','second')] = value
# becomes
dfmi.loc.__setitem__((slice(None), ('one', 'second')), value)
```

But this code is handled differently:

```
dfmi['one']['second'] = value
# becomes
dfmi.__getitem__('one').__setitem__('second', value)
```

See that `__getitem__` in there? Outside of simple cases, it's very hard to predict whether it will return a view or a copy (it depends on the memory layout of the array, about which *pandas* makes no guarantees), and therefore whether the `__setitem__` will modify `dfmi` or a temporary object that gets thrown out immediately afterward. **That's** what `SettingWithCopy` is warning you about!

Note: You may be wondering whether we should be concerned about the `loc` property in the first example. But `dfmi.loc` is guaranteed to be `dfmi` itself with modified indexing behavior, so `dfmi.loc.__getitem__` / `dfmi.loc.__setitem__` operate on `dfmi` directly. Of course, `dfmi.loc.__getitem__(idx)` may be a view or a copy of `dfmi`.

Sometimes a `SettingWithCopy` warning will arise at times when there's no obvious chained indexing going on. **These** are the bugs that `SettingWithCopy` is designed to catch! Pandas is probably trying to warn you that you've done this:

```
def do_something(df):
    foo = df[['bar', 'baz']]  # Is foo a view? A copy? Nobody knows!
    # ... many lines here ...
```

```
    foo['quux'] = value        # We don't know whether this will modify df or not!
    return foo
```

Yikes!

12.22.2 Evaluation order matters

Furthermore, in chained expressions, the order may determine whether a copy is returned or not. If an expression will set values on a copy of a slice, then a `SettingWithCopy` warning will be issued.

You can control the action of a chained assignment via the option `mode.chained_assignment`, which can take the values `['raise','warn',None]`, where showing a warning is the default.

```
In [343]: dfb = pd.DataFrame({'a' : ['one', 'one', 'two',
   .....:                            'three', 'two', 'one', 'six'],
   .....:                     'c' : np.arange(7)})
   .....:

# This will show the SettingWithCopyWarning
# but the frame values will be set
In [344]: dfb['c'][dfb.a.str.startswith('o')] = 42
```

This however is operating on a copy and will not work.

```
>>> pd.set_option('mode.chained_assignment','warn')
>>> dfb[dfb.a.str.startswith('o')]['c'] = 42
Traceback (most recent call last)
     ...
SettingWithCopyWarning:
     A value is trying to be set on a copy of a slice from a DataFrame.
     Try using .loc[row_index,col_indexer] = value instead
```

A chained assignment can also crop up in setting in a mixed dtype frame.

Note: These setting rules apply to all of `.loc/.iloc`

This is the correct access method

```
In [345]: dfc = pd.DataFrame({'A':['aaa','bbb','ccc'],'B':[1,2,3]})

In [346]: dfc.loc[0,'A'] = 11

In [347]: dfc
Out[347]:
     A  B
0   11  1
1  bbb  2
2  ccc  3
```

This *can* work at times, but is not guaranteed, and so should be avoided

```
In [348]: dfc = dfc.copy()

In [349]: dfc['A'][0] = 111
```

```
In [350]: dfc
Out[350]:
     A  B
0  111  1
1  bbb  2
2  ccc  3
```

This will **not** work at all, and so should be avoided

```
>>> pd.set_option('mode.chained_assignment','raise')
>>> dfc.loc[0]['A'] = 1111
Traceback (most recent call last)
     ...
SettingWithCopyException:
     A value is trying to be set on a copy of a slice from a DataFrame.
     Try using .loc[row_index,col_indexer] = value instead
```

> **Warning:** The chained assignment warnings / exceptions are aiming to inform the user of a possibly invalid assignment. There may be false positives; situations where a chained assignment is inadvertently reported.

CHAPTER

THIRTEEN

MULTIINDEX / ADVANCED INDEXING

This section covers indexing with a `MultiIndex` and more advanced indexing features.

See the *Indexing and Selecting Data* for general indexing documentation.

> **Warning:** Whether a copy or a reference is returned for a setting operation, may depend on the context. This is sometimes called `chained assignment` and should be avoided. See *Returning a View versus Copy*

See the *cookbook* for some advanced strategies

13.1 Hierarchical indexing (MultiIndex)

Hierarchical / Multi-level indexing is very exciting as it opens the door to some quite sophisticated data analysis and manipulation, especially for working with higher dimensional data. In essence, it enables you to store and manipulate data with an arbitrary number of dimensions in lower dimensional data structures like Series (1d) and DataFrame (2d).

In this section, we will show what exactly we mean by "hierarchical" indexing and how it integrates with all of the pandas indexing functionality described above and in prior sections. Later, when discussing *group by* and *pivoting and reshaping data*, we'll show non-trivial applications to illustrate how it aids in structuring data for analysis.

See the *cookbook* for some advanced strategies

13.1.1 Creating a MultiIndex (hierarchical index) object

The `MultiIndex` object is the hierarchical analogue of the standard `Index` object which typically stores the axis labels in pandas objects. You can think of `MultiIndex` as an array of tuples where each tuple is unique. A `MultiIndex` can be created from a list of arrays (using `MultiIndex.from_arrays`), an array of tuples (using `MultiIndex.from_tuples`), or a crossed set of iterables (using `MultiIndex.from_product`). The `Index` constructor will attempt to return a `MultiIndex` when it is passed a list of tuples. The following examples demo different ways to initialize MultiIndexes.

```
In [1]: arrays = [['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'],
   ...:           ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two']]
   ...:

In [2]: tuples = list(zip(*arrays))

In [3]: tuples
Out[3]:
[('bar', 'one'),
```

```
 ('bar', 'two'),
 ('baz', 'one'),
 ('baz', 'two'),
 ('foo', 'one'),
 ('foo', 'two'),
 ('qux', 'one'),
 ('qux', 'two')]

In [4]: index = pd.MultiIndex.from_tuples(tuples, names=['first', 'second'])

In [5]: index
Out[5]:
MultiIndex(levels=[['bar', 'baz', 'foo', 'qux'], ['one', 'two']],
           labels=[[0, 0, 1, 1, 2, 2, 3, 3], [0, 1, 0, 1, 0, 1, 0, 1]],
           names=['first', 'second'])

In [6]: s = pd.Series(np.random.randn(8), index=index)

In [7]: s
Out[7]:
first  second
bar    one       0.469112
       two      -0.282863
baz    one      -1.509059
       two      -1.135632
foo    one       1.212112
       two      -0.173215
qux    one       0.119209
       two      -1.044236
dtype: float64
```

When you want every pairing of the elements in two iterables, it can be easier to use the `MultiIndex.from_product` function:

```
In [8]: iterables = [['bar', 'baz', 'foo', 'qux'], ['one', 'two']]

In [9]: pd.MultiIndex.from_product(iterables, names=['first', 'second'])
Out[9]:
MultiIndex(levels=[['bar', 'baz', 'foo', 'qux'], ['one', 'two']],
           labels=[[0, 0, 1, 1, 2, 2, 3, 3], [0, 1, 0, 1, 0, 1, 0, 1]],
           names=['first', 'second'])
```

As a convenience, you can pass a list of arrays directly into Series or DataFrame to construct a MultiIndex automatically:

```
In [10]: arrays = [np.array(['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux']),
   ....:           np.array(['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two'])]
   ....:

In [11]: s = pd.Series(np.random.randn(8), index=arrays)

In [12]: s
Out[12]:
bar  one   -0.861849
     two   -2.104569
baz  one   -0.494929
     two    1.071804
foo  one    0.721555
```

```
     two   -0.706771
qux  one   -1.039575
     two    0.271860
dtype: float64

In [13]: df = pd.DataFrame(np.random.randn(8, 4), index=arrays)

In [14]: df
Out[14]: 
                0         1         2         3
bar one -0.424972  0.567020  0.276232 -1.087401
    two -0.673690  0.113648 -1.478427  0.524988
baz one  0.404705  0.577046 -1.715002 -1.039268
    two -0.370647 -1.157892 -1.344312  0.844885
foo one  1.075770 -0.109050  1.643563 -1.469388
    two  0.357021 -0.674600 -1.776904 -0.968914
qux one -1.294524  0.413738  0.276662 -0.472035
    two -0.013960 -0.362543 -0.006154 -0.923061
```

All of the `MultiIndex` constructors accept a `names` argument which stores string names for the levels themselves. If no names are provided, `None` will be assigned:

```
In [15]: df.index.names
Out[15]: FrozenList([None, None])
```

This index can back any axis of a pandas object, and the number of **levels** of the index is up to you:

```
In [16]: df = pd.DataFrame(np.random.randn(3, 8), index=['A', 'B', 'C'],␣
↪columns=index)

In [17]: df
Out[17]: 
first        bar                 baz                 foo                 qux  \
second       one       two       one       two       one       two       one   
A       0.895717  0.805244 -1.206412  2.565646  1.431256  1.340309 -1.170299   
B       0.410835  0.813850  0.132003 -0.827317 -0.076467 -1.187678  1.130127   
C      -1.413681  1.607920  1.024180  0.569605  0.875906 -2.211372  0.974466   

first             
second       two  
A      -0.226169  
B      -1.436737  
C      -2.006747  

In [18]: pd.DataFrame(np.random.randn(6, 6), index=index[:6], columns=index[:6])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
first              bar                 baz                 foo          
second             one       two       one       two       one       two
first second                                                            
bar   one    -0.410001 -0.078638  0.545952 -1.219217 -1.226825  0.769804
      two    -1.281247 -0.727707 -0.121306 -0.097883  0.695775  0.341734
baz   one     0.959726 -1.110336 -0.619976  0.149748 -0.732339  0.687738
      two     0.176444  0.403310 -0.154951  0.301624 -2.179861 -1.369849
foo   one    -0.954208  1.462696 -1.743161 -0.826591 -0.345352  1.314232
      two     0.690579  0.995761  2.396780  0.014871  3.357427 -0.317441
```

We’ve “sparsified” the higher levels of the indexes to make the console output a bit easier on the eyes.

It's worth keeping in mind that there's nothing preventing you from using tuples as atomic labels on an axis:

```
In [19]: pd.Series(np.random.randn(8), index=tuples)
Out[19]:
(bar, one)   -1.236269
(bar, two)    0.896171
(baz, one)   -0.487602
(baz, two)   -0.082240
(foo, one)   -2.182937
(foo, two)    0.380396
(qux, one)    0.084844
(qux, two)    0.432390
dtype: float64
```

The reason that the `MultiIndex` matters is that it can allow you to do grouping, selection, and reshaping operations as we will describe below and in subsequent areas of the documentation. As you will see in later sections, you can find yourself working with hierarchically-indexed data without creating a `MultiIndex` explicitly yourself. However, when loading data from a file, you may wish to generate your own `MultiIndex` when preparing the data set.

Note that how the index is displayed by be controlled using the `multi_sparse` option in `pandas.set_options()`:

```
In [20]: pd.set_option('display.multi_sparse', False)

In [21]: df
Out[21]:
first        bar       bar       baz       baz       foo       foo       qux  \
second       one       two       one       two       one       two       one
A       0.895717  0.805244 -1.206412  2.565646  1.431256  1.340309 -1.170299
B       0.410835  0.813850  0.132003 -0.827317 -0.076467 -1.187678  1.130127
C      -1.413681  1.607920  1.024180  0.569605  0.875906 -2.211372  0.974466

first        qux
second       two
A      -0.226169
B      -1.436737
C      -2.006747

In [22]: pd.set_option('display.multi_sparse', True)
```

13.1.2 Reconstructing the level labels

The method `get_level_values` will return a vector of the labels for each location at a particular level:

```
In [23]: index.get_level_values(0)
Out[23]: Index(['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'], dtype='object
↪', name='first')

In [24]: index.get_level_values('second')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Index(['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two'], dtype='object',␣
↪name='second')
```

13.1.3 Basic indexing on axis with MultiIndex

One of the important features of hierarchical indexing is that you can select data by a "partial" label identifying a subgroup in the data. **Partial** selection "drops" levels of the hierarchical index in the result in a completely analogous way to selecting a column in a regular DataFrame:

```
In [25]: df['bar']
Out[25]:
second       one       two
A       0.895717  0.805244
B       0.410835  0.813850
C      -1.413681  1.607920

In [26]: df['bar', 'one']
\\\
```

This is done to avoid a recomputation of the levels in order to make slicing highly performant. If you want to see the actual used levels.

```
In [31]: df[['foo','qux']].columns.values
Out[31]: array([('foo', 'one'), ('foo', 'two'), ('qux', 'one'), ('qux', 'two')],␣
↪dtype=object)

# for a specific level
In [32]: df[['foo','qux']].columns.get_level_values(0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[32
↪Index(['foo', 'foo', 'qux', 'qux'], dtype='object', name='first')
```

To reconstruct the multiindex with only the used levels

New in version 0.20.0.

```
In [33]: df[['foo','qux']].columns.remove_unused_levels()
Out[33]:
MultiIndex(levels=[['foo', 'qux'], ['one', 'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=['first', 'second'])
```

13.1.5 Data alignment and using `reindex`

Operations between differently-indexed objects having `MultiIndex` on the axes will work as you expect; data alignment will work the same as an Index of tuples:

```
In [34]: s + s[:-2]
Out[34]:
bar  one   -1.723698
     two   -4.209138
baz  one   -0.989859
     two    2.143608
foo  one    1.443110
     two   -1.413542
qux  one         NaN
     two         NaN
dtype: float64

In [35]: s + s[::2]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
bar  one   -1.723698
     two         NaN
baz  one   -0.989859
     two         NaN
foo  one    1.443110
     two         NaN
qux  one   -2.079150
     two         NaN
dtype: float64
```

`reindex` can be called with another `MultiIndex` or even a list or array of tuples:

```
In [36]: s.reindex(index[:3])
Out[36]:
first  second
```

```
bar    one      -0.861849
       two      -2.104569
baz    one      -0.494929
dtype: float64

In [37]: s.reindex([('foo', 'two'), ('bar', 'one'), ('qux', 'one'), ('baz', 'one')])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
foo  two   -0.706771
bar  one   -0.861849
qux  one   -1.039575
baz  one   -0.494929
dtype: float64
```

13.2 Advanced indexing with hierarchical index

Syntactically integrating `MultiIndex` in advanced indexing with `.loc` is a bit challenging, but we've made every effort to do so. for example the following works as you would expect:

```
In [38]: df = df.T

In [39]: df
Out[39]:
                     A         B         C
first second
bar   one     0.895717  0.410835 -1.413681
      two     0.805244  0.813850  1.607920
baz   one    -1.206412  0.132003  1.024180
      two     2.565646 -0.827317  0.569605
foo   one     1.431256 -0.076467  0.875906
      two     1.340309 -1.187678 -2.211372
qux   one    -1.170299  1.130127  0.974466
      two    -0.226169 -1.436737 -2.006747

In [40]: df.loc['bar']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
               A         B         C
second
one     0.895717  0.410835 -1.413681
two     0.805244  0.813850  1.607920

In [41]: df.loc['bar', 'two']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    0.805244
B    0.813850
C    1.607920
Name: (bar, two), dtype: float64
```

"Partial" slicing also works quite nicely.

```
In [42]: df.loc['baz':'foo']
Out[42]:
                     A         B         C
```

```
first second
baz   one    -1.206412  0.132003  1.024180
      two     2.565646 -0.827317  0.569605
foo   one     1.431256 -0.076467  0.875906
      two     1.340309 -1.187678 -2.211372
```

You can slice with a 'range' of values, by providing a slice of tuples.

```
In [43]: df.loc[('baz', 'two'):('qux', 'one')]
Out[43]:
                     A         B         C
first second
baz   two     2.565646 -0.827317  0.569605
foo   one     1.431256 -0.076467  0.875906
      two     1.340309 -1.187678 -2.211372
qux   one    -1.170299  1.130127  0.974466

In [44]: df.loc[('baz', 'two'):'foo']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                     A         B         C
first second
baz   two     2.565646 -0.827317  0.569605
foo   one     1.431256 -0.076467  0.875906
      two     1.340309 -1.187678 -2.211372
```

Passing a list of labels or tuples works similar to reindexing:

```
In [45]: df.loc[[('bar', 'two'), ('qux', 'one')]]
Out[45]:
                     A         B         C
first second
bar   two     0.805244  0.813850  1.607920
qux   one    -1.170299  1.130127  0.974466
```

13.2.1 Using slicers

You can slice a multi-index by providing multiple indexers.

You can provide any of the selectors as if you are indexing by label, see *Selection by Label*, including slices, lists of labels, labels, and boolean indexers.

You can use `slice(None)` to select all the contents of *that* level. You do not need to specify all the *deeper* levels, they will be implied as `slice(None)`.

As usual, **both sides** of the slicers are included as this is label indexing.

Warning: You should specify all axes in the `.loc` specifier, meaning the indexer for the **index** and for the **columns**. There are some ambiguous cases where the passed indexer could be mis-interpreted as indexing *both* axes, rather than into say the MuliIndex for the rows.

You should do this:

```
df.loc[(slice('A1','A3'),.....), :]
```

rather than this:

```
df.loc[(slice('A1','A3'),.....)]
```

```
In [46]: def mklbl(prefix,n):
   ....:     return ["%s%s" % (prefix,i)  for i in range(n)]
   ....:

In [47]: miindex = pd.MultiIndex.from_product([mklbl('A',4),
   ....:                                       mklbl('B',2),
   ....:                                       mklbl('C',4),
   ....:                                       mklbl('D',2)])
   ....:

In [48]: micolumns = pd.MultiIndex.from_tuples([('a','foo'),('a','bar'),
   ....:                                        ('b','foo'),('b','bah')],
   ....:                                       names=['lvl0', 'lvl1'])
   ....:

In [49]: dfmi = pd.DataFrame(np.arange(len(miindex)*len(micolumns)).
↪reshape((len(miindex),len(micolumns))),
   ....:                     index=miindex,
   ....:                     columns=micolumns).sort_index().sort_index(axis=1)
   ....:

In [50]: dfmi
Out[50]:
lvl0           a         b
lvl1         bar  foo  bah  foo
A0 B0 C0 D0    1    0    3    2
         D1    5    4    7    6
      C1 D0    9    8   11   10
         D1   13   12   15   14
      C2 D0   17   16   19   18
         D1   21   20   23   22
      C3 D0   25   24   27   26
...          ...  ...  ...  ...
A3 B1 C0 D1  229  228  231  230
      C1 D0  233  232  235  234
         D1  237  236  239  238
      C2 D0  241  240  243  242
         D1  245  244  247  246
      C3 D0  249  248  251  250
         D1  253  252  255  254

[64 rows x 4 columns]
```

Basic multi-index slicing using slices, lists, and labels.

```
In [51]: dfmi.loc[(slice('A1','A3'), slice(None), ['C1', 'C3']), :]
Out[51]:
lvl0           a         b
lvl1         bar  foo  bah  foo
A1 B0 C1 D0   73   72   75   74
         D1   77   76   79   78
      C3 D0   89   88   91   90
         D1   93   92   95   94
   B1 C1 D0  105  104  107  106
```

```
         D1  109  108  111  110
      C3 D0  121  120  123  122
...          ...  ...  ...  ...
A3 B0 C1 D1  205  204  207  206
      C3 D0  217  216  219  218
         D1  221  220  223  222
   B1 C1 D0  233  232  235  234
         D1  237  236  239  238
      C3 D0  249  248  251  250
         D1  253  252  255  254

[24 rows x 4 columns]
```

You can use a `pd.IndexSlice` to have a more natural syntax using `:` rather than using `slice(None)`

```
In [52]: idx = pd.IndexSlice

In [53]: dfmi.loc[idx[:, :, ['C1', 'C3']], idx[:, 'foo']]
Out[53]:
lvl0           a    b
lvl1         foo  foo
A0 B0 C1 D0    8   10
         D1   12   14
      C3 D0   24   26
         D1   28   30
   B1 C1 D0   40   42
         D1   44   46
      C3 D0   56   58
...          ...  ...
A3 B0 C1 D1  204  206
      C3 D0  216  218
         D1  220  222
   B1 C1 D0  232  234
         D1  236  238
      C3 D0  248  250
         D1  252  254

[32 rows x 2 columns]
```

It is possible to perform quite complicated selections using this method on multiple axes at the same time.

```
In [54]: dfmi.loc['A1', (slice(None), 'foo')]
Out[54]:
lvl0        a    b
lvl1      foo  foo
B0 C0 D0   64   66
      D1   68   70
   C1 D0   72   74
      D1   76   78
   C2 D0   80   82
      D1   84   86
   C3 D0   88   90
...       ...  ...
B1 C0 D1  100  102
   C1 D0  104  106
      D1  108  110
   C2 D0  112  114
      D1  116  118
```

```
   C3 D0  120  122
      D1  124  126

[16 rows x 2 columns]

In [55]: dfmi.loc[idx[:, :, ['C1', 'C3']], idx[:, 'foo']]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
lvl0           a    b
lvl1         foo  foo
A0 B0 C1 D0    8   10
         D1   12   14
      C3 D0   24   26
         D1   28   30
   B1 C1 D0   40   42
         D1   44   46
      C3 D0   56   58
...          ...  ...
A3 B0 C1 D1  204  206
      C3 D0  216  218
         D1  220  222
   B1 C1 D0  232  234
         D1  236  238
      C3 D0  248  250
         D1  252  254

[32 rows x 2 columns]
```

Using a boolean indexer you can provide selection related to the *values*.

```
In [56]: mask = dfmi[('a', 'foo')] > 200

In [57]: dfmi.loc[idx[mask, :, ['C1', 'C3']], idx[:, 'foo']]
Out[57]:
lvl0           a    b
lvl1         foo  foo
A3 B0 C1 D1  204  206
      C3 D0  216  218
         D1  220  222
   B1 C1 D0  232  234
         D1  236  238
      C3 D0  248  250
         D1  252  254
```

You can also specify the `axis` argument to `.loc` to interpret the passed slicers on a single axis.

```
In [58]: dfmi.loc(axis=0)[:, :, ['C1', 'C3']]
Out[58]:
lvl0           a         b
lvl1         bar  foo  bah  foo
A0 B0 C1 D0    9    8   11   10
         D1   13   12   15   14
      C3 D0   25   24   27   26
         D1   29   28   31   30
   B1 C1 D0   41   40   43   42
         D1   45   44   47   46
      C3 D0   57   56   59   58
...          ...  ...  ...  ...
```

```
A3 B0 C1 D1  205  204  207  206
      C3 D0  217  216  219  218
         D1  221  220  223  222
   B1 C1 D0  233  232  235  234
         D1  237  236  239  238
      C3 D0  249  248  251  250
         D1  253  252  255  254

[32 rows x 4 columns]
```

Furthermore you can *set* the values using these methods

```
In [59]: df2 = dfmi.copy()

In [60]: df2.loc(axis=0)[:, :, ['C1', 'C3']] = -10

In [61]: df2
Out[61]:
lvl0           a         b
lvl1         bar  foo  bah  foo
A0 B0 C0 D0    1    0    3    2
         D1    5    4    7    6
      C1 D0  -10  -10  -10  -10
         D1  -10  -10  -10  -10
      C2 D0   17   16   19   18
         D1   21   20   23   22
      C3 D0  -10  -10  -10  -10
...          ...  ...  ...  ...
A3 B1 C0 D1  229  228  231  230
      C1 D0  -10  -10  -10  -10
         D1  -10  -10  -10  -10
      C2 D0  241  240  243  242
         D1  245  244  247  246
      C3 D0  -10  -10  -10  -10
         D1  -10  -10  -10  -10

[64 rows x 4 columns]
```

You can use a right-hand-side of an alignable object as well.

```
In [62]: df2 = dfmi.copy()

In [63]: df2.loc[idx[:, :, ['C1', 'C3']], :] = df2 * 1000

In [64]: df2
Out[64]:
lvl0              a               b
lvl1            bar     foo     bah     foo
A0 B0 C0 D0       1       0       3       2
         D1       5       4       7       6
      C1 D0    9000    8000   11000   10000
         D1   13000   12000   15000   14000
      C2 D0      17      16      19      18
         D1      21      20      23      22
      C3 D0   25000   24000   27000   26000
...             ...     ...     ...     ...
A3 B1 C0 D1     229     228     231     230
      C1 D0  233000  232000  235000  234000
```

```
         D1  237000  236000  239000  238000
      C2 D0     241     240     243     242
         D1     245     244     247     246
      C3 D0  249000  248000  251000  250000
         D1  253000  252000  255000  254000

[64 rows x 4 columns]
```

13.2.2 Cross-section

The `xs` method of `DataFrame` additionally takes a level argument to make selecting data at a particular level of a MultiIndex easier.

```
In [65]: df
Out[65]:
                     A         B         C
first second
bar   one     0.895717  0.410835 -1.413681
      two     0.805244  0.813850  1.607920
baz   one    -1.206412  0.132003  1.024180
      two     2.565646 -0.827317  0.569605
foo   one     1.431256 -0.076467  0.875906
      two     1.340309 -1.187678 -2.211372
qux   one    -1.170299  1.130127  0.974466
      two    -0.226169 -1.436737 -2.006747

In [66]: df.xs('one', level='second')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
              A         B         C
first
bar    0.895717  0.410835 -1.413681
baz   -1.206412  0.132003  1.024180
foo    1.431256 -0.076467  0.875906
qux   -1.170299  1.130127  0.974466
```

```
# using the slicers
In [67]: df.loc[(slice(None),'one'),:]
Out[67]:
                     A         B         C
first second
bar   one     0.895717  0.410835 -1.413681
baz   one    -1.206412  0.132003  1.024180
foo   one     1.431256 -0.076467  0.875906
qux   one    -1.170299  1.130127  0.974466
```

You can also select on the columns with `xs()`, by providing the axis argument

```
In [68]: df = df.T

In [69]: df.xs('one', level='second', axis=1)
Out[69]:
first        bar       baz       foo       qux
A       0.895717 -1.206412  1.431256 -1.170299
B       0.410835  0.132003 -0.076467  1.130127
C      -1.413681  1.024180  0.875906  0.974466
```

```
# using the slicers
In [70]: df.loc[:,(slice(None),'one')]
Out[70]:
first        bar       baz       foo       qux
second       one       one       one       one
A       0.895717 -1.206412  1.431256 -1.170299
B       0.410835  0.132003 -0.076467  1.130127
C      -1.413681  1.024180  0.875906  0.974466
```

`xs()` also allows selection with multiple keys

```
In [71]: df.xs(('one', 'bar'), level=('second', 'first'), axis=1)
Out[71]:
first        bar
second       one
A       0.895717
B       0.410835
C      -1.413681
```

```
# using the slicers
In [72]: df.loc[:,('bar','one')]
Out[72]:
A    0.895717
B    0.410835
C   -1.413681
Name: (bar, one), dtype: float64
```

You can pass `drop_level=False` to `xs()` to retain the level that was selected

```
In [73]: df.xs('one', level='second', axis=1, drop_level=False)
Out[73]:
first        bar       baz       foo       qux
second       one       one       one       one
A       0.895717 -1.206412  1.431256 -1.170299
B       0.410835  0.132003 -0.076467  1.130127
C      -1.413681  1.024180  0.875906  0.974466
```

versus the result with `drop_level=True` (the default value)

```
In [74]: df.xs('one', level='second', axis=1, drop_level=True)
Out[74]:
first       bar       baz       foo       qux
A      0.895717 -1.206412  1.431256 -1.170299
B      0.410835  0.132003 -0.076467  1.130127
C     -1.413681  1.024180  0.875906  0.974466
```

13.2.3 Advanced reindexing and alignment

The parameter `level` has been added to the `reindex` and `align` methods of pandas objects. This is useful to broadcast values across a level. For instance:

```
In [75]: midx = pd.MultiIndex(levels=[['zero', 'one'], ['x','y']],
   ....:                      labels=[[1,1,0,0],[1,0,1,0]])
   ....:

In [76]: df = pd.DataFrame(np.random.randn(4,2), index=midx)
```

```
In [77]: df
Out[77]: 
               0         1
one  y  1.519970 -0.493662
     x  0.600178  0.274230
zero y  0.132885 -0.023688
     x  2.410179  1.450520

In [78]: df2 = df.mean(level=0)

In [79]: df2
Out[79]: 
             0         1
one   1.060074 -0.109716
zero  1.271532  0.713416

In [80]: df2.reindex(df.index, level=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[80]:␣
↪
               0         1
one  y  1.060074 -0.109716
     x  1.060074 -0.109716
zero y  1.271532  0.713416
     x  1.271532  0.713416

# aligning
In [81]: df_aligned, df2_aligned = df.align(df2, level=0)

In [82]: df_aligned
Out[82]: 
               0         1
one  y  1.519970 -0.493662
     x  0.600178  0.274230
zero y  0.132885 -0.023688
     x  2.410179  1.450520

In [83]: df2_aligned
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
               0         1
one  y  1.060074 -0.109716
     x  1.060074 -0.109716
zero y  1.271532  0.713416
     x  1.271532  0.713416
```

13.2.4 Swapping levels with `swaplevel()`

The `swaplevel` function can switch the order of two levels:

```
In [84]: df[:5]
Out[84]: 
               0         1
one  y  1.519970 -0.493662
     x  0.600178  0.274230
zero y  0.132885 -0.023688
```

```
     x  2.410179  1.450520

In [85]: df[:5].swaplevel(0, 1, axis=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
              0         1
y one   1.519970 -0.493662
x one   0.600178  0.274230
y zero  0.132885 -0.023688
x zero  2.410179  1.450520
```

13.2.5 Reordering levels with `reorder_levels()`

The `reorder_levels` function generalizes the `swaplevel` function, allowing you to permute the hierarchical index levels in one step:

```
In [86]: df[:5].reorder_levels([1,0], axis=0)
Out[86]:
              0         1
y one   1.519970 -0.493662
x one   0.600178  0.274230
y zero  0.132885 -0.023688
x zero  2.410179  1.450520
```

13.3 Sorting a `MultiIndex`

For MultiIndex-ed objects to be indexed & sliced effectively, they need to be sorted. As with any index, you can use `sort_index`.

```
In [87]: import random; random.shuffle(tuples)

In [88]: s = pd.Series(np.random.randn(8), index=pd.MultiIndex.from_tuples(tuples))

In [89]: s
Out[89]:
qux  one    0.206053
bar  one   -0.251905
foo  one   -2.213588
bar  two    1.063327
foo  two    1.266143
qux  two    0.299368
baz  two   -0.863838
     one    0.408204
dtype: float64

In [90]: s.sort_index()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
bar  one   -0.251905
     two    1.063327
baz  one    0.408204
     two   -0.863838
foo  one   -2.213588
     two    1.266143
```

```
qux  one    0.206053
     two    0.299368
dtype: float64

In [91]: s.sort_index(level=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
bar  one   -0.251905
     two    1.063327
baz  one    0.408204
     two   -0.863838
foo  one   -2.213588
     two    1.266143
qux  one    0.206053
     two    0.299368
dtype: float64

In [92]: s.sort_index(level=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
bar  one   -0.251905
baz  one    0.408204
foo  one   -2.213588
qux  one    0.206053
bar  two    1.063327
baz  two   -0.863838
foo  two    1.266143
qux  two    0.299368
dtype: float64
```

You may also pass a level name to `sort_index` if the MultiIndex levels are named.

```
In [93]: s.index.set_names(['L1', 'L2'], inplace=True)

In [94]: s.sort_index(level='L1')
Out[94]:
L1   L2
bar  one   -0.251905
     two    1.063327
baz  one    0.408204
     two   -0.863838
foo  one   -2.213588
     two    1.266143
qux  one    0.206053
     two    0.299368
dtype: float64

In [95]: s.sort_index(level='L2')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
L1   L2
bar  one   -0.251905
baz  one    0.408204
foo  one   -2.213588
qux  one    0.206053
bar  two    1.063327
baz  two   -0.863838
foo  two    1.266143
```

```
qux  two    0.299368
dtype: float64
```

On higher dimensional objects, you can sort any of the other axes by level if they have a MultiIndex:

```
In [96]: df.T.sort_index(level=1, axis=1)
Out[96]:
       zero       one      zero       one
          x         x         y         y
0  2.410179  0.600178  0.132885  1.519970
1  1.450520  0.274230 -0.023688 -0.493662
```

Indexing will work even if the data are not sorted, but will be rather inefficient (and show a `PerformanceWarning`). It will also return a copy of the data rather than a view:

```
In [97]: dfm = pd.DataFrame({'jim': [0, 0, 1, 1],
   ....:                     'joe': ['x', 'x', 'z', 'y'],
   ....:                     'jolie': np.random.rand(4)})
   ....:

In [98]: dfm = dfm.set_index(['jim', 'joe'])

In [99]: dfm
Out[99]:
            jolie
jim joe
0   x    0.490671
    x    0.120248
1   z    0.537020
    y    0.110968
```

```
In [4]: dfm.loc[(1, 'z')]
PerformanceWarning: indexing past lexsort depth may impact performance.

Out[4]:
           jolie
jim joe
1   z    0.64094
```

Furthermore if you try to index something that is not fully lexsorted, this can raise:

```
In [5]: dfm.loc[(0,'y'):(1, 'z')]
UnsortedIndexError: 'Key length (2) was greater than MultiIndex lexsort depth (1)'
```

The `is_lexsorted()` method on an `Index` show if the index is sorted, and the `lexsort_depth` property returns the sort depth:

```
In [100]: dfm.index.is_lexsorted()
Out[100]: False

In [101]: dfm.index.lexsort_depth
\\\\\\\\\\\\\\\Out[101]: 1
```

```
In [102]: dfm = dfm.sort_index()

In [103]: dfm
Out[103]:
```

```
            jolie
jim joe
0   x    0.490671
    x    0.120248
1   y    0.110968
    z    0.537020

In [104]: dfm.index.is_lexsorted()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪True

In [105]: dfm.index.lexsort_depth
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪2
```

And now selection works as expected.

```
In [106]: dfm.loc[(0,'y'):(1, 'z')]
Out[106]:
            jolie
jim joe
1   y    0.110968
    z    0.537020
```

13.4 Take Methods

Similar to numpy ndarrays, pandas Index, Series, and DataFrame also provides the `take` method that retrieves elements along a given axis at the given indices. The given indices must be either a list or an ndarray of integer index positions. `take` will also accept negative integers as relative positions to the end of the object.

```
In [107]: index = pd.Index(np.random.randint(0, 1000, 10))

In [108]: index
Out[108]: Int64Index([214, 502, 712, 567, 786, 175, 993, 133, 758, 329], dtype='int64
↪')

In [109]: positions = [0, 9, 3]

In [110]: index[positions]
Out[110]: Int64Index([214, 329, 567], dtype='int64')

In [111]: index.take(positions)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[111]: Int64Index([214, 329,␣
↪567], dtype='int64')

In [112]: ser = pd.Series(np.random.randn(10))

In [113]: ser.iloc[positions]
Out[113]:
0   -0.179666
9    1.824375
3    0.392149
dtype: float64

In [114]: ser.take(positions)
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[114]:
0   -0.179666
9    1.824375
3    0.392149
dtype: float64
```

For DataFrames, the given indices should be a 1d list or ndarray that specifies row or column positions.

```
In [115]: frm = pd.DataFrame(np.random.randn(5, 3))

In [116]: frm.take([1, 4, 3])
Out[116]:
          0         1         2
1 -1.237881  0.106854 -1.276829
4  0.629675 -1.425966  1.857704
3  0.979542 -1.633678  0.615855

In [117]: frm.take([0, 2], axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          0         2
0  0.595974  0.601544
1 -1.237881 -1.276829
2 -0.767101  1.499591
3  0.979542  0.615855
4  0.629675  1.857704
```

It is important to note that the `take` method on pandas objects are not intended to work on boolean indices and may return unexpected results.

```
In [118]: arr = np.random.randn(10)

In [119]: arr.take([False, False, True, True])
Out[119]: array([-1.1935, -1.1935,  0.6775,  0.6775])

In [120]: arr[[0, 1]]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[120]: array([-1.1935,  0.
↪6775])

In [121]: ser = pd.Series(np.random.randn(10))

In [122]: ser.take([False, False, True, True])
Out[122]:
0    0.233141
0    0.233141
1   -0.223540
1   -0.223540
dtype: float64

In [123]: ser.iloc[[0, 1]]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[123]:␣
↪
0    0.233141
1   -0.223540
dtype: float64
```

Finally, as a small note on performance, because the `take` method handles a narrower range of inputs, it can offer performance that is a good deal faster than fancy indexing.

13.5 Index Types

We have discussed `MultiIndex` in the previous sections pretty extensively. `DatetimeIndex` and `PeriodIndex` are shown *here*. `TimedeltaIndex` are *here*.

In the following sub-sections we will highlight some other index types.

13.5.1 CategoricalIndex

`CategoricalIndex` is a type of index that is useful for supporting indexing with duplicates. This is a container around a `Categorical` and allows efficient indexing and storage of an index with a large number of duplicated elements.

```
In [124]: from pandas.api.types import CategoricalDtype

In [125]: df = pd.DataFrame({'A': np.arange(6),
   .....:                    'B': list('aabbca')})
   .....:

In [126]: df['B'] = df['B'].astype(CategoricalDtype(list('cab')))

In [127]: df
Out[127]:
   A  B
0  0  a
1  1  a
2  2  b
3  3  b
4  4  c
5  5  a

In [128]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[128]:
A       int64
B    category
dtype: object

In [129]: df.B.cat.categories
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Index(['c', 'a', 'b'], dtype='object')
```

Setting the index, will create a `CategoricalIndex`

```
In [130]: df2 = df.set_index('B')

In [131]: df2.index
Out[131]: CategoricalIndex(['a', 'a', 'b', 'b', 'c', 'a'], categories=['c', 'a', 'b'],
↪ ordered=False, name='B', dtype='category')
```

Indexing with `__getitem__/.iloc/.loc` works similarly to an `Index` with duplicates. The indexers MUST be in the category or the operation will raise.

```
In [132]: df2.loc['a']
Out[132]:
   A
B
```

```
a   0
a   1
a   5
```

These PRESERVE the `CategoricalIndex`

```
In [133]: df2.loc['a'].index
Out[133]: CategoricalIndex(['a', 'a', 'a'], categories=['c', 'a', 'b'], ordered=False,
↪ name='B', dtype='category')
```

Sorting will order by the order of the categories

```
In [134]: df2.sort_index()
Out[134]: 
   A
B   
c  4
a  0
a  1
a  5
b  2
b  3
```

Groupby operations on the index will preserve the index nature as well

```
In [135]: df2.groupby(level=0).sum()
Out[135]: 
   A
B   
c  4
a  6
b  5

In [136]: df2.groupby(level=0).sum().index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[136]: CategoricalIndex(['c', 'a', 'b'],␣
↪categories=['c', 'a', 'b'], ordered=False, name='B', dtype='category')
```

Reindexing operations, will return a resulting index based on the type of the passed indexer, meaning that passing a list will return a plain-old-`Index`; indexing with a `Categorical` will return a `CategoricalIndex`, indexed according to the categories of the PASSED `Categorical` dtype. This allows one to arbitrarily index these even with values NOT in the categories, similarly to how you can reindex ANY pandas index.

```
In [137]: df2.reindex(['a','e'])
Out[137]: 
     A
B     
a  0.0
a  1.0
a  5.0
e  NaN

In [138]: df2.reindex(['a','e']).index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[138]: Index(['a', 'a', 'a',
↪'e'], dtype='object', name='B')

In [139]: df2.reindex(pd.Categorical(['a','e'],categories=list('abcde')))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
     A
B
a  0.0
a  1.0
a  5.0
e  NaN

In [140]: df2.reindex(pd.Categorical(['a','e'],categories=list('abcde'))).index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪CategoricalIndex(['a', 'a', 'a', 'e'], categories=['a', 'b', 'c', 'd', 'e'],␣
↪ordered=False, name='B', dtype='category')
```

> **Warning:** Reshaping and Comparison operations on a `CategoricalIndex` must have the same categories or a `TypeError` will be raised.
>
> ```
> In [9]: df3 = pd.DataFrame({'A' : np.arange(6),
>                             'B' : pd.Series(list('aabbca')).astype('category')})
>
> In [11]: df3 = df3.set_index('B')
>
> In [11]: df3.index
> Out[11]: CategoricalIndex([u'a', u'a', u'b', u'b', u'c', u'a'], categories=[u'a', u
>  ↪'b', u'c'], ordered=False, name=u'B', dtype='category')
>
> In [12]: pd.concat([df2, df3]
> TypeError: categories must match existing categories when appending
> ```

13.5.2 Int64Index and RangeIndex

> **Warning:** Indexing on an integer-based Index with floats has been clarified in 0.18.0, for a summary of the changes, see *here*.

`Int64Index` is a fundamental basic index in *pandas*. This is an Immutable array implementing an ordered, sliceable set. Prior to 0.18.0, the `Int64Index` would provide the default index for all `NDFrame` objects.

`RangeIndex` is a sub-class of `Int64Index` added in version 0.18.0, now providing the default index for all `NDFrame` objects. `RangeIndex` is an optimized version of `Int64Index` that can represent a monotonic ordered set. These are analogous to python range types.

13.5.3 Float64Index

By default a `Float64Index` will be automatically created when passing floating, or mixed-integer-floating values in index creation. This enables a pure label-based slicing paradigm that makes `[],ix,loc` for scalar indexing and slicing work exactly the same.

```
In [141]: indexf = pd.Index([1.5, 2, 3, 4.5, 5])

In [142]: indexf
Out[142]: Float64Index([1.5, 2.0, 3.0, 4.5, 5.0], dtype='float64')

In [143]: sf = pd.Series(range(5), index=indexf)
```

```
In [144]: sf
Out[144]:
1.5    0
2.0    1
3.0    2
4.5    3
5.0    4
dtype: int64
```

Scalar selection for `[],.loc` will always be label based. An integer will match an equal float index (e.g. `3` is equivalent to `3.0`)

```
In [145]: sf[3]
Out[145]: 2

In [146]: sf[3.0]
\\\\\\\\\\\\Out[146]: 2

In [147]: sf.loc[3]
\\\\\\\\\\\\\\\\\\\\\\\\Out[147]: 2

In [148]: sf.loc[3.0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[148]: 2
```

The only positional indexing is via `iloc`

```
In [149]: sf.iloc[3]
Out[149]: 3
```

A scalar index that is not found will raise `KeyError`

Slicing is ALWAYS on the values of the index, for `[],ix,loc` and ALWAYS positional with `iloc`

```
In [150]: sf[2:4]
Out[150]:
2.0    1
3.0    2
dtype: int64

In [151]: sf.loc[2:4]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[151]:
2.0    1
3.0    2
dtype: int64

In [152]: sf.iloc[2:4]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[152]:␣
↪
3.0    2
4.5    3
dtype: int64
```

In float indexes, slicing using floats is allowed

```
In [153]: sf[2.1:4.6]
Out[153]:
3.0    2
```

```
4.5    3
dtype: int64

In [154]: sf.loc[2.1:4.6]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[154]:
3.0    2
4.5    3
dtype: int64
```

In non-float indexes, slicing using floats will raise a `TypeError`

```
In [1]: pd.Series(range(5))[3.5]
TypeError: the label [3.5] is not a proper indexer for this index type (Int64Index)

In [1]: pd.Series(range(5))[3.5:4.5]
TypeError: the slice start [3.5] is not a proper indexer for this index type␣
↪(Int64Index)
```

Warning: Using a scalar float indexer for `.iloc` has been removed in 0.18.0, so the following will raise a `TypeError`

```
In [3]: pd.Series(range(5)).iloc[3.0]
TypeError: cannot do positional indexing on <class 'pandas.indexes.range.RangeIndex
↪'> with these indexers [3.0] of <type 'float'>
```

Here is a typical use-case for using this type of indexing. Imagine that you have a somewhat irregular timedelta-like indexing scheme, but the data is recorded as floats. This could for example be millisecond offsets.

```
In [155]: dfir = pd.concat([pd.DataFrame(np.random.randn(5,2),
   .....:                                index=np.arange(5) * 250.0,
   .....:                                columns=list('AB')),
   .....:                   pd.DataFrame(np.random.randn(6,2),
   .....:                                index=np.arange(4,10) * 250.1,
   .....:                                columns=list('AB'))])
   .....:

In [156]: dfir
Out[156]:
                A         B
0.0      0.997289 -1.693316
250.0   -0.179129 -1.598062
500.0    0.936914  0.912560
750.0   -1.003401  1.632781
1000.0  -0.724626  0.178219
1000.4   0.310610 -0.108002
1250.5  -0.974226 -1.147708
1500.6  -2.281374  0.760010
1750.7  -0.742532  1.533318
2000.8   2.495362 -0.432771
2250.9  -0.068954  0.043520
```

Selection operations then will always work on a value basis, for all selection operators.

```
In [157]: dfir[0:1000.4]
Out[157]:
                A         B
```

```
0.0     0.997289 -1.693316
250.0  -0.179129 -1.598062
500.0   0.936914  0.912560
750.0  -1.003401  1.632781
1000.0 -0.724626  0.178219
1000.4  0.310610 -0.108002

In [158]: dfir.loc[0:1001,'A']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0.0       0.997289
250.0    -0.179129
500.0     0.936914
750.0    -1.003401
1000.0   -0.724626
1000.4    0.310610
Name: A, dtype: float64

In [159]: dfir.loc[1000.4]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    0.310610
B   -0.108002
Name: 1000.4, dtype: float64
```

You could then easily pick out the first 1 second (1000 ms) of data then.

```
In [160]: dfir[0:1000]
Out[160]:
               A         B
0.0     0.997289 -1.693316
250.0  -0.179129 -1.598062
500.0   0.936914  0.912560
750.0  -1.003401  1.632781
1000.0 -0.724626  0.178219
```

Of course if you need integer based selection, then use `iloc`

```
In [161]: dfir.iloc[0:5]
Out[161]:
               A         B
0.0     0.997289 -1.693316
250.0  -0.179129 -1.598062
500.0   0.936914  0.912560
750.0  -1.003401  1.632781
1000.0 -0.724626  0.178219
```

13.5.4 IntervalIndex

`IntervalIndex` together with its own dtype, `interval` as well as the *`Interval`* scalar type, allow first-class support in pandas for interval notation.

The `IntervalIndex` allows some unique indexing and is also used as a return type for the categories in *`cut()`* and *`qcut()`*.

New in version 0.20.0.

Warning: These indexing behaviors are provisional and may change in a future version of pandas.

An `IntervalIndex` can be used in `Series` and in `DataFrame` as the index.

```
In [162]: df = pd.DataFrame({'A': [1, 2, 3, 4]},
   .....:                   index=pd.IntervalIndex.from_breaks([0, 1, 2, 3, 4]))
   .....:

In [163]: df
Out[163]: 
        A
(0, 1]  1
(1, 2]  2
(2, 3]  3
(3, 4]  4
```

Label based indexing via `.loc` along the edges of an interval works as you would expect, selecting that particular interval.

```
In [164]: df.loc[2]
Out[164]: 
A    2
Name: (1, 2], dtype: int64

In [165]: df.loc[[2, 3]]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[165]: 
        A
(1, 2]  2
(2, 3]  3
```

If you select a lable *contained* within an interval, this will also select the interval.

```
In [166]: df.loc[2.5]
Out[166]: 
A    3
Name: (2, 3], dtype: int64

In [167]: df.loc[[2.5, 3.5]]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[167]: 
        A
(2, 3]  3
(3, 4]  4
```

`Interval` and `IntervalIndex` are used by `cut` and `qcut`:

```
In [168]: c = pd.cut(range(4), bins=2)

In [169]: c
Out[169]: 
[(-0.003, 1.5], (-0.003, 1.5], (1.5, 3.0], (1.5, 3.0]]
Categories (2, interval[float64]): [(-0.003, 1.5] < (1.5, 3.0]]

In [170]: c.categories
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
IntervalIndex([(-0.003, 1.5], (1.5, 3.0]]
```

```
              closed='right',
              dtype='interval[float64]')
```

Furthermore, `IntervalIndex` allows one to bin *other* data with these same bins, with `NaN` representing a missing value similar to other dtypes.

```
In [171]: pd.cut([0, 3, 5, 1], bins=c.categories)
Out[171]:
[(-0.003, 1.5], (1.5, 3.0], NaN, (-0.003, 1.5]]
Categories (2, interval[float64]): [(-0.003, 1.5] < (1.5, 3.0]]
```

13.6 Miscellaneous indexing FAQ

13.6.1 Integer indexing

Label-based indexing with integer axis labels is a thorny topic. It has been discussed heavily on mailing lists and among various members of the scientific Python community. In pandas, our general viewpoint is that labels matter more than integer locations. Therefore, with an integer axis index *only* label-based indexing is possible with the standard tools like `.loc`. The following code will generate exceptions:

```
s = pd.Series(range(5))
s[-1]
df = pd.DataFrame(np.random.randn(5, 4))
df
df.loc[-2:]
```

This deliberate decision was made to prevent ambiguities and subtle bugs (many users reported finding bugs when the API change was made to stop “falling back” on position-based indexing).

13.6.2 Non-monotonic indexes require exact matches

If the index of a `Series` or `DataFrame` is monotonically increasing or decreasing, then the bounds of a label-based slice can be outside the range of the index, much like slice indexing a normal Python `list`. Monotonicity of an index can be tested with the `is_monotonic_increasing` and `is_monotonic_decreasing` attributes.

```
In [172]: df = pd.DataFrame(index=[2,3,3,4,5], columns=['data'], data=list(range(5)))

In [173]: df.index.is_monotonic_increasing
Out[173]: True

# no rows 0 or 1, but still returns rows 2, 3 (both of them), and 4:
In [174]: df.loc[0:4, :]
\\\\\\\\\\\\\\Out[174]:
   data
2     0
3     1
3     2
4     3

# slice is are outside the index, so empty DataFrame is returned
In [175]: df.loc[13:15, :]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[175]:
Empty DataFrame
```

```
Columns: [data]
Index: []
```

On the other hand, if the index is not monotonic, then both slice bounds must be *unique* members of the index.

```
In [176]: df = pd.DataFrame(index=[2,3,1,4,3,5], columns=['data'],␣
↪data=list(range(6)))

In [177]: df.index.is_monotonic_increasing
Out[177]: False

# OK because 2 and 4 are in the index
In [178]: df.loc[2:4, :]
\\\\\\\\\\\\\\\\Out[178]:
   data
2     0
3     1
1     2
4     3
```

```
# 0 is not in the index
In [9]: df.loc[0:4, :]
KeyError: 0

# 3 is not a unique label
In [11]: df.loc[2:3, :]
KeyError: 'Cannot get right slice bound for non-unique label: 3'
```

Index.is_monotonic_increasing() and *Index.is_monotonic_decreasing()* only check that an index is weakly monotonic. To check for strict montonicity, you can combine one of those with *Index.is_unique()*

```
In [179]: weakly_monotonic = pd.Index(['a', 'b', 'c', 'c'])

In [180]: weakly_monotonic
Out[180]: Index(['a', 'b', 'c', 'c'], dtype='object')

In [181]: weakly_monotonic.is_monotonic_increasing
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[181]: True

In [182]: weakly_monotonic.is_monotonic_increasing & weakly_monotonic.is_unique
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[182]: False
```

13.6.3 Endpoints are inclusive

Compared with standard Python sequence slicing in which the slice endpoint is not inclusive, label-based slicing in pandas **is inclusive**. The primary reason for this is that it is often not possible to easily determine the "successor" or next element after a particular label in an index. For example, consider the following Series:

```
In [183]: s = pd.Series(np.random.randn(6), index=list('abcdef'))

In [184]: s
Out[184]:
a    0.112246
b    0.871721
```

```
c   -0.816064
d   -0.784880
e    1.030659
f    0.187483
dtype: float64
```

Suppose we wished to slice from `c` to `e`, using integers this would be

```
In [185]: s[2:5]
Out[185]:
c   -0.816064
d   -0.784880
e    1.030659
dtype: float64
```

However, if you only had `c` and `e`, determining the next element in the index can be somewhat complicated. For example, the following does not work:

```
s.loc['c':'e'+1]
```

A very common use case is to limit a time series to start and end at two specific dates. To enable this, we made the design to make label-based slicing include both endpoints:

```
In [186]: s.loc['c':'e']
Out[186]:
c   -0.816064
d   -0.784880
e    1.030659
dtype: float64
```

This is most definitely a "practicality beats purity" sort of thing, but it is something to watch out for if you expect label-based slicing to behave exactly in the way that standard Python integer slicing works.

13.6.4 Indexing potentially changes underlying Series dtype

The different indexing operation can potentially change the dtype of a `Series`.

```
In [187]: series1 = pd.Series([1, 2, 3])

In [188]: series1.dtype
Out[188]: dtype('int64')

In [189]: res = series1.reindex([0, 4])

In [190]: res.dtype
Out[190]: dtype('float64')

In [191]: res
\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[191]:
0    1.0
4    NaN
dtype: float64
```

```
In [192]: series2 = pd.Series([True])

In [193]: series2.dtype
```

```
Out[193]: dtype('bool')

In [194]: res = series2.reindex_like(series1)

In [195]: res.dtype
Out[195]: dtype('O')

In [196]: res
\\\\\\\\\\\\\\\\\\\\Out[196]:
0    True
1     NaN
2     NaN
dtype: object
```

This is because the (re)indexing operations above silently inserts `NaNs` and the `dtype` changes accordingly. This can cause some issues when using `numpy` `ufuncs` such as `numpy.logical_and`.

See the this old issue for a more detailed discussion.

CHAPTER

FOURTEEN

COMPUTATIONAL TOOLS

14.1 Statistical Functions

14.1.1 Percent Change

`Series`, `DataFrame`, and `Panel` all have a method `pct_change` to compute the percent change over a given number of periods (using `fill_method` to fill NA/null values *before* computing the percent change).

```
In [1]: ser = pd.Series(np.random.randn(8))

In [2]: ser.pct_change()
Out[2]:
0         NaN
1   -1.602976
2    4.334938
3   -0.247456
4   -2.067345
5   -1.142903
6   -1.688214
7   -9.759729
dtype: float64
```

```
In [3]: df = pd.DataFrame(np.random.randn(10, 4))

In [4]: df.pct_change(periods=3)
Out[4]:
          0         1         2         3
0       NaN       NaN       NaN       NaN
1       NaN       NaN       NaN       NaN
2       NaN       NaN       NaN       NaN
3 -0.218320 -1.054001  1.987147 -0.510183
4 -0.439121 -1.816454  0.649715 -4.822809
5 -0.127833 -3.042065 -5.866604 -1.776977
6 -2.596833 -1.959538 -2.111697 -3.798900
7 -0.117826 -2.169058  0.036094 -0.067696
8  2.492606 -1.357320 -1.205802 -1.558697
9 -1.012977  2.324558 -1.003744 -0.371806
```

14.1.2 Covariance

The `Series` object has a method `cov` to compute covariance between series (excluding NA/null values).

```
In [5]: s1 = pd.Series(np.random.randn(1000))

In [6]: s2 = pd.Series(np.random.randn(1000))

In [7]: s1.cov(s2)
Out[7]: 0.00068010881743110871
```

Analogously, `DataFrame` has a method `cov` to compute pairwise covariances among the series in the DataFrame, also excluding NA/null values.

Note: Assuming the missing data are missing at random this results in an estimate for the covariance matrix which is unbiased. However, for many applications this estimate may not be acceptable because the estimated covariance matrix is not guaranteed to be positive semi-definite. This could lead to estimated correlations having absolute values which are greater than one, and/or a non-invertible covariance matrix. See Estimation of covariance matrices for more details.

```
In [8]: frame = pd.DataFrame(np.random.randn(1000, 5), columns=['a', 'b', 'c', 'd', 'e
↪'])

In [9]: frame.cov()
Out[9]: 
          a         b         c         d         e
a  1.000882 -0.003177 -0.002698 -0.006889  0.031912
b -0.003177  1.024721  0.000191  0.009212  0.000857
c -0.002698  0.000191  0.950735 -0.031743 -0.005087
d -0.006889  0.009212 -0.031743  1.002983 -0.047952
e  0.031912  0.000857 -0.005087 -0.047952  1.042487
```

`DataFrame.cov` also supports an optional `min_periods` keyword that specifies the required minimum number of observations for each column pair in order to have a valid result.

```
In [10]: frame = pd.DataFrame(np.random.randn(20, 3), columns=['a', 'b', 'c'])

In [11]: frame.loc[frame.index[:5], 'a'] = np.nan

In [12]: frame.loc[frame.index[5:10], 'b'] = np.nan

In [13]: frame.cov()
Out[13]: 
          a         b         c
a  1.123670 -0.412851  0.018169
b -0.412851  1.154141  0.305260
c  0.018169  0.305260  1.301149

In [14]: frame.cov(min_periods=12)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          a         b         c
a  1.123670       NaN  0.018169
b       NaN  1.154141  0.305260
c  0.018169  0.305260  1.301149
```

14.1.3 Correlation

Several methods for computing correlations are provided:

Method name	Description
`pearson (default)`	Standard correlation coefficient
`kendall`	Kendall Tau correlation coefficient
`spearman`	Spearman rank correlation coefficient

All of these are currently computed using pairwise complete observations.

Note: Please see the *caveats* associated with this method of calculating correlation matrices in the *covariance section*.

```
In [15]: frame = pd.DataFrame(np.random.randn(1000, 5), columns=['a', 'b', 'c', 'd',
↪'e'])

In [16]: frame.iloc[::2] = np.nan

# Series with Series
In [17]: frame['a'].corr(frame['b'])
Out[17]: 0.013479040400098794

In [18]: frame['a'].corr(frame['b'], method='spearman')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[18]: -0.0072898851595406371

# Pairwise correlation of DataFrame columns
In [19]: frame.corr()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[19]:
          a         b         c         d         e
a  1.000000  0.013479 -0.049269 -0.042239 -0.028525
b  0.013479  1.000000 -0.020433 -0.011139  0.005654
c -0.049269 -0.020433  1.000000  0.018587 -0.054269
d -0.042239 -0.011139  0.018587  1.000000 -0.017060
e -0.028525  0.005654 -0.054269 -0.017060  1.000000
```

Note that non-numeric columns will be automatically excluded from the correlation calculation.

Like `cov`, `corr` also supports the optional `min_periods` keyword:

```
In [20]: frame = pd.DataFrame(np.random.randn(20, 3), columns=['a', 'b', 'c'])

In [21]: frame.loc[frame.index[:5], 'a'] = np.nan

In [22]: frame.loc[frame.index[5:10], 'b'] = np.nan

In [23]: frame.corr()
Out[23]:
          a         b         c
a  1.000000 -0.121111  0.069544
b -0.121111  1.000000  0.051742
c  0.069544  0.051742  1.000000

In [24]: frame.corr(min_periods=12)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          a         b         c
a  1.000000       NaN  0.069544
```

```
b       NaN  1.000000  0.051742
c  0.069544  0.051742  1.000000
```

A related method `corrwith` is implemented on DataFrame to compute the correlation between like-labeled Series contained in different DataFrame objects.

```
In [25]: index = ['a', 'b', 'c', 'd', 'e']

In [26]: columns = ['one', 'two', 'three', 'four']

In [27]: df1 = pd.DataFrame(np.random.randn(5, 4), index=index, columns=columns)

In [28]: df2 = pd.DataFrame(np.random.randn(4, 4), index=index[:4], columns=columns)

In [29]: df1.corrwith(df2)
Out[29]:
one     -0.125501
two     -0.493244
three    0.344056
four     0.004183
dtype: float64

In [30]: df2.corrwith(df1, axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out
↪
a   -0.675817
b    0.458296
c    0.190809
d   -0.186275
e         NaN
dtype: float64
```

14.1.4 Data ranking

The `rank` method produces a data ranking with ties being assigned the mean of the ranks (by default) for the group:

```
In [31]: s = pd.Series(np.random.np.random.randn(5), index=list('abcde'))

In [32]: s['d'] = s['b'] # so there's a tie

In [33]: s.rank()
Out[33]:
a    5.0
b    2.5
c    1.0
d    2.5
e    4.0
dtype: float64
```

`rank` is also a DataFrame method and can rank either the rows (`axis=0`) or the columns (`axis=1`). `NaN` values are excluded from the ranking.

```
In [34]: df = pd.DataFrame(np.random.np.random.randn(10, 6))

In [35]: df[4] = df[2][:5] # some ties
```

```
In [36]: df
Out[36]:
          0         1         2         3         4         5
0 -0.904948 -1.163537 -1.457187  0.135463 -1.457187  0.294650
1 -0.976288 -0.244652 -0.748406 -0.999601 -0.748406 -0.800809
2  0.401965  1.460840  1.256057  1.308127  1.256057  0.876004
3  0.205954  0.369552 -0.669304  0.038378 -0.669304  1.140296
4 -0.477586 -0.730705 -1.129149 -0.601463 -1.129149 -0.211196
5 -1.092970 -0.689246  0.908114  0.204848       NaN  0.463347
6  0.376892  0.959292  0.095572 -0.593740       NaN -0.069180
7 -1.002601  1.957794 -0.120708  0.094214       NaN -1.467422
8 -0.547231  0.664402 -0.519424 -0.073254       NaN -1.263544
9 -0.250277 -0.237428 -1.056443  0.419477       NaN  1.375064

In [37]: df.rank(1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     0    1    2    3    4    5
0  4.0  3.0  1.5  5.0  1.5  6.0
1  2.0  6.0  4.5  1.0  4.5  3.0
2  1.0  6.0  3.5  5.0  3.5  2.0
3  4.0  5.0  1.5  3.0  1.5  6.0
4  5.0  3.0  1.5  4.0  1.5  6.0
5  1.0  2.0  5.0  3.0  NaN  4.0
6  4.0  5.0  3.0  1.0  NaN  2.0
7  2.0  5.0  3.0  4.0  NaN  1.0
8  2.0  5.0  3.0  4.0  NaN  1.0
9  2.0  3.0  1.0  4.0  NaN  5.0
```

`rank` optionally takes a parameter `ascending` which by default is true; when false, data is reverse-ranked, with larger values assigned a smaller rank.

`rank` supports different tie-breaking methods, specified with the `method` parameter:

- `average` : average rank of tied group
- `min` : lowest rank in the group
- `max` : highest rank in the group
- `first` : ranks assigned in the order they appear in the array

14.2 Window Functions

Warning: Prior to version 0.18.0, `pd.rolling_*`, `pd.expanding_*`, and `pd.ewm*` were module level functions and are now deprecated. These are replaced by using the `Rolling`, `Expanding` and `EWM`. objects and a corresponding method call.

The deprecation warning will show the new syntax, see an example *here* You can view the previous documentation here

For working with data, a number of windows functions are provided for computing common *window* or *rolling* statistics. Among these are count, sum, mean, median, correlation, variance, covariance, standard deviation, skewness, and kurtosis.

Starting in version 0.18.1, the `rolling()` and `expanding()` functions can be used directly from DataFrameGroupBy objects, see the *groupby docs*.

Note: The API for window statistics is quite similar to the way one works with `GroupBy` objects, see the documentation *here*

We work with `rolling`, `expanding` and `exponentially weighted` data through the corresponding objects, `Rolling`, `Expanding` and `EWM`.

```
In [38]: s = pd.Series(np.random.randn(1000), index=pd.date_range('1/1/2000',␣
↪periods=1000))

In [39]: s = s.cumsum()

In [40]: s
Out[40]:
2000-01-01    -0.268824
2000-01-02    -1.771855
2000-01-03    -0.818003
2000-01-04    -0.659244
2000-01-05    -1.942133
2000-01-06    -1.869391
2000-01-07     0.563674
                ...
2002-09-20   -68.233054
2002-09-21   -66.765687
2002-09-22   -67.457323
2002-09-23   -69.253182
2002-09-24   -70.296818
2002-09-25   -70.844674
2002-09-26   -72.475016
Freq: D, Length: 1000, dtype: float64
```

These are created from methods on `Series` and `DataFrame`.

```
In [41]: r = s.rolling(window=60)

In [42]: r
Out[42]: Rolling [window=60,center=False,axis=0]
```

These object provide tab-completion of the avaible methods and properties.

```
In [14]: r.
r.agg          r.apply        r.count        r.exclusions   r.max          r.median       r.
↪name          r.skew         r.sum
r.aggregate    r.corr         r.cov          r.kurt         r.mean         r.min          r.
↪quantile      r.std          r.var
```

Generally these methods all have the same interface. They all accept the following arguments:

- `window`: size of moving window
- `min_periods`: threshold of non-null data points to require (otherwise result is NA)
- `center`: boolean, whether to set the labels at the center (default is False)

Warning: The `freq` and `how` arguments were in the API prior to 0.18.0 changes. These are deprecated in the new API. You can simply resample the input prior to creating a window function.

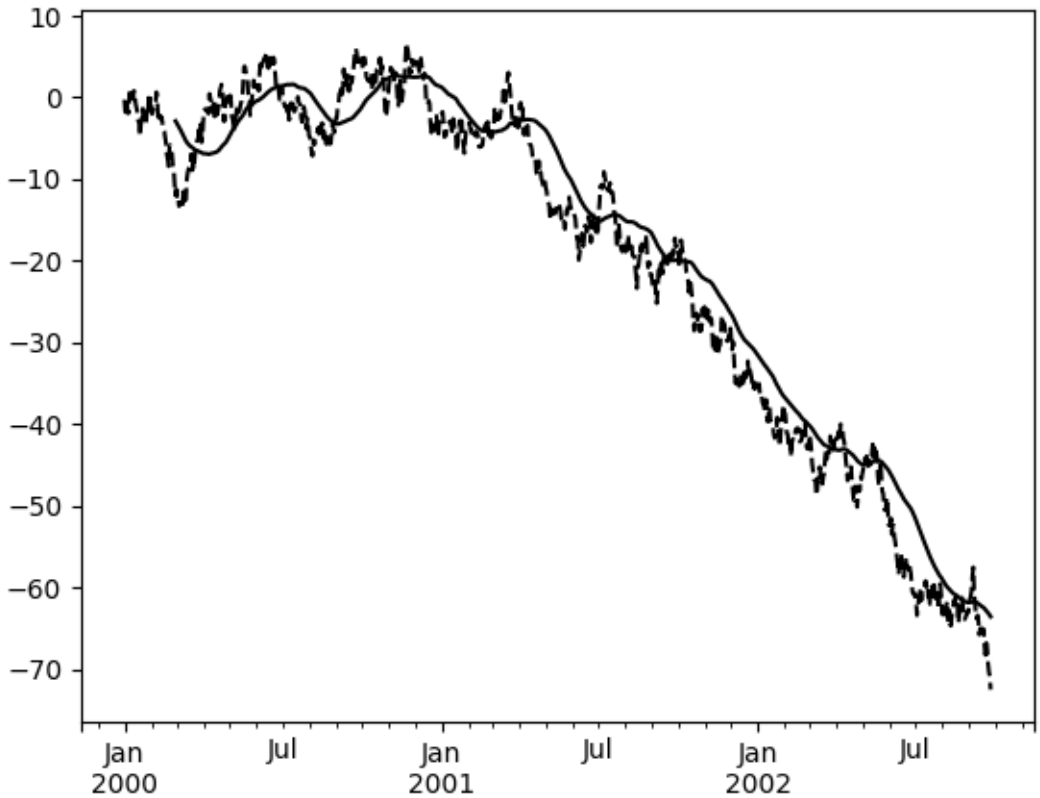
For example, instead of `s.rolling(window=5,freq='D').max()` to get the max value on a rolling 5 Day window, one could use `s.resample('D').max().rolling(window=5).max()`, which first resamples the data to daily data, then provides a rolling 5 day window.

We can then call methods on these `rolling` objects. These return like-indexed objects:

```
In [43]: r.mean()
Out[43]:
2000-01-01          NaN
2000-01-02          NaN
2000-01-03          NaN
2000-01-04          NaN
2000-01-05          NaN
2000-01-06          NaN
2000-01-07          NaN
                ...
2002-09-20   -62.694135
2002-09-21   -62.812190
2002-09-22   -62.914971
2002-09-23   -63.061867
2002-09-24   -63.213876
2002-09-25   -63.375074
2002-09-26   -63.539734
Freq: D, Length: 1000, dtype: float64
```

```
In [44]: s.plot(style='k--')
Out[44]: <matplotlib.axes._subplots.AxesSubplot at 0x121ceb748>

In [45]: r.mean().plot(style='k')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[45]: <matplotlib.
↪axes._subplots.AxesSubplot at 0x121ceb748>
```

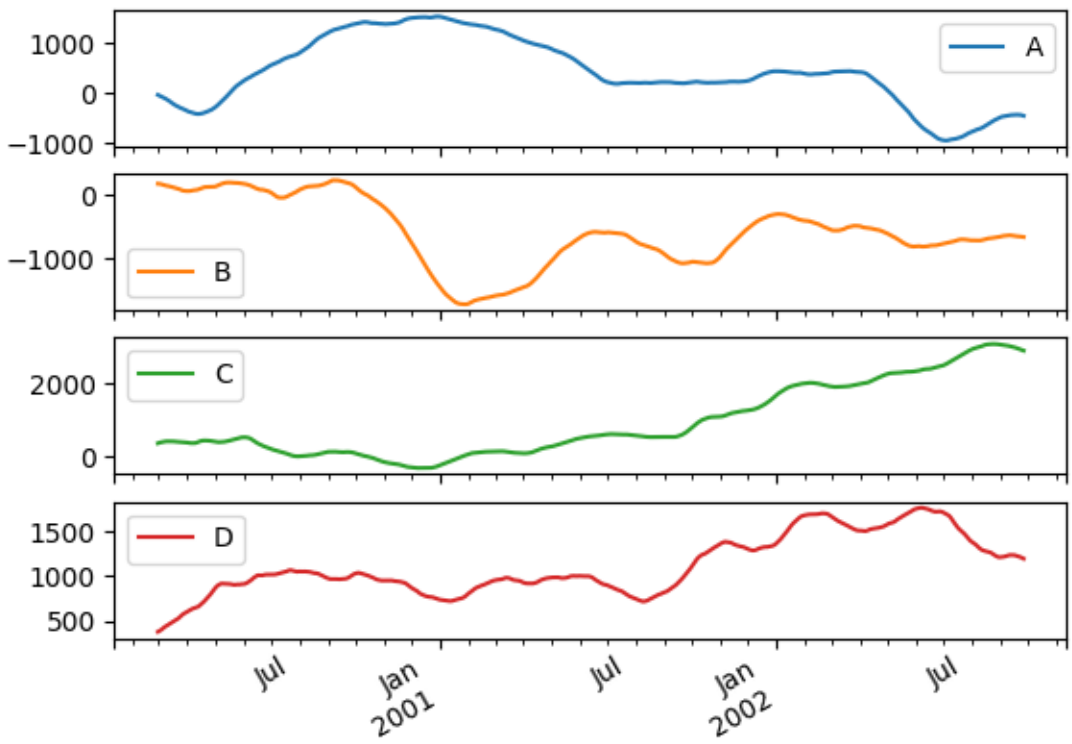


They can also be applied to DataFrame objects. This is really just syntactic sugar for applying the moving window operator to all of the DataFrame's columns:

```
In [46]: df = pd.DataFrame(np.random.randn(1000, 4),
   ....:                   index=pd.date_range('1/1/2000', periods=1000),
   ....:                   columns=['A', 'B', 'C', 'D'])
   ....:

In [47]: df = df.cumsum()

In [48]: df.rolling(window=60).sum().plot(subplots=True)
Out[48]:
array([<matplotlib.axes._subplots.AxesSubplot object at 0x116d566d8>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x121eb3320>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x121ff3160>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x12201ed30>], dtype=object)
```



14.2.1 Method Summary

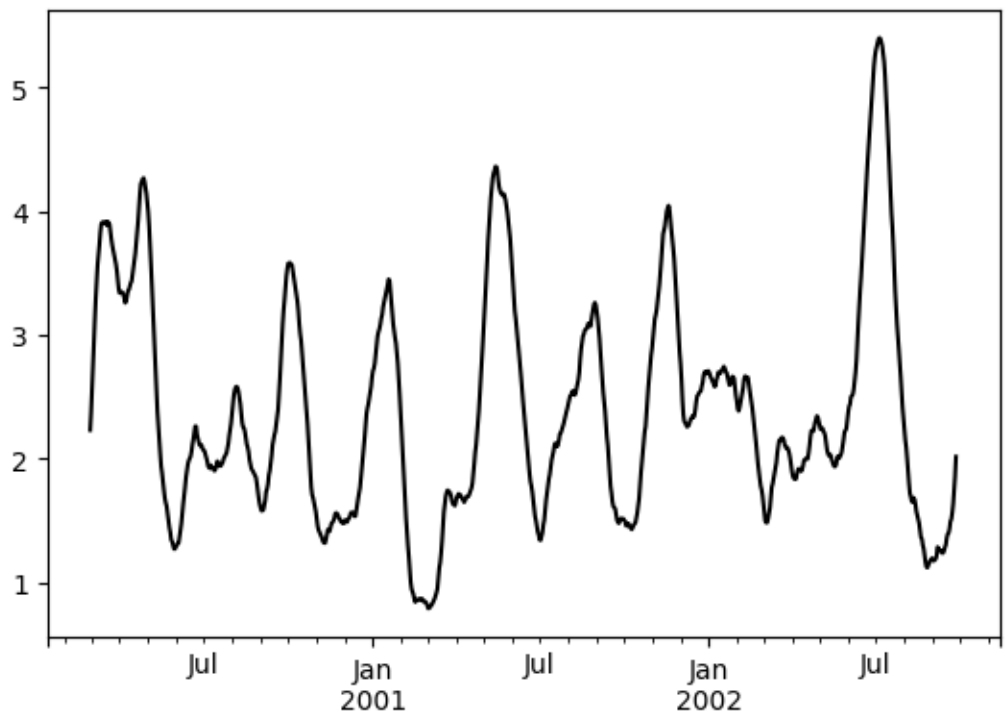
We provide a number of the common statistical functions:

Method	Description
count()	Number of non-null observations
sum()	Sum of values
mean()	Mean of values
median()	Arithmetic median of values
min()	Minimum
max()	Maximum
std()	Bessel-corrected sample standard deviation
var()	Unbiased variance
skew()	Sample skewness (3rd moment)
kurt()	Sample kurtosis (4th moment)
quantile()	Sample quantile (value at %)
apply()	Generic apply
cov()	Unbiased covariance (binary)
corr()	Correlation (binary)

The *apply()* function takes an extra `func` argument and performs generic rolling computations. The `func` argument should be a single function that produces a single value from an ndarray input. Suppose we wanted to compute the mean absolute deviation on a rolling basis:

```
In [49]: mad = lambda x: np.fabs(x - x.mean()).mean()

In [50]: s.rolling(window=60).apply(mad).plot(style='k')
Out[50]: <matplotlib.axes._subplots.AxesSubplot at 0x122067d68>
```



14.2.2 Rolling Windows

Passing `win_type` to `.rolling` generates a generic rolling window computation, that is weighted according the `win_type`. The following methods are available:

Method	Description
sum()	Sum of values
mean()	Mean of values

The weights used in the window are specified by the `win_type` keyword. The list of recognized types are:

- `boxcar`
- `triang`
- `blackman`
- `hamming`
- `bartlett`
- `parzen`
- `bohman`
- `blackmanharris`
- `nuttall`
- `barthann`
- `kaiser` (needs beta)
- `gaussian` (needs std)
- `general_gaussian` (needs power, width)

- `slepian` (needs width).

```
In [51]: ser = pd.Series(np.random.randn(10), index=pd.date_range('1/1/2000',␣
↪periods=10))

In [52]: ser.rolling(window=5, win_type='triang').mean()
Out[52]:
2000-01-01         NaN
2000-01-02         NaN
2000-01-03         NaN
2000-01-04         NaN
2000-01-05   -1.037870
2000-01-06   -0.767705
2000-01-07   -0.383197
2000-01-08   -0.395513
2000-01-09   -0.558440
2000-01-10   -0.672416
Freq: D, dtype: float64
```

Note that the `boxcar` window is equivalent to *`mean()`*.

```
In [53]: ser.rolling(window=5, win_type='boxcar').mean()
Out[53]:
2000-01-01         NaN
2000-01-02         NaN
2000-01-03         NaN
2000-01-04         NaN
2000-01-05   -0.841164
2000-01-06   -0.779948
2000-01-07   -0.565487
2000-01-08   -0.502815
2000-01-09   -0.553755
2000-01-10   -0.472211
Freq: D, dtype: float64

In [54]: ser.rolling(window=5).mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-01         NaN
2000-01-02         NaN
2000-01-03         NaN
2000-01-04         NaN
2000-01-05   -0.841164
2000-01-06   -0.779948
2000-01-07   -0.565487
2000-01-08   -0.502815
2000-01-09   -0.553755
2000-01-10   -0.472211
Freq: D, dtype: float64
```

For some windowing functions, additional parameters must be specified:

```
In [55]: ser.rolling(window=5, win_type='gaussian').mean(std=0.1)
Out[55]:
2000-01-01         NaN
2000-01-02         NaN
2000-01-03         NaN
2000-01-04         NaN
2000-01-05   -1.309989
```

```
2000-01-06   -1.153000
2000-01-07    0.606382
2000-01-08   -0.681101
2000-01-09   -0.289724
2000-01-10   -0.996632
Freq: D, dtype: float64
```

Note: For `.sum()` with a `win_type`, there is no normalization done to the weights for the window. Passing custom weights of `[1, 1, 1]` will yield a different result than passing weights of `[2, 2, 2]`, for example. When passing a `win_type` instead of explicitly specifying the weights, the weights are already normalized so that the largest weight is 1.

In contrast, the nature of the `.mean()` calculation is such that the weights are normalized with respect to each other. Weights of `[1, 1, 1]` and `[2, 2, 2]` yield the same result.

14.2.3 Time-aware Rolling

New in version 0.19.0.

New in version 0.19.0 are the ability to pass an offset (or convertible) to a `.rolling()` method and have it produce variable sized windows based on the passed time window. For each time point, this includes all preceding values occurring within the indicated time delta.

This can be particularly useful for a non-regular time frequency index.

```
In [56]: dft = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]},
   ....:                    index=pd.date_range('20130101 09:00:00', periods=5, freq=
↪'s'))
   ....:

In [57]: dft
Out[57]:
                       B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:01  1.0
2013-01-01 09:00:02  2.0
2013-01-01 09:00:03  NaN
2013-01-01 09:00:04  4.0
```

This is a regular frequency index. Using an integer window parameter works to roll along the window frequency.

```
In [58]: dft.rolling(2).sum()
Out[58]:
                       B
2013-01-01 09:00:00  NaN
2013-01-01 09:00:01  1.0
2013-01-01 09:00:02  3.0
2013-01-01 09:00:03  NaN
2013-01-01 09:00:04  NaN

In [59]: dft.rolling(2, min_periods=1).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                       B
2013-01-01 09:00:00  0.0
```

```
2013-01-01 09:00:01  1.0
2013-01-01 09:00:02  3.0
2013-01-01 09:00:03  2.0
2013-01-01 09:00:04  4.0
```

Specifying an offset allows a more intuitive specification of the rolling frequency.

```
In [60]: dft.rolling('2s').sum()
Out[60]:
                       B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:01  1.0
2013-01-01 09:00:02  3.0
2013-01-01 09:00:03  2.0
2013-01-01 09:00:04  4.0
```

Using a non-regular, but still monotonic index, rolling with an integer window does not impart any special calculation.

```
In [61]: dft = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]},
   ....:                    index = pd.Index([pd.Timestamp('20130101 09:00:00'),
   ....:                                      pd.Timestamp('20130101 09:00:02'),
   ....:                                      pd.Timestamp('20130101 09:00:03'),
   ....:                                      pd.Timestamp('20130101 09:00:05'),
   ....:                                      pd.Timestamp('20130101 09:00:06')],
   ....:                                     name='foo'))
   ....:

In [62]: dft
Out[62]:
                       B
foo
2013-01-01 09:00:00  0.0
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  2.0
2013-01-01 09:00:05  NaN
2013-01-01 09:00:06  4.0

In [63]: dft.rolling(2).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                       B
foo
2013-01-01 09:00:00  NaN
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  3.0
2013-01-01 09:00:05  NaN
2013-01-01 09:00:06  NaN
```

Using the time-specification generates variable windows for this sparse data.

```
In [64]: dft.rolling('2s').sum()
Out[64]:
                       B
foo
2013-01-01 09:00:00  0.0
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  3.0
2013-01-01 09:00:05  NaN
```

```
2013-01-01 09:00:06  4.0
```

Furthermore, we now allow an optional `on` parameter to specify a column (rather than the default of the index) in a DataFrame.

```
In [65]: dft = dft.reset_index()

In [66]: dft
Out[66]:
                  foo    B
0 2013-01-01 09:00:00  0.0
1 2013-01-01 09:00:02  1.0
2 2013-01-01 09:00:03  2.0
3 2013-01-01 09:00:05  NaN
4 2013-01-01 09:00:06  4.0

In [67]: dft.rolling('2s', on='foo').sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                  foo    B
0 2013-01-01 09:00:00  0.0
1 2013-01-01 09:00:02  1.0
2 2013-01-01 09:00:03  3.0
3 2013-01-01 09:00:05  NaN
4 2013-01-01 09:00:06  4.0
```

14.2.4 Rolling Window Endpoints

New in version 0.20.0.

The inclusion of the interval endpoints in rolling window calculations can be specified with the `closed` parameter:

`closed`	Description	Default for
`right`	close right endpoint	time-based windows
`left`	close left endpoint	
`both`	close both endpoints	fixed windows
`neither`	open endpoints	

For example, having the right endpoint open is useful in many problems that require that there is no contamination from present information back to past information. This allows the rolling window to compute statistics "up to that point in time", but not including that point in time.

```
In [68]: df = pd.DataFrame({'x': 1},
   ....:                   index = [pd.Timestamp('20130101 09:00:01'),
   ....:                            pd.Timestamp('20130101 09:00:02'),
   ....:                            pd.Timestamp('20130101 09:00:03'),
   ....:                            pd.Timestamp('20130101 09:00:04'),
   ....:                            pd.Timestamp('20130101 09:00:06')])
   ....:

In [69]: df["right"] = df.rolling('2s', closed='right').x.sum()  # default

In [70]: df["both"] = df.rolling('2s', closed='both').x.sum()

In [71]: df["left"] = df.rolling('2s', closed='left').x.sum()

In [72]: df["neither"] = df.rolling('2s', closed='neither').x.sum()
```

```
In [73]: df
Out[73]:
                     x  right  both  left  neither
2013-01-01 09:00:01  1    1.0   1.0   NaN      NaN
2013-01-01 09:00:02  1    2.0   2.0   1.0      1.0
2013-01-01 09:00:03  1    2.0   3.0   2.0      1.0
2013-01-01 09:00:04  1    2.0   3.0   2.0      1.0
2013-01-01 09:00:06  1    1.0   2.0   1.0      NaN
```

Currently, this feature is only implemented for time-based windows. For fixed windows, the closed parameter cannot be set and the rolling window will always have both endpoints closed.

14.2.5 Time-aware Rolling vs. Resampling

Using `.rolling()` with a time-based index is quite similar to *resampling*. They both operate and perform reductive operations on time-indexed pandas objects.

When using `.rolling()` with an offset. The offset is a time-delta. Take a backwards-in-time looking window, and aggregate all of the values in that window (including the end-point, but not the start-point). This is the new value at that point in the result. These are variable sized windows in time-space for each point of the input. You will get a same sized result as the input.

When using `.resample()` with an offset. Construct a new index that is the frequency of the offset. For each frequency bin, aggregate points from the input within a backwards-in-time looking window that fall in that bin. The result of this aggregation is the output for that frequency point. The windows are fixed size size in the frequency space. Your result will have the shape of a regular frequency between the min and the max of the original input object.

To summarize, `.rolling()` is a time-based window operation, while `.resample()` is a frequency-based window operation.

14.2.6 Centering Windows

By default the labels are set to the right edge of the window, but a `center` keyword is available so the labels can be set at the center.

```
In [74]: ser.rolling(window=5).mean()
Out[74]:
2000-01-01         NaN
2000-01-02         NaN
2000-01-03         NaN
2000-01-04         NaN
2000-01-05   -0.841164
2000-01-06   -0.779948
2000-01-07   -0.565487
2000-01-08   -0.502815
2000-01-09   -0.553755
2000-01-10   -0.472211
Freq: D, dtype: float64

In [75]: ser.rolling(window=5, center=True).mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-01         NaN
2000-01-02         NaN
2000-01-03   -0.841164
```

```
2000-01-04   -0.779948
2000-01-05   -0.565487
2000-01-06   -0.502815
2000-01-07   -0.553755
2000-01-08   -0.472211
2000-01-09         NaN
2000-01-10         NaN
Freq: D, dtype: float64
```

14.2.7 Binary Window Functions

cov() and *corr()* can compute moving window statistics about two `Series` or any combination of `DataFrame/Series` or `DataFrame/DataFrame`. Here is the behavior in each case:

- two `Series`: compute the statistic for the pairing.
- `DataFrame/Series`: compute the statistics for each column of the DataFrame with the passed Series, thus returning a DataFrame.
- `DataFrame/DataFrame`: by default compute the statistic for matching column names, returning a DataFrame. If the keyword argument `pairwise=True` is passed then computes the statistic for each pair of columns, returning a `MultiIndexed DataFrame` whose `index` are the dates in question (see *the next section*).

For example:

```
In [76]: df = pd.DataFrame(np.random.randn(1000, 4),
   ....:                   index=pd.date_range('1/1/2000', periods=1000),
   ....:                   columns=['A', 'B', 'C', 'D'])
   ....:

In [77]: df = df.cumsum()

In [78]: df2 = df[:20]

In [79]: df2.rolling(window=5).corr(df2['B'])
Out[79]:
                   A    B         C         D
2000-01-01       NaN  NaN       NaN       NaN
2000-01-02       NaN  NaN       NaN       NaN
2000-01-03       NaN  NaN       NaN       NaN
2000-01-04       NaN  NaN       NaN       NaN
2000-01-05  0.768775  1.0 -0.977990  0.800252
2000-01-06  0.744106  1.0 -0.967912  0.830021
2000-01-07  0.683257  1.0 -0.928969  0.384916
...              ...  ...       ...       ...
2000-01-14 -0.392318  1.0  0.570240 -0.591056
2000-01-15  0.017217  1.0  0.649900 -0.896258
2000-01-16  0.691078  1.0  0.807450 -0.939302
2000-01-17  0.274506  1.0  0.582601 -0.902954
2000-01-18  0.330459  1.0  0.515707 -0.545268
2000-01-19  0.046756  1.0 -0.104334 -0.419799
2000-01-20 -0.328241  1.0 -0.650974 -0.777777

[20 rows x 4 columns]
```

14.2.8 Computing rolling pairwise covariances and correlations

Warning: Prior to version 0.20.0 if `pairwise=True` was passed, a `Panel` would be returned. This will now return a 2-level MultiIndexed DataFrame, see the whatsnew *here*

In financial data analysis and other fields it's common to compute covariance and correlation matrices for a collection of time series. Often one is also interested in moving-window covariance and correlation matrices. This can be done by passing the `pairwise` keyword argument, which in the case of `DataFrame` inputs will yield a MultiIndexed `DataFrame` whose `index` are the dates in question. In the case of a single DataFrame argument the `pairwise` argument can even be omitted:

Note: Missing values are ignored and each entry is computed using the pairwise complete observations. Please see the *covariance section* for *caveats* associated with this method of calculating covariance and correlation matrices.

```
In [80]: covs = df[['B','C','D']].rolling(window=50).cov(df[['A','B','C']],␣
↪pairwise=True)

In [81]: covs.loc['2002-09-22':]
Out[81]:
                     B         C         D
2002-09-22 A  1.367467  8.676734 -8.047366
           B  3.067315  0.865946 -1.052533
           C  0.865946  7.739761 -4.943924
2002-09-23 A  0.910343  8.669065 -8.443062
           B  2.625456  0.565152 -0.907654
           C  0.565152  7.825521 -5.367526
2002-09-24 A  0.463332  8.514509 -8.776514
           B  2.306695  0.267746 -0.732186
           C  0.267746  7.771425 -5.696962
2002-09-25 A  0.467976  8.198236 -9.162599
           B  2.307129  0.267287 -0.754080
           C  0.267287  7.466559 -5.822650
2002-09-26 A  0.545781  7.899084 -9.326238
           B  2.311058  0.322295 -0.844451
           C  0.322295  7.038237 -5.684445
```

```
In [82]: correls = df.rolling(window=50).corr()

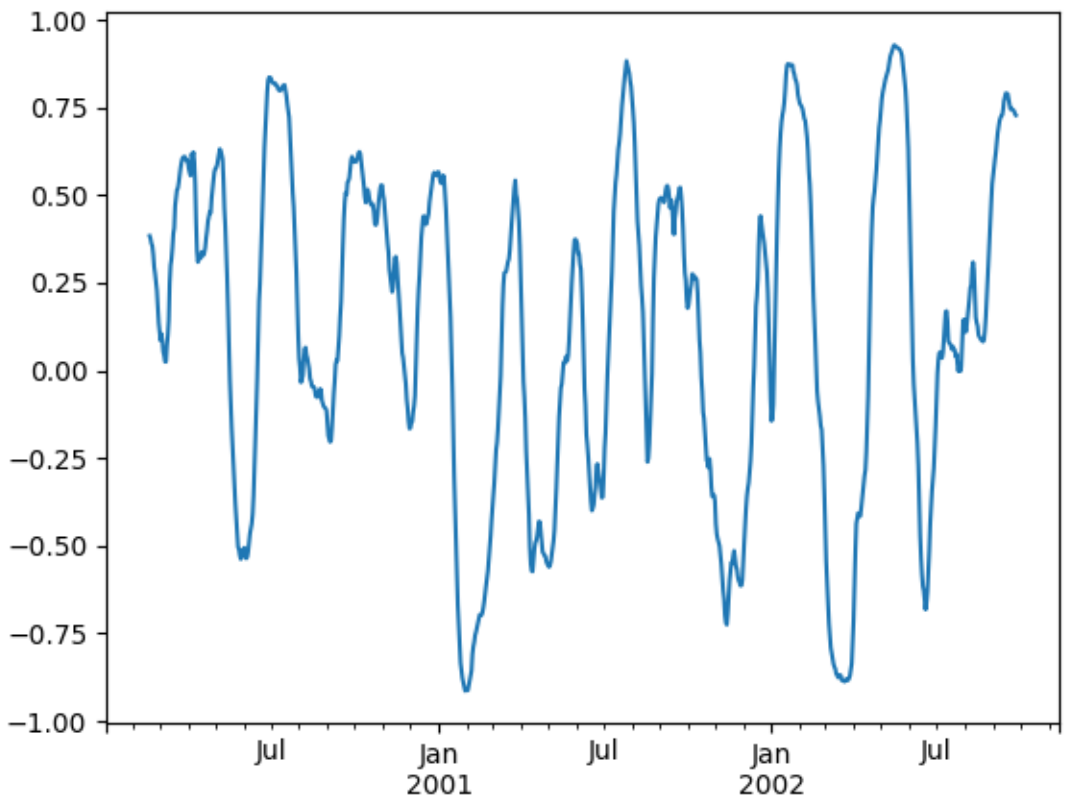
In [83]: correls.loc['2002-09-22':]
Out[83]:
                     A         B         C         D
2002-09-22 A  1.000000  0.186397  0.744551 -0.769767
           B  0.186397  1.000000  0.177725 -0.240802
           C  0.744551  0.177725  1.000000 -0.712051
           D -0.769767 -0.240802 -0.712051  1.000000
2002-09-23 A  1.000000  0.134723  0.743113 -0.758758
           B  0.134723  1.000000  0.124683 -0.209934
           C  0.743113  0.124683  1.000000 -0.719088
...                ...       ...       ...       ...
2002-09-25 B  0.075157  1.000000  0.064399 -0.164179
           C  0.731888  0.064399  1.000000 -0.704686
           D -0.739160 -0.164179 -0.704686  1.000000
2002-09-26 A  1.000000  0.087756  0.727792 -0.736562
           B  0.087756  1.000000  0.079913 -0.179477
```

```
           C  0.727792  0.079913  1.000000 -0.692303
           D -0.736562 -0.179477 -0.692303  1.000000

[20 rows x 4 columns]
```

You can efficiently retrieve the time series of correlations between two columns by reshaping and indexing:

```
In [84]: correls.unstack(1)[('A', 'C')].plot()
Out[84]: <matplotlib.axes._subplots.AxesSubplot at 0x122699320>
```



14.3 Aggregation

Once the `Rolling`, `Expanding` or `EWM` objects have been created, several methods are available to perform multiple computations on the data. These operations are similar to the *aggregating API*, *groupby API*, and *resample API*.

```
In [85]: dfa = pd.DataFrame(np.random.randn(1000, 3),
   ....:                    index=pd.date_range('1/1/2000', periods=1000),
   ....:                    columns=['A', 'B', 'C'])
   ....:

In [86]: r = dfa.rolling(window=60,min_periods=1)

In [87]: r
Out[87]: Rolling [window=60,min_periods=1,center=False,axis=0]
```

We can aggregate by passing a function to the entire DataFrame, or select a Series (or multiple Series) via standard

getitem.

```
In [88]: r.aggregate(np.sum)
Out[88]:
                   A          B         C
2000-01-01 -0.289838  -0.370545 -1.284206
2000-01-02 -0.216612  -1.675528 -1.169415
2000-01-03  1.154661  -1.634017 -1.566620
2000-01-04  2.969393  -4.003274 -1.816179
2000-01-05  4.690630  -4.682017 -2.717209
2000-01-06  3.880630  -4.447700 -1.078947
2000-01-07  4.001957  -2.884072 -3.116903
...              ...        ...       ...
2002-09-20  2.652493 -10.528875  9.867805
2002-09-21  0.844497  -9.280944  9.522649
2002-09-22  2.860036  -9.270337  6.415245
2002-09-23  3.510163  -8.151439  5.177219
2002-09-24  6.524983 -10.168078  5.792639
2002-09-25  6.409626  -9.956226  5.704050
2002-09-26  5.093787  -7.074515  6.905823

[1000 rows x 3 columns]

In [89]: r['A'].aggregate(np.sum)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-01   -0.289838
2000-01-02   -0.216612
2000-01-03    1.154661
2000-01-04    2.969393
2000-01-05    4.690630
2000-01-06    3.880630
2000-01-07    4.001957
                ...
2002-09-20    2.652493
2002-09-21    0.844497
2002-09-22    2.860036
2002-09-23    3.510163
2002-09-24    6.524983
2002-09-25    6.409626
2002-09-26    5.093787
Freq: D, Name: A, Length: 1000, dtype: float64

In [90]: r[['A','B']].aggregate(np.sum)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A          B
2000-01-01 -0.289838  -0.370545
2000-01-02 -0.216612  -1.675528
2000-01-03  1.154661  -1.634017
2000-01-04  2.969393  -4.003274
2000-01-05  4.690630  -4.682017
2000-01-06  3.880630  -4.447700
2000-01-07  4.001957  -2.884072
...              ...        ...
2002-09-20  2.652493 -10.528875
2002-09-21  0.844497  -9.280944
2002-09-22  2.860036  -9.270337
2002-09-23  3.510163  -8.151439
```

```
2002-09-24  6.524983 -10.168078
2002-09-25  6.409626  -9.956226
2002-09-26  5.093787  -7.074515

[1000 rows x 2 columns]
```

As you can see, the result of the aggregation will have the selected columns, or all columns if none are selected.

14.3.1 Applying multiple functions

With windowed `Series` you can also pass a list of functions to do aggregation with, outputting a DataFrame:

```
In [91]: r['A'].agg([np.sum, np.mean, np.std])
Out[91]:
                 sum      mean       std
2000-01-01 -0.289838 -0.289838       NaN
2000-01-02 -0.216612 -0.108306  0.256725
2000-01-03  1.154661  0.384887  0.873311
2000-01-04  2.969393  0.742348  1.009734
2000-01-05  4.690630  0.938126  0.977914
2000-01-06  3.880630  0.646772  1.128883
2000-01-07  4.001957  0.571708  1.049487
...              ...       ...       ...
2002-09-20  2.652493  0.044208  1.164919
2002-09-21  0.844497  0.014075  1.148231
2002-09-22  2.860036  0.047667  1.132051
2002-09-23  3.510163  0.058503  1.134296
2002-09-24  6.524983  0.108750  1.144204
2002-09-25  6.409626  0.106827  1.142913
2002-09-26  5.093787  0.084896  1.151416

[1000 rows x 3 columns]
```

On a windowed DataFrame, you can pass a list of functions to apply to each column, which produces an aggregated result with a hierarchical index:

```
In [92]: r.agg([np.sum, np.mean])
Out[92]:
                   A                    B                    C
                 sum      mean        sum      mean        sum      mean
2000-01-01 -0.289838 -0.289838  -0.370545 -0.370545 -1.284206 -1.284206
2000-01-02 -0.216612 -0.108306  -1.675528 -0.837764 -1.169415 -0.584708
2000-01-03  1.154661  0.384887  -1.634017 -0.544672 -1.566620 -0.522207
2000-01-04  2.969393  0.742348  -4.003274 -1.000819 -1.816179 -0.454045
2000-01-05  4.690630  0.938126  -4.682017 -0.936403 -2.717209 -0.543442
2000-01-06  3.880630  0.646772  -4.447700 -0.741283 -1.078947 -0.179825
2000-01-07  4.001957  0.571708  -2.884072 -0.412010 -3.116903 -0.445272
...              ...       ...        ...       ...       ...       ...
2002-09-20  2.652493  0.044208 -10.528875 -0.175481  9.867805  0.164463
2002-09-21  0.844497  0.014075  -9.280944 -0.154682  9.522649  0.158711
2002-09-22  2.860036  0.047667  -9.270337 -0.154506  6.415245  0.106921
2002-09-23  3.510163  0.058503  -8.151439 -0.135857  5.177219  0.086287
2002-09-24  6.524983  0.108750 -10.168078 -0.169468  5.792639  0.096544
2002-09-25  6.409626  0.106827  -9.956226 -0.165937  5.704050  0.095068
2002-09-26  5.093787  0.084896  -7.074515 -0.117909  6.905823  0.115097

[1000 rows x 6 columns]
```

Passing a dict of functions has different behavior by default, see the next section.

14.3.2 Applying different functions to DataFrame columns

By passing a dict to `aggregate` you can apply a different aggregation to the columns of a `DataFrame`:

```
In [93]: r.agg({'A' : np.sum,
   ....:        'B' : lambda x: np.std(x, ddof=1)})
   ....:
Out[93]:
                   A         B
2000-01-01 -0.289838       NaN
2000-01-02 -0.216612  0.660747
2000-01-03  1.154661  0.689929
2000-01-04  2.969393  1.072199
2000-01-05  4.690630  0.939657
2000-01-06  3.880630  0.966848
2000-01-07  4.001957  1.240137
...              ...       ...
2002-09-20  2.652493  1.114814
2002-09-21  0.844497  1.113220
2002-09-22  2.860036  1.113208
2002-09-23  3.510163  1.132381
2002-09-24  6.524983  1.080963
2002-09-25  6.409626  1.082911
2002-09-26  5.093787  1.136199

[1000 rows x 2 columns]
```

The function names can also be strings. In order for a string to be valid it must be implemented on the windowed object

```
In [94]: r.agg({'A' : 'sum', 'B' : 'std'})
Out[94]:
                   A         B
2000-01-01 -0.289838       NaN
2000-01-02 -0.216612  0.660747
2000-01-03  1.154661  0.689929
2000-01-04  2.969393  1.072199
2000-01-05  4.690630  0.939657
2000-01-06  3.880630  0.966848
2000-01-07  4.001957  1.240137
...              ...       ...
2002-09-20  2.652493  1.114814
2002-09-21  0.844497  1.113220
2002-09-22  2.860036  1.113208
2002-09-23  3.510163  1.132381
2002-09-24  6.524983  1.080963
2002-09-25  6.409626  1.082911
2002-09-26  5.093787  1.136199

[1000 rows x 2 columns]
```

Furthermore you can pass a nested dict to indicate different aggregations on different columns.

```
In [95]: r.agg({'A' : ['sum','std'], 'B' : ['mean','std'] })
Out[95]:
                   A                   B          
                 sum       std      mean       std
2000-01-01 -0.289838       NaN -0.370545       NaN
2000-01-02 -0.216612  0.256725 -0.837764  0.660747
2000-01-03  1.154661  0.873311 -0.544672  0.689929
2000-01-04  2.969393  1.009734 -1.000819  1.072199
2000-01-05  4.690630  0.977914 -0.936403  0.939657
2000-01-06  3.880630  1.128883 -0.741283  0.966848
2000-01-07  4.001957  1.049487 -0.412010  1.240137
...              ...       ...       ...       ...
2002-09-20  2.652493  1.164919 -0.175481  1.114814
2002-09-21  0.844497  1.148231 -0.154682  1.113220
2002-09-22  2.860036  1.132051 -0.154506  1.113208
2002-09-23  3.510163  1.134296 -0.135857  1.132381
2002-09-24  6.524983  1.144204 -0.169468  1.080963
2002-09-25  6.409626  1.142913 -0.165937  1.082911
2002-09-26  5.093787  1.151416 -0.117909  1.136199

[1000 rows x 4 columns]
```

14.4 Expanding Windows

A common alternative to rolling statistics is to use an *expanding* window, which yields the value of the statistic with all the data available up to that point in time.

These follow a similar interface to `.rolling`, with the `.expanding` method returning an `Expanding` object.

As these calculations are a special case of rolling statistics, they are implemented in pandas such that the following two calls are equivalent:

```
In [96]: df.rolling(window=len(df), min_periods=1).mean()[:5]
Out[96]:
                   A         B         C         D
2000-01-01  0.314226 -0.001675  0.071823  0.892566
2000-01-02  0.654522 -0.171495  0.179278  0.853361
2000-01-03  0.708733 -0.064489 -0.238271  1.371111
2000-01-04  0.987613  0.163472 -0.919693  1.566485
2000-01-05  1.426971  0.288267 -1.358877  1.808650

In [97]: df.expanding(min_periods=1).mean()[:5]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D
2000-01-01  0.314226 -0.001675  0.071823  0.892566
2000-01-02  0.654522 -0.171495  0.179278  0.853361
2000-01-03  0.708733 -0.064489 -0.238271  1.371111
2000-01-04  0.987613  0.163472 -0.919693  1.566485
2000-01-05  1.426971  0.288267 -1.358877  1.808650
```

These have a similar set of methods to `.rolling` methods.

14.4.1 Method Summary

Function	Description
`count()`	Number of non-null observations
`sum()`	Sum of values
`mean()`	Mean of values
`median()`	Arithmetic median of values
`min()`	Minimum
`max()`	Maximum
`std()`	Unbiased standard deviation
`var()`	Unbiased variance
`skew()`	Unbiased skewness (3rd moment)
`kurt()`	Unbiased kurtosis (4th moment)
`quantile()`	Sample quantile (value at %)
`apply()`	Generic apply
`cov()`	Unbiased covariance (binary)
`corr()`	Correlation (binary)

Aside from not having a `window` parameter, these functions have the same interfaces as their `.rolling` counterparts. Like above, the parameters they all accept are:

- `min_periods`: threshold of non-null data points to require. Defaults to minimum needed to compute statistic. No `NaNs` will be output once `min_periods` non-null data points have been seen.
- `center`: boolean, whether to set the labels at the center (default is False)

Note: The output of the `.rolling` and `.expanding` methods do not return a `NaN` if there are at least `min_periods` non-null values in the current window. For example,

```
In [98]: sn = pd.Series([1, 2, np.nan, 3, np.nan, 4])

In [99]: sn
Out[99]:
0    1.0
1    2.0
2    NaN
3    3.0
4    NaN
5    4.0
dtype: float64

In [100]: sn.rolling(2).max()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[100]:␣
↪
0    NaN
1    2.0
2    NaN
3    NaN
4    NaN
5    NaN
dtype: float64

In [101]: sn.rolling(2, min_periods=1).max()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1.0
1    2.0
```

```
2    2.0
3    3.0
4    3.0
5    4.0
dtype: float64
```

In case of expanding functions, this differs from `cumsum()`, `cumprod()`, `cummax()`, and `cummin()`, which return `NaN` in the output wherever a `NaN` is encountered in the input. In order to match the output of `cumsum` with `expanding`, use `fillna()`:

```
In [102]: sn.expanding().sum()
Out[102]: 
0     1.0
1     3.0
2     3.0
3     6.0
4     6.0
5    10.0
dtype: float64

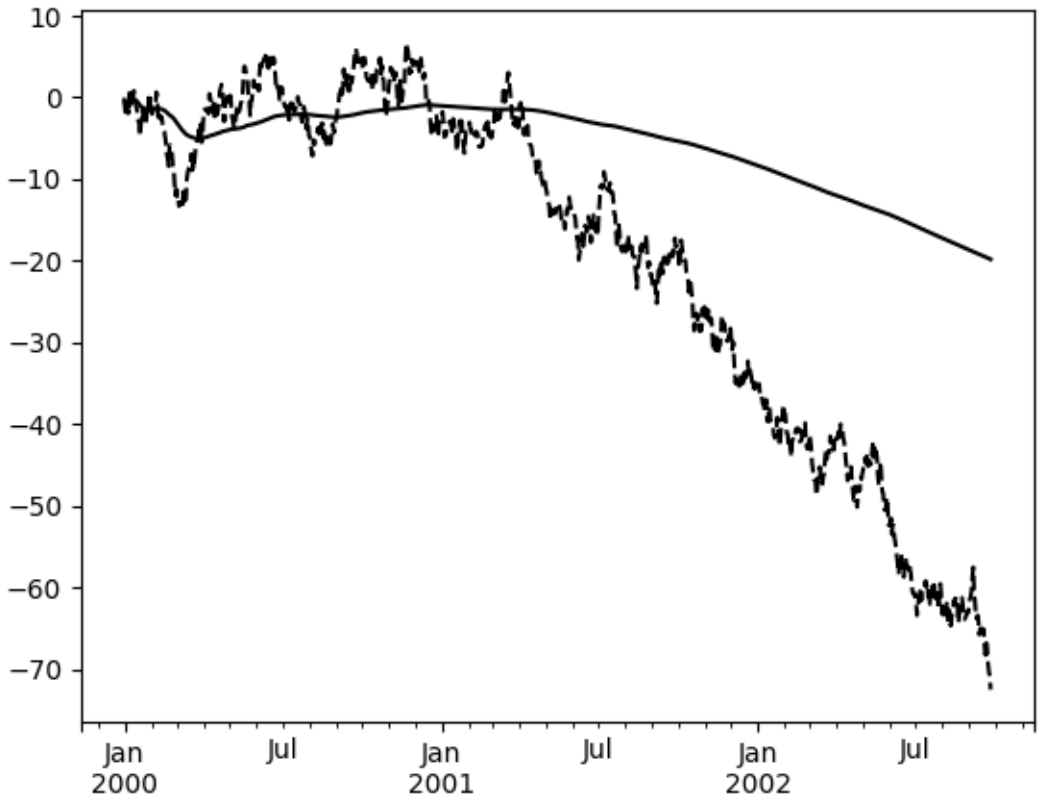
In [103]: sn.cumsum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[103]:␣
↪
0     1.0
1     3.0
2     NaN
3     6.0
4     NaN
5    10.0
dtype: float64

In [104]: sn.cumsum().fillna(method='ffill')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0     1.0
1     3.0
2     3.0
3     6.0
4     6.0
5    10.0
dtype: float64
```

An expanding window statistic will be more stable (and less responsive) than its rolling window counterpart as the increasing window size decreases the relative impact of an individual data point. As an example, here is the `mean()` output for the previous time series dataset:

```
In [105]: s.plot(style='k--')
Out[105]: <matplotlib.axes._subplots.AxesSubplot at 0x1226fc5c0>

In [106]: s.expanding().mean().plot(style='k')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[106]:
↪<matplotlib.axes._subplots.AxesSubplot at 0x1226fc5c0>
```



14.5 Exponentially Weighted Windows

A related set of functions are exponentially weighted versions of several of the above statistics. A similar interface to `.rolling` and `.expanding` is accessed through the `.ewm` method to receive an `EWM` object. A number of expanding EW (exponentially weighted) methods are provided:

Function	Description
mean()	EW moving average
var()	EW moving variance
std()	EW moving standard deviation
corr()	EW moving correlation
cov()	EW moving covariance

In general, a weighted moving average is calculated as

$$y_t = \frac{\sum_{i=0}^{t} w_i x_{t-i}}{\sum_{i=0}^{t} w_i},$$

where x_t is the input and y_t is the result.

The EW functions support two variants of exponential weights. The default, `adjust=True`, uses the weights $w_i = (1-\alpha)^i$ which gives

$$y_t = \frac{x_t + (1-\alpha)x_{t-1} + (1-\alpha)^2 x_{t-2} + ... + (1-\alpha)^t x_0}{1 + (1-\alpha) + (1-\alpha)^2 + ... + (1-\alpha)^t}$$

When `adjust=False` is specified, moving averages are calculated as

$$\begin{aligned} y_0 &= x_0 \\ y_t &= (1-\alpha)y_{t-1} + \alpha x_t, \end{aligned}$$

which is equivalent to using weights

$$w_i = \begin{cases} \alpha(1-\alpha)^i & \text{if } i < t \\ (1-\alpha)^i & \text{if } i = t. \end{cases}$$

Note: These equations are sometimes written in terms of $\alpha' = 1 - \alpha$, e.g.

$$y_t = \alpha' y_{t-1} + (1-\alpha')x_t.$$

The difference between the above two variants arises because we are dealing with series which have finite history. Consider a series of infinite history:

$$y_t = \frac{x_t + (1-\alpha)x_{t-1} + (1-\alpha)^2 x_{t-2} + ...}{1 + (1-\alpha) + (1-\alpha)^2 + ...}$$

Noting that the denominator is a geometric series with initial term equal to 1 and a ratio of $1-\alpha$ we have

$$\begin{aligned} y_t &= \frac{x_t + (1-\alpha)x_{t-1} + (1-\alpha)^2 x_{t-2} + ...}{\frac{1}{1-(1-\alpha)}} \\ &= [x_t + (1-\alpha)x_{t-1} + (1-\alpha)^2 x_{t-2} + ...]\alpha \\ &= \alpha x_t + [(1-\alpha)x_{t-1} + (1-\alpha)^2 x_{t-2} + ...]\alpha \\ &= \alpha x_t + (1-\alpha)[x_{t-1} + (1-\alpha)x_{t-2} + ...]\alpha \\ &= \alpha x_t + (1-\alpha)y_{t-1} \end{aligned}$$

which shows the equivalence of the above two variants for infinite series. When `adjust=True` we have $y_0 = x_0$ and from the last representation above we have $y_t = \alpha x_t + (1-\alpha)y_{t-1}$, therefore there is an assumption that x_0 is not an ordinary value but rather an exponentially weighted moment of the infinite series up to that point.

One must have $0 < \alpha \leq 1$, and while since version 0.18.0 it has been possible to pass α directly, it's often easier to think about either the **span**, **center of mass (com)** or **half-life** of an EW moment:

$$\alpha = \begin{cases} \frac{2}{s+1}, & \text{for span } s \geq 1 \\ \frac{1}{1+c}, & \text{for center of mass } c \geq 0 \\ 1 - \exp^{\frac{\log 0.5}{h}}, & \text{for half-life } h > 0 \end{cases}$$

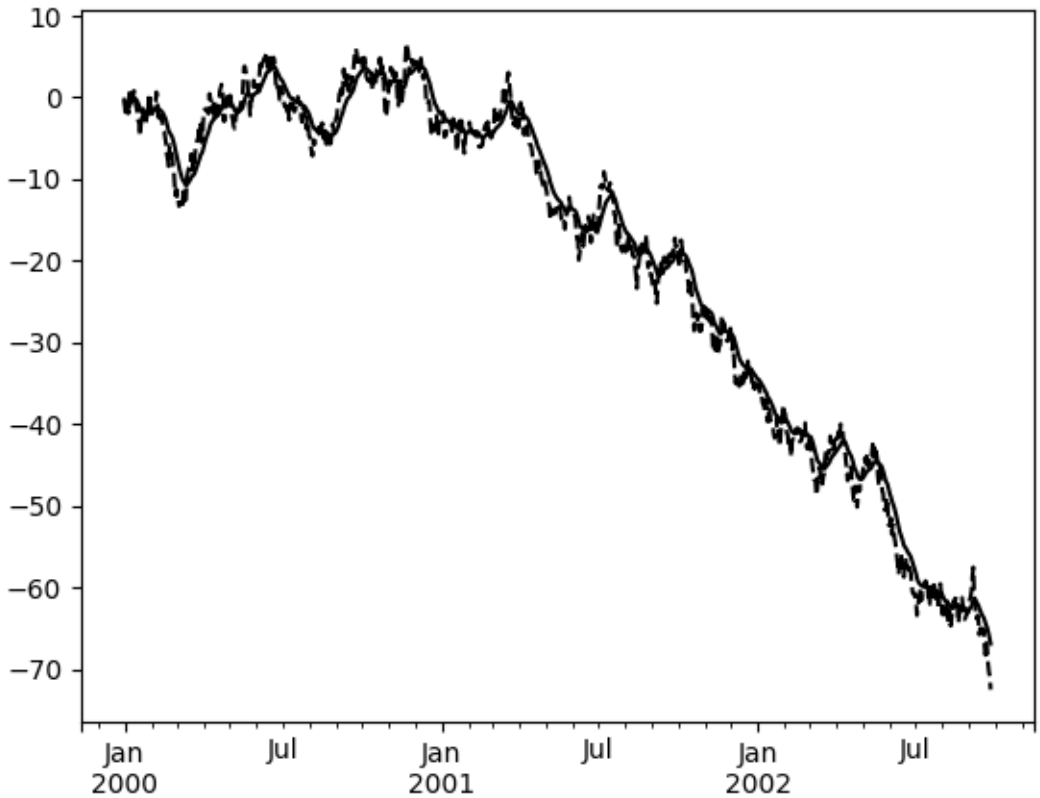
One must specify precisely one of **span**, **center of mass**, **half-life** and **alpha** to the EW functions:

- **Span** corresponds to what is commonly called an "N-day EW moving average".
- **Center of mass** has a more physical interpretation and can be thought of in terms of span: $c = (s-1)/2$.
- **Half-life** is the period of time for the exponential weight to reduce to one half.
- **Alpha** specifies the smoothing factor directly.

Here is an example for a univariate time series:

```
In [107]: s.plot(style='k--')
Out[107]: <matplotlib.axes._subplots.AxesSubplot at 0x121e3bb70>

In [108]: s.ewm(span=20).mean().plot(style='k')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[108]:
↪<matplotlib.axes._subplots.AxesSubplot at 0x121e3bb70>
```



EWM has a `min_periods` argument, which has the same meaning it does for all the `.expanding` and `.rolling` methods: no output values will be set until at least `min_periods` non-null values are encountered in the (expanding) window.

EWM also has an `ignore_na` argument, which determines how intermediate null values affect the calculation of the weights. When `ignore_na=False` (the default), weights are calculated based on absolute positions, so that intermediate null values affect the result. When `ignore_na=True`, weights are calculated by ignoring intermediate null values. For example, assuming `adjust=True`, if `ignore_na=False`, the weighted average of `3, NaN, 5` would be calculated as

$$\frac{(1-\alpha)^2 \cdot 3 + 1 \cdot 5}{(1-\alpha)^2 + 1}$$

Whereas if `ignore_na=True`, the weighted average would be calculated as

$$\frac{(1-\alpha) \cdot 3 + 1 \cdot 5}{(1-\alpha) + 1}.$$

The `var()`, `std()`, and `cov()` functions have a `bias` argument, specifying whether the result should contain biased or unbiased statistics. For example, if `bias=True`, `ewmvar(x)` is calculated as `ewmvar(x) = ewma(x**2) - ewma(x)**2`; whereas if `bias=False` (the default), the biased variance statistics are scaled by debiasing factors

$$\frac{\left(\sum_{i=0}^{t} w_i\right)^2}{\left(\sum_{i=0}^{t} w_i\right)^2 - \sum_{i=0}^{t} w_i^2}.$$

(For $w_i = 1$, this reduces to the usual $N/(N-1)$ factor, with $N = t + 1$.) See Weighted Sample Variance for further details.

CHAPTER

FIFTEEN

WORKING WITH MISSING DATA

In this section, we will discuss missing (also referred to as NA) values in pandas.

Note: The choice of using `NaN` internally to denote missing data was largely for simplicity and performance reasons. It differs from the MaskedArray approach of, for example, `scikits.timeseries`. We are hopeful that NumPy will soon be able to provide a native NA type solution (similar to R) performant enough to be used in pandas.

See the *cookbook* for some advanced strategies

15.1 Missing data basics

15.1.1 When / why does data become missing?

Some might quibble over our usage of *missing*. By "missing" we simply mean **NA** ("not available") or "not present for whatever reason". Many data sets simply arrive with missing data, either because it exists and was not collected or it never existed. For example, in a collection of financial time series, some of the time series might start on different dates. Thus, values prior to the start date would generally be marked as missing.

In pandas, one of the most common ways that missing data is **introduced** into a data set is by reindexing. For example

```
In [1]: df = pd.DataFrame(np.random.randn(5, 3), index=['a', 'c', 'e', 'f', 'h'],
   ...:                   columns=['one', 'two', 'three'])
   ...:

In [2]: df['four'] = 'bar'

In [3]: df['five'] = df['one'] > 0

In [4]: df
Out[4]:
        one       two     three four   five
a -0.166778  0.501113 -0.355322  bar  False
c -0.337890  0.580967  0.983801  bar  False
e  0.057802  0.761948 -0.712964  bar   True
f -0.443160 -0.974602  1.047704  bar  False
h -0.717852 -1.053898 -0.019369  bar  False

In [5]: df2 = df.reindex(['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h'])

In [6]: df2
Out[6]:
```

```
        one       two     three four   five
a -0.166778  0.501113 -0.355322  bar  False
b       NaN       NaN       NaN  NaN    NaN
c -0.337890  0.580967  0.983801  bar  False
d       NaN       NaN       NaN  NaN    NaN
e  0.057802  0.761948 -0.712964  bar   True
f -0.443160 -0.974602  1.047704  bar  False
g       NaN       NaN       NaN  NaN    NaN
h -0.717852 -1.053898 -0.019369  bar  False
```

15.1.2 Values considered "missing"

As data comes in many shapes and forms, pandas aims to be flexible with regard to handling missing data. While `NaN` is the default missing value marker for reasons of computational speed and convenience, we need to be able to easily detect this value with data of different types: floating point, integer, boolean, and general object. In many cases, however, the Python `None` will arise and we wish to also consider that "missing" or "not available" or "NA".

Note: If you want to consider `inf` and `-inf` to be "NA" in computations, you can set `pandas.options.mode.use_inf_as_na = True`.

To make detecting missing values easier (and across different array dtypes), pandas provides the *`isna()`* and *`notna()`* functions, which are also methods on `Series` and `DataFrame` objects:

```
In [7]: df2['one']
Out[7]:
a   -0.166778
b         NaN
c   -0.337890
d         NaN
e    0.057802
f   -0.443160
g         NaN
h   -0.717852
Name: one, dtype: float64

In [8]: pd.isna(df2['one'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a    False
b     True
c    False
d     True
e    False
f    False
g     True
h    False
Name: one, dtype: bool

In [9]: df2['four'].notna()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a     True
b    False
c     True
```

```
d    False
e     True
f     True
g    False
h     True
Name: four, dtype: bool

In [10]: df2.isna()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     one    two  three   four   five
a  False  False  False  False  False
b   True   True   True   True   True
c  False  False  False  False  False
d   True   True   True   True   True
e  False  False  False  False  False
f  False  False  False  False  False
g   True   True   True   True   True
h  False  False  False  False  False
```

Warning: One has to be mindful that in python (and numpy), the `nan's` don't compare equal, but `None's` **do**. Note that Pandas/numpy uses the fact that `np.nan != np.nan`, and treats `None` like `np.nan`.

```
In [11]: None == None
Out[11]: True

In [12]: np.nan == np.nan
\\\\\\\\\\\\\\Out[12]: False
```

So as compared to above, a scalar equality comparison versus a `None/np.nan` doesn't provide useful information.

```
In [13]: df2['one'] == np.nan
Out[13]:
a    False
b    False
c    False
d    False
e    False
f    False
g    False
h    False
Name: one, dtype: bool
```

15.2 Datetimes

For datetime64[ns] types, `NaT` represents missing values. This is a pseudo-native sentinel value that can be represented by numpy in a singular dtype (datetime64[ns]). pandas objects provide intercompatibility between `NaT` and `NaN`.

```
In [14]: df2 = df.copy()

In [15]: df2['timestamp'] = pd.Timestamp('20120101')

In [16]: df2
```

```
Out[16]:
        one       two     three four   five  timestamp
a -0.166778  0.501113 -0.355322  bar  False 2012-01-01
c -0.337890  0.580967  0.983801  bar  False 2012-01-01
e  0.057802  0.761948 -0.712964  bar   True 2012-01-01
f -0.443160 -0.974602  1.047704  bar  False 2012-01-01
h -0.717852 -1.053898 -0.019369  bar  False 2012-01-01

In [17]: df2.loc[['a','c','h'],['one','timestamp']] = np.nan

In [18]: df2
Out[18]:
        one       two     three four   five  timestamp
a       NaN  0.501113 -0.355322  bar  False        NaT
c       NaN  0.580967  0.983801  bar  False        NaT
e  0.057802  0.761948 -0.712964  bar   True 2012-01-01
f -0.443160 -0.974602  1.047704  bar  False 2012-01-01
h       NaN -1.053898 -0.019369  bar  False        NaT

In [19]: df2.get_dtype_counts()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
bool              1
datetime64[ns]    1
float64           3
object            1
dtype: int64
```

15.3 Inserting missing data

You can insert missing values by simply assigning to containers. The actual missing value used will be chosen based on the dtype.

For example, numeric containers will always use `NaN` regardless of the missing value type chosen:

```
In [20]: s = pd.Series([1, 2, 3])

In [21]: s.loc[0] = None

In [22]: s
Out[22]:
0    NaN
1    2.0
2    3.0
dtype: float64
```

Likewise, datetime containers will always use `NaT`.

For object containers, pandas will use the value given:

```
In [23]: s = pd.Series(["a", "b", "c"])

In [24]: s.loc[0] = None

In [25]: s.loc[1] = np.nan
```

```
In [26]: s
Out[26]:
0    None
1     NaN
2       c
dtype: object
```

15.4 Calculations with missing data

Missing values propagate naturally through arithmetic operations between pandas objects.

```
In [27]: a
Out[27]:
        one       two
a       NaN  0.501113
c       NaN  0.580967
e  0.057802  0.761948
f -0.443160 -0.974602
h -0.443160 -1.053898

In [28]: b
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one       two     three
a       NaN  0.501113 -0.355322
c       NaN  0.580967  0.983801
e  0.057802  0.761948 -0.712964
f -0.443160 -0.974602  1.047704
h       NaN -1.053898 -0.019369

In [29]: a + b
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one  three       two
a       NaN    NaN  1.002226
c       NaN    NaN  1.161935
e  0.115604    NaN  1.523896
f -0.886321    NaN -1.949205
h       NaN    NaN -2.107796
```

The descriptive statistics and computational methods discussed in the *data structure overview* (and listed *here* and *here*) are all written to account for missing data. For example:

- When summing data, NA (missing) values will be treated as zero
- If the data are all NA, the result will be NA
- Methods like **cumsum** and **cumprod** ignore NA values, but preserve them in the resulting arrays

```
In [30]: df
Out[30]:
        one       two     three
a       NaN  0.501113 -0.355322
c       NaN  0.580967  0.983801
e  0.057802  0.761948 -0.712964
f -0.443160 -0.974602  1.047704
```

```
h       NaN -1.053898 -0.019369

In [31]: df['one'].sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪-0.38535826528461409

In [32]: df.mean(1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a    0.072895
c    0.782384
e    0.035595
f   -0.123353
h   -0.536633
dtype: float64

In [33]: df.cumsum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one       two     three
a       NaN  0.501113 -0.355322
c       NaN  1.082080  0.628479
e  0.057802  1.844028 -0.084485
f -0.385358  0.869426  0.963219
h       NaN -0.184472  0.943850
```

15.4.1 Sum/Prod of Empties/Nans

Warning: This behavior is now standard as of v0.21.0; previously sum/prod would give different results if the `bottleneck` package was installed. See the *here*.

With `sum` or `prod` on an empty or all-`NaN` `Series`, or columns of a `DataFrame`, the result will be all-`NaN`.

```
In [34]: s = pd.Series([np.nan])

In [35]: s.sum()
Out[35]: nan
```

Summing of an empty `Series`

```
In [36]: pd.Series([]).sum()
Out[36]: nan
```

Warning: These behaviors differ from the default in `numpy` where an empty sum returns zero.

```
In [37]: np.nansum(np.array([np.nan]))
Out[37]: 0.0

In [38]: np.nansum(np.array([]))
\\\\\\\\\\\\\Out[38]: 0.0
```

15.4.2 NA values in GroupBy

NA groups in GroupBy are automatically excluded. This behavior is consistent with R, for example:

```
In [39]: df
Out[39]:
        one       two     three
a       NaN  0.501113 -0.355322
c       NaN  0.580967  0.983801
e  0.057802  0.761948 -0.712964
f -0.443160 -0.974602  1.047704
h       NaN -1.053898 -0.019369

In [40]: df.groupby('one').mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                two     three
one
-0.443160 -0.974602  1.047704
 0.057802  0.761948 -0.712964
```

See the groupby section *here* for more information.

15.5 Cleaning / filling missing data

pandas objects are equipped with various data manipulation methods for dealing with missing data.

15.5.1 Filling missing values: fillna

The **fillna** function can “fill in” NA values with non-NA data in a couple of ways, which we illustrate:

Replace NA with a scalar value

```
In [41]: df2
Out[41]:
        one       two     three four   five  timestamp
a       NaN  0.501113 -0.355322  bar  False        NaT
c       NaN  0.580967  0.983801  bar  False        NaT
e  0.057802  0.761948 -0.712964  bar   True 2012-01-01
f -0.443160 -0.974602  1.047704  bar  False 2012-01-01
h       NaN -1.053898 -0.019369  bar  False        NaT

In [42]: df2.fillna(0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one       two     three four   five            timestamp
a  0.000000  0.501113 -0.355322  bar  False                    0
c  0.000000  0.580967  0.983801  bar  False                    0
e  0.057802  0.761948 -0.712964  bar   True  2012-01-01 00:00:00
f -0.443160 -0.974602  1.047704  bar  False  2012-01-01 00:00:00
h  0.000000 -1.053898 -0.019369  bar  False                    0

In [43]: df2['four'].fillna('missing')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
a    bar
c    bar
e    bar
f    bar
h    bar
Name: four, dtype: object
```

Fill gaps forward or backward

Using the same filling arguments as *reindexing*, we can propagate non-NA values forward or backward:

```
In [44]: df
Out[44]:
        one       two     three
a       NaN  0.501113 -0.355322
c       NaN  0.580967  0.983801
e  0.057802  0.761948 -0.712964
f -0.443160 -0.974602  1.047704
h       NaN -1.053898 -0.019369

In [45]: df.fillna(method='pad')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        one       two     three
a       NaN  0.501113 -0.355322
c       NaN  0.580967  0.983801
e  0.057802  0.761948 -0.712964
f -0.443160 -0.974602  1.047704
h -0.443160 -1.053898 -0.019369
```

Limit the amount of filling

If we only want consecutive gaps filled up to a certain number of data points, we can use the *limit* keyword:

```
In [46]: df
Out[46]:
   one       two     three
a  NaN  0.501113 -0.355322
c  NaN  0.580967  0.983801
e  NaN       NaN       NaN
f  NaN       NaN       NaN
h  NaN -1.053898 -0.019369

In [47]: df.fillna(method='pad', limit=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   one       two     three
a  NaN  0.501113 -0.355322
c  NaN  0.580967  0.983801
e  NaN  0.580967  0.983801
f  NaN       NaN       NaN
h  NaN -1.053898 -0.019369
```

To remind you, these are the available filling methods:

Method	Action
pad / ffill	Fill values forward
bfill / backfill	Fill values backward

With time series data, using pad/ffill is extremely common so that the "last known value" is available at every time point.

The `ffill()` function is equivalent to `fillna(method='ffill')` and `bfill()` is equivalent to `fillna(method='bfill')`

15.5.2 Filling with a PandasObject

You can also fillna using a dict or Series that is alignable. The labels of the dict or index of the Series must match the columns of the frame you wish to fill. The use case of this is to fill a DataFrame with the mean of that column.

```
In [48]: dff = pd.DataFrame(np.random.randn(10,3), columns=list('ABC'))

In [49]: dff.iloc[3:5,0] = np.nan

In [50]: dff.iloc[4:6,1] = np.nan

In [51]: dff.iloc[5:8,2] = np.nan

In [52]: dff
Out[52]: 
          A         B         C
0  0.758887  2.340598  0.219039
1 -1.235583  0.031785  0.701683
2 -1.557016 -0.636986 -1.238610
3       NaN -1.002278  0.654052
4       NaN       NaN  1.053999
5  0.651981       NaN       NaN
6  0.109001 -0.533294       NaN
7 -1.037831 -1.150016       NaN
8 -0.687693  1.921056 -0.121113
9 -0.258742 -0.706329  0.402547

In [53]: dff.fillna(dff.mean())
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B         C
0  0.758887  2.340598  0.219039
1 -1.235583  0.031785  0.701683
2 -1.557016 -0.636986 -1.238610
3 -0.407125 -1.002278  0.654052
4 -0.407125  0.033067  1.053999
5  0.651981  0.033067  0.238800
6  0.109001 -0.533294  0.238800
7 -1.037831 -1.150016  0.238800
8 -0.687693  1.921056 -0.121113
9 -0.258742 -0.706329  0.402547

In [54]: dff.fillna(dff.mean()['B':'C'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A         B         C
0  0.758887  2.340598  0.219039
1 -1.235583  0.031785  0.701683
2 -1.557016 -0.636986 -1.238610
3       NaN -1.002278  0.654052
4       NaN  0.033067  1.053999
```

```
5  0.651981  0.033067  0.238800
6  0.109001 -0.533294  0.238800
7 -1.037831 -1.150016  0.238800
8 -0.687693  1.921056 -0.121113
9 -0.258742 -0.706329  0.402547
```

Same result as above, but is aligning the ‘fill’ value which is a Series in this case.

```
In [55]: dff.where(pd.notna(dff), dff.mean(), axis='columns')
Out[55]: 
          A         B         C
0  0.758887  2.340598  0.219039
1 -1.235583  0.031785  0.701683
2 -1.557016 -0.636986 -1.238610
3 -0.407125 -1.002278  0.654052
4 -0.407125  0.033067  1.053999
5  0.651981  0.033067  0.238800
6  0.109001 -0.533294  0.238800
7 -1.037831 -1.150016  0.238800
8 -0.687693  1.921056 -0.121113
9 -0.258742 -0.706329  0.402547
```

15.5.3 Dropping axis labels with missing data: dropna

You may wish to simply exclude labels from a data set which refer to missing data. To do this, use the **dropna** method:

```
In [56]: df
Out[56]: 
   one       two     three
a  NaN  0.501113 -0.355322
c  NaN  0.580967  0.983801
e  NaN  0.000000  0.000000
f  NaN  0.000000  0.000000
h  NaN -1.053898 -0.019369

In [57]: df.dropna(axis=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
Empty DataFrame
Columns: [one, two, three]
Index: []

In [58]: df.dropna(axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
        two     three
a  0.501113 -0.355322
c  0.580967  0.983801
e  0.000000  0.000000
f  0.000000  0.000000
h -1.053898 -0.019369

In [59]: df['one'].dropna()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪Series([], Name: one, dtype: float64)
```

Series.dropna is a simpler method as it only has one axis to consider. DataFrame.dropna has considerably more options than Series.dropna, which can be examined *in the API*.

15.5.4 Interpolation

New in version 0.17.0: The `limit_direction` keyword argument was added.

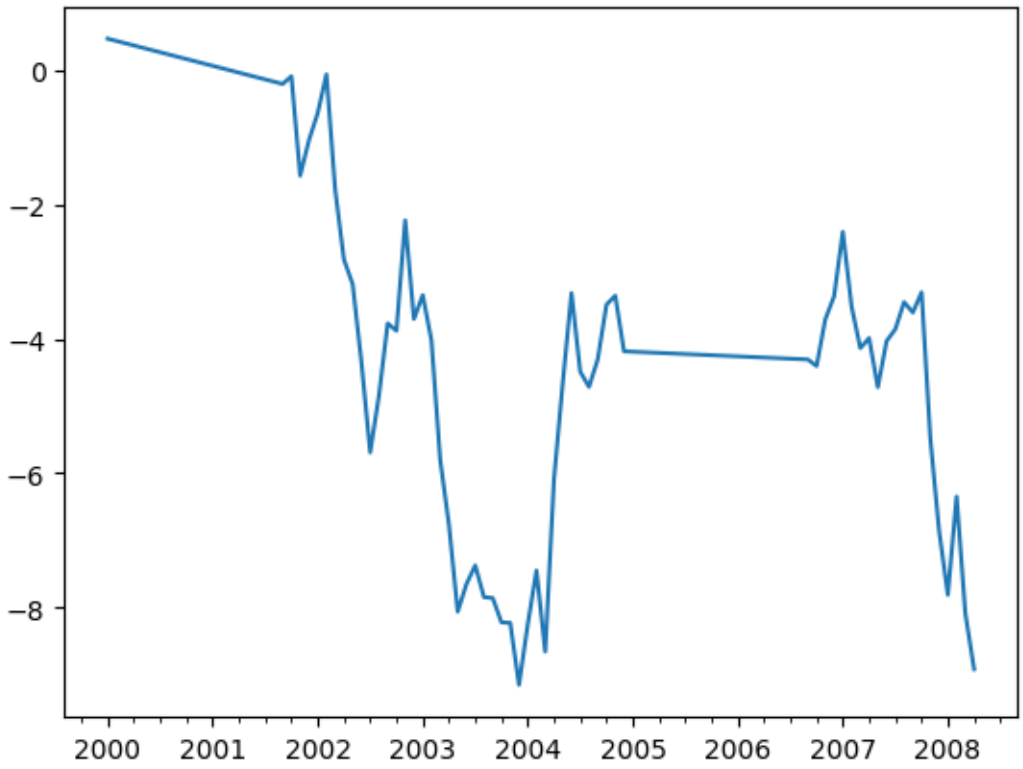
Both Series and DataFrame objects have an `interpolate` method that, by default, performs linear interpolation at missing datapoints.

```
In [60]: ts
Out[60]:
2000-01-31    0.469112
2000-02-29         NaN
2000-03-31         NaN
2000-04-28         NaN
2000-05-31         NaN
2000-06-30         NaN
2000-07-31         NaN
                ...
2007-10-31   -3.305259
2007-11-30   -5.485119
2007-12-31   -6.854968
2008-01-31   -7.809176
2008-02-29   -6.346480
2008-03-31   -8.089641
2008-04-30   -8.916232
Freq: BM, Length: 100, dtype: float64

In [61]: ts.count()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪61

In [62]: ts.interpolate().count()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪100

In [63]: ts.interpolate().plot()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪<matplotlib.axes._subplots.AxesSubplot at 0x13130c160>
```



Index aware interpolation is available via the `method` keyword:

```
In [64]: ts2
Out[64]:
2000-01-31    0.469112
2000-02-29         NaN
2002-07-31   -5.689738
2005-01-31         NaN
2008-04-30   -8.916232
dtype: float64

In [65]: ts2.interpolate()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-31    0.469112
2000-02-29   -2.610313
2002-07-31   -5.689738
2005-01-31   -7.302985
2008-04-30   -8.916232
dtype: float64

In [66]: ts2.interpolate(method='time')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2000-01-31    0.469112
2000-02-29    0.273272
2002-07-31   -5.689738
2005-01-31   -7.095568
2008-04-30   -8.916232
dtype: float64
```

For a floating-point index, use `method='values'`:

```
In [67]: ser
Out[67]:
0.0      0.0
1.0      NaN
10.0    10.0
dtype: float64

In [68]: ser.interpolate()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[68]:
0.0      0.0
1.0      5.0
10.0    10.0
dtype: float64

In [69]: ser.interpolate(method='values')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0.0      0.0
1.0      1.0
10.0    10.0
dtype: float64
```

You can also interpolate with a DataFrame:

```
In [70]: df = pd.DataFrame({'A': [1, 2.1, np.nan, 4.7, 5.6, 6.8],
   ....:                    'B': [.25, np.nan, np.nan, 4, 12.2, 14.4]})
   ....:

In [71]: df
Out[71]:
     A      B
0  1.0   0.25
1  2.1    NaN
2  NaN    NaN
3  4.7   4.00
4  5.6  12.20
5  6.8  14.40

In [72]: df.interpolate()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
     A      B
0  1.0   0.25
1  2.1   1.50
2  3.4   2.75
3  4.7   4.00
4  5.6  12.20
5  6.8  14.40
```

The `method` argument gives access to fancier interpolation methods. If you have scipy installed, you can set pass the name of a 1-d interpolation routine to `method`. You'll want to consult the full scipy interpolation documentation and reference guide for details. The appropriate interpolation method will depend on the type of data you are working with.

- If you are dealing with a time series that is growing at an increasing rate, `method='quadratic'` may be appropriate.

- If you have values approximating a cumulative distribution function, then `method='pchip'` should work well.
- To fill missing values with goal of smooth plotting, use `method='akima'`.

Warning: These methods require `scipy`.

```
In [73]: df.interpolate(method='barycentric')
Out[73]: 
      A       B
0  1.00   0.250
1  2.10  -7.660
2  3.53  -4.515
3  4.70   4.000
4  5.60  12.200
5  6.80  14.400

In [74]: df.interpolate(method='pchip')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
         A          B
0  1.00000   0.250000
1  2.10000   0.672808
2  3.43454   1.928950
3  4.70000   4.000000
4  5.60000  12.200000
5  6.80000  14.400000

In [75]: df.interpolate(method='akima')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A          B
0  1.000000   0.250000
1  2.100000  -0.873316
2  3.406667   0.320034
3  4.700000   4.000000
4  5.600000  12.200000
5  6.800000  14.400000
```

When interpolating via a polynomial or spline approximation, you must also specify the degree or order of the approximation:

```
In [76]: df.interpolate(method='spline', order=2)
Out[76]: 
          A          B
0  1.000000   0.250000
1  2.100000  -0.428598
2  3.404545   1.206900
3  4.700000   4.000000
4  5.600000  12.200000
5  6.800000  14.400000

In [77]: df.interpolate(method='polynomial', order=2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          A          B
0  1.000000   0.250000
```

```
1  2.100000  -2.703846
2  3.451351  -1.453846
3  4.700000   4.000000
4  5.600000  12.200000
5  6.800000  14.400000
```

Compare several methods:

```
In [78]: np.random.seed(2)

In [79]: ser = pd.Series(np.arange(1, 10.1, .25)**2 + np.random.randn(37))

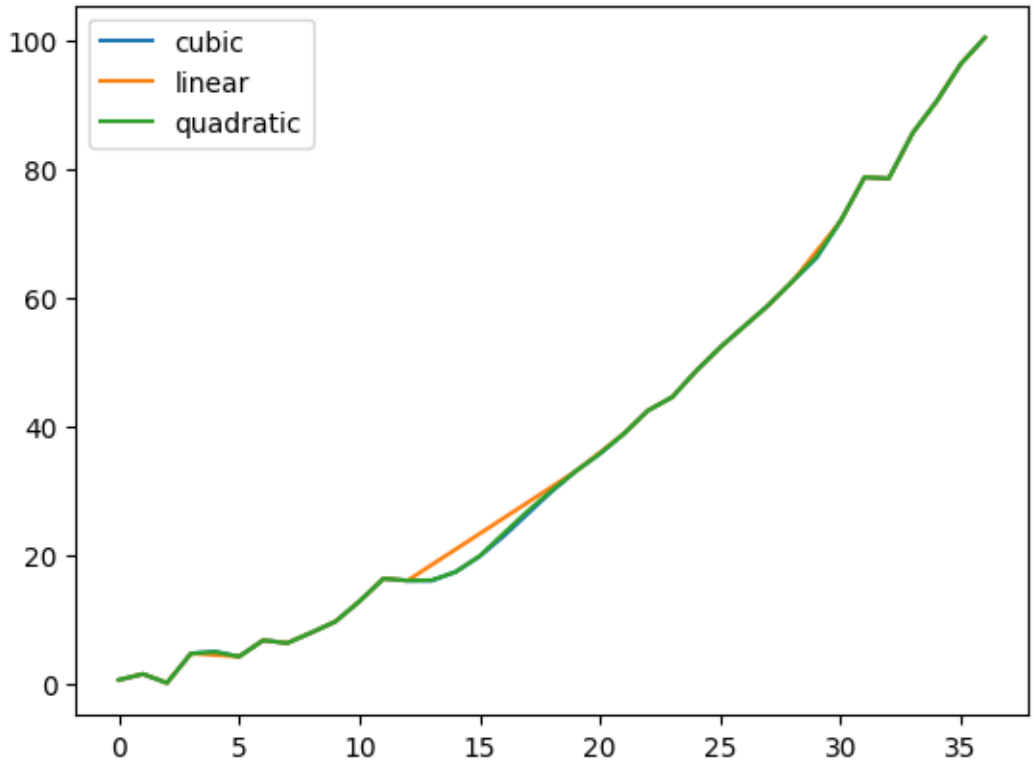
In [80]: bad = np.array([4, 13, 14, 15, 16, 17, 18, 20, 29])

In [81]: ser[bad] = np.nan

In [82]: methods = ['linear', 'quadratic', 'cubic']

In [83]: df = pd.DataFrame({m: ser.interpolate(method=m) for m in methods})

In [84]: df.plot()
Out[84]: <matplotlib.axes._subplots.AxesSubplot at 0x1312fcfd0>
```



Another use case is interpolation at *new* values. Suppose you have 100 observations from some distribution. And let's suppose that you're particularly interested in what's happening around the middle. You can mix pandas' `reindex` and `interpolate` methods to interpolate at the new values.

```
In [85]: ser = pd.Series(np.sort(np.random.uniform(size=100)))

# interpolate at new_index
```

```
In [86]: new_index = ser.index | pd.Index([49.25, 49.5, 49.75, 50.25, 50.5, 50.75])

In [87]: interp_s = ser.reindex(new_index).interpolate(method='pchip')

In [88]: interp_s[49:51]
Out[88]:
49.00    0.471410
49.25    0.476841
49.50    0.481780
49.75    0.485998
50.00    0.489266
50.25    0.491814
50.50    0.493995
50.75    0.495763
51.00    0.497074
dtype: float64
```

15.5.4.1 Interpolation Limits

Like other pandas fill methods, `interpolate` accepts a `limit` keyword argument. Use this argument to limit the number of consecutive interpolations, keeping `NaN` values for interpolations that are too far from the last valid observation:

```
In [89]: ser = pd.Series([np.nan, np.nan, 5, np.nan, np.nan, np.nan, 13])

In [90]: ser.interpolate(limit=2)
Out[90]:
0     NaN
1     NaN
2     5.0
3     7.0
4     9.0
5     NaN
6    13.0
dtype: float64
```

By default, `limit` applies in a forward direction, so that only `NaN` values after a non-`NaN` value can be filled. If you provide `'backward'` or `'both'` for the `limit_direction` keyword argument, you can fill `NaN` values before non-`NaN` values, or both before and after non-`NaN` values, respectively:

```
In [91]: ser.interpolate(limit=1)  # limit_direction == 'forward'
Out[91]:
0     NaN
1     NaN
2     5.0
3     7.0
4     NaN
5     NaN
6    13.0
dtype: float64

In [92]: ser.interpolate(limit=1, limit_direction='backward')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[92
↪
0     NaN
1     5.0
```

```
2     5.0
3     NaN
4     NaN
5    11.0
6    13.0
dtype: float64

In [93]: ser.interpolate(limit=1, limit_direction='both')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
0     NaN
1     5.0
2     5.0
3     7.0
4     NaN
5    11.0
6    13.0
dtype: float64
```

15.5.5 Replacing Generic Values

Often times we want to replace arbitrary values with other values. The `replace` method in Series/DataFrame provides an efficient yet flexible way to perform such replacements.

For a Series, you can replace a single value or a list of values by another value:

```
In [94]: ser = pd.Series([0., 1., 2., 3., 4.])

In [95]: ser.replace(0, 5)
Out[95]:
0    5.0
1    1.0
2    2.0
3    3.0
4    4.0
dtype: float64
```

You can replace a list of values by a list of other values:

```
In [96]: ser.replace([0, 1, 2, 3, 4], [4, 3, 2, 1, 0])
Out[96]:
0    4.0
1    3.0
2    2.0
3    1.0
4    0.0
dtype: float64
```

You can also specify a mapping dict:

```
In [97]: ser.replace({0: 10, 1: 100})
Out[97]:
0     10.0
1    100.0
2      2.0
3      3.0
```

```
4      4.0
dtype: float64
```

For a DataFrame, you can specify individual values by column:

```
In [98]: df = pd.DataFrame({'a': [0, 1, 2, 3, 4], 'b': [5, 6, 7, 8, 9]})

In [99]: df.replace({'a': 0, 'b': 5}, 100)
Out[99]:
     a    b
0  100  100
1    1    6
2    2    7
3    3    8
4    4    9
```

Instead of replacing with specified values, you can treat all given values as missing and interpolate over them:

```
In [100]: ser.replace([1, 2, 3], method='pad')
Out[100]:
0    0.0
1    0.0
2    0.0
3    0.0
4    4.0
dtype: float64
```

15.5.6 String/Regular Expression Replacement

Note: Python strings prefixed with the `r` character such as `r'hello world'` are so-called "raw" strings. They have different semantics regarding backslashes than strings without this prefix. Backslashes in raw strings will be interpreted as an escaped backslash, e.g., `r'\' == '\\'`. You should read about them if this is unclear.

Replace the '.' with `NaN` (str -> str)

```
In [101]: d = {'a': list(range(4)), 'b': list('ab..'), 'c': ['a', 'b', np.nan, 'd']}

In [102]: df = pd.DataFrame(d)

In [103]: df.replace('.', np.nan)
Out[103]:
   a    b    c
0  0    a    a
1  1    b    b
2  2  NaN  NaN
3  3  NaN    d
```

Now do it with a regular expression that removes surrounding whitespace (regex -> regex)

```
In [104]: df.replace(r'\s*\.\s*', np.nan, regex=True)
Out[104]:
   a    b    c
0  0    a    a
1  1    b    b
```

```
2  2  NaN  NaN
3  3  NaN    d
```

Replace a few different values (list -> list)

```
In [105]: df.replace(['a', '.'], ['b', np.nan])
Out[105]:
   a    b    c
0  0    b    b
1  1    b    b
2  2  NaN  NaN
3  3  NaN    d
```

list of regex -> list of regex

```
In [106]: df.replace([r'\.', r'(a)'], ['dot', '\1stuff'], regex=True)
Out[106]:
   a       b       c
0  0  {stuff  {stuff
1  1       b       b
2  2     dot     NaN
3  3     dot       d
```

Only search in column `'b'` (dict -> dict)

```
In [107]: df.replace({'b': '.'}, {'b': np.nan})
Out[107]:
   a    b    c
0  0    a    a
1  1    b    b
2  2  NaN  NaN
3  3  NaN    d
```

Same as the previous example, but use a regular expression for searching instead (dict of regex -> dict)

```
In [108]: df.replace({'b': r'\s*\.\s*'}, {'b': np.nan}, regex=True)
Out[108]:
   a    b    c
0  0    a    a
1  1    b    b
2  2  NaN  NaN
3  3  NaN    d
```

You can pass nested dictionaries of regular expressions that use `regex=True`

```
In [109]: df.replace({'b': {'b': r''}}, regex=True)
Out[109]:
   a  b    c
0  0  a    a
1  1       b
2  2  .  NaN
3  3  .    d
```

or you can pass the nested dictionary like so

```
In [110]: df.replace(regex={'b': {r'\s*\.\s*': np.nan}})
Out[110]:
   a    b    c
```

```
0  0    a    a
1  1    b    b
2  2  NaN  NaN
3  3  NaN    d
```

You can also use the group of a regular expression match when replacing (dict of regex -> dict of regex), this works for lists as well

```
In [111]: df.replace({'b': r'\s*(\.)\s*'}, {'b': r'\1ty'}, regex=True)
Out[111]:
   a    b    c
0  0    a    a
1  1    b    b
2  2  .ty  NaN
3  3  .ty    d
```

You can pass a list of regular expressions, of which those that match will be replaced with a scalar (list of regex -> regex)

```
In [112]: df.replace([r'\s*\.\s*', r'a|b'], np.nan, regex=True)
Out[112]:
   a   b    c
0  0 NaN  NaN
1  1 NaN  NaN
2  2 NaN  NaN
3  3 NaN    d
```

All of the regular expression examples can also be passed with the `to_replace` argument as the `regex` argument. In this case the `value` argument must be passed explicitly by name or `regex` must be a nested dictionary. The previous example, in this case, would then be

```
In [113]: df.replace(regex=[r'\s*\.\s*', r'a|b'], value=np.nan)
Out[113]:
   a   b    c
0  0 NaN  NaN
1  1 NaN  NaN
2  2 NaN  NaN
3  3 NaN    d
```

This can be convenient if you do not want to pass `regex=True` every time you want to use a regular expression.

Note: Anywhere in the above `replace` examples that you see a regular expression a compiled regular expression is valid as well.

15.5.7 Numeric Replacement

Similar to `DataFrame.fillna`

```
In [114]: df = pd.DataFrame(np.random.randn(10, 2))

In [115]: df[np.random.rand(df.shape[0]) > 0.5] = 1.5

In [116]: df.replace(1.5, np.nan)
Out[116]:
```

```
          0         1
0 -0.844214 -1.021415
1  0.432396 -0.323580
2  0.423825  0.799180
3  1.262614  0.751965
4       NaN       NaN
5       NaN       NaN
6 -0.498174 -1.060799
7  0.591667 -0.183257
8  1.019855 -1.482465
9       NaN       NaN
```

Replacing more than one value via lists works as well

```
In [117]: df00 = df.values[0, 0]

In [118]: df.replace([1.5, df00], [np.nan, 'a'])
Out[118]: 
          0         1
0         a  -1.02141
1  0.432396  -0.32358
2  0.423825   0.79918
3   1.26261  0.751965
4       NaN       NaN
5       NaN       NaN
6 -0.498174   -1.0608
7  0.591667 -0.183257
8   1.01985  -1.48247
9       NaN       NaN

In [119]: df[1].dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪dtype('float64')
```

You can also operate on the DataFrame in place

```
In [120]: df.replace(1.5, np.nan, inplace=True)
```

Warning: When replacing multiple `bool` or `datetime64` objects, the first argument to `replace` (`to_replace`) must match the type of the value being replaced type. For example,

```
s = pd.Series([True, False, True])
s.replace({'a string': 'new value', True: False})  # raises

TypeError: Cannot compare types 'ndarray(dtype=bool)' and 'str'
```

will raise a `TypeError` because one of the `dict` keys is not of the correct type for replacement.

However, when replacing a *single* object such as,

```
In [121]: s = pd.Series([True, False, True])

In [122]: s.replace('a string', 'another string')
Out[122]: 
0     True
1    False
2     True
dtype: bool
```

the original `NDFrame` object will be returned untouched. We're working on unifying this API, but for backwards compatibility reasons we cannot break the latter behavior. See GH6354 for more details.

15.6 Missing data casting rules and indexing

While pandas supports storing arrays of integer and boolean type, these types are not capable of storing missing data. Until we can switch to using a native NA type in NumPy, we've established some "casting rules" when reindexing will cause missing data to be introduced into, say, a Series or DataFrame. Here they are:

data type	Cast to
integer	float
boolean	object
float	no cast
object	no cast

For example:

```
In [123]: s = pd.Series(np.random.randn(5), index=[0, 2, 4, 6, 7])

In [124]: s > 0
Out[124]:
0    True
2    True
4    True
6    True
7    True
dtype: bool

In [125]: (s > 0).dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[125]:␣
↪dtype('bool')

In [126]: crit = (s > 0).reindex(list(range(8)))

In [127]: crit
Out[127]:
0    True
1     NaN
2    True
3     NaN
4    True
5     NaN
6    True
7    True
dtype: object

In [128]: crit.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪dtype('O')
```

Ordinarily NumPy will complain if you try to use an object array (even if it contains boolean values) instead of a boolean array to get or set values from an ndarray (e.g. selecting values based on some criteria). If a boolean vector contains NAs, an exception will be generated:

```
In [129]: reindexed = s.reindex(list(range(8))).fillna(0)

In [130]: reindexed[crit]
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-130-2da204ed1ac7> in <module>()
----> 1 reindexed[crit]

~/Envs/pandas-dev/lib/python3.6/site-packages/pandas/pandas/core/series.py in __
↪getitem__(self, key)
    659             key = list(key)
    660 
--> 661         if com.is_bool_indexer(key):
    662             key = check_bool_indexer(self.index, key)
    663 

~/Envs/pandas-dev/lib/python3.6/site-packages/pandas/pandas/core/common.py in is_bool_
↪indexer(key)
    189             if not lib.is_bool_array(key):
    190                 if isna(key).any():
--> 191                     raise ValueError('cannot index with vector containing '
    192                                      'NA / NaN values')
    193                 return False

ValueError: cannot index with vector containing NA / NaN values
```

However, these can be filled in using **fillna** and it will work fine:

```
In [131]: reindexed[crit.fillna(False)]
Out[131]: 
0    0.126504
2    0.696198
4    0.697416
6    0.601516
7    0.003659
dtype: float64

In [132]: reindexed[crit.fillna(True)]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[
↪
0    0.126504
1    0.000000
2    0.696198
3    0.000000
4    0.697416
5    0.000000
6    0.601516
7    0.003659
dtype: float64
```

CHAPTER

SIXTEEN

GROUP BY: SPLIT-APPLY-COMBINE

By "group by" we are referring to a process involving one or more of the following steps

- **Splitting** the data into groups based on some criteria
- **Applying** a function to each group independently
- **Combining** the results into a data structure

Of these, the split step is the most straightforward. In fact, in many situations you may wish to split the data set into groups and do something with those groups yourself. In the apply step, we might wish to one of the following:

- **Aggregation**: computing a summary statistic (or statistics) about each group. Some examples:
  - Compute group sums or means
  - Compute group sizes / counts
- **Transformation**: perform some group-specific computations and return a like-indexed. Some examples:
  - Standardizing data (zscore) within group
  - Filling NAs within groups with a value derived from each group
- **Filtration**: discard some groups, according to a group-wise computation that evaluates True or False. Some examples:
  - Discarding data that belongs to groups with only a few members
  - Filtering out data based on the group sum or mean
- Some combination of the above: GroupBy will examine the results of the apply step and try to return a sensibly combined result if it doesn't fit into either of the above two categories

Since the set of object instance methods on pandas data structures are generally rich and expressive, we often simply want to invoke, say, a DataFrame function on each group. The name GroupBy should be quite familiar to those who have used a SQL-based tool (or `itertools`), in which you can write code like:

```
SELECT Column1, Column2, mean(Column3), sum(Column4)
FROM SomeTable
GROUP BY Column1, Column2
```

We aim to make operations like this natural and easy to express using pandas. We'll address each area of GroupBy functionality then provide some non-trivial examples / use cases.

See the *cookbook* for some advanced strategies

16.1 Splitting an object into groups

pandas objects can be split on any of their axes. The abstract definition of grouping is to provide a mapping of labels to group names. To create a GroupBy object (more on what the GroupBy object is later), you do the following:

```
# default is axis=0
>>> grouped = obj.groupby(key)
>>> grouped = obj.groupby(key, axis=1)
>>> grouped = obj.groupby([key1, key2])
```

The mapping can be specified many different ways:

- A Python function, to be called on each of the axis labels
- A list or NumPy array of the same length as the selected axis
- A dict or Series, providing a `label -> group name` mapping
- For DataFrame objects, a string indicating a column to be used to group. Of course `df.groupby('A')` is just syntactic sugar for `df.groupby(df['A'])`, but it makes life simpler
- For DataFrame objects, a string indicating an index level to be used to group.
- A list of any of the above things

Collectively we refer to the grouping objects as the **keys**. For example, consider the following DataFrame:

Note: New in version 0.20.

A string passed to `groupby` may refer to either a column or an index level. If a string matches both a column name and an index level name then a warning is issued and the column takes precedence. This will result in an ambiguity error in a future version.

```
In [1]: df = pd.DataFrame({'A' : ['foo', 'bar', 'foo', 'bar',
   ...:                           'foo', 'bar', 'foo', 'foo'],
   ...:                       'B' : ['one', 'one', 'two', 'three',
   ...:                           'two', 'two', 'one', 'three'],
   ...:                       'C' : np.random.randn(8),
   ...:                       'D' : np.random.randn(8)})
   ...:

In [2]: df
Out[2]:
     A      B         C         D
0  foo    one  0.469112 -0.861849
1  bar    one -0.282863 -2.104569
2  foo    two -1.509059 -0.494929
3  bar  three -1.135632  1.071804
4  foo    two  1.212112  0.721555
5  bar    two -0.173215 -0.706771
6  foo    one  0.119209 -1.039575
7  foo  three -1.044236  0.271860
```

We could naturally group by either the `A` or `B` columns or both:

```
In [3]: grouped = df.groupby('A')

In [4]: grouped = df.groupby(['A', 'B'])
```

These will split the DataFrame on its index (rows). We could also split by the columns:

```
In [5]: def get_letter_type(letter):
   ...:     if letter.lower() in 'aeiou':
   ...:         return 'vowel'
   ...:     else:
   ...:         return 'consonant'
   ...:

In [6]: grouped = df.groupby(get_letter_type, axis=1)
```

pandas Index objects support duplicate values. If a non-unique index is used as the group key in a groupby operation, all values for the same index value will be considered to be in one group and thus the output of aggregation functions will only contain unique index values:

```
In [7]: lst = [1, 2, 3, 1, 2, 3]

In [8]: s = pd.Series([1, 2, 3, 10, 20, 30], lst)

In [9]: grouped = s.groupby(level=0)

In [10]: grouped.first()
Out[10]:
1    1
2    2
3    3
dtype: int64

In [11]: grouped.last()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[11]:
1    10
2    20
3    30
dtype: int64

In [12]: grouped.sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[12]:␣
↪
1    11
2    22
3    33
dtype: int64
```

Note that **no splitting occurs** until it's needed. Creating the GroupBy object only verifies that you've passed a valid mapping.

Note: Many kinds of complicated data manipulations can be expressed in terms of GroupBy operations (though can't be guaranteed to be the most efficient). You can get quite creative with the label mapping functions.

16.1.1 GroupBy sorting

By default the group keys are sorted during the `groupby` operation. You may however pass `sort=False` for potential speedups:

```
In [13]: df2 = pd.DataFrame({'X' : ['B', 'B', 'A', 'A'], 'Y' : [1, 2, 3, 4]})

In [14]: df2.groupby(['X']).sum()
Out[14]:
   Y
X
A  7
B  3

In [15]: df2.groupby(['X'], sort=False).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[15]:
   Y
X
B  3
A  7
```

Note that `groupby` will preserve the order in which *observations* are sorted *within* each group. For example, the groups created by `groupby()` below are in the order they appeared in the original `DataFrame`:

```
In [16]: df3 = pd.DataFrame({'X' : ['A', 'B', 'A', 'B'], 'Y' : [1, 4, 3, 2]})

In [17]: df3.groupby(['X']).get_group('A')
Out[17]:
   X  Y
0  A  1
2  A  3

In [18]: df3.groupby(['X']).get_group('B')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[18]:
   X  Y
1  B  4
3  B  2
```

16.1.2 GroupBy object attributes

The `groups` attribute is a dict whose keys are the computed unique groups and corresponding values being the axis labels belonging to each group. In the above example we have:

```
In [19]: df.groupby('A').groups
Out[19]:
{'bar': Int64Index([1, 3, 5], dtype='int64'),
 'foo': Int64Index([0, 2, 4, 6, 7], dtype='int64')}

In [20]: df.groupby(get_letter_type, axis=1).groups
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
{'consonant': Index(['B', 'C', 'D'], dtype='object'),
 'vowel': Index(['A'], dtype='object')}
```

Calling the standard Python `len` function on the GroupBy object just returns the length of the `groups` dict, so it is largely just a convenience:

```
In [21]: grouped = df.groupby(['A', 'B'])

In [22]: grouped.groups
Out[22]:
```

```
{('bar', 'one'): Int64Index([1], dtype='int64'),
 ('bar', 'three'): Int64Index([3], dtype='int64'),
 ('bar', 'two'): Int64Index([5], dtype='int64'),
 ('foo', 'one'): Int64Index([0, 6], dtype='int64'),
 ('foo', 'three'): Int64Index([7], dtype='int64'),
 ('foo', 'two'): Int64Index([2, 4], dtype='int64')}

In [23]: len(grouped)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪6
```

`GroupBy` will tab complete column names (and other attributes)

```
In [24]: df
Out[24]:
            gender     height      weight
2000-01-01    male  42.849980  157.500553
2000-01-02    male  49.607315  177.340407
2000-01-03    male  56.293531  171.524640
2000-01-04  female  48.421077  144.251986
2000-01-05    male  46.556882  152.526206
2000-01-06  female  68.448851  168.272968
2000-01-07    male  70.757698  136.431469
2000-01-08  female  58.909500  176.499753
2000-01-09  female  76.435631  174.094104
2000-01-10    male  45.306120  177.540920

In [25]: gb = df.groupby('gender')
```

```
In [26]: gb.<TAB>
gb.agg        gb.boxplot    gb.cummin     gb.describe   gb.filter     gb.get_group ␣
↪gb.height      gb.last       gb.median     gb.ngroups    gb.plot       gb.rank      ␣
↪gb.std         gb.transform
gb.aggregate  gb.count      gb.cumprod    gb.dtype      gb.first      gb.groups    ␣
↪gb.hist        gb.max        gb.min        gb.nth        gb.prod       gb.resample  ␣
↪gb.sum         gb.var
gb.apply      gb.cummax     gb.cumsum     gb.fillna     gb.gender     gb.head      ␣
↪gb.indices     gb.mean       gb.name       gb.ohlc       gb.quantile   gb.size      ␣
↪gb.tail        gb.weight
```

16.1.3 GroupBy with MultiIndex

With *hierarchically-indexed data*, it's quite natural to group by one of the levels of the hierarchy.

Let's create a Series with a two-level `MultiIndex`.

```
In [27]: arrays = [['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'],
   ....:           ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two']]
   ....:

In [28]: index = pd.MultiIndex.from_arrays(arrays, names=['first', 'second'])

In [29]: s = pd.Series(np.random.randn(8), index=index)

In [30]: s
Out[30]:
```

```
first  second
bar    one      -0.919854
       two      -0.042379
baz    one       1.247642
       two      -0.009920
foo    one       0.290213
       two       0.495767
qux    one       0.362949
       two       1.548106
dtype: float64
```

We can then group by one of the levels in `s`.

```
In [31]: grouped = s.groupby(level=0)

In [32]: grouped.sum()
Out[32]:
first
bar   -0.962232
baz    1.237723
foo    0.785980
qux    1.911055
dtype: float64
```

If the MultiIndex has names specified, these can be passed instead of the level number:

```
In [33]: s.groupby(level='second').sum()
Out[33]:
second
one    0.980950
two    1.991575
dtype: float64
```

The aggregation functions such as `sum` will take the level parameter directly. Additionally, the resulting index will be named according to the chosen level:

```
In [34]: s.sum(level='second')
Out[34]:
second
one    0.980950
two    1.991575
dtype: float64
```

Grouping with multiple levels is supported.

```
In [35]: s
Out[35]:
first  second  third
bar    doo     one     -1.131345
               two     -0.089329
baz    bee     one      0.337863
               two     -0.945867
foo    bop     one     -0.932132
               two      1.956030
qux    bop     one      0.017587
               two     -0.016692
dtype: float64
```

```
In [36]: s.groupby(level=['first', 'second']).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
first  second
bar    doo       -1.220674
baz    bee       -0.608004
foo    bop        1.023898
qux    bop        0.000895
dtype: float64
```

New in version 0.20.

Index level names may be supplied as keys.

```
In [37]: s.groupby(['first', 'second']).sum()
Out[37]:
first  second
bar    doo       -1.220674
baz    bee       -0.608004
foo    bop        1.023898
qux    bop        0.000895
dtype: float64
```

More on the `sum` function and aggregation later.

16.1.4 Grouping DataFrame with Index Levels and Columns

A DataFrame may be grouped by a combination of columns and index levels by specifying the column names as strings and the index levels as `pd.Grouper` objects.

```
In [38]: arrays = [['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'],
   ....:           ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two']]
   ....:

In [39]: index = pd.MultiIndex.from_arrays(arrays, names=['first', 'second'])

In [40]: df = pd.DataFrame({'A': [1, 1, 1, 1, 2, 2, 3, 3],
   ....:                    'B': np.arange(8)},
   ....:                   index=index)
   ....:

In [41]: df
Out[41]:
              A  B
first second
bar   one     1  0
      two     1  1
baz   one     1  2
      two     1  3
foo   one     2  4
      two     2  5
qux   one     3  6
      two     3  7
```

The following example groups `df` by the `second` index level and the `A` column.

```
In [42]: df.groupby([pd.Grouper(level=1), 'A']).sum()
Out[42]:
           B
second A
one    1   2
       2   4
       3   6
two    1   4
       2   5
       3   7
```

Index levels may also be specified by name.

```
In [43]: df.groupby([pd.Grouper(level='second'), 'A']).sum()
Out[43]:
           B
second A
one    1   2
       2   4
       3   6
two    1   4
       2   5
       3   7
```

New in version 0.20.

Index level names may be specified as keys directly to `groupby`.

```
In [44]: df.groupby(['second', 'A']).sum()
Out[44]:
           B
second A
one    1   2
       2   4
       3   6
two    1   4
       2   5
       3   7
```

16.1.5 DataFrame column selection in GroupBy

Once you have created the GroupBy object from a DataFrame, for example, you might want to do something different for each of the columns. Thus, using `[]` similar to getting a column from a DataFrame, you can do:

```
In [45]: grouped = df.groupby(['A'])

In [46]: grouped_C = grouped['C']

In [47]: grouped_D = grouped['D']
```

This is mainly syntactic sugar for the alternative and much more verbose:

```
In [48]: df['C'].groupby(df['A'])
Out[48]: <pandas.core.groupby.SeriesGroupBy object at 0x11513a550>
```

Additionally this method avoids recomputing the internal grouping information derived from the passed key.

16.2 Iterating through groups

With the GroupBy object in hand, iterating through the grouped data is very natural and functions similarly to `itertools.groupby`:

```
In [49]: grouped = df.groupby('A')

In [50]: for name, group in grouped:
   ....:        print(name)
   ....:        print(group)
   ....:
bar
     A      B         C         D
1  bar    one  0.254161  1.511763
3  bar  three  0.215897 -0.990582
5  bar    two -0.077118  1.211526
foo
     A      B         C         D
0  foo    one -0.575247  1.346061
2  foo    two -1.143704  1.627081
4  foo    two  1.193555 -0.441652
6  foo    one -0.408530  0.268520
7  foo  three -0.862495  0.024580
```

In the case of grouping by multiple keys, the group name will be a tuple:

```
In [51]: for name, group in df.groupby(['A', 'B']):
   ....:        print(name)
   ....:        print(group)
   ....:
('bar', 'one')
     A    B         C         D
1  bar  one  0.254161  1.511763
('bar', 'three')
     A      B         C         D
3  bar  three  0.215897 -0.990582
('bar', 'two')
     A    B         C         D
5  bar  two -0.077118  1.211526
('foo', 'one')
     A    B         C         D
0  foo  one -0.575247  1.346061
6  foo  one -0.408530  0.268520
('foo', 'three')
     A      B         C        D
7  foo  three -0.862495  0.02458
('foo', 'two')
     A    B         C         D
2  foo  two -1.143704  1.627081
4  foo  two  1.193555 -0.441652
```

It's standard Python-fu but remember you can unpack the tuple in the for loop statement if you wish: `for (k1, k2), group in grouped:`.

16.3 Selecting a group

A single group can be selected using `GroupBy.get_group()`:

```
In [52]: grouped.get_group('bar')
Out[52]:
     A      B         C         D
1  bar    one  0.254161  1.511763
3  bar  three  0.215897 -0.990582
5  bar    two -0.077118  1.211526
```

Or for an object grouped on multiple columns:

```
In [53]: df.groupby(['A', 'B']).get_group(('bar', 'one'))
Out[53]:
     A    B         C         D
1  bar  one  0.254161  1.511763
```

16.4 Aggregation

Once the GroupBy object has been created, several methods are available to perform a computation on the grouped data. These operations are similar to the *aggregating API*, *window functions API*, and *resample API*.

An obvious one is aggregation via the `aggregate` or equivalently `agg` method:

```
In [54]: grouped = df.groupby('A')

In [55]: grouped.aggregate(np.sum)
Out[55]:
            C         D
A
bar  0.392940  1.732707
foo -1.796421  2.824590

In [56]: grouped = df.groupby(['A', 'B'])

In [57]: grouped.aggregate(np.sum)
Out[57]:
                  C         D
A   B
bar one    0.254161  1.511763
    three  0.215897 -0.990582
    two   -0.077118  1.211526
foo one   -0.983776  1.614581
    three -0.862495  0.024580
    two    0.049851  1.185429
```

As you can see, the result of the aggregation will have the group names as the new index along the grouped axis. In the case of multiple keys, the result is a *MultiIndex* by default, though this can be changed by using the `as_index` option:

```
In [58]: grouped = df.groupby(['A', 'B'], as_index=False)

In [59]: grouped.aggregate(np.sum)
Out[59]:
```

```
     A      B         C         D
0  bar    one  0.254161  1.511763
1  bar  three  0.215897 -0.990582
2  bar    two -0.077118  1.211526
3  foo    one -0.983776  1.614581
4  foo  three -0.862495  0.024580
5  foo    two  0.049851  1.185429

In [60]: df.groupby('A', as_index=False).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
     A         C         D
0  bar  0.392940  1.732707
1  foo -1.796421  2.824590
```

Note that you could use the `reset_index` DataFrame function to achieve the same result as the column names are stored in the resulting `MultiIndex`:

```
In [61]: df.groupby(['A', 'B']).sum().reset_index()
Out[61]:
     A      B         C         D
0  bar    one  0.254161  1.511763
1  bar  three  0.215897 -0.990582
2  bar    two -0.077118  1.211526
3  foo    one -0.983776  1.614581
4  foo  three -0.862495  0.024580
5  foo    two  0.049851  1.185429
```

Another simple aggregation example is to compute the size of each group. This is included in GroupBy as the `size` method. It returns a Series whose index are the group names and whose values are the sizes of each group.

```
In [62]: grouped.size()
Out[62]:
A    B
bar  one      1
     three    1
     two      1
foo  one      2
     three    1
     two      2
dtype: int64
```

```
In [63]: grouped.describe()
Out[63]:
      C                                                                         \
  count      mean       std       min       25%       50%       75%       max
0   1.0  0.254161       NaN  0.254161  0.254161  0.254161  0.254161  0.254161
1   1.0  0.215897       NaN  0.215897  0.215897  0.215897  0.215897  0.215897
2   1.0 -0.077118       NaN -0.077118 -0.077118 -0.077118 -0.077118 -0.077118
3   2.0 -0.491888  0.117887 -0.575247 -0.533567 -0.491888 -0.450209 -0.408530
4   1.0 -0.862495       NaN -0.862495 -0.862495 -0.862495 -0.862495 -0.862495
5   2.0  0.024925  1.652692 -1.143704 -0.559389  0.024925  0.609240  1.193555

      D
  count      mean       std       min       25%       50%       75%       max
0   1.0  1.511763       NaN  1.511763  1.511763  1.511763  1.511763  1.511763
1   1.0 -0.990582       NaN -0.990582 -0.990582 -0.990582 -0.990582 -0.990582
```

```
2   1.0  1.211526       NaN  1.211526  1.211526  1.211526  1.211526  1.211526
3   2.0  0.807291  0.761937  0.268520  0.537905  0.807291  1.076676  1.346061
4   1.0  0.024580       NaN  0.024580  0.024580  0.024580  0.024580  0.024580
5   2.0  0.592714  1.462816 -0.441652  0.075531  0.592714  1.109898  1.627081
```

Note: Aggregation functions **will not** return the groups that you are aggregating over if they are named *columns*, when `as_index=True`, the default. The grouped columns will be the **indices** of the returned object.

Passing `as_index=False` **will** return the groups that you are aggregating over, if they are named *columns*.

Aggregating functions are ones that reduce the dimension of the returned objects, for example: `mean, sum, size, count, std, var, sem, describe, first, last, nth, min, max`. This is what happens when you do for example `DataFrame.sum()` and get back a `Series`.

`nth` can act as a reducer *or* a filter, see *here*

16.4.1 Applying multiple functions at once

With grouped `Series` you can also pass a list or dict of functions to do aggregation with, outputting a DataFrame:

```
In [64]: grouped = df.groupby('A')

In [65]: grouped['C'].agg([np.sum, np.mean, np.std])
Out[65]:
          sum      mean       std
A
bar  0.392940  0.130980  0.181231
foo -1.796421 -0.359284  0.912265
```

On a grouped `DataFrame`, you can pass a list of functions to apply to each column, which produces an aggregated result with a hierarchical index:

```
In [66]: grouped.agg([np.sum, np.mean, np.std])
Out[66]:
            C                              D
          sum      mean       std       sum      mean       std
A
bar  0.392940  0.130980  0.181231  1.732707  0.577569  1.366330
foo -1.796421 -0.359284  0.912265  2.824590  0.564918  0.884785
```

The resulting aggregations are named for the functions themselves. If you need to rename, then you can add in a chained operation for a `Series` like this:

```
In [67]: (grouped['C'].agg([np.sum, np.mean, np.std])
   ....:              .rename(columns={'sum': 'foo',
   ....:                               'mean': 'bar',
   ....:                               'std': 'baz'})
   ....: )
   ....:
Out[67]:
          foo       bar       baz
A
bar  0.392940  0.130980  0.181231
foo -1.796421 -0.359284  0.912265
```

For a grouped `DataFrame`, you can rename in a similar manner:

```
In [68]: (grouped.agg([np.sum, np.mean, np.std])
   ....:          .rename(columns={'sum': 'foo',
   ....:                           'mean': 'bar',
   ....:                           'std': 'baz'})
   ....:  )
   ....:
Out[68]:
            C                               D
          foo       bar       baz         foo       bar       baz
A
bar  0.392940  0.130980  0.181231  1.732707  0.577569  1.366330
foo -1.796421 -0.359284  0.912265  2.824590  0.564918  0.884785
```

16.4.2 Applying different functions to DataFrame columns

By passing a dict to `aggregate` you can apply a different aggregation to the columns of a DataFrame:

```
In [69]: grouped.agg({'C' : np.sum,
   ....:              'D' : lambda x: np.std(x, ddof=1)})
   ....:
Out[69]:
            C         D
A
bar  0.392940  1.366330
foo -1.796421  0.884785
```

The function names can also be strings. In order for a string to be valid it must be either implemented on GroupBy or available via *dispatching*:

```
In [70]: grouped.agg({'C' : 'sum', 'D' : 'std'})
Out[70]:
            C         D
A
bar  0.392940  1.366330
foo -1.796421  0.884785
```

Note: If you pass a dict to `aggregate`, the ordering of the output columns is non-deterministic. If you want to be sure the output columns will be in a specific order, you can use an `OrderedDict`. Compare the output of the following two commands:

```
In [71]: grouped.agg({'D': 'std', 'C': 'mean'})
Out[71]:
            D         C
A
bar  1.366330  0.130980
foo  0.884785 -0.359284

In [72]: grouped.agg(OrderedDict([('D', 'std'), ('C', 'mean')]))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
            D         C
A
```

```
bar  1.366330  0.130980
foo  0.884785 -0.359284
```

16.4.3 Cython-optimized aggregation functions

Some common aggregations, currently only `sum`, `mean`, `std`, and `sem`, have optimized Cython implementations:

```
In [73]: df.groupby('A').sum()
Out[73]:
            C         D
A
bar  0.392940  1.732707
foo -1.796421  2.824590

In [74]: df.groupby(['A', 'B']).mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                  C         D
A   B
bar one    0.254161  1.511763
    three  0.215897 -0.990582
    two   -0.077118  1.211526
foo one   -0.491888  0.807291
    three -0.862495  0.024580
    two    0.024925  0.592714
```

Of course `sum` and `mean` are implemented on pandas objects, so the above code would work even without the special versions via dispatching (see below).

16.5 Transformation

The `transform` method returns an object that is indexed the same (same size) as the one being grouped. The transform function must:

- Return a result that is either the same size as the group chunk or broadcastable to the size of the group chunk (e.g., a scalar, `grouped.transform(lambda x:  x.iloc[-1])`).
- Operate column-by-column on the group chunk. The transform is applied to the first group chunk using chunk.apply.
- Not perform in-place operations on the group chunk. Group chunks should be treated as immutable, and changes to a group chunk may produce unexpected results. For example, when using `fillna`, `inplace` must be `False` (`grouped.transform(lambda x:  x.fillna(inplace=False))`).
- (Optionally) operates on the entire group chunk. If this is supported, a fast path is used starting from the *second* chunk.

For example, suppose we wished to standardize the data within each group:

```
In [75]: index = pd.date_range('10/1/1999', periods=1100)

In [76]: ts = pd.Series(np.random.normal(0.5, 2, 1100), index)

In [77]: ts = ts.rolling(window=100,min_periods=100).mean().dropna()
```

```
In [78]: ts.head()
Out[78]:
2000-01-08    0.779333
2000-01-09    0.778852
2000-01-10    0.786476
2000-01-11    0.782797
2000-01-12    0.798110
Freq: D, dtype: float64

In [79]: ts.tail()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2002-09-30    0.660294
2002-10-01    0.631095
2002-10-02    0.673601
2002-10-03    0.709213
2002-10-04    0.719369
Freq: D, dtype: float64

In [80]: key = lambda x: x.year

In [81]: zscore = lambda x: (x - x.mean()) / x.std()

In [82]: transformed = ts.groupby(key).transform(zscore)
```

We would expect the result to now have mean 0 and standard deviation 1 within each group, which we can easily check:

```
# Original Data
In [83]: grouped = ts.groupby(key)

In [84]: grouped.mean()
Out[84]:
2000    0.442441
2001    0.526246
2002    0.459365
dtype: float64

In [85]: grouped.std()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[85]:
2000    0.131752
2001    0.210945
2002    0.128753
dtype: float64

# Transformed Data
In [86]: grouped_trans = transformed.groupby(key)

In [87]: grouped_trans.mean()
Out[87]:
2000    1.168208e-15
2001    1.454544e-15
2002    1.726657e-15
dtype: float64

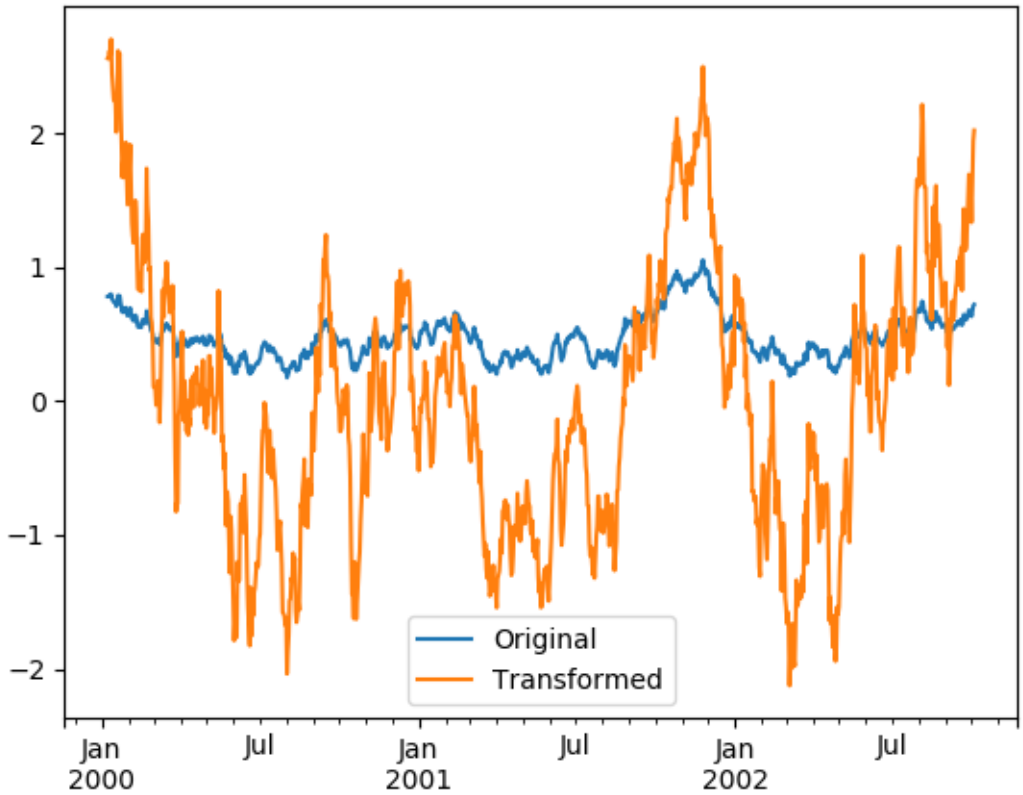
In [88]: grouped_trans.std()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[88]:␣
↪
```

```
2000    1.0
2001    1.0
2002    1.0
dtype: float64
```

We can also visually compare the original and transformed data sets.

```
In [89]: compare = pd.DataFrame({'Original': ts, 'Transformed': transformed})

In [90]: compare.plot()
Out[90]: <matplotlib.axes._subplots.AxesSubplot at 0x12772ff98>
```



Transformation functions that have lower dimension outputs are broadcast to match the shape of the input array.

```
In [91]: data_range = lambda x: x.max() - x.min()

In [92]: ts.groupby(key).transform(data_range)
Out[92]:
2000-01-08    0.623893
2000-01-09    0.623893
2000-01-10    0.623893
2000-01-11    0.623893
2000-01-12    0.623893
2000-01-13    0.623893
2000-01-14    0.623893
                ...
2002-09-28    0.558275
2002-09-29    0.558275
2002-09-30    0.558275
```

```
2002-10-01    0.558275
2002-10-02    0.558275
2002-10-03    0.558275
2002-10-04    0.558275
Freq: D, Length: 1001, dtype: float64
```

Alternatively the built-in methods can be could be used to produce the same outputs

```
In [93]: ts.groupby(key).transform('max') - ts.groupby(key).transform('min')
Out[93]:
2000-01-08    0.623893
2000-01-09    0.623893
2000-01-10    0.623893
2000-01-11    0.623893
2000-01-12    0.623893
2000-01-13    0.623893
2000-01-14    0.623893
                ...
2002-09-28    0.558275
2002-09-29    0.558275
2002-09-30    0.558275
2002-10-01    0.558275
2002-10-02    0.558275
2002-10-03    0.558275
2002-10-04    0.558275
Freq: D, Length: 1001, dtype: float64
```

Another common data transform is to replace missing data with the group mean.

```
In [94]: data_df
Out[94]:
            A         B         C
0    1.539708 -1.166480  0.533026
1    1.302092 -0.505754       NaN
2   -0.371983  1.104803 -0.651520
3   -1.309622  1.118697 -1.161657
4   -1.924296  0.396437  0.812436
5    0.815643  0.367816 -0.469478
6   -0.030651  1.376106 -0.645129
..        ...       ...       ...
993  0.012359  0.554602 -1.976159
994  0.042312 -1.628835  1.013822
995 -0.093110  0.683847 -0.774753
996 -0.185043  1.438572       NaN
997 -0.394469 -0.642343  0.011374
998 -1.174126  1.857148       NaN
999  0.234564  0.517098  0.393534

[1000 rows x 3 columns]

In [95]: countries = np.array(['US', 'UK', 'GR', 'JP'])

In [96]: key = countries[np.random.randint(0, 4, 1000)]

In [97]: grouped = data_df.groupby(key)

# Non-NA count in each group
In [98]: grouped.count()
```

```
Out[98]:
      A    B    C
GR  209  217  189
JP  240  255  217
UK  216  231  193
US  239  250  217

In [99]: f = lambda x: x.fillna(x.mean())

In [100]: transformed = grouped.transform(f)
```

We can verify that the group means have not changed in the transformed data and that the transformed data contains no NAs.

```
In [101]: grouped_trans = transformed.groupby(key)

In [102]: grouped.mean() # original group means
Out[102]:
           A         B         C
GR -0.098371 -0.015420  0.068053
JP  0.069025  0.023100 -0.077324
UK  0.034069 -0.052580 -0.116525
US  0.058664 -0.020399  0.028603

In [103]: grouped_trans.mean() # transformation did not change group means
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
           A         B         C
GR -0.098371 -0.015420  0.068053
JP  0.069025  0.023100 -0.077324
UK  0.034069 -0.052580 -0.116525
US  0.058664 -0.020399  0.028603

In [104]: grouped.count() # original has some missing data points
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      A    B    C
GR  209  217  189
JP  240  255  217
UK  216  231  193
US  239  250  217

In [105]: grouped_trans.count() # counts after transformation
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      A    B    C
GR  228  228  228
JP  267  267  267
UK  247  247  247
US  258  258  258

In [106]: grouped_trans.size() # Verify non-NA count equals group size
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
GR    228
JP    267
UK    247
US    258
```

```
dtype: int64
```

Note: Some functions when applied to a groupby object will automatically transform the input, returning an object of the same shape as the original. Passing `as_index=False` will not affect these transformation methods.

For example: `fillna, ffill, bfill, shift.`

```
In [107]: grouped.ffill()
Out[107]:
             A         B         C
0    1.539708 -1.166480  0.533026
1    1.302092 -0.505754  0.533026
2   -0.371983  1.104803 -0.651520
3   -1.309622  1.118697 -1.161657
4   -1.924296  0.396437  0.812436
5    0.815643  0.367816 -0.469478
6   -0.030651  1.376106 -0.645129
..        ...       ...       ...
993  0.012359  0.554602 -1.976159
994  0.042312 -1.628835  1.013822
995 -0.093110  0.683847 -0.774753
996 -0.185043  1.438572 -0.774753
997 -0.394469 -0.642343  0.011374
998 -1.174126  1.857148 -0.774753
999  0.234564  0.517098  0.393534

[1000 rows x 3 columns]
```

16.5.1 New syntax to window and resample operations

New in version 0.18.1.

Working with the resample, expanding or rolling operations on the groupby level used to require the application of helper functions. However, now it is possible to use `resample()`, `expanding()` and `rolling()` as methods on groupbys.

The example below will apply the `rolling()` method on the samples of the column B based on the groups of column A.

```
In [108]: df_re = pd.DataFrame({'A': [1] * 10 + [5] * 10,
   .....:                       'B': np.arange(20)})
   .....:

In [109]: df_re
Out[109]:
    A   B
0   1   0
1   1   1
2   1   2
3   1   3
4   1   4
5   1   5
6   1   6
.. ..  ..
13  5  13
```

```
14  5  14
15  5  15
16  5  16
17  5  17
18  5  18
19  5  19

[20 rows x 2 columns]

In [110]: df_re.groupby('A').rolling(4).B.mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A
1   0       NaN
    1       NaN
    2       NaN
    3       1.5
    4       2.5
    5       3.5
    6       4.5
           ...
5   13     11.5
    14     12.5
    15     13.5
    16     14.5
    17     15.5
    18     16.5
    19     17.5
Name: B, Length: 20, dtype: float64
```

The `expanding()` method will accumulate a given operation (`sum()` in the example) for all the members of each particular group.

```
In [111]: df_re.groupby('A').expanding().sum()
Out[111]:
         A      B
A
1 0    1.0    0.0
  1    2.0    1.0
  2    3.0    3.0
  3    4.0    6.0
  4    5.0   10.0
  5    6.0   15.0
  6    7.0   21.0
...    ...    ...
5 13  20.0   46.0
  14  25.0   60.0
  15  30.0   75.0
  16  35.0   91.0
  17  40.0  108.0
  18  45.0  126.0
  19  50.0  145.0

[20 rows x 2 columns]
```

Suppose you want to use the `resample()` method to get a daily frequency in each group of your dataframe and wish to complete the missing values with the `ffill()` method.

```
In [112]: df_re = pd.DataFrame({'date': pd.date_range(start='2016-01-01',
   .....:                             periods=4,
   .....:                             freq='W'),
   .....:                             'group': [1, 1, 2, 2],
   .....:                             'val': [5, 6, 7, 8]}).set_index('date')
   .....:

In [113]: df_re
Out[113]: 
            group  val
date                  
2016-01-03      1    5
2016-01-10      1    6
2016-01-17      2    7
2016-01-24      2    8

In [114]: df_re.groupby('group').resample('1D').ffill()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                  group  val
group date                  
1     2016-01-03      1    5
      2016-01-04      1    5
      2016-01-05      1    5
      2016-01-06      1    5
      2016-01-07      1    5
      2016-01-08      1    5
      2016-01-09      1    5
...                 ...  ...
2     2016-01-18      2    7
      2016-01-19      2    7
      2016-01-20      2    7
      2016-01-21      2    7
      2016-01-22      2    7
      2016-01-23      2    7
      2016-01-24      2    8

[16 rows x 2 columns]
```

16.6 Filtration

The `filter` method returns a subset of the original object. Suppose we want to take only elements that belong to groups with a group sum greater than 2.

```
In [115]: sf = pd.Series([1, 1, 2, 3, 3, 3])

In [116]: sf.groupby(sf).filter(lambda x: x.sum() > 2)
Out[116]: 
3    3
4    3
5    3
dtype: int64
```

The argument of `filter` must be a function that, applied to the group as a whole, returns `True` or `False`.

Another useful operation is filtering out elements that belong to groups with only a couple members.

```
In [117]: dff = pd.DataFrame({'A': np.arange(8), 'B': list('aabbbbcc')})

In [118]: dff.groupby('B').filter(lambda x: len(x) > 2)
Out[118]:
   A  B
2  2  b
3  3  b
4  4  b
5  5  b
```

Alternatively, instead of dropping the offending groups, we can return a like-indexed objects where the groups that do not pass the filter are filled with NaNs.

```
In [119]: dff.groupby('B').filter(lambda x: len(x) > 2, dropna=False)
Out[119]:
     A    B
0  NaN  NaN
1  NaN  NaN
2  2.0    b
3  3.0    b
4  4.0    b
5  5.0    b
6  NaN  NaN
7  NaN  NaN
```

For DataFrames with multiple columns, filters should explicitly specify a column as the filter criterion.

```
In [120]: dff['C'] = np.arange(8)

In [121]: dff.groupby('B').filter(lambda x: len(x['C']) > 2)
Out[121]:
   A  B  C
2  2  b  2
3  3  b  3
4  4  b  4
5  5  b  5
```

Note: Some functions when applied to a groupby object will act as a **filter** on the input, returning a reduced shape of the original (and potentially eliminating groups), but with the index unchanged. Passing `as_index=False` will not affect these transformation methods.

For example: `head, tail`.

```
In [122]: dff.groupby('B').head(2)
Out[122]:
   A  B  C
0  0  a  0
1  1  a  1
2  2  b  2
3  3  b  3
6  6  c  6
7  7  c  7
```

16.7 Dispatching to instance methods

When doing an aggregation or transformation, you might just want to call an instance method on each data group. This is pretty easy to do by passing lambda functions:

```
In [123]: grouped = df.groupby('A')

In [124]: grouped.agg(lambda x: x.std())
Out[124]:
            C         D
A
bar  0.181231  1.366330
foo  0.912265  0.884785
```

But, it's rather verbose and can be untidy if you need to pass additional arguments. Using a bit of metaprogramming cleverness, GroupBy now has the ability to "dispatch" method calls to the groups:

```
In [125]: grouped.std()
Out[125]:
            C         D
A
bar  0.181231  1.366330
foo  0.912265  0.884785
```

What is actually happening here is that a function wrapper is being generated. When invoked, it takes any passed arguments and invokes the function with any arguments on each group (in the above example, the `std` function). The results are then combined together much in the style of `agg` and `transform` (it actually uses `apply` to infer the gluing, documented next). This enables some operations to be carried out rather succinctly:

```
In [126]: tsdf = pd.DataFrame(np.random.randn(1000, 3),
   .....:                     index=pd.date_range('1/1/2000', periods=1000),
   .....:                     columns=['A', 'B', 'C'])
   .....:

In [127]: tsdf.iloc[::2] = np.nan

In [128]: grouped = tsdf.groupby(lambda x: x.year)

In [129]: grouped.fillna(method='pad')
Out[129]:
                   A         B         C
2000-01-01       NaN       NaN       NaN
2000-01-02 -0.353501 -0.080957 -0.876864
2000-01-03 -0.353501 -0.080957 -0.876864
2000-01-04  0.050976  0.044273 -0.559849
2000-01-05  0.050976  0.044273 -0.559849
2000-01-06  0.030091  0.186460 -0.680149
2000-01-07  0.030091  0.186460 -0.680149
...              ...       ...       ...
2002-09-20  2.310215  0.157482 -0.064476
2002-09-21  2.310215  0.157482 -0.064476
2002-09-22  0.005011  0.053897 -1.026922
2002-09-23  0.005011  0.053897 -1.026922
2002-09-24 -0.456542 -1.849051  1.559856
2002-09-25 -0.456542 -1.849051  1.559856
2002-09-26  1.123162  0.354660  1.128135
```

```
[1000 rows x 3 columns]
```

In this example, we chopped the collection of time series into yearly chunks then independently called *fillna* on the groups.

The `nlargest` and `nsmallest` methods work on `Series` style groupbys:

```
In [130]: s = pd.Series([9, 8, 7, 5, 19, 1, 4.2, 3.3])

In [131]: g = pd.Series(list('abababab'))

In [132]: gb = s.groupby(g)

In [133]: gb.nlargest(3)
Out[133]:
a  4    19.0
   0     9.0
   2     7.0
b  1     8.0
   3     5.0
   7     3.3
dtype: float64

In [134]: gb.nsmallest(3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a  6    4.2
   2    7.0
   0    9.0
b  5    1.0
   7    3.3
   3    5.0
dtype: float64
```

16.8 Flexible `apply`

Some operations on the grouped data might not fit into either the aggregate or transform categories. Or, you may simply want GroupBy to infer how to combine the results. For these, use the `apply` function, which can be substituted for both `aggregate` and `transform` in many standard use cases. However, `apply` can handle some exceptional use cases, for example:

```
In [135]: df
Out[135]:
     A      B         C         D
0  foo    one -0.575247  1.346061
1  bar    one  0.254161  1.511763
2  foo    two -1.143704  1.627081
3  bar  three  0.215897 -0.990582
4  foo    two  1.193555 -0.441652
5  bar    two -0.077118  1.211526
6  foo    one -0.408530  0.268520
7  foo  three -0.862495  0.024580

In [136]: grouped = df.groupby('A')
```

```
# could also just call .describe()
In [137]: grouped['C'].apply(lambda x: x.describe())
Out[137]:
A
bar   count    3.000000
      mean     0.130980
      std      0.181231
      min     -0.077118
      25%      0.069390
      50%      0.215897
      75%      0.235029
                  ...
foo   mean    -0.359284
      std      0.912265
      min     -1.143704
      25%     -0.862495
      50%     -0.575247
      75%     -0.408530
      max      1.193555
Name: C, Length: 16, dtype: float64
```

The dimension of the returned result can also change:

```
In [138]: grouped = df.groupby('A')['C']

In [139]: def f(group):
   .....:     return pd.DataFrame({'original' : group,
   .....:                          'demeaned' : group - group.mean()})
   .....:

In [140]: grouped.apply(f)
Out[140]:
   demeaned  original
0 -0.215962 -0.575247
1  0.123181  0.254161
2 -0.784420 -1.143704
3  0.084917  0.215897
4  1.552839  1.193555
5 -0.208098 -0.077118
6 -0.049245 -0.408530
7 -0.503211 -0.862495
```

`apply` on a Series can operate on a returned value from the applied function, that is itself a series, and possibly upcast the result to a DataFrame

```
In [141]: def f(x):
   .....:   return pd.Series([ x, x**2 ], index = ['x', 'x^2'])
   .....:

In [142]: s
Out[142]:
0     9.0
1     8.0
2     7.0
3     5.0
4    19.0
5     1.0
6     4.2
```

```
7     3.3
dtype: float64

In [143]: s.apply(f)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
      x     x^2
0   9.0   81.00
1   8.0   64.00
2   7.0   49.00
3   5.0   25.00
4  19.0  361.00
5   1.0    1.00
6   4.2   17.64
7   3.3   10.89
```

Note: `apply` can act as a reducer, transformer, *or* filter function, depending on exactly what is passed to it. So depending on the path taken, and exactly what you are grouping. Thus the grouped columns(s) may be included in the output as well as set the indices.

Warning: In the current implementation apply calls func twice on the first group to decide whether it can take a fast or slow code path. This can lead to unexpected behavior if func has side-effects, as they will take effect twice for the first group.

```
In [144]: d = pd.DataFrame({"a":["x", "y"], "b":[1,2]})

In [145]: def identity(df):
   .....:     print(df)
   .....:     return df
   .....:

In [146]: d.groupby("a").apply(identity)
   a  b
0  x  1
   a  b
0  x  1
   a  b
1  y  2
Out[146]:
   a  b
0  x  1
1  y  2
```

16.9 Other useful features

16.9.1 Automatic exclusion of "nuisance" columns

Again consider the example DataFrame we've been looking at:

```
In [147]: df
Out[147]:
```

```
     A      B         C         D
0  foo    one -0.575247  1.346061
1  bar    one  0.254161  1.511763
2  foo    two -1.143704  1.627081
3  bar  three  0.215897 -0.990582
4  foo    two  1.193555 -0.441652
5  bar    two -0.077118  1.211526
6  foo    one -0.408530  0.268520
7  foo  three -0.862495  0.024580
```

Suppose we wish to compute the standard deviation grouped by the `A` column. There is a slight problem, namely that we don't care about the data in column `B`. We refer to this as a "nuisance" column. If the passed aggregation function can't be applied to some columns, the troublesome columns will be (silently) dropped. Thus, this does not pose any problems:

```
In [148]: df.groupby('A').std()
Out[148]:
            C         D
A
bar  0.181231  1.366330
foo  0.912265  0.884785
```

16.9.2 NA and NaT group handling

If there are any NaN or NaT values in the grouping key, these will be automatically excluded. So there will never be an "NA group" or "NaT group". This was not the case in older versions of pandas, but users were generally discarding the NA group anyway (and supporting it was an implementation headache).

16.9.3 Grouping with ordered factors

Categorical variables represented as instance of pandas's `Categorical` class can be used as group keys. If so, the order of the levels will be preserved:

```
In [149]: data = pd.Series(np.random.randn(100))

In [150]: factor = pd.qcut(data, [0, .25, .5, .75, 1.])

In [151]: data.groupby(factor).mean()
Out[151]:
(-2.618, -0.684]    -1.331461
(-0.684, -0.0232]   -0.272816
(-0.0232, 0.541]     0.263607
(0.541, 2.369]       1.166038
dtype: float64
```

16.9.4 Grouping with a Grouper specification

You may need to specify a bit more data to properly group. You can use the `pd.Grouper` to provide this local control.

```
In [152]: import datetime

In [153]: df = pd.DataFrame({
```

```
   .....:          'Branch' : 'A A A A A A A B'.split(),
   .....:          'Buyer': 'Carl Mark Carl Carl Joe Joe Joe Carl'.split(),
   .....:          'Quantity': [1,3,5,1,8,1,9,3],
   .....:          'Date' : [
   .....:              datetime.datetime(2013,1,1,13,0),
   .....:              datetime.datetime(2013,1,1,13,5),
   .....:              datetime.datetime(2013,10,1,20,0),
   .....:              datetime.datetime(2013,10,2,10,0),
   .....:              datetime.datetime(2013,10,1,20,0),
   .....:              datetime.datetime(2013,10,2,10,0),
   .....:              datetime.datetime(2013,12,2,12,0),
   .....:              datetime.datetime(2013,12,2,14,0),
   .....:              ]
   .....:          })
   .....:

In [154]: df
Out[154]: 
  Branch Buyer                Date  Quantity
0      A  Carl 2013-01-01 13:00:00         1
1      A  Mark 2013-01-01 13:05:00         3
2      A  Carl 2013-10-01 20:00:00         5
3      A  Carl 2013-10-02 10:00:00         1
4      A   Joe 2013-10-01 20:00:00         8
5      A   Joe 2013-10-02 10:00:00         1
6      A   Joe 2013-12-02 12:00:00         9
7      B  Carl 2013-12-02 14:00:00         3
```

Groupby a specific column with the desired frequency. This is like resampling.

```
In [155]: df.groupby([pd.Grouper(freq='1M',key='Date'),'Buyer']).sum()
Out[155]: 
                  Quantity
Date       Buyer          
2013-01-31 Carl          1
           Mark          3
2013-10-31 Carl          6
           Joe           9
2013-12-31 Carl          3
           Joe           9
```

You have an ambiguous specification in that you have a named index and a column that could be potential groupers.

```
In [156]: df = df.set_index('Date')

In [157]: df['Date'] = df.index + pd.offsets.MonthEnd(2)

In [158]: df.groupby([pd.Grouper(freq='6M',key='Date'),'Buyer']).sum()
Out[158]: 
                  Quantity
Date       Buyer          
2013-02-28 Carl          1
           Mark          3
2014-02-28 Carl          9
           Joe          18

In [159]: df.groupby([pd.Grouper(freq='6M',level='Date'),'Buyer']).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
                  Quantity
Date       Buyer
2013-01-31 Carl          1
           Mark          3
2014-01-31 Carl          9
           Joe          18
```

16.9.5 Taking the first rows of each group

Just like for a DataFrame or Series you can call head and tail on a groupby:

```
In [160]: df = pd.DataFrame([[1, 2], [1, 4], [5, 6]], columns=['A', 'B'])

In [161]: df
Out[161]:
   A  B
0  1  2
1  1  4
2  5  6

In [162]: g = df.groupby('A')

In [163]: g.head(1)
Out[163]:
   A  B
0  1  2
2  5  6

In [164]: g.tail(1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[164]:
   A  B
1  1  4
2  5  6
```

This shows the first or last n rows from each group.

16.9.6 Taking the nth row of each group

To select from a DataFrame or Series the nth item, use the nth method. This is a reduction method, and will return a single row (or no row) per group if you pass an int for n:

```
In [165]: df = pd.DataFrame([[1, np.nan], [1, 4], [5, 6]], columns=['A', 'B'])

In [166]: g = df.groupby('A')

In [167]: g.nth(0)
Out[167]:
     B
A
1  NaN
5  6.0

In [168]: g.nth(-1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[168]:
     B
```

```
A
1  4.0
5  6.0

In [169]: g.nth(1)
\\\
```

```
In [176]: g = df.groupby('A',as_index=False)

In [177]: g.nth(0)
Out[177]:
   A    B
0  1  NaN
2  5  6.0

In [178]: g.nth(-1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[178]:
   A    B
1  1  4.0
2  5  6.0
```

You can also select multiple rows from each group by specifying multiple nth values as a list of ints.

```
In [179]: business_dates = pd.date_range(start='4/1/2014', end='6/30/2014', freq='B')

In [180]: df = pd.DataFrame(1, index=business_dates, columns=['a', 'b'])

# get the first, 4th, and last date index for each month
In [181]: df.groupby((df.index.year, df.index.month)).nth([0, 3, -1])
Out[181]:
        a  b
2014 4  1  1
     4  1  1
     4  1  1
     5  1  1
     5  1  1
     5  1  1
     6  1  1
     6  1  1
     6  1  1
```

16.9.7 Enumerate group items

To see the order in which each row appears within its group, use the `cumcount` method:

```
In [182]: dfg = pd.DataFrame(list('aaabba'), columns=['A'])

In [183]: dfg
Out[183]:
   A
0  a
1  a
2  a
3  b
4  b
5  a

In [184]: dfg.groupby('A').cumcount()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[184]:
0    0
1    1
2    2
3    0
```

```
4    1
5    3
dtype: int64

In [185]: dfg.groupby('A').cumcount(ascending=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    3
1    2
2    1
3    1
4    0
5    0
dtype: int64
```

16.9.8 Enumerate groups

New in version 0.20.2.

To see the ordering of the groups (as opposed to the order of rows within a group given by `cumcount`) you can use the `ngroup` method.

Note that the numbers given to the groups match the order in which the groups would be seen when iterating over the groupby object, not the order they are first observed.

```
In [186]: dfg = pd.DataFrame(list('aaabba'), columns=['A'])

In [187]: dfg
Out[187]:
   A
0  a
1  a
2  a
3  b
4  b
5  a

In [188]: dfg.groupby('A').ngroup()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[188]:
0    0
1    0
2    0
3    1
4    1
5    0
dtype: int64

In [189]: dfg.groupby('A').ngroup(ascending=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    1
2    1
3    0
4    0
5    1
dtype: int64
```

16.9.9 Plotting

Groupby also works with some plotting methods. For example, suppose we suspect that some features in a DataFrame may differ by group, in this case, the values in column 1 where the group is "B" are 3 higher on average.

```
In [190]: np.random.seed(1234)

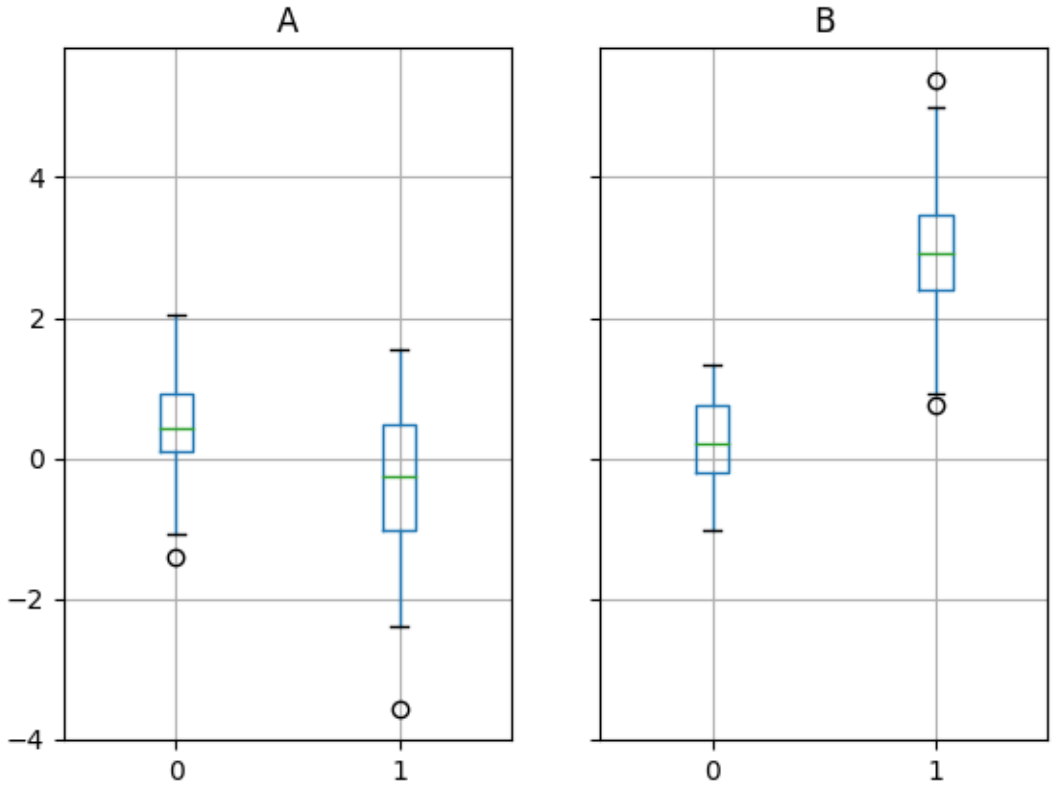
In [191]: df = pd.DataFrame(np.random.randn(50, 2))

In [192]: df['g'] = np.random.choice(['A', 'B'], size=50)

In [193]: df.loc[df['g'] == 'B', 1] += 3
```

We can easily visualize this with a boxplot:

```
In [194]: df.groupby('g').boxplot()
Out[194]:
A         AxesSubplot(0.1,0.15;0.363636x0.75)
B    AxesSubplot(0.536364,0.15;0.363636x0.75)
dtype: object
```



The result of calling `boxplot` is a dictionary whose keys are the values of our grouping column `g` ("A" and "B"). The values of the resulting dictionary can be controlled by the `return_type` keyword of `boxplot`. See the *visualization documentation* for more.

Warning: For historical reasons, `df.groupby("g").boxplot()` is not equivalent to `df.boxplot(by="g")`. See *here* for an explanation.

16.9.10 Piping function calls

New in version 0.21.0.

Similar to the functionality provided by `DataFrame` and `Series`, functions that take `GroupBy` objects can be chained together using a `pipe` method to allow for a cleaner, more readable syntax. To read about `.pipe` in general terms, see *here*.

Combining `.groupby` and `.pipe` is often useful when you need to reuse GroupB objects.

For an example, imagine having a DataFrame with columns for stores, products, revenue and sold quantity. We'd like to do a groupwise calculation of *prices* (i.e. revenue/quantity) per store and per product. We could do this in a multi-step operation, but expressing it in terms of piping can make the code more readable. First we set the data:

```
In [195]: import numpy as np

In [196]: n = 1000

In [197]: df = pd.DataFrame({'Store': np.random.choice(['Store_1', 'Store_2'], n),
   .....:                    'Product': np.random.choice(['Product_1', 'Product_2',
↪'Product_3'], n),
   .....:                    'Revenue': (np.random.random(n)*50+10).round(2),
   .....:                    'Quantity': np.random.randint(1, 10, size=n)})
   .....:

In [198]: df.head(2)
Out[198]:
     Product  Quantity  Revenue    Store
0  Product_1         6    30.35  Store_2
1  Product_3         2    35.69  Store_2
```

Now, to find prices per store/product, we can simply do:

```
In [199]: (df.groupby(['Store', 'Product'])
   .....:    .pipe(lambda grp: grp.Revenue.sum()/grp.Quantity.sum())
   .....:    .unstack().round(2))
   .....:
Out[199]:
Product  Product_1  Product_2  Product_3
Store
Store_1       6.93       6.82       7.15
Store_2       6.69       6.64       6.77
```

Piping can also be expressive when you want to deliver a grouped object to some arbitrary function, for example:

```
(df.groupby(['Store', 'Product']).pipe(report_func)
```

where `report_func` takes a GroupBy object and creates a report from that.

16.10 Examples

16.10.1 Regrouping by factor

Regroup columns of a DataFrame according to their sum, and sum the aggregated ones.

```
In [200]: df = pd.DataFrame({'a':[1,0,0], 'b':[0,1,0], 'c':[1,0,0], 'd':[2,3,4]})

In [201]: df
Out[201]:
   a  b  c  d
0  1  0  1  2
1  0  1  0  3
2  0  0  0  4

In [202]: df.groupby(df.sum(), axis=1).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[202]:
   1  9
0  2  2
1  1  3
2  0  4
```

16.10.2 Multi-column factorization

By using `.ngroup()`, we can extract information about the groups in a way similar to *`factorize()`* (as described further in the *reshaping API*) but which applies naturally to multiple columns of mixed type and different sources. This can be useful as an intermediate categorical-like step in processing, when the relationships between the group rows are more important than their content, or as input to an algorithm which only accepts the integer encoding. (For more information about support in pandas for full categorical data, see the *Categorical introduction* and the *API documentation*.)

```
In [203]: dfg = pd.DataFrame({"A": [1, 1, 2, 3, 2], "B": list("aaaba")})

In [204]: dfg
Out[204]:
   A  B
0  1  a
1  1  a
2  2  a
3  3  b
4  2  a

In [205]: dfg.groupby(["A", "B"]).ngroup()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[205]:
0    0
1    0
2    1
3    2
4    1
dtype: int64

In [206]: dfg.groupby(["A", [0, 0, 0, 1, 1]]).ngroup()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    0
1    0
2    1
3    3
4    2
dtype: int64
```

16.10.3 Groupby by Indexer to 'resample' data

Resampling produces new hypothetical samples (resamples) from already existing observed data or from a model that generates data. These new samples are similar to the pre-existing samples.

In order to resample to work on indices that are non-datetimelike, the following procedure can be utilized.

In the following examples, **df.index // 5** returns a binary array which is used to determine what gets selected for the groupby operation.

Note: The below example shows how we can downsample by consolidation of samples into fewer samples. Here by using **df.index // 5**, we are aggregating the samples in bins. By applying **std()** function, we aggregate the information contained in many samples into a small subset of values which is their standard deviation thereby reducing the number of samples.

```
In [207]: df = pd.DataFrame(np.random.randn(10,2))

In [208]: df
Out[208]:
          0         1
0  0.431670  0.882143
1 -0.026213 -1.941880
2 -1.106825 -0.667835
3  0.210712 -0.530195
4 -0.295191 -0.172722
5  0.638454  1.807622
6  1.008900  0.672822
7  0.770658  1.533002
8  0.576321 -0.819781
9 -1.302052  1.599477

In [209]: df.index // 5
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Int64Index([0, 0, 0, 0, 0, 1, 1, 1, 1, 1], dtype='int64')

In [210]: df.groupby(df.index // 5).std()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          0         1
0  0.595843  1.015451
1  0.931952  1.084644
```

16.10.4 Returning a Series to propagate names

Group DataFrame columns, compute a set of metrics and return a named Series. The Series name is used as the name for the column index. This is especially useful in conjunction with reshaping operations such as stacking in which the column index name will be used as the name of the inserted column:

```
In [211]: df = pd.DataFrame({
   .....:          'a':  [0, 0, 0, 0, 1, 1, 1, 1, 2, 2, 2, 2],
   .....:          'b':  [0, 0, 1, 1, 0, 0, 1, 1, 0, 0, 1, 1],
   .....:          'c':  [1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0],
   .....:          'd':  [0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1],
   .....:          })
   .....:
```

```
In [212]: def compute_metrics(x):
   .....:     result = {'b_sum': x['b'].sum(), 'c_mean': x['c'].mean()}
   .....:     return pd.Series(result, name='metrics')
   .....:

In [213]: result = df.groupby('a').apply(compute_metrics)

In [214]: result
Out[214]:
metrics  b_sum  c_mean
a
0          2.0     0.5
1          2.0     0.5
2          2.0     0.5

In [215]: result.stack()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a  metrics
0  b_sum      2.0
   c_mean     0.5
1  b_sum      2.0
   c_mean     0.5
2  b_sum      2.0
   c_mean     0.5
dtype: float64
```

CHAPTER

SEVENTEEN

MERGE, JOIN, AND CONCATENATE

pandas provides various facilities for easily combining together Series, DataFrame, and Panel objects with various kinds of set logic for the indexes and relational algebra functionality in the case of join / merge-type operations.

17.1 Concatenating objects

The `concat` function (in the main pandas namespace) does all of the heavy lifting of performing concatenation operations along an axis while performing optional set logic (union or intersection) of the indexes (if any) on the other axes. Note that I say "if any" because there is only a single possible axis of concatenation for Series.

Before diving into all of the details of `concat` and what it can do, here is a simple example:

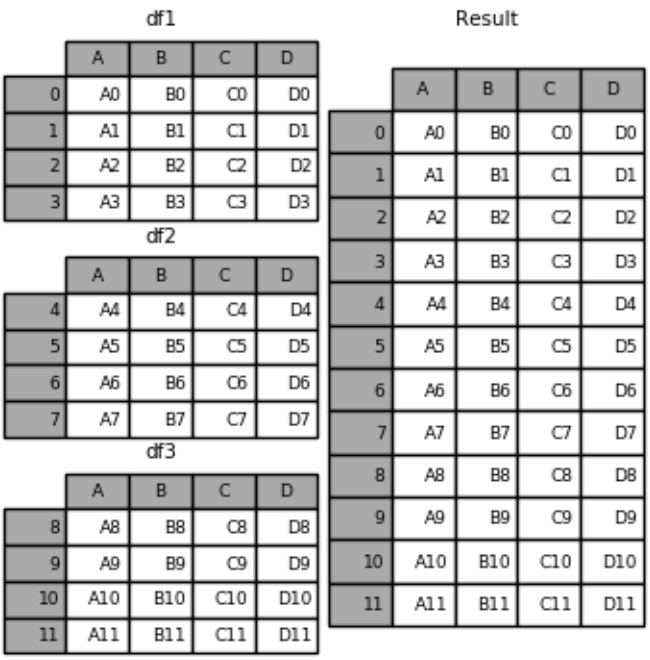
```
In [1]: df1 = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
   ...:                     'B': ['B0', 'B1', 'B2', 'B3'],
   ...:                     'C': ['C0', 'C1', 'C2', 'C3'],
   ...:                     'D': ['D0', 'D1', 'D2', 'D3']},
   ...:                    index=[0, 1, 2, 3])
   ...:

In [2]: df2 = pd.DataFrame({'A': ['A4', 'A5', 'A6', 'A7'],
   ...:                     'B': ['B4', 'B5', 'B6', 'B7'],
   ...:                     'C': ['C4', 'C5', 'C6', 'C7'],
   ...:                     'D': ['D4', 'D5', 'D6', 'D7']},
   ...:                      index=[4, 5, 6, 7])
   ...:

In [3]: df3 = pd.DataFrame({'A': ['A8', 'A9', 'A10', 'A11'],
   ...:                     'B': ['B8', 'B9', 'B10', 'B11'],
   ...:                     'C': ['C8', 'C9', 'C10', 'C11'],
   ...:                     'D': ['D8', 'D9', 'D10', 'D11']},
   ...:                    index=[8, 9, 10, 11])
   ...:

In [4]: frames = [df1, df2, df3]

In [5]: result = pd.concat(frames)
```



Like its sibling function on ndarrays, `numpy.concatenate`, `pandas.concat` takes a list or dict of homogeneously-typed objects and concatenates them with some configurable handling of "what to do with the other axes":

```
pd.concat(objs, axis=0, join='outer', join_axes=None, ignore_index=False,
          keys=None, levels=None, names=None, verify_integrity=False,
          copy=True)
```

- `objs` : a sequence or mapping of Series, DataFrame, or Panel objects. If a dict is passed, the sorted keys will be used as the *keys* argument, unless it is passed, in which case the values will be selected (see below). Any None objects will be dropped silently unless they are all None in which case a ValueError will be raised.
- `axis` : {0, 1, ...}, default 0. The axis to concatenate along.
- `join` : {'inner', 'outer'}, default 'outer'. How to handle indexes on other axis(es). Outer for union and inner for intersection.
- `ignore_index` : boolean, default False. If True, do not use the index values on the concatenation axis. The resulting axis will be labeled 0, ..., n - 1. This is useful if you are concatenating objects where the concatenation axis does not have meaningful indexing information. Note the index values on the other axes are still respected in the join.
- `join_axes` : list of Index objects. Specific indexes to use for the other n - 1 axes instead of performing inner/outer set logic.
- `keys` : sequence, default None. Construct hierarchical index using the passed keys as the outermost level. If multiple levels passed, should contain tuples.
- `levels` : list of sequences, default None. Specific levels (unique values) to use for constructing a MultiIndex. Otherwise they will be inferred from the keys.
- `names` : list, default None. Names for the levels in the resulting hierarchical index.
- `verify_integrity` : boolean, default False. Check whether the new concatenated axis contains duplicates. This can be very expensive relative to the actual data concatenation.

- `copy` : boolean, default True. If False, do not copy data unnecessarily.

Without a little bit of context and example many of these arguments don't make much sense. Let's take the above example. Suppose we wanted to associate specific keys with each of the pieces of the chopped up DataFrame. We can do this using the `keys` argument:

```
In [6]: result = pd.concat(frames, keys=['x', 'y', 'z'])
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df2

	A	B	C	D
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7

df3

	A	B	C	D
8	A8	B8	C8	D8
9	A9	B9	C9	D9
10	A10	B10	C10	D10
11	A11	B11	C11	D11

Result

		A	B	C	D
x	0	A0	B0	C0	D0
x	1	A1	B1	C1	D1
x	2	A2	B2	C2	D2
x	3	A3	B3	C3	D3
y	4	A4	B4	C4	D4
y	5	A5	B5	C5	D5
y	6	A6	B6	C6	D6
y	7	A7	B7	C7	D7
z	8	A8	B8	C8	D8
z	9	A9	B9	C9	D9
z	10	A10	B10	C10	D10
z	11	A11	B11	C11	D11

As you can see (if you've read the rest of the documentation), the resulting object's index has a *hierarchical index*. This means that we can now do stuff like select out each chunk by key:

```
In [7]: result.loc['y']
Out[7]:
    A   B   C   D
4  A4  B4  C4  D4
5  A5  B5  C5  D5
6  A6  B6  C6  D6
7  A7  B7  C7  D7
```

It's not a stretch to see how this can be very useful. More detail on this functionality below.

Note: It is worth noting however, that `concat` (and therefore `append`) makes a full copy of the data, and that constantly reusing this function can create a significant performance hit. If you need to use the operation over several datasets, use a list comprehension.

```
frames = [ process_your_file(f) for f in files ]
result = pd.concat(frames)
```

17.1.1 Set logic on the other axes

When gluing together multiple DataFrames (or Panels or...), for example, you have a choice of how to handle the other axes (other than the one being concatenated). This can be done in three ways:

- Take the (sorted) union of them all, `join='outer'`. This is the default option as it results in zero information loss.
- Take the intersection, `join='inner'`.
- Use a specific index (in the case of DataFrame) or indexes (in the case of Panel or future higher dimensional objects), i.e. the `join_axes` argument

Here is a example of each of these methods. First, the default `join='outer'` behavior:

```
In [8]: df4 = pd.DataFrame({'B': ['B2', 'B3', 'B6', 'B7'],
   ...:                     'D': ['D2', 'D3', 'D6', 'D7'],
   ...:                     'F': ['F2', 'F3', 'F6', 'F7']},
   ...:                    index=[2, 3, 6, 7])
   ...:

In [9]: result = pd.concat([df1, df4], axis=1)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df4

	B	D	F
2	B2	D2	F2
3	B3	D3	F3
6	B6	D6	F6
7	B7	D7	F7

Result

	A	B	C	D	B	D	F
0	A0	B0	C0	D0	NaN	NaN	NaN
1	A1	B1	C1	D1	NaN	NaN	NaN
2	A2	B2	C2	D2	B2	D2	F2
3	A3	B3	C3	D3	B3	D3	F3
6	NaN	NaN	NaN	NaN	B6	D6	F6
7	NaN	NaN	NaN	NaN	B7	D7	F7

Note that the row indexes have been unioned and sorted. Here is the same thing with `join='inner'`:

```
In [10]: result = pd.concat([df1, df4], axis=1, join='inner')
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df4

	B	D	F
2	B2	D2	F2
3	B3	D3	F3
6	B6	D6	F6
7	B7	D7	F7

Result

	A	B	C	D	B	D	F
2	A2	B2	C2	D2	B2	D2	F2
3	A3	B3	C3	D3	B3	D3	F3

Lastly, suppose we just wanted to reuse the *exact index* from the original DataFrame:

```
In [11]: result = pd.concat([df1, df4], axis=1, join_axes=[df1.index])
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df4

	B	D	F
2	B2	D2	F2
3	B3	D3	F3
6	B6	D6	F6
7	B7	D7	F7

Result

	A	B	C	D	B	D	F
0	A0	B0	C0	D0	NaN	NaN	NaN
1	A1	B1	C1	D1	NaN	NaN	NaN
2	A2	B2	C2	D2	B2	D2	F2
3	A3	B3	C3	D3	B3	D3	F3

17.1.2 Concatenating using `append`

A useful shortcut to `concat` are the `append` instance methods on Series and DataFrame. These methods actually predated `concat`. They concatenate along `axis=0`, namely the index:

```
In [12]: result = df1.append(df2)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df2

	A	B	C	D
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7

Result

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7

In the case of DataFrame, the indexes must be disjoint but the columns do not need to be:

```
In [13]: result = df1.append(df4)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df4

	B	D	F
2	B2	D2	F2
3	B3	D3	F3
6	B6	D6	F6
7	B7	D7	F7

Result

	A	B	C	D	F
0	A0	B0	C0	D0	NaN
1	A1	B1	C1	D1	NaN
2	A2	B2	C2	D2	NaN
3	A3	B3	C3	D3	NaN
2	NaN	B2	NaN	D2	F2
3	NaN	B3	NaN	D3	F3
6	NaN	B6	NaN	D6	F6
7	NaN	B7	NaN	D7	F7

`append` may take multiple objects to concatenate:

```
In [14]: result = df1.append([df2, df3])
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df2

	A	B	C	D
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7

df3

	A	B	C	D
8	A8	B8	C8	D8
9	A9	B9	C9	D9
10	A10	B10	C10	D10
11	A11	B11	C11	D11

Result

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7
8	A8	B8	C8	D8
9	A9	B9	C9	D9
10	A10	B10	C10	D10
11	A11	B11	C11	D11

Note: Unlike *list.append* method, which appends to the original list and returns nothing, `append` here **does not** modify `df1` and returns its copy with `df2` appended.

17.1.3 Ignoring indexes on the concatenation axis

For DataFrames which don't have a meaningful index, you may wish to append them and ignore the fact that they may have overlapping indexes:

To do this, use the `ignore_index` argument:

```
In [15]: result = pd.concat([df1, df4], ignore_index=True)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df4

	B	D	F
2	B2	D2	F2
3	B3	D3	F3
6	B6	D6	F6
7	B7	D7	F7

Result

	A	B	C	D	F
0	A0	B0	C0	D0	NaN
1	A1	B1	C1	D1	NaN
2	A2	B2	C2	D2	NaN
3	A3	B3	C3	D3	NaN
4	NaN	B2	NaN	D2	F2
5	NaN	B3	NaN	D3	F3
6	NaN	B6	NaN	D6	F6
7	NaN	B7	NaN	D7	F7

This is also a valid argument to `DataFrame.append`:

```
In [16]: result = df1.append(df4, ignore_index=True)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df4

	B	D	F
2	B2	D2	F2
3	B3	D3	F3
6	B6	D6	F6
7	B7	D7	F7

Result

	A	B	C	D	F
0	A0	B0	C0	D0	NaN
1	A1	B1	C1	D1	NaN
2	A2	B2	C2	D2	NaN
3	A3	B3	C3	D3	NaN
4	NaN	B2	NaN	D2	F2
5	NaN	B3	NaN	D3	F3
6	NaN	B6	NaN	D6	F6
7	NaN	B7	NaN	D7	F7

17.1.4 Concatenating with mixed ndims

You can concatenate a mix of Series and DataFrames. The Series will be transformed to DataFrames with the column name as the name of the Series.

```
In [17]: s1 = pd.Series(['X0', 'X1', 'X2', 'X3'], name='X')

In [18]: result = pd.concat([df1, s1], axis=1)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

s1

	X
0	X0
1	X1
2	X2
3	X3

Result

	A	B	C	D	X
0	A0	B0	C0	D0	X0
1	A1	B1	C1	D1	X1
2	A2	B2	C2	D2	X2
3	A3	B3	C3	D3	X3

If unnamed Series are passed they will be numbered consecutively.

```
In [19]: s2 = pd.Series(['_0', '_1', '_2', '_3'])

In [20]: result = pd.concat([df1, s2, s2, s2], axis=1)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

s2

0	_0
1	_1
2	_2
3	_3

Result

	A	B	C	D	0	1	2
0	A0	B0	C0	D0	_0	_0	_0
1	A1	B1	C1	D1	_1	_1	_1
2	A2	B2	C2	D2	_2	_2	_2
3	A3	B3	C3	D3	_3	_3	_3

Passing `ignore_index=True` will drop all name references.

```
In [21]: result = pd.concat([df1, s1], axis=1, ignore_index=True)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

s1

	X
0	X0
1	X1
2	X2
3	X3

Result

	0	1	2	3	4
0	A0	B0	C0	D0	X0
1	A1	B1	C1	D1	X1
2	A2	B2	C2	D2	X2
3	A3	B3	C3	D3	X3

17.1.5 More concatenating with group keys

A fairly common use of the `keys` argument is to override the column names when creating a new DataFrame based on existing Series. Notice how the default behaviour consists on letting the resulting DataFrame inherits the parent Series' name, when these existed.

```
In [22]: s3 = pd.Series([0, 1, 2, 3], name='foo')

In [23]: s4 = pd.Series([0, 1, 2, 3])

In [24]: s5 = pd.Series([0, 1, 4, 5])

In [25]: pd.concat([s3, s4, s5], axis=1)
Out[25]:
   foo  0  1
0    0  0  0
1    1  1  1
2    2  2  4
3    3  3  5
```

Through the `keys` argument we can override the existing column names.

```
In [26]: pd.concat([s3, s4, s5], axis=1, keys=['red','blue','yellow'])
Out[26]:
   red  blue  yellow
0    0     0       0
1    1     1       1
2    2     2       4
3    3     3       5
```

Let's consider now a variation on the very first example presented:

```
In [27]: result = pd.concat(frames, keys=['x', 'y', 'z'])
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df2

	A	B	C	D
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7

df3

	A	B	C	D
8	A8	B8	C8	D8
9	A9	B9	C9	D9
10	A10	B10	C10	D10
11	A11	B11	C11	D11

Result

		A	B	C	D
x	0	A0	B0	C0	D0
x	1	A1	B1	C1	D1
x	2	A2	B2	C2	D2
x	3	A3	B3	C3	D3
y	4	A4	B4	C4	D4
y	5	A5	B5	C5	D5
y	6	A6	B6	C6	D6
y	7	A7	B7	C7	D7
z	8	A8	B8	C8	D8
z	9	A9	B9	C9	D9
z	10	A10	B10	C10	D10
z	11	A11	B11	C11	D11

You can also pass a dict to `concat` in which case the dict keys will be used for the `keys` argument (unless other keys are specified):

```
In [28]: pieces = {'x': df1, 'y': df2, 'z': df3}

In [29]: result = pd.concat(pieces)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df2

	A	B	C	D
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7

df3

	A	B	C	D
8	A8	B8	C8	D8
9	A9	B9	C9	D9
10	A10	B10	C10	D10
11	A11	B11	C11	D11

Result

		A	B	C	D
x	0	A0	B0	C0	D0
x	1	A1	B1	C1	D1
x	2	A2	B2	C2	D2
x	3	A3	B3	C3	D3
y	4	A4	B4	C4	D4
y	5	A5	B5	C5	D5
y	6	A6	B6	C6	D6
y	7	A7	B7	C7	D7
z	8	A8	B8	C8	D8
z	9	A9	B9	C9	D9
z	10	A10	B10	C10	D10
z	11	A11	B11	C11	D11

```
In [30]: result = pd.concat(pieces, keys=['z', 'y'])
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

df2

	A	B	C	D
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7

df3

	A	B	C	D
8	A8	B8	C8	D8
9	A9	B9	C9	D9
10	A10	B10	C10	D10
11	A11	B11	C11	D11

Result

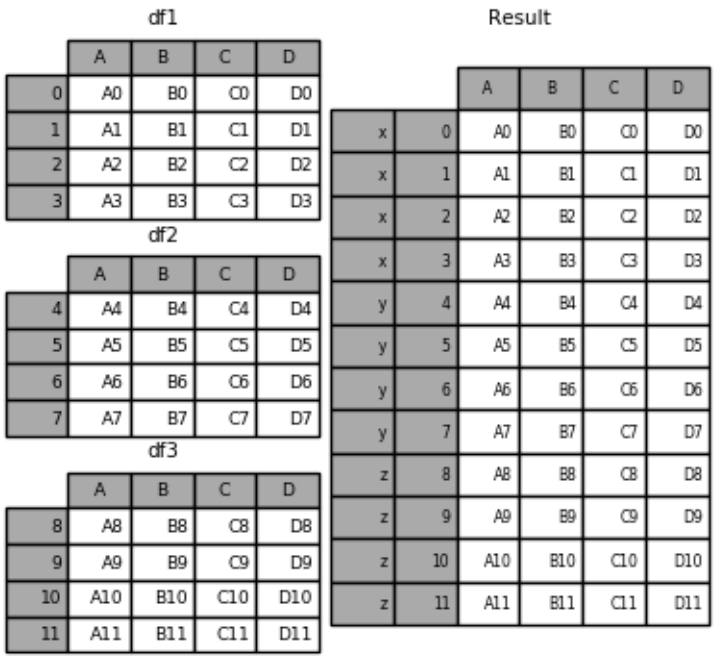
		A	B	C	D
z	8	A8	B8	C8	D8
z	9	A9	B9	C9	D9
z	10	A10	B10	C10	D10
z	11	A11	B11	C11	D11
y	4	A4	B4	C4	D4
y	5	A5	B5	C5	D5
y	6	A6	B6	C6	D6
y	7	A7	B7	C7	D7

The MultiIndex created has levels that are constructed from the passed keys and the index of the DataFrame pieces:

```
In [31]: result.index.levels
Out[31]: FrozenList([['z', 'y'], [4, 5, 6, 7, 8, 9, 10, 11]])
```

If you wish to specify other levels (as will occasionally be the case), you can do so using the `levels` argument:

```
In [32]: result = pd.concat(pieces, keys=['x', 'y', 'z'],
   ....:                    levels=[['z', 'y', 'x', 'w']],
   ....:                    names=['group_key'])
   ....:
```




```
In [33]: result.index.levels
Out[33]: FrozenList([['z', 'y', 'x', 'w'], [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]])
```

Yes, this is fairly esoteric, but is actually necessary for implementing things like GroupBy where the order of a categorical variable is meaningful.

17.1.6 Appending rows to a DataFrame

While not especially efficient (since a new object must be created), you can append a single row to a DataFrame by passing a Series or dict to `append`, which returns a new DataFrame as above.

```
In [34]: s2 = pd.Series(['X0', 'X1', 'X2', 'X3'], index=['A', 'B', 'C', 'D'])

In [35]: result = df1.append(s2, ignore_index=True)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

s2

A	X0
B	X1
C	X2
D	X3

Result

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3
4	X0	X1	X2	X3

You should use `ignore_index` with this method to instruct DataFrame to discard its index. If you wish to preserve the index, you should construct an appropriately-indexed DataFrame and append or concatenate those objects.

You can also pass a list of dicts or Series:

```
In [36]: dicts = [{'A': 1, 'B': 2, 'C': 3, 'X': 4},
   ....:          {'A': 5, 'B': 6, 'C': 7, 'Y': 8}]
   ....:

In [37]: result = df1.append(dicts, ignore_index=True)
```

df1

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

dicts

	A	B	C	X	Y
0	1	2	3	4.0	NaN
1	5	6	7	NaN	8.0

Result

	A	B	C	D	X	Y
0	A0	B0	C0	D0	NaN	NaN
1	A1	B1	C1	D1	NaN	NaN
2	A2	B2	C2	D2	NaN	NaN
3	A3	B3	C3	D3	NaN	NaN
4	1	2	3	NaN	4.0	NaN
5	5	6	7	NaN	NaN	8.0

17.2 Database-style DataFrame joining/merging

pandas has full-featured, **high performance** in-memory join operations idiomatically very similar to relational databases like SQL. These methods perform significantly better (in some cases well over an order of magnitude better) than other open source implementations (like `base::merge.data.frame` in R). The reason for this is careful algorithmic design and internal layout of the data in DataFrame.

See the *cookbook* for some advanced strategies.

Users who are familiar with SQL but new to pandas might be interested in a *comparison with SQL*.

pandas provides a single function, `merge`, as the entry point for all standard database join operations between DataFrame objects:

```
pd.merge(left, right, how='inner', on=None, left_on=None, right_on=None,
         left_index=False, right_index=False, sort=True,
         suffixes=('_x', '_y'), copy=True, indicator=False,
         validate=None)
```

- `left`: A DataFrame object
- `right`: Another DataFrame object
- `on`: Columns (names) to join on. Must be found in both the left and right DataFrame objects. If not passed and `left_index` and `right_index` are `False`, the intersection of the columns in the DataFrames will be inferred to be the join keys
- `left_on`: Columns from the left DataFrame to use as keys. Can either be column names or arrays with length equal to the length of the DataFrame
- `right_on`: Columns from the right DataFrame to use as keys. Can either be column names or arrays with length equal to the length of the DataFrame
- `left_index`: If `True`, use the index (row labels) from the left DataFrame as its join key(s). In the case of a DataFrame with a MultiIndex (hierarchical), the number of levels must match the number of join keys from the right DataFrame
- `right_index`: Same usage as `left_index` for the right DataFrame
- `how`: One of `'left'`, `'right'`, `'outer'`, `'inner'`. Defaults to `inner`. See below for more detailed description of each method
- `sort`: Sort the result DataFrame by the join keys in lexicographical order. Defaults to `True`, setting to `False` will improve performance substantially in many cases
- `suffixes`: A tuple of string suffixes to apply to overlapping columns. Defaults to `('_x', '_y')`.
- `copy`: Always copy data (default `True`) from the passed DataFrame objects, even when reindexing is not necessary. Cannot be avoided in many cases but may improve performance / memory usage. The cases where copying can be avoided are somewhat pathological but this option is provided nonetheless.
- `indicator`: Add a column to the output DataFrame called `_merge` with information on the source of each row. `_merge` is Categorical-type and takes on a value of `left_only` for observations whose merge key only appears in `'left'` DataFrame, `right_only` for observations whose merge key only appears in `'right'` DataFrame, and `both` if the observation's merge key is found in both.

  New in version 0.17.0.
- `validate` : string, default None. If specified, checks if merge is of specified type.
  - "one_to_one" or "1:1": checks if merge keys are unique in both left and right datasets.
  - "one_to_many" or "1:m": checks if merge keys are unique in left dataset.
  - "many_to_one" or "m:1": checks if merge keys are unique in right dataset.
  - "many_to_many" or "m:m": allowed, but does not result in checks.

  New in version 0.21.0.

The return type will be the same as `left`. If `left` is a `DataFrame` and `right` is a subclass of DataFrame, the return type will still be `DataFrame`.

`merge` is a function in the pandas namespace, and it is also available as a DataFrame instance method, with the calling DataFrame being implicitly considered the left object in the join.

The related `DataFrame.join` method, uses `merge` internally for the index-on-index (by default) and column(s)-on-index join. If you are joining on index only, you may wish to use `DataFrame.join` to save yourself some typing.

17.2.1 Brief primer on merge methods (relational algebra)

Experienced users of relational databases like SQL will be familiar with the terminology used to describe join operations between two SQL-table like structures (DataFrame objects). There are several cases to consider which are very important to understand:

- **one-to-one** joins: for example when joining two DataFrame objects on their indexes (which must contain unique values)
- **many-to-one** joins: for example when joining an index (unique) to one or more columns in a DataFrame
- **many-to-many** joins: joining columns on columns.

Note: When joining columns on columns (potentially a many-to-many join), any indexes on the passed DataFrame objects **will be discarded**.

It is worth spending some time understanding the result of the **many-to-many** join case. In SQL / standard relational algebra, if a key combination appears more than once in both tables, the resulting table will have the **Cartesian product** of the associated data. Here is a very basic example with one unique key combination:

```
In [38]: left = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3'],
   ....:                      'A': ['A0', 'A1', 'A2', 'A3'],
   ....:                      'B': ['B0', 'B1', 'B2', 'B3']})
   ....:

In [39]: right = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3'],
   ....:                       'C': ['C0', 'C1', 'C2', 'C3'],
   ....:                       'D': ['D0', 'D1', 'D2', 'D3']})
   ....:

In [40]: result = pd.merge(left, right, on='key')
```

left

	A	B	key
0	A0	B0	K0
1	A1	B1	K1
2	A2	B2	K2
3	A3	B3	K3

right

	C	D	key
0	C0	D0	K0
1	C1	D1	K1
2	C2	D2	K2
3	C3	D3	K3

Result

	A	B	key	C	D
0	A0	B0	K0	C0	D0
1	A1	B1	K1	C1	D1
2	A2	B2	K2	C2	D2
3	A3	B3	K3	C3	D3

Here is a more complicated example with multiple join keys:

```
In [41]: left = pd.DataFrame({'key1': ['K0', 'K0', 'K1', 'K2'],
   ....:                      'key2': ['K0', 'K1', 'K0', 'K1'],
```

```
   ....:                        'A': ['A0', 'A1', 'A2', 'A3'],
   ....:                        'B': ['B0', 'B1', 'B2', 'B3']})
   ....:

In [42]: right = pd.DataFrame({'key1': ['K0', 'K1', 'K1', 'K2'],
   ....:                        'key2': ['K0', 'K0', 'K0', 'K0'],
   ....:                        'C': ['C0', 'C1', 'C2', 'C3'],
   ....:                        'D': ['D0', 'D1', 'D2', 'D3']})
   ....:

In [43]: result = pd.merge(left, right, on=['key1', 'key2'])
```

left

	A	B	key1	key2
0	A0	B0	K0	K0
1	A1	B1	K0	K1
2	A2	B2	K1	K0
3	A3	B3	K2	K1

right

	C	D	key1	key2
0	C0	D0	K0	K0
1	C1	D1	K1	K0
2	C2	D2	K1	K0
3	C3	D3	K2	K0

Result

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A2	B2	K1	K0	C1	D1
2	A2	B2	K1	K0	C2	D2

The `how` argument to `merge` specifies how to determine which keys are to be included in the resulting table. If a key combination **does not appear** in either the left or right tables, the values in the joined table will be `NA`. Here is a summary of the `how` options and their SQL equivalent names:

Merge method	SQL Join Name	Description
`left`	`LEFT OUTER JOIN`	Use keys from left frame only
`right`	`RIGHT OUTER JOIN`	Use keys from right frame only
`outer`	`FULL OUTER JOIN`	Use union of keys from both frames
`inner`	`INNER JOIN`	Use intersection of keys from both frames

```
In [44]: result = pd.merge(left, right, how='left', on=['key1', 'key2'])
```

left

	A	B	key1	key2
0	A0	B0	K0	K0
1	A1	B1	K0	K1
2	A2	B2	K1	K0
3	A3	B3	K2	K1

right

	C	D	key1	key2
0	C0	D0	K0	K0
1	C1	D1	K1	K0
2	C2	D2	K1	K0
3	C3	D3	K2	K0

Result

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A1	B1	K0	K1	NaN	NaN
2	A2	B2	K1	K0	C1	D1
3	A2	B2	K1	K0	C2	D2
4	A3	B3	K2	K1	NaN	NaN

```
In [45]: result = pd.merge(left, right, how='right', on=['key1', 'key2'])
```

left

	A	B	key1	key2
0	A0	B0	K0	K0
1	A1	B1	K0	K1
2	A2	B2	K1	K0
3	A3	B3	K2	K1

right

	C	D	key1	key2
0	C0	D0	K0	K0
1	C1	D1	K1	K0
2	C2	D2	K1	K0
3	C3	D3	K2	K0

Result

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A2	B2	K1	K0	C1	D1
2	A2	B2	K1	K0	C2	D2
3	NaN	NaN	K2	K0	C3	D3

```
In [46]: result = pd.merge(left, right, how='outer', on=['key1', 'key2'])
```

left

	A	B	key1	key2
0	A0	B0	K0	K0
1	A1	B1	K0	K1
2	A2	B2	K1	K0
3	A3	B3	K2	K1

right

	C	D	key1	key2
0	C0	D0	K0	K0
1	C1	D1	K1	K0
2	C2	D2	K1	K0
3	C3	D3	K2	K0

Result

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A1	B1	K0	K1	NaN	NaN
2	A2	B2	K1	K0	C1	D1
3	A2	B2	K1	K0	C2	D2
4	A3	B3	K2	K1	NaN	NaN
5	NaN	NaN	K2	K0	C3	D3

```
In [47]: result = pd.merge(left, right, how='inner', on=['key1', 'key2'])
```

left

	A	B	key1	key2
0	A0	B0	K0	K0
1	A1	B1	K0	K1
2	A2	B2	K1	K0
3	A3	B3	K2	K1

right

	C	D	key1	key2
0	C0	D0	K0	K0
1	C1	D1	K1	K0
2	C2	D2	K1	K0
3	C3	D3	K2	K0

Result

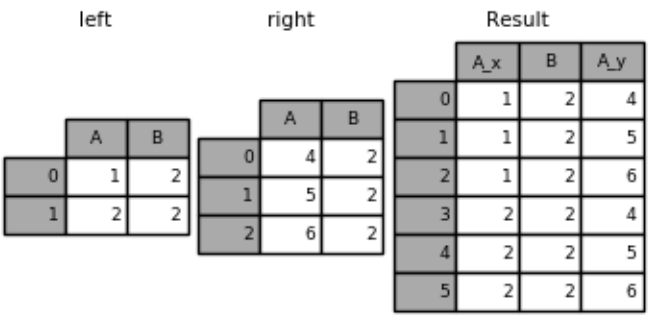
	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A2	B2	K1	K0	C1	D1
2	A2	B2	K1	K0	C2	D2

Here is another example with duplicate join keys in DataFrames:

```
In [48]: left = pd.DataFrame({'A' : [1,2], 'B' : [2, 2]})

In [49]: right = pd.DataFrame({'A' : [4,5,6], 'B': [2,2,2]})

In [50]: result = pd.merge(left, right, on='B', how='outer')
```



Warning: Joining / merging on duplicate keys can cause a returned frame that is the multiplication of the row dimensions, which may result in memory overflow. It is the user' s responsibility to manage duplicate values in keys before joining large DataFrames.

17.2.2 Checking for duplicate keys

New in version 0.21.0.

Users can use the `validate` argument to automatically check whether there are unexpected duplicates in their merge keys. Key uniqueness is checked before merge operations and so should protect against memory overflows. Checking key uniqueness is also a good way to ensure user data structures are as expected.

In the following example, there are duplicate values of `B` in the right DataFrame. As this is not a one-to-one merge – as specified in the `validate` argument – an exception will be raised.

```
In [51]: left = pd.DataFrame({'A' : [1,2], 'B' : [1, 2]})

In [52]: right = pd.DataFrame({'A' : [4,5,6], 'B': [2, 2, 2]})
```

```
In [53]: result = pd.merge(left, right, on='B', how='outer', validate="one_to_one")
...
MergeError: Merge keys are not unique in right dataset; not a one-to-one merge
```

If the user is aware of the duplicates in the right *DataFrame* but wants to ensure there are no duplicates in the left DataFrame, one can use the *validate='one_to_many'* argument instead, which will not raise an exception.

```
In [53]: pd.merge(left, right, on='B', how='outer', validate="one_to_many")
Out[53]:
   A_x  B  A_y
0    1  1  NaN
1    2  2  4.0
2    2  2  5.0
3    2  2  6.0
```

17.2.3 The merge indicator

New in version 0.17.0.

`merge` now accepts the argument `indicator`. If `True`, a Categorical-type column called `_merge` will be added to the output object that takes on values:

Observation Origin	_merge value
Merge key only in 'left' frame	left_only
Merge key only in 'right' frame	right_only
Merge key in both frames	both

```
In [54]: df1 = pd.DataFrame({'col1': [0, 1], 'col_left':['a', 'b']})

In [55]: df2 = pd.DataFrame({'col1': [1, 2, 2],'col_right':[2, 2, 2]})

In [56]: pd.merge(df1, df2, on='col1', how='outer', indicator=True)
Out[56]:
   col1 col_left  col_right      _merge
0     0        a        NaN   left_only
1     1        b        2.0        both
2     2      NaN        2.0  right_only
3     2      NaN        2.0  right_only
```

The `indicator` argument will also accept string arguments, in which case the indicator function will use the value of the passed string as the name for the indicator column.

```
In [57]: pd.merge(df1, df2, on='col1', how='outer', indicator='indicator_column')
Out[57]:
   col1 col_left  col_right indicator_column
0     0        a        NaN        left_only
1     1        b        2.0             both
2     2      NaN        2.0       right_only
3     2      NaN        2.0       right_only
```

17.2.4 Merge Dtypes

New in version 0.19.0.

Merging will preserve the dtype of the join keys.

```
In [58]: left = pd.DataFrame({'key': [1], 'v1': [10]})

In [59]: left
Out[59]:
   key  v1
0    1  10

In [60]: right = pd.DataFrame({'key': [1, 2], 'v1': [20, 30]})

In [61]: right
Out[61]:
   key  v1
0    1  20
1    2  30
```

We are able to preserve the join keys

```
In [62]: pd.merge(left, right, how='outer')
Out[62]:
   key  v1
0    1  10
1    1  20
2    2  30
```

```
In [63]: pd.merge(left, right, how='outer').dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[63]:
key    int64
v1     int64
dtype: object
```

Of course if you have missing values that are introduced, then the resulting dtype will be upcast.

```
In [64]: pd.merge(left, right, how='outer', on='key')
Out[64]:
   key  v1_x  v1_y
0    1  10.0    20
1    2   NaN    30

In [65]: pd.merge(left, right, how='outer', on='key').dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[65]:
key       int64
v1_x    float64
v1_y      int64
dtype: object
```

New in version 0.20.0.

Merging will preserve `category` dtypes of the mergands. See also the section on *categoricals*

The left frame.

```
In [66]: from pandas.api.types import CategoricalDtype

In [67]: X = pd.Series(np.random.choice(['foo', 'bar'], size=(10,)))

In [68]: X = X.astype(CategoricalDtype(categories=['foo', 'bar']))

In [69]: left = pd.DataFrame({'X': X,
   ....:                      'Y': np.random.choice(['one', 'two', 'three'], size=(10,
↪))})
   ....:

In [70]: left
Out[70]:
     X      Y
0  bar    one
1  foo    one
2  foo  three
3  bar  three
4  foo    one
5  bar    one
6  bar  three
7  bar  three
8  bar  three
9  foo  three

In [71]: left.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
X    category
Y      object
dtype: object
```

The right frame.

```
In [72]: right = pd.DataFrame({
   ....:      'X': pd.Series(['foo', 'bar'],
   ....:                     dtype=CategoricalDtype(['foo', 'bar'])),
   ....:      'Z': [1, 2]
   ....: })
   ....:

In [73]: right
Out[73]:
     X  Z
0  foo  1
1  bar  2

In [74]: right.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[74]:
X    category
Z       int64
dtype: object
```

The merged result

```
In [75]: result = pd.merge(left, right, how='outer')

In [76]: result
Out[76]:
     X      Y  Z
0  bar    one  2
1  bar  three  2
2  bar    one  2
3  bar  three  2
4  bar  three  2
5  bar  three  2
6  foo    one  1
7  foo  three  1
8  foo    one  1
9  foo  three  1

In [77]: result.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
X    category
Y      object
Z       int64
dtype: object
```

Note: The category dtypes must be *exactly* the same, meaning the same categories and the ordered attribute. Otherwise the result will coerce to `object` dtype.

Note: Merging on `category` dtypes that are the same can be quite performant compared to `object` dtype merging.

17.2.5 Joining on index

`DataFrame.join` is a convenient method for combining the columns of two potentially differently-indexed DataFrames into a single result DataFrame. Here is a very basic example:

```
In [78]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2'],
   ....:                      'B': ['B0', 'B1', 'B2']},
   ....:                     index=['K0', 'K1', 'K2'])
   ....:

In [79]: right = pd.DataFrame({'C': ['C0', 'C2', 'C3'],
   ....:                       'D': ['D0', 'D2', 'D3']},
   ....:                      index=['K0', 'K2', 'K3'])
   ....:

In [80]: result = left.join(right)
```

left

	A	B
K0	A0	B0
K1	A1	B1
K2	A2	B2

right

	C	D
K0	C0	D0
K2	C2	D2
K3	C3	D3

Result

	A	B	C	D
K0	A0	B0	C0	D0
K1	A1	B1	NaN	NaN
K2	A2	B2	C2	D2

```
In [81]: result = left.join(right, how='outer')
```

left

	A	B
K0	A0	B0
K1	A1	B1
K2	A2	B2

right

	C	D
K0	C0	D0
K2	C2	D2
K3	C3	D3

Result

	A	B	C	D
K0	A0	B0	C0	D0
K1	A1	B1	NaN	NaN
K2	A2	B2	C2	D2
K3	NaN	NaN	C3	D3

```
In [82]: result = left.join(right, how='inner')
```

left

	A	B
K0	A0	B0
K1	A1	B1
K2	A2	B2

right

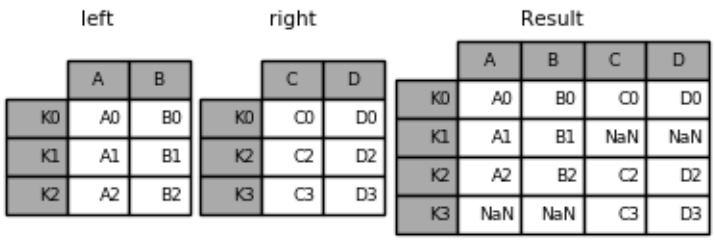
	C	D
K0	C0	D0
K2	C2	D2
K3	C3	D3

Result

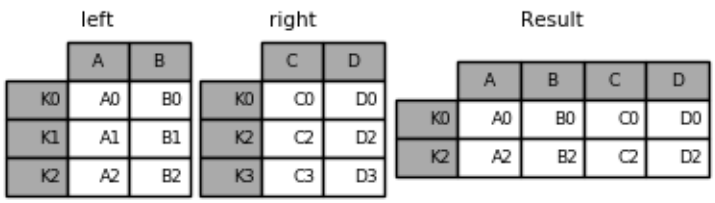
	A	B	C	D
K0	A0	B0	C0	D0
K2	A2	B2	C2	D2

The data alignment here is on the indexes (row labels). This same behavior can be achieved using `merge` plus additional arguments instructing it to use the indexes:

```
In [83]: result = pd.merge(left, right, left_index=True, right_index=True, how='outer
↪')
```




```
In [84]: result = pd.merge(left, right, left_index=True, right_index=True, how='inner
↪');
```



17.2.6 Joining key columns on an index

`join` takes an optional `on` argument which may be a column or multiple column names, which specifies that the passed DataFrame is to be aligned on that column in the DataFrame. These two function calls are completely equivalent:

```
left.join(right, on=key_or_keys)
pd.merge(left, right, left_on=key_or_keys, right_index=True,
      how='left', sort=False)
```

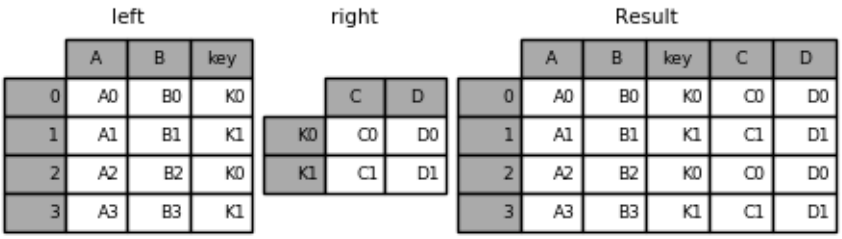
Obviously you can choose whichever form you find more convenient. For many-to-one joins (where one of the DataFrame's is already indexed by the join key), using `join` may be more convenient. Here is a simple example:

```
In [85]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
   ....:                      'B': ['B0', 'B1', 'B2', 'B3'],
   ....:                      'key': ['K0', 'K1', 'K0', 'K1']})
   ....:

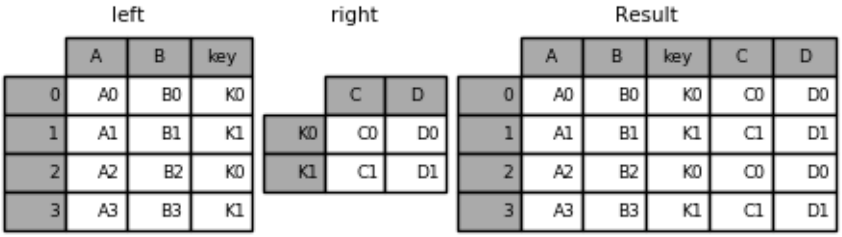
In [86]: right = pd.DataFrame({'C': ['C0', 'C1'],
   ....:                       'D': ['D0', 'D1']},
   ....:                       index=['K0', 'K1'])
```

```
   ....:

In [87]: result = left.join(right, on='key')
```




```
In [88]: result = pd.merge(left, right, left_on='key', right_index=True,
   ....:                   how='left', sort=False);
   ....:
```



To join on multiple keys, the passed DataFrame must have a `MultiIndex`:

```
In [89]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
   ....:                      'B': ['B0', 'B1', 'B2', 'B3'],
   ....:                      'key1': ['K0', 'K0', 'K1', 'K2'],
   ....:                      'key2': ['K0', 'K1', 'K0', 'K1']})
   ....:

In [90]: index = pd.MultiIndex.from_tuples([('K0', 'K0'), ('K1', 'K0'),
   ....:                                    ('K2', 'K0'), ('K2', 'K1')])
   ....:

In [91]: right = pd.DataFrame({'C': ['C0', 'C1', 'C2', 'C3'],
   ....:                       'D': ['D0', 'D1', 'D2', 'D3']},
   ....:                      index=index)
   ....:
```

Now this can be joined by passing the two key column names:

```
In [92]: result = left.join(right, on=['key1', 'key2'])
```

left

	A	B	key1	key2
0	A0	B0	K0	K0
1	A1	B1	K0	K1
2	A2	B2	K1	K0
3	A3	B3	K2	K1

right

		C	D
K0	K0	C0	D0
K1	K0	C1	D1
K2	K0	C2	D2
K2	K1	C3	D3

Result

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A1	B1	K0	K1	NaN	NaN
2	A2	B2	K1	K0	C1	D1
3	A3	B3	K2	K1	C3	D3

The default for `DataFrame.join` is to perform a left join (essentially a "VLOOKUP" operation, for Excel users), which uses only the keys found in the calling DataFrame. Other join types, for example inner join, can be just as easily performed:

```
In [93]: result = left.join(right, on=['key1', 'key2'], how='inner')
```

left

	A	B	key1	key2
0	A0	B0	K0	K0
1	A1	B1	K0	K1
2	A2	B2	K1	K0
3	A3	B3	K2	K1

right

		C	D
K0	K0	C0	D0
K1	K0	C1	D1
K2	K0	C2	D2
K2	K1	C3	D3

Result

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
2	A2	B2	K1	K0	C1	D1
3	A3	B3	K2	K1	C3	D3

As you can see, this drops any rows where there was no match.

17.2.7 Joining a single Index to a Multi-index

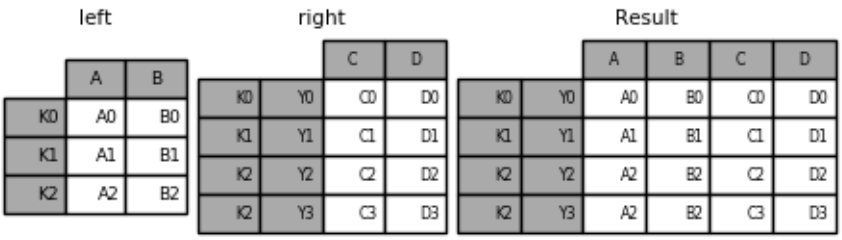
You can join a singly-indexed `DataFrame` with a level of a multi-indexed `DataFrame`. The level will match on the name of the index of the singly-indexed frame against a level name of the multi-indexed frame.

```
In [94]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2'],
   ....:                      'B': ['B0', 'B1', 'B2']},
   ....:                     index=pd.Index(['K0', 'K1', 'K2'], name='key'))
   ....:

In [95]: index = pd.MultiIndex.from_tuples([('K0', 'Y0'), ('K1', 'Y1'),
   ....:                                    ('K2', 'Y2'), ('K2', 'Y3')],
   ....:                                     names=['key', 'Y'])
   ....:

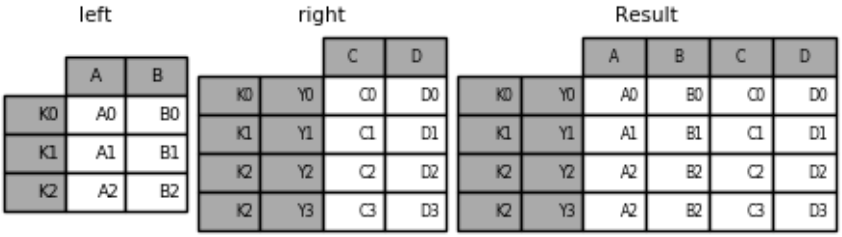
In [96]: right = pd.DataFrame({'C': ['C0', 'C1', 'C2', 'C3'],
   ....:                       'D': ['D0', 'D1', 'D2', 'D3']},
   ....:                       index=index)
   ....:

In [97]: result = left.join(right, how='inner')
```



This is equivalent but less verbose and more memory efficient / faster than this.

```
In [98]: result = pd.merge(left.reset_index(), right.reset_index(),
   ....:       on=['key'], how='inner').set_index(['key','Y'])
   ....:
```



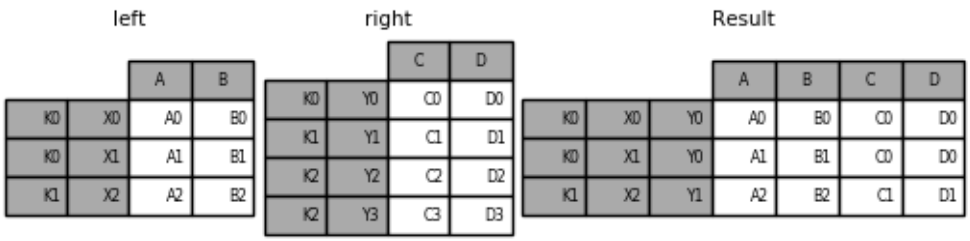
17.2.8 Joining with two multi-indexes

This is not Implemented via `join` at-the-moment, however it can be done using the following.

```
In [99]: index = pd.MultiIndex.from_tuples([('K0', 'X0'), ('K0', 'X1'),
   ....:                                    ('K1', 'X2')],
   ....:                                     names=['key', 'X'])
   ....:

In [100]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2'],
   .....:                      'B': ['B0', 'B1', 'B2']},
   .....:                       index=index)
   .....:

In [101]: result = pd.merge(left.reset_index(), right.reset_index(),
   .....:                   on=['key'], how='inner').set_index(['key','X','Y'])
   .....:
```



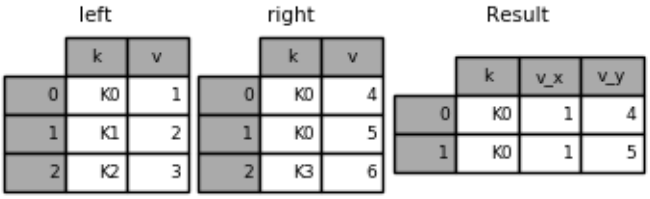
17.2.9 Overlapping value columns

The merge `suffixes` argument takes a tuple of list of strings to append to overlapping column names in the input DataFrames to disambiguate the result columns:

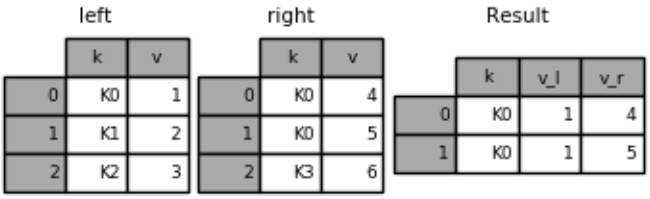
```
In [102]: left = pd.DataFrame({'k': ['K0', 'K1', 'K2'], 'v': [1, 2, 3]})

In [103]: right = pd.DataFrame({'k': ['K0', 'K0', 'K3'], 'v': [4, 5, 6]})

In [104]: result = pd.merge(left, right, on='k')
```




```
In [105]: result = pd.merge(left, right, on='k', suffixes=['_l', '_r'])
```

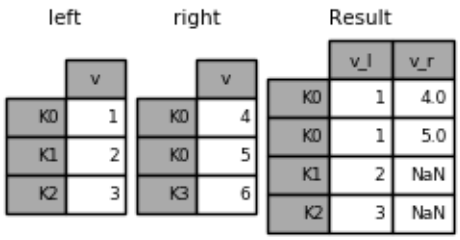


`DataFrame.join` has `lsuffix` and `rsuffix` arguments which behave similarly.

```
In [106]: left = left.set_index('k')

In [107]: right = right.set_index('k')

In [108]: result = left.join(right, lsuffix='_l', rsuffix='_r')
```

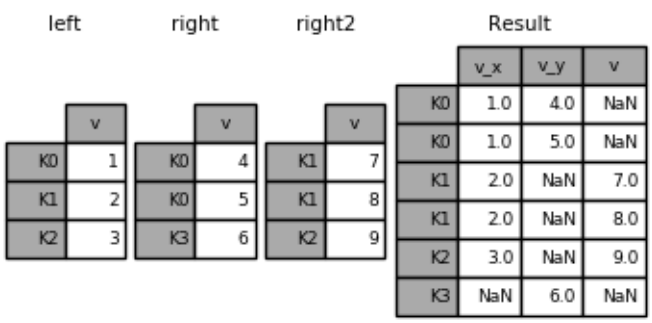


17.2.10 Joining multiple DataFrame or Panel objects

A list or tuple of DataFrames can also be passed to `DataFrame.join` to join them together on their indexes. The same is true for `Panel.join`.

```
In [109]: right2 = pd.DataFrame({'v': [7, 8, 9]}, index=['K1', 'K1', 'K2'])

In [110]: result = left.join([right, right2])
```



17.2.11 Merging together values within Series or DataFrame columns

Another fairly common situation is to have two like-indexed (or similarly indexed) Series or DataFrame objects and wanting to "patch" values in one object from values for matching indices in the other. Here is an example:

```
In [111]: df1 = pd.DataFrame([[np.nan, 3., 5.], [-4.6, np.nan, np.nan],
   .....:                     [np.nan, 7., np.nan]])
   .....:

In [112]: df2 = pd.DataFrame([[-42.6, np.nan, -8.2], [-5., 1.6, 4]],
   .....:                     index=[1, 2])
   .....:
```

For this, use the `combine_first` method:

```
In [113]: result = df1.combine_first(df2)
```

df1

	0	1	2
0	NaN	3.0	5.0
1	-4.6	NaN	NaN
2	NaN	7.0	NaN

df2

	0	1	2
1	-42.6	NaN	-8.2
2	-5.0	1.6	4.0

Result

	0	1	2
0	NaN	3.0	5.0
1	-4.6	NaN	-8.2
2	-5.0	7.0	4.0

Note that this method only takes values from the right DataFrame if they are missing in the left DataFrame. A related method, `update`, alters non-NA values inplace:

```
In [114]: df1.update(df2)
```

df1

	0	1	2
0	NaN	3.0	5.0
1	-4.6	NaN	NaN
2	NaN	7.0	NaN

df2

	0	1	2
1	-42.6	NaN	-8.2
2	-5.0	1.6	4.0

Result

	0	1	2
0	NaN	3.0	5.0
1	-42.6	NaN	-8.2
2	-5.0	1.6	4.0

17.3 Timeseries friendly merging

17.3.1 Merging Ordered Data

A *`merge_ordered()`* function allows combining time series and other ordered data. In particular it has an optional `fill_method` keyword to fill/interpolate missing data:

```
In [115]: left = pd.DataFrame({'k': ['K0', 'K1', 'K1', 'K2'],
   .....:                      'lv': [1, 2, 3, 4],
   .....:                      's': ['a', 'b', 'c', 'd']})
   .....:

In [116]: right = pd.DataFrame({'k': ['K1', 'K2', 'K4'],
   .....:                       'rv': [1, 2, 3]})
   .....:

In [117]: pd.merge_ordered(left, right, fill_method='ffill', left_by='s')
Out[117]:
     k   lv  s   rv
0   K0  1.0  a  NaN
1   K1  1.0  a  1.0
2   K2  1.0  a  2.0
3   K4  1.0  a  3.0
```

```
4   K1  2.0  b  1.0
5   K2  2.0  b  2.0
6   K4  2.0  b  3.0
7   K1  3.0  c  1.0
8   K2  3.0  c  2.0
9   K4  3.0  c  3.0
10  K1  NaN  d  1.0
11  K2  4.0  d  2.0
12  K4  4.0  d  3.0
```

17.3.2 Merging AsOf

New in version 0.19.0.

A *merge_asof()* is similar to an ordered left-join except that we match on nearest key rather than equal keys. For each row in the `left` DataFrame, we select the last row in the `right` DataFrame whose `on` key is less than the left's key. Both DataFrames must be sorted by the key.

Optionally an asof merge can perform a group-wise merge. This matches the `by` key equally, in addition to the nearest match on the `on` key.

For example; we might have `trades` and `quotes` and we want to `asof` merge them.

```
In [118]: trades = pd.DataFrame({
   .....:     'time': pd.to_datetime(['20160525 13:30:00.023',
   .....:                             '20160525 13:30:00.038',
   .....:                             '20160525 13:30:00.048',
   .....:                             '20160525 13:30:00.048',
   .....:                             '20160525 13:30:00.048']),
   .....:     'ticker': ['MSFT', 'MSFT',
   .....:                'GOOG', 'GOOG', 'AAPL'],
   .....:     'price': [51.95, 51.95,
   .....:               720.77, 720.92, 98.00],
   .....:     'quantity': [75, 155,
   .....:                  100, 100, 100]},
   .....:     columns=['time', 'ticker', 'price', 'quantity'])
   .....:

In [119]: quotes = pd.DataFrame({
   .....:     'time': pd.to_datetime(['20160525 13:30:00.023',
   .....:                             '20160525 13:30:00.023',
   .....:                             '20160525 13:30:00.030',
   .....:                             '20160525 13:30:00.041',
   .....:                             '20160525 13:30:00.048',
   .....:                             '20160525 13:30:00.049',
   .....:                             '20160525 13:30:00.072',
   .....:                             '20160525 13:30:00.075']),
   .....:     'ticker': ['GOOG', 'MSFT', 'MSFT',
   .....:                'MSFT', 'GOOG', 'AAPL', 'GOOG',
   .....:                'MSFT'],
   .....:     'bid': [720.50, 51.95, 51.97, 51.99,
   .....:             720.50, 97.99, 720.50, 52.01],
   .....:     'ask': [720.93, 51.96, 51.98, 52.00,
   .....:             720.93, 98.01, 720.88, 52.03]},
   .....:     columns=['time', 'ticker', 'bid', 'ask'])
   .....:
```

```
In [120]: trades
Out[120]:
                     time ticker   price  quantity
0 2016-05-25 13:30:00.023   MSFT   51.95        75
1 2016-05-25 13:30:00.038   MSFT   51.95       155
2 2016-05-25 13:30:00.048   GOOG  720.77       100
3 2016-05-25 13:30:00.048   GOOG  720.92       100
4 2016-05-25 13:30:00.048   AAPL   98.00       100

In [121]: quotes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                     time ticker     bid     ask
0 2016-05-25 13:30:00.023   GOOG  720.50  720.93
1 2016-05-25 13:30:00.023   MSFT   51.95   51.96
2 2016-05-25 13:30:00.030   MSFT   51.97   51.98
3 2016-05-25 13:30:00.041   MSFT   51.99   52.00
4 2016-05-25 13:30:00.048   GOOG  720.50  720.93
5 2016-05-25 13:30:00.049   AAPL   97.99   98.01
6 2016-05-25 13:30:00.072   GOOG  720.50  720.88
7 2016-05-25 13:30:00.075   MSFT   52.01   52.03
```

By default we are taking the asof of the quotes.

```
In [122]: pd.merge_asof(trades, quotes,
   .....:               on='time',
   .....:               by='ticker')
   .....:
Out[122]:
                     time ticker   price  quantity     bid     ask
0 2016-05-25 13:30:00.023   MSFT   51.95        75   51.95   51.96
1 2016-05-25 13:30:00.038   MSFT   51.95       155   51.97   51.98
2 2016-05-25 13:30:00.048   GOOG  720.77       100  720.50  720.93
3 2016-05-25 13:30:00.048   GOOG  720.92       100  720.50  720.93
4 2016-05-25 13:30:00.048   AAPL   98.00       100     NaN     NaN
```

We only asof within `2ms` between the quote time and the trade time.

```
In [123]: pd.merge_asof(trades, quotes,
   .....:               on='time',
   .....:               by='ticker',
   .....:               tolerance=pd.Timedelta('2ms'))
   .....:
Out[123]:
                     time ticker   price  quantity     bid     ask
0 2016-05-25 13:30:00.023   MSFT   51.95        75   51.95   51.96
1 2016-05-25 13:30:00.038   MSFT   51.95       155     NaN     NaN
2 2016-05-25 13:30:00.048   GOOG  720.77       100  720.50  720.93
3 2016-05-25 13:30:00.048   GOOG  720.92       100  720.50  720.93
4 2016-05-25 13:30:00.048   AAPL   98.00       100     NaN     NaN
```

We only asof within `10ms` between the quote time and the trade time and we exclude exact matches on time. Note that though we exclude the exact matches (of the quotes), prior quotes DO propagate to that point in time.

```
In [124]: pd.merge_asof(trades, quotes,
   .....:               on='time',
   .....:               by='ticker',
   .....:               tolerance=pd.Timedelta('10ms'),
```

```
   .....:                allow_exact_matches=False)
   .....:
Out[124]:
                     time ticker   price  quantity    bid    ask
0 2016-05-25 13:30:00.023   MSFT   51.95        75    NaN    NaN
1 2016-05-25 13:30:00.038   MSFT   51.95       155  51.97  51.98
2 2016-05-25 13:30:00.048   GOOG  720.77       100    NaN    NaN
3 2016-05-25 13:30:00.048   GOOG  720.92       100    NaN    NaN
4 2016-05-25 13:30:00.048   AAPL   98.00       100    NaN    NaN
```

CHAPTER

EIGHTEEN

RESHAPING AND PIVOT TABLES

18.1 Reshaping by pivoting DataFrame objects

Data is often stored in CSV files or databases in so-called "stacked" or "record" format:

```
In [1]: df
Out[1]:
         date variable     value
0  2000-01-03        A  0.469112
1  2000-01-04        A -0.282863
2  2000-01-05        A -1.509059
3  2000-01-03        B -1.135632
4  2000-01-04        B  1.212112
5  2000-01-05        B -0.173215
6  2000-01-03        C  0.119209
7  2000-01-04        C -1.044236
8  2000-01-05        C -0.861849
9  2000-01-03        D -2.104569
10 2000-01-04        D -0.494929
11 2000-01-05        D  1.071804
```

For the curious here is how the above DataFrame was created:

```
import pandas.util.testing as tm; tm.N = 3
def unpivot(frame):
    N, K = frame.shape
    data = {'value' : frame.values.ravel('F'),
            'variable' : np.asarray(frame.columns).repeat(N),
            'date' : np.tile(np.asarray(frame.index), K)}
    return pd.DataFrame(data, columns=['date', 'variable', 'value'])
df = unpivot(tm.makeTimeDataFrame())
```

To select out everything for variable `A` we could do:

```
In [2]: df[df['variable'] == 'A']
Out[2]:
        date variable     value
0 2000-01-03        A  0.469112
1 2000-01-04        A -0.282863
2 2000-01-05        A -1.509059
```

But suppose we wish to do time series operations with the variables. A better representation would be where the `columns` are the unique variables and an `index` of dates identifies individual observations. To reshape the data into this form, use the `pivot` function:

```
In [3]: df.pivot(index='date', columns='variable', values='value')
Out[3]:
variable           A         B         C         D
date
2000-01-03  0.469112 -1.135632  0.119209 -2.104569
2000-01-04 -0.282863  1.212112 -1.044236 -0.494929
2000-01-05 -1.509059 -0.173215 -0.861849  1.071804
```

If the `values` argument is omitted, and the input DataFrame has more than one column of values which are not used as column or index inputs to `pivot`, then the resulting "pivoted" DataFrame will have *hierarchical columns* whose topmost level indicates the respective value column:

```
In [4]: df['value2'] = df['value'] * 2

In [5]: pivoted = df.pivot('date', 'variable')

In [6]: pivoted
Out[6]:
               value                                   value2             \
variable           A         B         C         D         A         B
date
2000-01-03  0.469112 -1.135632  0.119209 -2.104569  0.938225 -2.271265
2000-01-04 -0.282863  1.212112 -1.044236 -0.494929 -0.565727  2.424224
2000-01-05 -1.509059 -0.173215 -0.861849  1.071804 -3.018117 -0.346429


variable           C         D
date
2000-01-03  0.238417 -4.209138
2000-01-04 -2.088472 -0.989859
2000-01-05 -1.723698  2.143608
```

You of course can then select subsets from the pivoted DataFrame:

```
In [7]: pivoted['value2']
Out[7]:
variable           A         B         C         D
date
2000-01-03  0.938225 -2.271265  0.238417 -4.209138
2000-01-04 -0.565727  2.424224 -2.088472 -0.989859
2000-01-05 -3.018117 -0.346429 -1.723698  2.143608
```

Note that this returns a view on the underlying data in the case where the data are homogeneously-typed.

18.2 Reshaping by stacking and unstacking

Closely related to the `pivot` function are the related `stack` and `unstack` functions currently available on Series and DataFrame. These functions are designed to work together with `MultiIndex` objects (see the section on *hierarchical indexing*). Here are essentially what these functions do:

- `stack`: "pivot" a level of the (possibly hierarchical) column labels, returning a DataFrame with an index with a new inner-most level of row labels.
- `unstack`: inverse operation from `stack`: "pivot" a level of the (possibly hierarchical) row index to the column axis, producing a reshaped DataFrame with a new inner-most level of column labels.

The clearest way to explain is by example. Let's take a prior example data set from the hierarchical indexing section:

```
In [8]: tuples = list(zip(*[['bar', 'bar', 'baz', 'baz',
   ...:                      'foo', 'foo', 'qux', 'qux'],
   ...:                     ['one', 'two', 'one', 'two',
   ...:                      'one', 'two', 'one', 'two']]))
   ...:

In [9]: index = pd.MultiIndex.from_tuples(tuples, names=['first', 'second'])

In [10]: df = pd.DataFrame(np.random.randn(8, 2), index=index, columns=['A', 'B'])

In [11]: df2 = df[:4]

In [12]: df2
Out[12]:
                     A         B
first second
bar   one     0.721555 -0.706771
      two    -1.039575  0.271860
baz   one    -0.424972  0.567020
      two     0.276232 -1.087401
```

The `stack` function "compresses" a level in the DataFrame's columns to produce either:

- A Series, in the case of a simple column Index
- A DataFrame, in the case of a `MultiIndex` in the columns

If the columns have a `MultiIndex`, you can choose which level to stack. The stacked level becomes the new lowest level in a `MultiIndex` on the columns:

```
In [13]: stacked = df2.stack()

In [14]: stacked
Out[14]:
first  second
bar    one     A    0.721555
               B   -0.706771
       two     A   -1.039575
               B    0.271860
baz    one     A   -0.424972
               B    0.567020
       two     A    0.276232
               B   -1.087401
dtype: float64
```

With a "stacked" DataFrame or Series (having a `MultiIndex` as the `index`), the inverse operation of `stack` is `unstack`, which by default unstacks the **last level**:

```
In [15]: stacked.unstack()
Out[15]:
                     A         B
first second
bar   one     0.721555 -0.706771
      two    -1.039575  0.271860
baz   one    -0.424972  0.567020
      two     0.276232 -1.087401

In [16]: stacked.unstack(1)
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
second         one       two
first
bar    A  0.721555 -1.039575
       B -0.706771  0.271860
baz    A -0.424972  0.276232
       B  0.567020 -1.087401

In [17]: stacked.unstack(0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
first          bar       baz
second
one     A  0.721555 -0.424972
        B -0.706771  0.567020
two     A -1.039575  0.276232
        B  0.271860 -1.087401
```

If the indexes have names, you can use the level names instead of specifying the level numbers:

```
In [18]: stacked.unstack('second')
Out[18]:
second         one       two
first
bar    A  0.721555 -1.039575
       B -0.706771  0.271860
baz    A -0.424972  0.276232
       B  0.567020 -1.087401
```

Notice that the `stack` and `unstack` methods implicitly sort the index levels involved. Hence a call to `stack` and then `unstack`, or vice versa, will result in a **sorted** copy of the original DataFrame or Series:

```
In [19]: index = pd.MultiIndex.from_product([[2,1], ['a', 'b']])

In [20]: df = pd.DataFrame(np.random.randn(4), index=index, columns=['A'])

In [21]: df
Out[21]:
            A
2 a -0.370647
  b -1.157892
1 a -1.344312
  b  0.844885

In [22]: all(df.unstack().stack() == df.sort_index())
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[22]:␣
↪True
```

while the above code will raise a `TypeError` if the call to `sort_index` is removed.

18.2.1 Multiple Levels

You may also stack or unstack more than one level at a time by passing a list of levels, in which case the end result is as if each level in the list were processed individually.

```
In [23]: columns = pd.MultiIndex.from_tuples([
   ....:         ('A', 'cat', 'long'), ('B', 'cat', 'long'),
   ....:         ('A', 'dog', 'short'), ('B', 'dog', 'short')
   ....:     ],
   ....:     names=['exp', 'animal', 'hair_length']
   ....: )
   ....: 

In [24]: df = pd.DataFrame(np.random.randn(4, 4), columns=columns)

In [25]: df
Out[25]: 
exp                 A         B         A         B
animal            cat       cat       dog       dog
hair_length      long      long     short     short
0            1.075770 -0.109050  1.643563 -1.469388
1            0.357021 -0.674600 -1.776904 -0.968914
2           -1.294524  0.413738  0.276662 -0.472035
3           -0.013960 -0.362543 -0.006154 -0.923061

In [26]: df.stack(level=['animal', 'hair_length'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
exp                          A         B
  animal hair_length                    
0 cat    long         1.075770 -0.109050
  dog    short        1.643563 -1.469388
1 cat    long         0.357021 -0.674600
  dog    short       -1.776904 -0.968914
2 cat    long        -1.294524  0.413738
  dog    short        0.276662 -0.472035
3 cat    long        -0.013960 -0.362543
  dog    short       -0.006154 -0.923061
```

The list of levels can contain either level names or level numbers (but not a mixture of the two).

```
# df.stack(level=['animal', 'hair_length'])
# from above is equivalent to:
In [27]: df.stack(level=[1, 2])
Out[27]: 
exp                          A         B
  animal hair_length                    
0 cat    long         1.075770 -0.109050
  dog    short        1.643563 -1.469388
1 cat    long         0.357021 -0.674600
  dog    short       -1.776904 -0.968914
2 cat    long        -1.294524  0.413738
  dog    short        0.276662 -0.472035
3 cat    long        -0.013960 -0.362543
  dog    short       -0.006154 -0.923061
```

18.2.2 Missing Data

These functions are intelligent about handling missing data and do not expect each subgroup within the hierarchical index to have the same set of labels. They also can handle the index being unsorted (but you can make it sorted by calling `sort_index`, of course). Here is a more complex example:

```
In [28]: columns = pd.MultiIndex.from_tuples([('A', 'cat'), ('B', 'dog'),
   ....:                                      ('B', 'cat'), ('A', 'dog')],
   ....:                                     names=['exp', 'animal'])
   ....:

In [29]: index = pd.MultiIndex.from_product([('bar', 'baz', 'foo', 'qux'),
   ....:                                     ('one', 'two')],
   ....:                                    names=['first', 'second'])
   ....:

In [30]: df = pd.DataFrame(np.random.randn(8, 4), index=index, columns=columns)

In [31]: df2 = df.iloc[[0, 1, 2, 4, 5, 7]]

In [32]: df2
Out[32]:
exp                  A         B                   A
animal             cat       dog       cat       dog
first second
bar   one     0.895717  0.805244 -1.206412  2.565646
      two     1.431256  1.340309 -1.170299 -0.226169
baz   one     0.410835  0.813850  0.132003 -0.827317
foo   one    -1.413681  1.607920  1.024180  0.569605
      two     0.875906 -2.211372  0.974466 -2.006747
qux   two    -1.226825  0.769804 -1.281247 -0.727707
```

As mentioned above, `stack` can be called with a `level` argument to select which level in the columns to stack:

```
In [33]: df2.stack('exp')
Out[33]:
animal                 cat       dog
first second exp
bar   one    A    0.895717  2.565646
             B   -1.206412  0.805244
      two    A    1.431256 -0.226169
             B   -1.170299  1.340309
baz   one    A    0.410835 -0.827317
             B    0.132003  0.813850
foo   one    A   -1.413681  0.569605
             B    1.024180  1.607920
      two    A    0.875906 -2.006747
             B    0.974466 -2.211372
qux   two    A   -1.226825 -0.727707
             B   -1.281247  0.769804

In [34]: df2.stack('animal')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
exp                         A         B
first second animal
bar   one    cat     0.895717 -1.206412
             dog     2.565646  0.805244
      two    cat     1.431256 -1.170299
             dog    -0.226169  1.340309
baz   one    cat     0.410835  0.132003
             dog    -0.827317  0.813850
foo   one    cat    -1.413681  1.024180
             dog     0.569605  1.607920
```

```
      two    cat     0.875906  0.974466
             dog    -2.006747 -2.211372
qux   two    cat    -1.226825 -1.281247
             dog    -0.727707  0.769804
```

Unstacking can result in missing values if subgroups do not have the same set of labels. By default, missing values will be replaced with the default fill value for that data type, `NaN` for float, `NaT` for datetimelike, etc. For integer types, by default data will converted to float and missing values will be set to `NaN`.

```
In [35]: df3 = df.iloc[[0, 1, 4, 7], [1, 2]]

In [36]: df3
Out[36]:
exp                    B
animal               dog       cat
first second
bar   one       0.805244 -1.206412
      two       1.340309 -1.170299
foo   one       1.607920  1.024180
qux   two       0.769804 -1.281247

In [37]: df3.unstack()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
exp            B
animal       dog                 cat
second       one       two       one       two
first
bar     0.805244  1.340309 -1.206412 -1.170299
foo     1.607920       NaN  1.024180       NaN
qux          NaN  0.769804       NaN -1.281247
```

Alternatively, unstack takes an optional `fill_value` argument, for specifying the value of missing data.

```
In [38]: df3.unstack(fill_value=-1e9)
Out[38]:
exp                  B
animal             dog                           cat
second             one            two            one            two
first
bar     8.052440e-01  1.340309e+00 -1.206412e+00 -1.170299e+00
foo     1.607920e+00 -1.000000e+09  1.024180e+00 -1.000000e+09
qux    -1.000000e+09  7.698036e-01 -1.000000e+09 -1.281247e+00
```

18.2.3 With a MultiIndex

Unstacking when the columns are a `MultiIndex` is also careful about doing the right thing:

```
In [39]: df[:3].unstack(0)
Out[39]:
exp            A                   B                                       A   \
animal       cat                 dog                cat                 dog
first        bar       baz       bar      baz       bar       baz       bar
second
one     0.895717  0.410835  0.805244  0.81385 -1.206412  0.132003  2.565646
two     1.431256       NaN  1.340309      NaN -1.170299       NaN -0.226169
```

```
exp
animal
first        baz
second
one    -0.827317
two          NaN

In [40]: df2.unstack(1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
exp            A                   B                                       A  \
animal       cat                 dog                 cat                 dog
second       one       two       one       two       one       two       one
first
bar     0.895717  1.431256  0.805244  1.340309 -1.206412 -1.170299  2.565646
baz     0.410835       NaN  0.813850       NaN  0.132003       NaN -0.827317
foo    -1.413681  0.875906  1.607920 -2.211372  1.024180  0.974466  0.569605
qux          NaN -1.226825       NaN  0.769804       NaN -1.281247       NaN

exp
animal
second       two
first
bar    -0.226169
baz          NaN
foo    -2.006747
qux    -0.727707
```

18.3 Reshaping by Melt

The top-level `melt()` and `melt()` functions are useful to massage a DataFrame into a format where one or more columns are identifier variables, while all other columns, considered measured variables, are "unpivoted" to the row axis, leaving just two non-identifier columns, "variable" and "value". The names of those columns can be customized by supplying the `var_name` and `value_name` parameters.

For instance,

```
In [41]: cheese = pd.DataFrame({'first' : ['John', 'Mary'],
   ....:                        'last' : ['Doe', 'Bo'],
   ....:                        'height' : [5.5, 6.0],
   ....:                        'weight' : [130, 150]})
   ....:

In [42]: cheese
Out[42]:
  first  height last  weight
0  John     5.5  Doe     130
1  Mary     6.0   Bo     150

In [43]: cheese.melt(id_vars=['first', 'last'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out
↪
  first last variable  value
0  John  Doe   height    5.5
1  Mary   Bo   height    6.0
```

```
2   John   Doe    weight  130.0
3   Mary    Bo    weight  150.0

In [44]: cheese.melt(id_vars=['first', 'last'], var_name='quantity')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
  first last quantity  value
0  John   Doe   height    5.5
1  Mary    Bo   height    6.0
2  John   Doe   weight  130.0
3  Mary    Bo   weight  150.0
```

Another way to transform is to use the `wide_to_long` panel data convenience function.

```
In [45]: dft = pd.DataFrame({"A1970" : {0 : "a", 1 : "b", 2 : "c"},
   ....:                     "A1980" : {0 : "d", 1 : "e", 2 : "f"},
   ....:                     "B1970" : {0 : 2.5, 1 : 1.2, 2 : .7},
   ....:                     "B1980" : {0 : 3.2, 1 : 1.3, 2 : .1},
   ....:                     "X"     : dict(zip(range(3), np.random.randn(3)))
   ....:                    })
   ....:

In [46]: dft["id"] = dft.index

In [47]: dft
Out[47]:
  A1970 A1980  B1970  B1980         X  id
0     a     d    2.5    3.2 -0.121306   0
1     b     e    1.2    1.3 -0.097883   1
2     c     f    0.7    0.1  0.695775   2

In [48]: pd.wide_to_long(dft, ["A", "B"], i="id", j="year")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
               X  A    B
id year
0  1970 -0.121306  a  2.5
1  1970 -0.097883  b  1.2
2  1970  0.695775  c  0.7
0  1980 -0.121306  d  3.2
1  1980 -0.097883  e  1.3
2  1980  0.695775  f  0.1
```

18.4 Combining with stats and GroupBy

It should be no shock that combining `pivot` / `stack` / `unstack` with GroupBy and the basic Series and DataFrame statistical functions can produce some very expressive and fast data manipulations.

```
In [49]: df
Out[49]:
exp                  A         B                   A
animal             cat       dog       cat       dog
first second
bar   one     0.895717  0.805244 -1.206412  2.565646
      two     1.431256  1.340309 -1.170299 -0.226169
```

```
baz   one     0.410835  0.813850  0.132003 -0.827317
      two    -0.076467 -1.187678  1.130127 -1.436737
foo   one    -1.413681  1.607920  1.024180  0.569605
      two     0.875906 -2.211372  0.974466 -2.006747
qux   one    -0.410001 -0.078638  0.545952 -1.219217
      two    -1.226825  0.769804 -1.281247 -0.727707

In [50]: df.stack().mean(1).unstack()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
animal              cat       dog
first second
bar   one    -0.155347  1.685445
      two     0.130479  0.557070
baz   one     0.271419 -0.006733
      two     0.526830 -1.312207
foo   one    -0.194750  1.088763
      two     0.925186 -2.109060
qux   one     0.067976 -0.648927
      two    -1.254036  0.021048

# same result, another way
In [51]: df.groupby(level=1, axis=1).mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
animal              cat       dog
first second
bar   one    -0.155347  1.685445
      two     0.130479  0.557070
baz   one     0.271419 -0.006733
      two     0.526830 -1.312207
foo   one    -0.194750  1.088763
      two     0.925186 -2.109060
qux   one     0.067976 -0.648927
      two    -1.254036  0.021048

In [52]: df.stack().groupby(level=1).mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
exp            A         B
second
one     0.071448  0.455513
two    -0.424186 -0.204486

In [53]: df.mean().unstack(0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
exp            A         B
animal
cat     0.060843  0.018596
dog    -0.413580  0.232430
```

18.5 Pivot tables

While `pivot` provides general purpose pivoting of DataFrames with various data types (strings, numerics, etc.), Pandas also provides the `pivot_table` function for pivoting with aggregation of numeric data.

The function `pandas.pivot_table` can be used to create spreadsheet-style pivot tables. See the *cookbook* for some advanced strategies

It takes a number of arguments

- `data`: A DataFrame object
- `values`: a column or a list of columns to aggregate
- `index`: a column, Grouper, array which has the same length as data, or list of them. Keys to group by on the pivot table index. If an array is passed, it is being used as the same manner as column values.
- `columns`: a column, Grouper, array which has the same length as data, or list of them. Keys to group by on the pivot table column. If an array is passed, it is being used as the same manner as column values.
- `aggfunc`: function to use for aggregation, defaulting to `numpy.mean`

Consider a data set like this:

```
In [54]: import datetime

In [55]: df = pd.DataFrame({'A': ['one', 'one', 'two', 'three'] * 6,
   ....:                    'B': ['A', 'B', 'C'] * 8,
   ....:                    'C': ['foo', 'foo', 'foo', 'bar', 'bar', 'bar'] * 4,
   ....:                    'D': np.random.randn(24),
   ....:                    'E': np.random.randn(24),
   ....:                    'F': [datetime.datetime(2013, i, 1) for i in range(1,␣
↪13)] +
   ....:                         [datetime.datetime(2013, i, 15) for i in range(1,␣
↪13)]})
   ....:

In [56]: df
Out[56]:
        A  B    C         D         E          F
0     one  A  foo  0.341734 -0.317441 2013-01-01
1     one  B  foo  0.959726 -1.236269 2013-02-01
2     two  C  foo -1.110336  0.896171 2013-03-01
3   three  A  bar -0.619976 -0.487602 2013-04-01
4     one  B  bar  0.149748 -0.082240 2013-05-01
5     one  C  bar -0.732339 -2.182937 2013-06-01
6     two  A  foo  0.687738  0.380396 2013-07-01
..    ... ..  ...       ...       ...        ...
17    one  C  bar -0.345352  0.206053 2013-06-15
18    two  A  foo  1.314232 -0.251905 2013-07-15
19  three  B  foo  0.690579 -2.213588 2013-08-15
20    one  C  foo  0.995761  1.063327 2013-09-15
21    one  A  bar  2.396780  1.266143 2013-10-15
22    two  B  bar  0.014871  0.299368 2013-11-15
23  three  C  bar  3.357427 -0.863838 2013-12-15

[24 rows x 6 columns]
```

We can produce pivot tables from this data very easily:

```
In [57]: pd.pivot_table(df, values='D', index=['A', 'B'], columns=['C'])
Out[57]:
C             bar       foo
A     B
one   A  1.120915 -0.514058
      B -0.338421  0.002759
      C -0.538846  0.699535
three A -1.181568       NaN
      B       NaN  0.433512
      C  0.588783       NaN
two   A       NaN  1.000985
      B  0.158248       NaN
      C       NaN  0.176180

In [58]: pd.pivot_table(df, values='D', index=['B'], columns=['A', 'C'], aggfunc=np.
↪sum)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A       one                three                two
C       bar       foo        bar       foo        bar       foo
B
A  2.241830 -1.028115 -2.363137       NaN       NaN  2.001971
B -0.676843  0.005518       NaN  0.867024  0.316495       NaN
C -1.077692  1.399070  1.177566       NaN       NaN  0.352360

In [59]: pd.pivot_table(df, values=['D','E'], index=['B'], columns=['A', 'C'],␣
↪aggfunc=np.sum)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          D                                                            E   \
A       one                three                two                  one
C       bar       foo        bar       foo        bar       foo        bar
B
A  2.241830 -1.028115 -2.363137       NaN       NaN  2.001971   2.786113
B -0.676843  0.005518       NaN  0.867024  0.316495       NaN   1.368280
C -1.077692  1.399070  1.177566       NaN       NaN  0.352360  -1.976883


A                  three                two
C       foo        bar       foo        bar       foo
B
A -0.043211   1.922577       NaN       NaN  0.128491
B -1.103384        NaN -2.128743 -0.194294       NaN
C  1.495717  -0.263660       NaN       NaN  0.872482
```

The result object is a DataFrame having potentially hierarchical indexes on the rows and columns. If the `values` column name is not given, the pivot table will include all of the data that can be aggregated in an additional level of hierarchy in the columns:

```
In [60]: pd.pivot_table(df, index=['A', 'B'], columns=['C'])
Out[60]:
                D                   E
C             bar       foo       bar       foo
A     B
one   A  1.120915 -0.514058  1.393057 -0.021605
      B -0.338421  0.002759  0.684140 -0.551692
      C -0.538846  0.699535 -0.988442  0.747859
three A -1.181568       NaN  0.961289       NaN
```

```
      B       NaN  0.433512       NaN -1.064372
      C  0.588783       NaN -0.131830       NaN
two   A       NaN  1.000985       NaN  0.064245
      B  0.158248       NaN -0.097147       NaN
      C       NaN  0.176180       NaN  0.436241
```

Also, you can use `Grouper` for `index` and `columns` keywords. For detail of `Grouper`, see *Grouping with a Grouper specification*.

```
In [61]: pd.pivot_table(df, values='D', index=pd.Grouper(freq='M', key='F'), columns=
↪'C')
Out[61]:
C                 bar       foo
F
2013-01-31        NaN -0.514058
2013-02-28        NaN  0.002759
2013-03-31        NaN  0.176180
2013-04-30 -1.181568       NaN
2013-05-31 -0.338421       NaN
2013-06-30 -0.538846       NaN
2013-07-31        NaN  1.000985
2013-08-31        NaN  0.433512
2013-09-30        NaN  0.699535
2013-10-31  1.120915       NaN
2013-11-30  0.158248       NaN
2013-12-31  0.588783       NaN
```

You can render a nice output of the table omitting the missing values by calling `to_string` if you wish:

```
In [62]: table = pd.pivot_table(df, index=['A', 'B'], columns=['C'])

In [63]: print(table.to_string(na_rep=''))
                D                   E
C             bar       foo       bar       foo
A     B
one   A  1.120915 -0.514058  1.393057 -0.021605
      B -0.338421  0.002759  0.684140 -0.551692
      C -0.538846  0.699535 -0.988442  0.747859
three A -1.181568            0.961289
      B            0.433512           -1.064372
      C  0.588783           -0.131830
two   A            1.000985            0.064245
      B  0.158248           -0.097147
      C            0.176180            0.436241
```

Note that `pivot_table` is also available as an instance method on DataFrame.

18.5.1 Adding margins

If you pass `margins=True` to `pivot_table`, special `All` columns and rows will be added with partial group aggregates across the categories on the rows and columns:

```
In [64]: df.pivot_table(index=['A', 'B'], columns='C', margins=True, aggfunc=np.std)
Out[64]:
                D                             E
C             bar       foo       All       bar       foo       All
```

```
A     B
one   A  1.804346  1.210272  1.569879  0.179483  0.418374  0.858005
      B  0.690376  1.353355  0.898998  1.083825  0.968138  1.101401
      C  0.273641  0.418926  0.771139  1.689271  0.446140  1.422136
three A  0.794212       NaN  0.794212  2.049040       NaN  2.049040
      B       NaN  0.363548  0.363548       NaN  1.625237  1.625237
      C  3.915454       NaN  3.915454  1.035215       NaN  1.035215
two   A       NaN  0.442998  0.442998       NaN  0.447104  0.447104
      B  0.202765       NaN  0.202765  0.560757       NaN  0.560757
      C       NaN  1.819408  1.819408       NaN  0.650439  0.650439
All      1.556686  0.952552  1.246608  1.250924  0.899904  1.059389
```

18.6 Cross tabulations

Use the `crosstab` function to compute a cross-tabulation of two (or more) factors. By default `crosstab` computes a frequency table of the factors unless an array of values and an aggregation function are passed.

It takes a number of arguments

- `index`: array-like, values to group by in the rows
- `columns`: array-like, values to group by in the columns
- `values`: array-like, optional, array of values to aggregate according to the factors
- `aggfunc`: function, optional, If no values array is passed, computes a frequency table
- `rownames`: sequence, default `None`, must match number of row arrays passed
- `colnames`: sequence, default `None`, if passed, must match number of column arrays passed
- `margins`: boolean, default `False`, Add row/column margins (subtotals)
- `normalize`: boolean, {'all', 'index', 'columns'}, or {0,1}, default `False`. Normalize by dividing all values by the sum of values.

Any Series passed will have their name attributes used unless row or column names for the cross-tabulation are specified

For example:

```
In [65]: foo, bar, dull, shiny, one, two = 'foo', 'bar', 'dull', 'shiny', 'one', 'two'

In [66]: a = np.array([foo, foo, bar, bar, foo, foo], dtype=object)

In [67]: b = np.array([one, one, two, one, two, one], dtype=object)

In [68]: c = np.array([dull, dull, shiny, dull, dull, shiny], dtype=object)

In [69]: pd.crosstab(a, [b, c], rownames=['a'], colnames=['b', 'c'])
Out[69]:
b    one        two
c   dull shiny dull shiny
a
bar    1     0    0     1
foo    2     1    1     0
```

If `crosstab` receives only two Series, it will provide a frequency table.

```
In [70]: df = pd.DataFrame({'A': [1, 2, 2, 2, 2], 'B': [3, 3, 4, 4, 4],
   ....:                    'C': [1, 1, np.nan, 1, 1]})
   ....:

In [71]: df
Out[71]:
   A  B    C
0  1  3  1.0
1  2  3  1.0
2  2  4  NaN
3  2  4  1.0
4  2  4  1.0

In [72]: pd.crosstab(df.A, df.B)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[72]:␣
↪
B  3  4
A
1  1  0
2  1  3
```

Any input passed containing `Categorical` data will have **all** of its categories included in the cross-tabulation, even if the actual data does not contain any instances of a particular category.

```
In [73]: foo = pd.Categorical(['a', 'b'], categories=['a', 'b', 'c'])

In [74]: bar = pd.Categorical(['d', 'e'], categories=['d', 'e', 'f'])

In [75]: pd.crosstab(foo, bar)
Out[75]:
col_0  d  e  f
row_0
a      1  0  0
b      0  1  0
c      0  0  0
```

18.6.1 Normalization

New in version 0.18.1.

Frequency tables can also be normalized to show percentages rather than counts using the `normalize` argument:

```
In [76]: pd.crosstab(df.A, df.B, normalize=True)
Out[76]:
B    3    4
A
1  0.2  0.0
2  0.2  0.6
```

`normalize` can also normalize values within each row or within each column:

```
In [77]: pd.crosstab(df.A, df.B, normalize='columns')
Out[77]:
B    3    4
A
1  0.5  0.0
2  0.5  1.0
```

`crosstab` can also be passed a third Series and an aggregation function (`aggfunc`) that will be applied to the values of the third Series within each group defined by the first two Series:

```
In [78]: pd.crosstab(df.A, df.B, values=df.C, aggfunc=np.sum)
Out[78]:
B    3    4
A
1  1.0  NaN
2  1.0  2.0
```

18.6.2 Adding Margins

Finally, one can also add margins or normalize this output.

```
In [79]: pd.crosstab(df.A, df.B, values=df.C, aggfunc=np.sum, normalize=True,
   ....:             margins=True)
   ....:
Out[79]:
B       3    4   All
A
1    0.25  0.0  0.25
2    0.25  0.5  0.75
All  0.50  0.5  1.00
```

18.7 Tiling

The `cut` function computes groupings for the values of the input array and is often used to transform continuous variables to discrete or categorical variables:

```
In [80]: ages = np.array([10, 15, 13, 12, 23, 25, 28, 59, 60])

In [81]: pd.cut(ages, bins=3)
Out[81]:
[(9.95, 26.667], (9.95, 26.667], (9.95, 26.667], (9.95, 26.667], (9.95, 26.667], (9.
↪95, 26.667], (26.667, 43.333], (43.333, 60.0], (43.333, 60.0]]
Categories (3, interval[float64]): [(9.95, 26.667] < (26.667, 43.333] < (43.333, 60.
↪0]]
```

If the `bins` keyword is an integer, then equal-width bins are formed. Alternatively we can specify custom bin-edges:

```
In [82]: c = pd.cut(ages, bins=[0, 18, 35, 70])

In [83]: c
Out[83]:
[(0, 18], (0, 18], (0, 18], (0, 18], (18, 35], (18, 35], (18, 35], (35, 70], (35, 70]]
Categories (3, interval[int64]): [(0, 18] < (18, 35] < (35, 70]]
```

New in version 0.20.0.

If the `bins` keyword is an `IntervalIndex`, then these will be used to bin the passed data.

pd.cut([25, 20, 50], bins=c.categories)

18.8 Computing indicator / dummy variables

To convert a categorical variable into a “dummy” or “indicator” DataFrame, for example a column in a DataFrame (a Series) which has `k` distinct values, can derive a DataFrame containing `k` columns of 1s and 0s:

```
In [84]: df = pd.DataFrame({'key': list('bbacab'), 'data1': range(6)})

In [85]: pd.get_dummies(df['key'])
Out[85]:
   a  b  c
0  0  1  0
1  0  1  0
2  1  0  0
3  0  0  1
4  1  0  0
5  0  1  0
```

Sometimes it’s useful to prefix the column names, for example when merging the result with the original DataFrame:

```
In [86]: dummies = pd.get_dummies(df['key'], prefix='key')

In [87]: dummies
Out[87]:
   key_a  key_b  key_c
0      0      1      0
1      0      1      0
2      1      0      0
3      0      0      1
4      1      0      0
5      0      1      0

In [88]: df[['data1']].join(dummies)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   data1  key_a  key_b  key_c
0      0      0      1      0
1      1      0      1      0
2      2      1      0      0
3      3      0      0      1
4      4      1      0      0
5      5      0      1      0
```

This function is often used along with discretization functions like `cut`:

```
In [89]: values = np.random.randn(10)

In [90]: values
Out[90]:
array([ 0.4082, -1.0481, -0.0257, -0.9884,  0.0941,  1.2627,  1.29  ,
        0.0824, -0.0558,  0.5366])

In [91]: bins = [0, 0.2, 0.4, 0.6, 0.8, 1]

In [92]: pd.get_dummies(pd.cut(values, bins))
Out[92]:
   (0.0, 0.2]  (0.2, 0.4]  (0.4, 0.6]  (0.6, 0.8]  (0.8, 1.0]
0           0           0           1           0           0
1           0           0           0           0           0
```

```
2            0            0            0            0            0
3            0            0            0            0            0
4            1            0            0            0            0
5            0            0            0            0            0
6            0            0            0            0            0
7            1            0            0            0            0
8            0            0            0            0            0
9            0            0            1            0            0
```

See also `Series.str.get_dummies`.

`get_dummies()` also accepts a DataFrame. By default all categorical variables (categorical in the statistical sense, those with *object* or *categorical* dtype) are encoded as dummy variables.

```
In [93]: df = pd.DataFrame({'A': ['a', 'b', 'a'], 'B': ['c', 'c', 'b'],
   ....:                    'C': [1, 2, 3]})
   ....:

In [94]: pd.get_dummies(df)
Out[94]:
   C  A_a  A_b  B_b  B_c
0  1    1    0    0    1
1  2    0    1    0    1
2  3    1    0    1    0
```

All non-object columns are included untouched in the output.

You can control the columns that are encoded with the `columns` keyword.

```
In [95]: pd.get_dummies(df, columns=['A'])
Out[95]:
   B  C  A_a  A_b
0  c  1    1    0
1  c  2    0    1
2  b  3    1    0
```

Notice that the `B` column is still included in the output, it just hasn't been encoded. You can drop `B` before calling `get_dummies` if you don't want to include it in the output.

As with the Series version, you can pass values for the `prefix` and `prefix_sep`. By default the column name is used as the prefix, and '_' as the prefix separator. You can specify `prefix` and `prefix_sep` in 3 ways

- string: Use the same value for `prefix` or `prefix_sep` for each column to be encoded
- list: Must be the same length as the number of columns being encoded.
- dict: Mapping column name to prefix

```
In [96]: simple = pd.get_dummies(df, prefix='new_prefix')

In [97]: simple
Out[97]:
   C  new_prefix_a  new_prefix_b  new_prefix_b  new_prefix_c
0  1             1             0             0             1
1  2             0             1             0             1
2  3             1             0             1             0

In [98]: from_list = pd.get_dummies(df, prefix=['from_A', 'from_B'])

In [99]: from_list
```

```
Out[99]:
   C  from_A_a  from_A_b  from_B_b  from_B_c
0  1         1         0         0         1
1  2         0         1         0         1
2  3         1         0         1         0

In [100]: from_dict = pd.get_dummies(df, prefix={'B': 'from_B', 'A': 'from_A'})

In [101]: from_dict
Out[101]:
   C  from_A_a  from_A_b  from_B_b  from_B_c
0  1         1         0         0         1
1  2         0         1         0         1
2  3         1         0         1         0
```

New in version 0.18.0.

Sometimes it will be useful to only keep k-1 levels of a categorical variable to avoid collinearity when feeding the result to statistical models. You can switch to this mode by turn on `drop_first`.

```
In [102]: s = pd.Series(list('abcaa'))

In [103]: pd.get_dummies(s)
Out[103]:
   a  b  c
0  1  0  0
1  0  1  0
2  0  0  1
3  1  0  0
4  1  0  0

In [104]: pd.get_dummies(s, drop_first=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[104]:␣
↪
   b  c
0  0  0
1  1  0
2  0  1
3  0  0
4  0  0
```

When a column contains only one level, it will be omitted in the result.

```
In [105]: df = pd.DataFrame({'A':list('aaaaa'),'B':list('ababc')})

In [106]: pd.get_dummies(df)
Out[106]:
   A_a  B_a  B_b  B_c
0    1    1    0    0
1    1    0    1    0
2    1    1    0    0
3    1    0    1    0
4    1    0    0    1

In [107]: pd.get_dummies(df, drop_first=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   B_b  B_c
```

```
0    0    0
1    1    0
2    0    0
3    1    0
4    0    1
```

18.9 Factorizing values

To encode 1-d values as an enumerated type use `factorize`:

```
In [108]: x = pd.Series(['A', 'A', np.nan, 'B', 3.14, np.inf])

In [109]: x
Out[109]:
0       A
1       A
2     NaN
3       B
4    3.14
5     inf
dtype: object

In [110]: labels, uniques = pd.factorize(x)

In [111]: labels
Out[111]: array([ 0,  0, -1,  1,  2,  3])

In [112]: uniques
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[112]: Index(['A', 'B', 3.14, inf],␣
↪dtype='object')
```

Note that `factorize` is similar to `numpy.unique`, but differs in its handling of NaN:

Note: The following `numpy.unique` will fail under Python 3 with a `TypeError` because of an ordering bug. See also Here

```
In [2]: pd.factorize(x, sort=True)
Out[2]:
(array([ 2,  2, -1,  3,  0,  1]),
 Index([3.14, inf, u'A', u'B'], dtype='object'))

In [3]: np.unique(x, return_inverse=True)[::-1]
Out[3]: (array([3, 3, 0, 4, 1, 2]), array([nan, 3.14, inf, 'A', 'B'], dtype=object))
```

Note: If you just want to handle one column as a categorical variable (like R's factor), you can use `df["cat_col"] = pd.Categorical(df["col"])` or `df["cat_col"] = df["col"].astype("category")`. For full docs on `Categorical`, see the *Categorical introduction* and the *API documentation*.

CHAPTER

NINETEEN

TIME SERIES / DATE FUNCTIONALITY

pandas has proven very successful as a tool for working with time series data, especially in the financial data analysis space. Using the NumPy `datetime64` and `timedelta64` dtypes, we have consolidated a large number of features from other Python libraries like `scikits.timeseries` as well as created a tremendous amount of new functionality for manipulating time series data.

In working with time series data, we will frequently seek to:

- generate sequences of fixed-frequency dates and time spans
- conform or convert time series to a particular frequency
- compute "relative" dates based on various non-standard time increments (e.g. 5 business days before the last business day of the year), or "roll" dates forward or backward

pandas provides a relatively compact and self-contained set of tools for performing the above tasks.

Create a range of dates:

```
# 72 hours starting with midnight Jan 1st, 2011
In [1]: rng = pd.date_range('1/1/2011', periods=72, freq='H')

In [2]: rng[:5]
Out[2]:
DatetimeIndex(['2011-01-01 00:00:00', '2011-01-01 01:00:00',
               '2011-01-01 02:00:00', '2011-01-01 03:00:00',
               '2011-01-01 04:00:00'],
              dtype='datetime64[ns]', freq='H')
```

Index pandas objects with dates:

```
In [3]: ts = pd.Series(np.random.randn(len(rng)), index=rng)

In [4]: ts.head()
Out[4]:
2011-01-01 00:00:00    0.469112
2011-01-01 01:00:00   -0.282863
2011-01-01 02:00:00   -1.509059
2011-01-01 03:00:00   -1.135632
2011-01-01 04:00:00    1.212112
Freq: H, dtype: float64
```

Change frequency and fill gaps:

```
# to 45 minute frequency and forward fill
In [5]: converted = ts.asfreq('45Min', method='pad')
```

```
In [6]: converted.head()
Out[6]:
2011-01-01 00:00:00    0.469112
2011-01-01 00:45:00    0.469112
2011-01-01 01:30:00   -0.282863
2011-01-01 02:15:00   -1.509059
2011-01-01 03:00:00   -1.135632
Freq: 45T, dtype: float64
```

Resample:

```
# Daily means
In [7]: ts.resample('D').mean()
Out[7]:
2011-01-01   -0.319569
2011-01-02   -0.337703
2011-01-03    0.117258
Freq: D, dtype: float64
```

19.1 Overview

Following table shows the type of time-related classes pandas can handle and how to create them.

Class	Remarks	How to create
`Timestamp`	Represents a single timestamp	`to_datetime`, `Timestamp`
`DatetimeIndex`	Index of `Timestamp`	`to_datetime`, `date_range`, `bdate_range`, `DatetimeIndex`
`Period`	Represents a single time span	`Period`
`PeriodIndex`	Index of `Period`	`period_range`, `PeriodIndex`

19.2 Timestamps vs. Time Spans

Timestamped data is the most basic type of time series data that associates values with points in time. For pandas objects it means using the points in time.

```
In [8]: pd.Timestamp(datetime(2012, 5, 1))
Out[8]: Timestamp('2012-05-01 00:00:00')

In [9]: pd.Timestamp('2012-05-01')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[9]: Timestamp('2012-05-01 00:00:00')

In [10]: pd.Timestamp(2012, 5, 1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[10]:␣
↪Timestamp('2012-05-01 00:00:00')
```

However, in many cases it is more natural to associate things like change variables with a time span instead. The span represented by `Period` can be specified explicitly, or inferred from datetime string format.

For example:

```
In [11]: pd.Period('2011-01')
Out[11]: Period('2011-01', 'M')

In [12]: pd.Period('2012-05', freq='D')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[12]: Period('2012-05-01', 'D')
```

`Timestamp` and `Period` can be the index. Lists of `Timestamp` and `Period` are automatically coerced to `DatetimeIndex` and `PeriodIndex` respectively.

```
In [13]: dates = [pd.Timestamp('2012-05-01'), pd.Timestamp('2012-05-02'), pd.
↪Timestamp('2012-05-03')]

In [14]: ts = pd.Series(np.random.randn(3), dates)

In [15]: type(ts.index)
Out[15]: pandas.core.indexes.datetimes.DatetimeIndex

In [16]: ts.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[16]: DatetimeIndex(['2012-05-
↪01', '2012-05-02', '2012-05-03'], dtype='datetime64[ns]', freq=None)

In [17]: ts
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-05-01   -0.410001
2012-05-02   -0.078638
2012-05-03    0.545952
dtype: float64

In [18]: periods = [pd.Period('2012-01'), pd.Period('2012-02'), pd.Period('2012-03')]

In [19]: ts = pd.Series(np.random.randn(3), periods)

In [20]: type(ts.index)
Out[20]: pandas.core.indexes.period.PeriodIndex

In [21]: ts.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[21]: PeriodIndex(['2012-01',
↪'2012-02', '2012-03'], dtype='period[M]', freq='M')

In [22]: ts
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-01   -1.219217
2012-02   -1.226825
2012-03    0.769804
Freq: M, dtype: float64
```

pandas allows you to capture both representations and convert between them. Under the hood, pandas represents timestamps using instances of `Timestamp` and sequences of timestamps using instances of `DatetimeIndex`. For regular time spans, pandas uses `Period` objects for scalar values and `PeriodIndex` for sequences of spans. Better support for irregular intervals with arbitrary start and end points are forth-coming in future releases.

19.3 Converting to Timestamps

To convert a `Series` or list-like object of date-like objects e.g. strings, epochs, or a mixture, you can use the `to_datetime` function. When passed a `Series`, this returns a `Series` (with the same index), while a list-like is converted to a `DatetimeIndex`:

```
In [23]: pd.to_datetime(pd.Series(['Jul 31, 2009', '2010-01-10', None]))
Out[23]: 
0   2009-07-31
1   2010-01-10
2          NaT
dtype: datetime64[ns]

In [24]: pd.to_datetime(['2005/11/23', '2010.12.31'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[24]:␣
↪DatetimeIndex(['2005-11-23', '2010-12-31'], dtype='datetime64[ns]', freq=None)
```

If you use dates which start with the day first (i.e. European style), you can pass the `dayfirst` flag:

```
In [25]: pd.to_datetime(['04-01-2012 10:00'], dayfirst=True)
Out[25]: DatetimeIndex(['2012-01-04 10:00:00'], dtype='datetime64[ns]', freq=None)

In [26]: pd.to_datetime(['14-01-2012', '01-14-2012'], dayfirst=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[26]:␣
↪DatetimeIndex(['2012-01-14', '2012-01-14'], dtype='datetime64[ns]', freq=None)
```

Warning: You see in the above example that `dayfirst` isn't strict, so if a date can't be parsed with the day being first it will be parsed as if `dayfirst` were False.

If you pass a single string to `to_datetime`, it returns a single `Timestamp`. `Timestamp` can also accept string input, but it doesn't accept string parsing options like `dayfirst` or `format`, so use `to_datetime` if these are required.

```
In [27]: pd.to_datetime('2010/11/12')
Out[27]: Timestamp('2010-11-12 00:00:00')

In [28]: pd.Timestamp('2010/11/12')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[28]: Timestamp('2010-11-12 00:00:00')
```

19.3.1 Providing a Format Argument

In addition to the required datetime string, a `format` argument can be passed to ensure specific parsing. This could also potentially speed up the conversion considerably.

```
In [29]: pd.to_datetime('2010/11/12', format='%Y/%m/%d')
Out[29]: Timestamp('2010-11-12 00:00:00')

In [30]: pd.to_datetime('12-11-2010 00:00', format='%d-%m-%Y %H:%M')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[30]: Timestamp('2010-11-12 00:00:00')
```

For more information on how to specify the `format` options, see https://docs.python.org/3/library/datetime.html#strftime-and-strptime-behavior.

19.3.2 Assembling Datetime from Multiple DataFrame Columns

New in version 0.18.1.

You can also pass a `DataFrame` of integer or string columns to assemble into a `Series` of `Timestamps`.

```
In [31]: df = pd.DataFrame({'year': [2015, 2016],
   ....:                    'month': [2, 3],
   ....:                    'day': [4, 5],
   ....:                    'hour': [2, 3]})
   ....:

In [32]: pd.to_datetime(df)
Out[32]:
0   2015-02-04 02:00:00
1   2016-03-05 03:00:00
dtype: datetime64[ns]
```

You can pass only the columns that you need to assemble.

```
In [33]: pd.to_datetime(df[['year', 'month', 'day']])
Out[33]:
0   2015-02-04
1   2016-03-05
dtype: datetime64[ns]
```

`pd.to_datetime` looks for standard designations of the datetime component in the column names, including:

- required: `year`, `month`, `day`
- optional: `hour`, `minute`, `second`, `millisecond`, `microsecond`, `nanosecond`

19.3.3 Invalid Data

Note: In version 0.17.0, the default for `to_datetime` is now `errors='raise'`, rather than `errors='ignore'`. This means that invalid parsing will raise rather that return the original input as in previous versions.

The default behavior, `errors='raise'`, is to raise when unparseable:

```
In [2]: pd.to_datetime(['2009/07/31', 'asd'], errors='raise')
ValueError: Unknown string format
```

Pass `errors='ignore'` to return the original input when unparseable:

```
In [34]: pd.to_datetime(['2009/07/31', 'asd'], errors='ignore')
Out[34]: array(['2009/07/31', 'asd'], dtype=object)
```

Pass `errors='coerce'` to convert unparseable data to `NaT` (not a time):

```
In [35]: pd.to_datetime(['2009/07/31', 'asd'], errors='coerce')
Out[35]: DatetimeIndex(['2009-07-31', 'NaT'], dtype='datetime64[ns]', freq=None)
```

19.3.4 Epoch Timestamps

pandas supports converting integer or float epoch times to `Timestamp` and `DatetimeIndex`. The default unit is nanoseconds, since that is how `Timestamp` objects are stored internally. However, epochs are often stored in another `unit` which can be specified. These are computed from the starting point specified by the `origin` parameter.

```
In [36]: pd.to_datetime([1349720105, 1349806505, 1349892905,
   ....:                 1349979305, 1350065705], unit='s')
   ....:
Out[36]:
DatetimeIndex(['2012-10-08 18:15:05', '2012-10-09 18:15:05',
               '2012-10-10 18:15:05', '2012-10-11 18:15:05',
               '2012-10-12 18:15:05'],
              dtype='datetime64[ns]', freq=None)

In [37]: pd.to_datetime([1349720105100, 1349720105200, 1349720105300,
   ....:                 1349720105400, 1349720105500 ], unit='ms')
   ....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2012-10-08 18:15:05.100000', '2012-10-08 18:15:05.200000',
               '2012-10-08 18:15:05.300000', '2012-10-08 18:15:05.400000',
               '2012-10-08 18:15:05.500000'],
              dtype='datetime64[ns]', freq=None)
```

Note: Epoch times will be rounded to the nearest nanosecond.

Warning: Conversion of float epoch times can lead to inaccurate and unexpected results. Python floats have about 15 digits precision in decimal. Rounding during conversion from float to high precision `Timestamp` is unavoidable. The only way to achieve exact precision is to use a fixed-width types (e.g. an int64).

```
In [38]: pd.to_datetime([1490195805.433, 1490195805.433502912], unit='s')
Out[38]: DatetimeIndex(['2017-03-22 15:16:45.433000', '2017-03-22 15:16:45.433503'],
↪ dtype='datetime64[ns]', freq=None)

In [39]: pd.to_datetime(1490195805433502912, unit='ns')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2017-03-22 15:16:45.433502912')
```

See also:

Using the origin Parameter

19.3.5 From Timestamps to Epoch

To invert the operation from above, namely, to convert from a `Timestamp` to a 'unix' epoch:

```
In [40]: stamps = pd.date_range('2012-10-08 18:15:05', periods=4, freq='D')

In [41]: stamps
Out[41]:
DatetimeIndex(['2012-10-08 18:15:05', '2012-10-09 18:15:05',
```

```
                '2012-10-10 18:15:05', '2012-10-11 18:15:05'],
               dtype='datetime64[ns]', freq='D')
```

We convert the `DatetimeIndex` to an `int64` array, then divide by the conversion unit.

```
In [42]: stamps.view('int64') // pd.Timedelta(1, unit='s')
Out[42]: array([1349720105, 1349806505, 1349892905, 1349979305])
```

19.3.6 Using the `origin` Parameter

New in version 0.20.0.

Using the `origin` parameter, one can specify an alternative starting point for creation of a `DatetimeIndex`. For example, to use 1960-01-01 as the starting date:

```
In [43]: pd.to_datetime([1, 2, 3], unit='D', origin=pd.Timestamp('1960-01-01'))
Out[43]: DatetimeIndex(['1960-01-02', '1960-01-03', '1960-01-04'], dtype=
↪'datetime64[ns]', freq=None)
```

The default is set at `origin='unix'`, which defaults to `1970-01-01 00:00:00`. Commonly called 'unix epoch' or POSIX time.

```
In [44]: pd.to_datetime([1, 2, 3], unit='D')
Out[44]: DatetimeIndex(['1970-01-02', '1970-01-03', '1970-01-04'], dtype=
↪'datetime64[ns]', freq=None)
```

19.4 Generating Ranges of Timestamps

To generate an index with timestamps, you can use either the `DatetimeIndex` or `Index` constructor and pass in a list of datetime objects:

```
In [45]: dates = [datetime(2012, 5, 1), datetime(2012, 5, 2), datetime(2012, 5, 3)]

# Note the frequency information
In [46]: index = pd.DatetimeIndex(dates)

In [47]: index
Out[47]: DatetimeIndex(['2012-05-01', '2012-05-02', '2012-05-03'], dtype=
↪'datetime64[ns]', freq=None)

# Automatically converted to DatetimeIndex
In [48]: index = pd.Index(dates)

In [49]: index
Out[49]: DatetimeIndex(['2012-05-01', '2012-05-02', '2012-05-03'], dtype=
↪'datetime64[ns]', freq=None)
```

In practice this becomes very cumbersome because we often need a very long index with a large number of timestamps. If we need timestamps on a regular frequency, we can use the *`date_range()`* and *`bdate_range()`* functions to create a `DatetimeIndex`. The default frequency for `date_range` is a **calendar day** while the default for `bdate_range` is a **business day**:

```
In [50]: start = datetime(2011, 1, 1)

In [51]: end = datetime(2012, 1, 1)

In [52]: index = pd.date_range(start, end)

In [53]: index
Out[53]:
DatetimeIndex(['2011-01-01', '2011-01-02', '2011-01-03', '2011-01-04',
               '2011-01-05', '2011-01-06', '2011-01-07', '2011-01-08',
               '2011-01-09', '2011-01-10',
               ...
               '2011-12-23', '2011-12-24', '2011-12-25', '2011-12-26',
               '2011-12-27', '2011-12-28', '2011-12-29', '2011-12-30',
               '2011-12-31', '2012-01-01'],
              dtype='datetime64[ns]', length=366, freq='D')

In [54]: index = pd.bdate_range(start, end)

In [55]: index
Out[55]:
DatetimeIndex(['2011-01-03', '2011-01-04', '2011-01-05', '2011-01-06',
               '2011-01-07', '2011-01-10', '2011-01-11', '2011-01-12',
               '2011-01-13', '2011-01-14',
               ...
               '2011-12-19', '2011-12-20', '2011-12-21', '2011-12-22',
               '2011-12-23', '2011-12-26', '2011-12-27', '2011-12-28',
               '2011-12-29', '2011-12-30'],
              dtype='datetime64[ns]', length=260, freq='B')
```

Convenience functions like `date_range` and `bdate_range` can utilize a variety of *frequency aliases*:

```
In [56]: pd.date_range(start, periods=1000, freq='M')
Out[56]:
DatetimeIndex(['2011-01-31', '2011-02-28', '2011-03-31', '2011-04-30',
               '2011-05-31', '2011-06-30', '2011-07-31', '2011-08-31',
               '2011-09-30', '2011-10-31',
               ...
               '2093-07-31', '2093-08-31', '2093-09-30', '2093-10-31',
               '2093-11-30', '2093-12-31', '2094-01-31', '2094-02-28',
               '2094-03-31', '2094-04-30'],
              dtype='datetime64[ns]', length=1000, freq='M')

In [57]: pd.bdate_range(start, periods=250, freq='BQS')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2011-01-03', '2011-04-01', '2011-07-01', '2011-10-03',
               '2012-01-02', '2012-04-02', '2012-07-02', '2012-10-01',
               '2013-01-01', '2013-04-01',
               ...
               '2071-01-01', '2071-04-01', '2071-07-01', '2071-10-01',
               '2072-01-01', '2072-04-01', '2072-07-01', '2072-10-03',
               '2073-01-02', '2073-04-03'],
              dtype='datetime64[ns]', length=250, freq='BQS-JAN')
```

`date_range` and `bdate_range` make it easy to generate a range of dates using various combinations of parameters like `start`, `end`, `periods`, and `freq`. The start and end dates are strictly inclusive, so dates outside of those specified will not be generated:

```
In [58]: pd.date_range(start, end, freq='BM')
Out[58]:
DatetimeIndex(['2011-01-31', '2011-02-28', '2011-03-31', '2011-04-29',
               '2011-05-31', '2011-06-30', '2011-07-29', '2011-08-31',
               '2011-09-30', '2011-10-31', '2011-11-30', '2011-12-30'],
              dtype='datetime64[ns]', freq='BM')

In [59]: pd.date_range(start, end, freq='W')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2011-01-02', '2011-01-09', '2011-01-16', '2011-01-23',
               '2011-01-30', '2011-02-06', '2011-02-13', '2011-02-20',
               '2011-02-27', '2011-03-06', '2011-03-13', '2011-03-20',
               '2011-03-27', '2011-04-03', '2011-04-10', '2011-04-17',
               '2011-04-24', '2011-05-01', '2011-05-08', '2011-05-15',
               '2011-05-22', '2011-05-29', '2011-06-05', '2011-06-12',
               '2011-06-19', '2011-06-26', '2011-07-03', '2011-07-10',
               '2011-07-17', '2011-07-24', '2011-07-31', '2011-08-07',
               '2011-08-14', '2011-08-21', '2011-08-28', '2011-09-04',
               '2011-09-11', '2011-09-18', '2011-09-25', '2011-10-02',
               '2011-10-09', '2011-10-16', '2011-10-23', '2011-10-30',
               '2011-11-06', '2011-11-13', '2011-11-20', '2011-11-27',
               '2011-12-04', '2011-12-11', '2011-12-18', '2011-12-25',
               '2012-01-01'],
              dtype='datetime64[ns]', freq='W-SUN')

In [60]: pd.bdate_range(end=end, periods=20)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2011-12-05', '2011-12-06', '2011-12-07', '2011-12-08',
               '2011-12-09', '2011-12-12', '2011-12-13', '2011-12-14',
               '2011-12-15', '2011-12-16', '2011-12-19', '2011-12-20',
               '2011-12-21', '2011-12-22', '2011-12-23', '2011-12-26',
               '2011-12-27', '2011-12-28', '2011-12-29', '2011-12-30'],
              dtype='datetime64[ns]', freq='B')

In [61]: pd.bdate_range(start=start, periods=20)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2011-01-03', '2011-01-04', '2011-01-05', '2011-01-06',
               '2011-01-07', '2011-01-10', '2011-01-11', '2011-01-12',
               '2011-01-13', '2011-01-14', '2011-01-17', '2011-01-18',
               '2011-01-19', '2011-01-20', '2011-01-21', '2011-01-24',
               '2011-01-25', '2011-01-26', '2011-01-27', '2011-01-28'],
              dtype='datetime64[ns]', freq='B')
```

19.4.1 Custom Frequency Ranges

> **Warning:** This functionality was originally exclusive to `cdate_range`, which is deprecated as of version 0.21.0 in favor of `bdate_range`. Note that `cdate_range` only utilizes the `weekmask` and `holidays` parameters when custom business day, 'C', is passed as the frequency string. Support has been expanded with `bdate_range` to work with any custom frequency string.

New in version 0.21.0.

`bdate_range` can also generate a range of custom frequency dates by using the `weekmask` and `holidays` parameters. These parameters will only be used if a custom frequency string is passed.

```
In [62]: weekmask = 'Mon Wed Fri'

In [63]: holidays = [datetime(2011, 1, 5), datetime(2011, 3, 14)]

In [64]: pd.bdate_range(start, end, freq='C', weekmask=weekmask, holidays=holidays)
Out[64]:
DatetimeIndex(['2011-01-03', '2011-01-07', '2011-01-10', '2011-01-12',
               '2011-01-14', '2011-01-17', '2011-01-19', '2011-01-21',
               '2011-01-24', '2011-01-26',
               ...
               '2011-12-09', '2011-12-12', '2011-12-14', '2011-12-16',
               '2011-12-19', '2011-12-21', '2011-12-23', '2011-12-26',
               '2011-12-28', '2011-12-30'],
              dtype='datetime64[ns]', length=154, freq='C')

In [65]: pd.bdate_range(start, end, freq='CBMS', weekmask=weekmask)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2011-01-03', '2011-02-02', '2011-03-02', '2011-04-01',
               '2011-05-02', '2011-06-01', '2011-07-01', '2011-08-01',
               '2011-09-02', '2011-10-03', '2011-11-02', '2011-12-02'],
              dtype='datetime64[ns]', freq='CBMS')
```

See also:

Custom Business Days

19.5 Timestamp Limitations

Since pandas represents timestamps in nanosecond resolution, the time span that can be represented using a 64-bit integer is limited to approximately 584 years:

```
In [66]: pd.Timestamp.min
Out[66]: Timestamp('1677-09-21 00:12:43.145225')

In [67]: pd.Timestamp.max
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[67]: Timestamp('2262-04-11␣
↪23:47:16.854775807')
```

See also:

Representing Out-of-Bounds Spans

19.6 Indexing

One of the main uses for `DatetimeIndex` is as an index for pandas objects. The `DatetimeIndex` class contains many time series related optimizations:

- A large range of dates for various offsets are pre-computed and cached under the hood in order to make generating subsequent date ranges very fast (just have to grab a slice)
- Fast shifting using the `shift` and `tshift` method on pandas objects

- Unioning of overlapping `DatetimeIndex` objects with the same frequency is very fast (important for fast data alignment)
- Quick access to date fields via properties such as `year`, `month`, etc.
- Regularization functions like `snap` and very fast `asof` logic

`DatetimeIndex` objects have all the basic functionality of regular `Index` objects, and a smorgasbord of advanced time series specific methods for easy frequency processing.

See also:

Reindexing methods

Note: While pandas does not force you to have a sorted date index, some of these methods may have unexpected or incorrect behavior if the dates are unsorted.

`DatetimeIndex` can be used like a regular index and offers all of its intelligent functionality like selection, slicing, etc.

```
In [68]: rng = pd.date_range(start, end, freq='BM')

In [69]: ts = pd.Series(np.random.randn(len(rng)), index=rng)

In [70]: ts.index
Out[70]:
DatetimeIndex(['2011-01-31', '2011-02-28', '2011-03-31', '2011-04-29',
               '2011-05-31', '2011-06-30', '2011-07-29', '2011-08-31',
               '2011-09-30', '2011-10-31', '2011-11-30', '2011-12-30'],
              dtype='datetime64[ns]', freq='BM')

In [71]: ts[:5].index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2011-01-31', '2011-02-28', '2011-03-31', '2011-04-29',
               '2011-05-31'],
              dtype='datetime64[ns]', freq='BM')

In [72]: ts[::2].index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2011-01-31', '2011-03-31', '2011-05-31', '2011-07-29',
               '2011-09-30', '2011-11-30'],
              dtype='datetime64[ns]', freq='2BM')
```

19.6.1 Partial String Indexing

Dates and strings that parse to timestamps can be passed as indexing parameters:

```
In [73]: ts['1/31/2011']
Out[73]: -1.2812473076599531

In [74]: ts[datetime(2011, 12, 25):]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[74]:
2011-12-30    0.687738
Freq: BM, dtype: float64
```

```
In [75]: ts['10/31/2011':'12/31/2011']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[75]:␣
↪
2011-10-31    0.149748
2011-11-30   -0.732339
2011-12-30    0.687738
Freq: BM, dtype: float64
```

To provide convenience for accessing longer time series, you can also pass in the year or year and month as strings:

```
In [76]: ts['2011']
Out[76]:
2011-01-31   -1.281247
2011-02-28   -0.727707
2011-03-31   -0.121306
2011-04-29   -0.097883
2011-05-31    0.695775
2011-06-30    0.341734
2011-07-29    0.959726
2011-08-31   -1.110336
2011-09-30   -0.619976
2011-10-31    0.149748
2011-11-30   -0.732339
2011-12-30    0.687738
Freq: BM, dtype: float64

In [77]: ts['2011-6']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2011-06-30    0.341734
Freq: BM, dtype: float64
```

This type of slicing will work on a `DataFrame` with a `DatetimeIndex` as well. Since the partial string selection is a form of label slicing, the endpoints **will be** included. This would include matching times on an included date:

```
In [78]: dft = pd.DataFrame(randn(100000,1),
   ....:                    columns=['A'],
   ....:                    index=pd.date_range('20130101',periods=100000,freq='T'))
   ....:

In [79]: dft
Out[79]:
                            A
2013-01-01 00:00:00  0.176444
2013-01-01 00:01:00  0.403310
2013-01-01 00:02:00 -0.154951
2013-01-01 00:03:00  0.301624
2013-01-01 00:04:00 -2.179861
2013-01-01 00:05:00 -1.369849
2013-01-01 00:06:00 -0.954208
...                       ...
2013-03-11 10:33:00 -0.293083
2013-03-11 10:34:00 -0.059881
2013-03-11 10:35:00  1.252450
2013-03-11 10:36:00  0.046611
2013-03-11 10:37:00  0.059478
2013-03-11 10:38:00 -0.286539
2013-03-11 10:39:00  0.841669
```

```
[100000 rows x 1 columns]

In [80]: dft['2013']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                            A
2013-01-01 00:00:00  0.176444
2013-01-01 00:01:00  0.403310
2013-01-01 00:02:00 -0.154951
2013-01-01 00:03:00  0.301624
2013-01-01 00:04:00 -2.179861
2013-01-01 00:05:00 -1.369849
2013-01-01 00:06:00 -0.954208
...                       ...
2013-03-11 10:33:00 -0.293083
2013-03-11 10:34:00 -0.059881
2013-03-11 10:35:00  1.252450
2013-03-11 10:36:00  0.046611
2013-03-11 10:37:00  0.059478
2013-03-11 10:38:00 -0.286539
2013-03-11 10:39:00  0.841669

[100000 rows x 1 columns]
```

This starts on the very first time in the month, and includes the last date & time for the month

```
In [81]: dft['2013-1':'2013-2']
Out[81]:
                            A
2013-01-01 00:00:00  0.176444
2013-01-01 00:01:00  0.403310
2013-01-01 00:02:00 -0.154951
2013-01-01 00:03:00  0.301624
2013-01-01 00:04:00 -2.179861
2013-01-01 00:05:00 -1.369849
2013-01-01 00:06:00 -0.954208
...                       ...
2013-02-28 23:53:00  0.103114
2013-02-28 23:54:00 -1.303422
2013-02-28 23:55:00  0.451943
2013-02-28 23:56:00  0.220534
2013-02-28 23:57:00 -1.624220
2013-02-28 23:58:00  0.093915
2013-02-28 23:59:00 -1.087454

[84960 rows x 1 columns]
```

This specifies a stop time **that includes all of the times on the last day**

```
In [82]: dft['2013-1':'2013-2-28']
Out[82]:
                            A
2013-01-01 00:00:00  0.176444
2013-01-01 00:01:00  0.403310
2013-01-01 00:02:00 -0.154951
2013-01-01 00:03:00  0.301624
2013-01-01 00:04:00 -2.179861
```

```
2013-01-01 00:05:00 -1.369849
2013-01-01 00:06:00 -0.954208
...                       ...
2013-02-28 23:53:00  0.103114
2013-02-28 23:54:00 -1.303422
2013-02-28 23:55:00  0.451943
2013-02-28 23:56:00  0.220534
2013-02-28 23:57:00 -1.624220
2013-02-28 23:58:00  0.093915
2013-02-28 23:59:00 -1.087454

[84960 rows x 1 columns]
```

This specifies an **exact** stop time (and is not the same as the above)

```
In [83]: dft['2013-1':'2013-2-28 00:00:00']
Out[83]:
                           A
2013-01-01 00:00:00  0.176444
2013-01-01 00:01:00  0.403310
2013-01-01 00:02:00 -0.154951
2013-01-01 00:03:00  0.301624
2013-01-01 00:04:00 -2.179861
2013-01-01 00:05:00 -1.369849
2013-01-01 00:06:00 -0.954208
...                       ...
2013-02-27 23:54:00  0.897051
2013-02-27 23:55:00 -0.309230
2013-02-27 23:56:00  1.944713
2013-02-27 23:57:00  0.369265
2013-02-27 23:58:00  0.053071
2013-02-27 23:59:00 -0.019734
2013-02-28 00:00:00  1.388189

[83521 rows x 1 columns]
```

We are stopping on the included end-point as it is part of the index

```
In [84]: dft['2013-1-15':'2013-1-15 12:30:00']
Out[84]:
                           A
2013-01-15 00:00:00  0.501288
2013-01-15 00:01:00 -0.605198
2013-01-15 00:02:00  0.215146
2013-01-15 00:03:00  0.924732
2013-01-15 00:04:00 -2.228519
2013-01-15 00:05:00  1.517331
2013-01-15 00:06:00 -1.188774
...                       ...
2013-01-15 12:24:00  1.358314
2013-01-15 12:25:00 -0.737727
2013-01-15 12:26:00  1.838323
2013-01-15 12:27:00 -0.774090
2013-01-15 12:28:00  0.622261
2013-01-15 12:29:00 -0.631649
2013-01-15 12:30:00  0.193284

[751 rows x 1 columns]
```

New in version 0.18.0.

`DatetimeIndex` partial string indexing also works on a `DataFrame` with a `MultiIndex`:

```
In [85]: dft2 = pd.DataFrame(np.random.randn(20, 1),
   ....:                     columns=['A'],
   ....:                     index=pd.MultiIndex.from_product([pd.date_range('20130101
↪',
   ....:                                                                    ␣
↪periods=10,
   ....:                                                                     freq='12H
↪'),
   ....:                                                      ['a', 'b']]))
   ....:

In [86]: dft2
Out[86]:
                              A
2013-01-01 00:00:00 a -0.659574
                    b  1.494522
2013-01-01 12:00:00 a -0.778425
                    b -0.253355
2013-01-02 00:00:00 a -2.816159
                    b -1.210929
2013-01-02 12:00:00 a  0.144669
...                         ...
2013-01-04 00:00:00 b -1.624463
2013-01-04 12:00:00 a  0.056912
                    b  0.149867
2013-01-05 00:00:00 a -1.256173
                    b  2.324544
2013-01-05 12:00:00 a -1.067396
                    b -0.660996

[20 rows x 1 columns]

In [87]: dft2.loc['2013-01-05']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                              A
2013-01-05 00:00:00 a -1.256173
                    b  2.324544
2013-01-05 12:00:00 a -1.067396
                    b -0.660996

In [88]: idx = pd.IndexSlice

In [89]: dft2 = dft2.swaplevel(0, 1).sort_index()

In [90]: dft2.loc[idx[:, '2013-01-05'], :]
Out[90]:
                              A
a 2013-01-05 00:00:00 -1.256173
  2013-01-05 12:00:00 -1.067396
b 2013-01-05 00:00:00  2.324544
  2013-01-05 12:00:00 -0.660996
```

19.6.2 Slice vs. Exact Match

Changed in version 0.20.0.

The same string used as an indexing parameter can be treated either as a slice or as an exact match depending on the resolution of the index. If the string is less accurate than the index, it will be treated as a slice, otherwise as an exact match.

Consider a `Series` object with a minute resolution index:

```
In [91]: series_minute = pd.Series([1, 2, 3],
   ....:                           pd.DatetimeIndex(['2011-12-31 23:59:00',
   ....:                                             '2012-01-01 00:00:00',
   ....:                                             '2012-01-01 00:02:00']))
   ....:

In [92]: series_minute.index.resolution
Out[92]: 'minute'
```

A timestamp string less accurate than a minute gives a `Series` object.

```
In [93]: series_minute['2011-12-31 23']
Out[93]:
2011-12-31 23:59:00    1
dtype: int64
```

A timestamp string with minute resolution (or more accurate), gives a scalar instead, i.e. it is not casted to a slice.

```
In [94]: series_minute['2011-12-31 23:59']
Out[94]: 1

In [95]: series_minute['2011-12-31 23:59:00']
\\\\\\\\\\Out[95]: 1
```

If index resolution is second, then, the minute-accurate timestamp gives a `Series`.

```
In [96]: series_second = pd.Series([1, 2, 3],
   ....:                           pd.DatetimeIndex(['2011-12-31 23:59:59',
   ....:                                             '2012-01-01 00:00:00',
   ....:                                             '2012-01-01 00:00:01']))
   ....:

In [97]: series_second.index.resolution
Out[97]: 'second'

In [98]: series_second['2011-12-31 23:59']
\\\\\\\\\\\\\\\\\Out[98]:
2011-12-31 23:59:59    1
dtype: int64
```

If the timestamp string is treated as a slice, it can be used to index `DataFrame` with `[]` as well.

```
In [99]: dft_minute = pd.DataFrame({'a': [1, 2, 3], 'b': [4, 5, 6]},
   ....:                            index=series_minute.index)
   ....:

In [100]: dft_minute['2011-12-31 23']
Out[100]:
```

```
                     a  b
2011-12-31 23:59:00  1  4
```

Warning: However, if the string is treated as an exact match, the selection in `DataFrame`s `[]` will be column-wise and not row-wise, see *Indexing Basics*. For example `dft_minute['2011-12-31 23:59']` will raise `KeyError` as `'2012-12-31 23:59'` has the same resolution as the index and there is no column with such name:

To *always* have unambiguous selection, whether the row is treated as a slice or a single selection, use `.loc`.

```
In [101]: dft_minute.loc['2011-12-31 23:59']
Out[101]:
a    1
b    4
Name: 2011-12-31 23:59:00, dtype: int64
```

Note also that `DatetimeIndex` resolution cannot be less precise than day.

```
In [102]: series_monthly = pd.Series([1, 2, 3],
   .....:                            pd.DatetimeIndex(['2011-12',
   .....:                                              '2012-01',
   .....:                                              '2012-02']))
   .....:

In [103]: series_monthly.index.resolution
Out[103]: 'day'

In [104]: series_monthly['2011-12'] # returns Series
\\\\\\\\\\\\\\\Out[104]:
2011-12-01    1
dtype: int64
```

19.6.3 Exact Indexing

As discussed in previous section, indexing a `DatetimeIndex` with a partial string depends on the "accuracy" of the period, in other words how specific the interval is in relation to the resolution of the index. In contrast, indexing with `Timestamp` or `datetime` objects is exact, because the objects have exact meaning. These also follow the semantics of *including both endpoints*.

These `Timestamp` and `datetime` objects have exact `hours, minutes,` and `seconds`, even though they were not explicitly specified (they are `0`).

```
In [105]: dft[datetime(2013, 1, 1):datetime(2013,2,28)]
Out[105]:
                           A
2013-01-01 00:00:00  0.176444
2013-01-01 00:01:00  0.403310
2013-01-01 00:02:00 -0.154951
2013-01-01 00:03:00  0.301624
2013-01-01 00:04:00 -2.179861
2013-01-01 00:05:00 -1.369849
2013-01-01 00:06:00 -0.954208
...                       ...
2013-02-27 23:54:00  0.897051
```

```
2013-02-27 23:55:00 -0.309230
2013-02-27 23:56:00  1.944713
2013-02-27 23:57:00  0.369265
2013-02-27 23:58:00  0.053071
2013-02-27 23:59:00 -0.019734
2013-02-28 00:00:00  1.388189

[83521 rows x 1 columns]
```

With no defaults.

```
In [106]: dft[datetime(2013, 1, 1, 10, 12, 0):datetime(2013, 2, 28, 10, 12, 0)]
Out[106]: 
                            A
2013-01-01 10:12:00 -0.246733
2013-01-01 10:13:00 -1.429225
2013-01-01 10:14:00 -1.265339
2013-01-01 10:15:00  0.710986
2013-01-01 10:16:00 -0.818200
2013-01-01 10:17:00  0.543542
2013-01-01 10:18:00  1.577713
...                       ...
2013-02-28 10:06:00  0.311249
2013-02-28 10:07:00  2.366080
2013-02-28 10:08:00 -0.490372
2013-02-28 10:09:00  0.373340
2013-02-28 10:10:00  0.638442
2013-02-28 10:11:00  1.330135
2013-02-28 10:12:00 -0.945450

[83521 rows x 1 columns]
```

19.6.4 Truncating & Fancy Indexing

A `truncate` convenience function is provided that is similar to slicing. Note that `truncate` assumes a 0 value for any unspecified date component in a `DatetimeIndex` in contrast to slicing which returns any partially matching dates:

```
In [107]: rng2 = pd.date_range('2011-01-01', '2012-01-01', freq='W')

In [108]: ts2 = pd.Series(np.random.randn(len(rng2)), index=rng2)

In [109]: ts2.truncate(before='2011-11', after='2011-12')
Out[109]: 
2011-11-06   -0.773743
2011-11-13    0.247216
2011-11-20    0.591308
2011-11-27    2.228500
Freq: W-SUN, dtype: float64

In [110]: ts2['2011-11':'2011-12']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2011-11-06   -0.773743
2011-11-13    0.247216
2011-11-20    0.591308
```

```
2011-11-27    2.228500
2011-12-04    0.838769
2011-12-11    0.658538
2011-12-18    0.567353
2011-12-25   -1.076735
Freq: W-SUN, dtype: float64
```

Even complicated fancy indexing that breaks the `DatetimeIndex` frequency regularity will result in a `DatetimeIndex`, although frequency is lost:

```
In [111]: ts2[[0, 2, 6]].index
Out[111]: DatetimeIndex(['2011-01-02', '2011-01-16', '2011-02-13'], dtype=
↪'datetime64[ns]', freq=None)
```

19.7 Time/Date Components

There are several time/date properties that one can access from `Timestamp` or a collection of timestamps like a `DatetimeIndex`.

Property	Description
year	The year of the datetime
month	The month of the datetime
day	The days of the datetime
hour	The hour of the datetime
minute	The minutes of the datetime
second	The seconds of the datetime
microsecond	The microseconds of the datetime
nanosecond	The nanoseconds of the datetime
date	Returns datetime.date (does not contain timezone information)
time	Returns datetime.time (does not contain timezone information)
dayofyear	The ordinal day of year
weekofyear	The week ordinal of the year
week	The week ordinal of the year
dayofweek	The number of the day of the week with Monday=0, Sunday=6
weekday	The number of the day of the week with Monday=0, Sunday=6
weekday_name	The name of the day in a week (ex: Friday)
quarter	Quarter of the date: Jan-Mar = 1, Apr-Jun = 2, etc.
days_in_month	The number of days in the month of the datetime
is_month_start	Logical indicating if first day of month (defined by frequency)
is_month_end	Logical indicating if last day of month (defined by frequency)
is_quarter_start	Logical indicating if first day of quarter (defined by frequency)
is_quarter_end	Logical indicating if last day of quarter (defined by frequency)
is_year_start	Logical indicating if first day of year (defined by frequency)
is_year_end	Logical indicating if last day of year (defined by frequency)
is_leap_year	Logical indicating if the date belongs to a leap year

Furthermore, if you have a `Series` with datetimelike values, then you can access these properties via the `.dt` accessor, see the *docs*

19.8 DateOffset Objects

In the preceding examples, we created `DatetimeIndex` objects at various frequencies by passing in *frequency strings* like 'M', 'W', and 'BM to the `freq` keyword. Under the hood, these frequency strings are being translated into an instance of pandas `DateOffset`, which represents a regular frequency increment. Specific offset logic like "month", "business day", or "one hour" is represented in its various subclasses.

Class name	Description
DateOffset	Generic offset class, defaults to 1 calendar day
BDay	business day (weekday)
CDay	custom business day
Week	one week, optionally anchored on a day of the week
WeekOfMonth	the x-th day of the y-th week of each month
LastWeekOfMonth	the x-th day of the last week of each month
MonthEnd	calendar month end
MonthBegin	calendar month begin
BMonthEnd	business month end
BMonthBegin	business month begin
CBMonthEnd	custom business month end
CBMonthBegin	custom business month begin
SemiMonthEnd	15th (or other day_of_month) and calendar month end
SemiMonthBegin	15th (or other day_of_month) and calendar month begin
QuarterEnd	calendar quarter end
QuarterBegin	calendar quarter begin
BQuarterEnd	business quarter end
BQuarterBegin	business quarter begin
FY5253Quarter	retail (aka 52-53 week) quarter
YearEnd	calendar year end
YearBegin	calendar year begin
BYearEnd	business year end
BYearBegin	business year begin
FY5253	retail (aka 52-53 week) year
BusinessHour	business hour
CustomBusinessHour	custom business hour
Hour	one hour
Minute	one minute
Second	one second
Milli	one millisecond
Micro	one microsecond
Nano	one nanosecond

The basic `DateOffset` takes the same arguments as `dateutil.relativedelta`, which works like:

```
In [112]: d = datetime(2008, 8, 18, 9, 0)

In [113]: d + relativedelta(months=4, days=5)
Out[113]: datetime.datetime(2008, 12, 23, 9, 0)
```

We could have done the same thing with `DateOffset`:

```
In [114]: from pandas.tseries.offsets import *
```

```
In [115]: d + DateOffset(months=4, days=5)
Out[115]: Timestamp('2008-12-23 09:00:00')
```

The key features of a `DateOffset` object are:

- it can be added / subtracted to/from a datetime object to obtain a shifted date
- it can be multiplied by an integer (positive or negative) so that the increment will be applied multiple times
- it has `rollforward` and `rollback` methods for moving a date forward or backward to the next or previous "offset date"

Subclasses of `DateOffset` define the `apply` function which dictates custom date increment logic, such as adding business days:

```
class BDay(DateOffset):
    """DateOffset increments between business days"""
    def apply(self, other):
        ...
```

```
In [116]: d - 5 * BDay()
Out[116]: Timestamp('2008-08-11 09:00:00')

In [117]: d + BMonthEnd()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[117]: Timestamp('2008-08-29 09:00:00')
```

The `rollforward` and `rollback` methods do exactly what you would expect:

```
In [118]: d
Out[118]: datetime.datetime(2008, 8, 18, 9, 0)

In [119]: offset = BMonthEnd()

In [120]: offset.rollforward(d)
Out[120]: Timestamp('2008-08-29 09:00:00')

In [121]: offset.rollback(d)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[121]: Timestamp('2008-07-31 09:00:00')
```

It's definitely worth exploring the `pandas.tseries.offsets` module and the various docstrings for the classes.

These operations (`apply`, `rollforward` and `rollback`) preserves time (hour, minute, etc) information by default. To reset time, use `normalize=True` keyword when creating the offset instance. If `normalize=True`, result is normalized after the function is applied.

```
In [122]: day = Day()

In [123]: day.apply(pd.Timestamp('2014-01-01 09:00'))
Out[123]: Timestamp('2014-01-02 09:00:00')

In [124]: day = Day(normalize=True)

In [125]: day.apply(pd.Timestamp('2014-01-01 09:00'))
Out[125]: Timestamp('2014-01-02 00:00:00')

In [126]: hour = Hour()

In [127]: hour.apply(pd.Timestamp('2014-01-01 22:00'))
Out[127]: Timestamp('2014-01-01 23:00:00')
```

```
In [128]: hour = Hour(normalize=True)

In [129]: hour.apply(pd.Timestamp('2014-01-01 22:00'))
Out[129]: Timestamp('2014-01-01 00:00:00')

In [130]: hour.apply(pd.Timestamp('2014-01-01 23:00'))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[130]: Timestamp('2014-01-02 00:00:00')
```

19.8.1 Parametric Offsets

Some of the offsets can be "parameterized" when created to result in different behaviors. For example, the `Week` offset for generating weekly data accepts a `weekday` parameter which results in the generated dates always lying on a particular day of the week:

```
In [131]: d
Out[131]: datetime.datetime(2008, 8, 18, 9, 0)

In [132]: d + Week()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[132]: Timestamp('2008-08-25␣
↪09:00:00')

In [133]: d + Week(weekday=4)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[133]:␣
↪Timestamp('2008-08-22 09:00:00')

In [134]: (d + Week(weekday=4)).weekday()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪4

In [135]: d - Week()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2008-08-11 09:00:00')
```

`normalize` option will be effective for addition and subtraction.

```
In [136]: d + Week(normalize=True)
Out[136]: Timestamp('2008-08-25 00:00:00')

In [137]: d - Week(normalize=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[137]: Timestamp('2008-08-11 00:00:00')
```

Another example is parameterizing `YearEnd` with the specific ending month:

```
In [138]: d + YearEnd()
Out[138]: Timestamp('2008-12-31 09:00:00')

In [139]: d + YearEnd(month=6)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[139]: Timestamp('2009-06-30 09:00:00')
```

19.8.2 Using Offsets with `Series` / `DatetimeIndex`

Offsets can be used with either a `Series` or `DatetimeIndex` to apply the offset to each element.

```
In [140]: rng = pd.date_range('2012-01-01', '2012-01-03')

In [141]: s = pd.Series(rng)

In [142]: rng
Out[142]: DatetimeIndex(['2012-01-01', '2012-01-02', '2012-01-03'], dtype=
 ↪'datetime64[ns]', freq='D')

In [143]: rng + DateOffset(months=2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪DatetimeIndex(['2012-03-01', '2012-03-02', '2012-03-03'], dtype='datetime64[ns]',␣
 ↪freq='D')

In [144]: s + DateOffset(months=2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
0   2012-03-01
1   2012-03-02
2   2012-03-03
dtype: datetime64[ns]

In [145]: s - DateOffset(months=2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
0   2011-11-01
1   2011-11-02
2   2011-11-03
dtype: datetime64[ns]
```

If the offset class maps directly to a `Timedelta` (`Day`, `Hour`, `Minute`, `Second`, `Micro`, `Milli`, `Nano`) it can be used exactly like a `Timedelta` - see the *Timedelta section* for more examples.

```
In [146]: s - Day(2)
Out[146]:
0   2011-12-30
1   2011-12-31
2   2012-01-01
dtype: datetime64[ns]

In [147]: td = s - pd.Series(pd.date_range('2011-12-29', '2011-12-31'))

In [148]: td
Out[148]:
0   3 days
1   3 days
2   3 days
dtype: timedelta64[ns]

In [149]: td + Minute(15)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[149]:
0   3 days 00:15:00
1   3 days 00:15:00
2   3 days 00:15:00
dtype: timedelta64[ns]
```

Note that some offsets (such as `BQuarterEnd`) do not have a vectorized implementation. They can still be used but may calculate significantly slower and will show a `PerformanceWarning`

```
In [150]: rng + BQuarterEnd()
Out[150]: DatetimeIndex(['2012-03-30', '2012-03-30', '2012-03-30'], dtype=
↪'datetime64[ns]', freq=None)
```

19.8.3 Custom Business Days

The `CDay` or `CustomBusinessDay` class provides a parametric `BusinessDay` class which can be used to create customized business day calendars which account for local holidays and local weekend conventions.

As an interesting example, let's look at Egypt where a Friday-Saturday weekend is observed.

```
In [151]: from pandas.tseries.offsets import CustomBusinessDay

In [152]: weekmask_egypt = 'Sun Mon Tue Wed Thu'

# They also observe International Workers' Day so let's
# add that for a couple of years
In [153]: holidays = ['2012-05-01', datetime(2013, 5, 1), np.datetime64('2014-05-01')]

In [154]: bday_egypt = CustomBusinessDay(holidays=holidays, weekmask=weekmask_egypt)

In [155]: dt = datetime(2013, 4, 30)

In [156]: dt + 2 * bday_egypt
Out[156]: Timestamp('2013-05-05 00:00:00')
```

Let's map to the weekday names

```
In [157]: dts = pd.date_range(dt, periods=5, freq=bday_egypt)

In [158]: pd.Series(dts.weekday, dts).map(pd.Series('Mon Tue Wed Thu Fri Sat Sun'.
↪split()))
Out[158]:
2013-04-30    Tue
2013-05-02    Thu
2013-05-05    Sun
2013-05-06    Mon
2013-05-07    Tue
Freq: C, dtype: object
```

Holiday calendars can be used to provide the list of holidays. See the *holiday calendar* section for more information.

```
In [159]: from pandas.tseries.holiday import USFederalHolidayCalendar

In [160]: bday_us = CustomBusinessDay(calendar=USFederalHolidayCalendar())

# Friday before MLK Day
In [161]: dt = datetime(2014, 1, 17)

# Tuesday after MLK Day (Monday is skipped because it's a holiday)
In [162]: dt + bday_us
Out[162]: Timestamp('2014-01-21 00:00:00')
```

Monthly offsets that respect a certain holiday calendar can be defined in the usual way.

```
In [163]: from pandas.tseries.offsets import CustomBusinessMonthBegin

In [164]: bmth_us = CustomBusinessMonthBegin(calendar=USFederalHolidayCalendar())

# Skip new years
In [165]: dt = datetime(2013, 12, 17)

In [166]: dt + bmth_us
Out[166]: Timestamp('2014-01-02 00:00:00')

# Define date index with custom offset
In [167]: pd.DatetimeIndex(start='20100101',end='20120101',freq=bmth_us)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[167]:
DatetimeIndex(['2010-01-04', '2010-02-01', '2010-03-01', '2010-04-01',
               '2010-05-03', '2010-06-01', '2010-07-01', '2010-08-02',
               '2010-09-01', '2010-10-01', '2010-11-01', '2010-12-01',
               '2011-01-03', '2011-02-01', '2011-03-01', '2011-04-01',
               '2011-05-02', '2011-06-01', '2011-07-01', '2011-08-01',
               '2011-09-01', '2011-10-03', '2011-11-01', '2011-12-01'],
              dtype='datetime64[ns]', freq='CBMS')
```

Note: The frequency string 'C' is used to indicate that a CustomBusinessDay DateOffset is used, it is important to note that since CustomBusinessDay is a parameterised type, instances of CustomBusinessDay may differ and this is not detectable from the 'C' frequency string. The user therefore needs to ensure that the 'C' frequency string is used consistently within the user's application.

19.8.4 Business Hour

The `BusinessHour` class provides a business hour representation on `BusinessDay`, allowing to use specific start and end times.

By default, `BusinessHour` uses 9:00 - 17:00 as business hours. Adding `BusinessHour` will increment `Timestamp` by hourly. If target `Timestamp` is out of business hours, move to the next business hour then increment it. If the result exceeds the business hours end, remaining is added to the next business day.

```
In [168]: bh = BusinessHour()

In [169]: bh
Out[169]: <BusinessHour: BH=09:00-17:00>

# 2014-08-01 is Friday
In [170]: pd.Timestamp('2014-08-01 10:00').weekday()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[170]: 4

In [171]: pd.Timestamp('2014-08-01 10:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[171]: Timestamp('2014-08-01␣
↪11:00:00')

# Below example is the same as: pd.Timestamp('2014-08-01 09:00') + bh
In [172]: pd.Timestamp('2014-08-01 08:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[
↪Timestamp('2014-08-01 10:00:00')

# If the results is on the end time, move to the next business day
```

```
In [173]: pd.Timestamp('2014-08-01 16:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-08-04 09:00:00')

# Remainings are added to the next day
In [174]: pd.Timestamp('2014-08-01 16:30') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-08-04 09:30:00')

# Adding 2 business hours
In [175]: pd.Timestamp('2014-08-01 10:00') + BusinessHour(2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-08-01 12:00:00')

# Subtracting 3 business hours
In [176]: pd.Timestamp('2014-08-01 10:00') + BusinessHour(-3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-07-31 15:00:00')
```

Also, you can specify `start` and `end` time by keywords. Argument must be `str` which has `hour:minute` representation or `datetime.time` instance. Specifying seconds, microseconds and nanoseconds as business hour results in `ValueError`.

```
In [177]: bh = BusinessHour(start='11:00', end=time(20, 0))

In [178]: bh
Out[178]: <BusinessHour: BH=11:00-20:00>

In [179]: pd.Timestamp('2014-08-01 13:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[179]: Timestamp('2014-08-01 14:00:00')

In [180]: pd.Timestamp('2014-08-01 09:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[180]:␣
↪Timestamp('2014-08-01 12:00:00')

In [181]: pd.Timestamp('2014-08-01 18:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-08-01 19:00:00')
```

Passing `start` time later than `end` represents midnight business hour. In this case, business hour exceeds midnight and overlap to the next day. Valid business hours are distinguished by whether it started from valid `BusinessDay`.

```
In [182]: bh = BusinessHour(start='17:00', end='09:00')

In [183]: bh
Out[183]: <BusinessHour: BH=17:00-09:00>

In [184]: pd.Timestamp('2014-08-01 17:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[184]: Timestamp('2014-08-01 18:00:00')

In [185]: pd.Timestamp('2014-08-01 23:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[185]:␣
↪Timestamp('2014-08-02 00:00:00')

# Although 2014-08-02 is Satuaday,
# it is valid because it starts from 08-01 (Friday).
In [186]: pd.Timestamp('2014-08-02 04:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-08-02 05:00:00')
```

```
# Although 2014-08-04 is Monday,
# it is out of business hours because it starts from 08-03 (Sunday).
In [187]: pd.Timestamp('2014-08-04 04:00') + bh
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-08-04 18:00:00')
```

Applying `BusinessHour.rollforward` and `rollback` to out of business hours results in the next business hour start or previous day's end. Different from other offsets, `BusinessHour.rollforward` may output different results from `apply` by definition.

This is because one day's business hour end is equal to next day's business hour start. For example, under the default business hours (9:00 - 17:00), there is no gap (0 minutes) between `2014-08-01 17:00` and `2014-08-04 09:00`.

```
# This adjusts a Timestamp to business hour edge
In [188]: BusinessHour().rollback(pd.Timestamp('2014-08-02 15:00'))
Out[188]: Timestamp('2014-08-01 17:00:00')

In [189]: BusinessHour().rollforward(pd.Timestamp('2014-08-02 15:00'))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[189]: Timestamp('2014-08-04 09:00:00')

# It is the same as BusinessHour().apply(pd.Timestamp('2014-08-01 17:00')).
# And it is the same as BusinessHour().apply(pd.Timestamp('2014-08-04 09:00'))
In [190]: BusinessHour().apply(pd.Timestamp('2014-08-02 15:00'))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[190]:␣
↪Timestamp('2014-08-04 10:00:00')

# BusinessDay results (for reference)
In [191]: BusinessHour().rollforward(pd.Timestamp('2014-08-02'))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-08-04 09:00:00')

# It is the same as BusinessDay().apply(pd.Timestamp('2014-08-01'))
# The result is the same as rollworward because BusinessDay never overlap.
In [192]: BusinessHour().apply(pd.Timestamp('2014-08-02'))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-08-04 10:00:00')
```

`BusinessHour` regards Saturday and Sunday as holidays. To use arbitrary holidays, you can use `CustomBusinessHour` offset, see *Custom Business Hour*:

19.8.5 Custom Business Hour

New in version 0.18.1.

The `CustomBusinessHour` is a mixture of `BusinessHour` and `CustomBusinessDay` which allows you to specify arbitrary holidays. `CustomBusinessHour` works as the same as `BusinessHour` except that it skips specified custom holidays.

```
In [193]: from pandas.tseries.holiday import USFederalHolidayCalendar

In [194]: bhour_us = CustomBusinessHour(calendar=USFederalHolidayCalendar())

# Friday before MLK Day
In [195]: dt = datetime(2014, 1, 17, 15)
```

```
In [196]: dt + bhour_us
Out[196]: Timestamp('2014-01-17 16:00:00')

# Tuesday after MLK Day (Monday is skipped because it's a holiday)
In [197]: dt + bhour_us * 2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[197]: Timestamp('2014-01-21 09:00:00')
```

You can use keyword arguments supported by either `BusinessHour` and `CustomBusinessDay`.

```
In [198]: bhour_mon = CustomBusinessHour(start='10:00', weekmask='Tue Wed Thu Fri')

# Monday is skipped because it's a holiday, business hour starts from 10:00
In [199]: dt + bhour_mon * 2
Out[199]: Timestamp('2014-01-21 10:00:00')
```

19.8.6 Offset Aliases

A number of string aliases are given to useful common time series frequencies. We will refer to these aliases as *offset aliases*.

Alias	Description
B	business day frequency
C	custom business day frequency
D	calendar day frequency
W	weekly frequency
M	month end frequency
SM	semi-month end frequency (15th and end of month)
BM	business month end frequency
CBM	custom business month end frequency
MS	month start frequency
SMS	semi-month start frequency (1st and 15th)
BMS	business month start frequency
CBMS	custom business month start frequency
Q	quarter end frequency
BQ	business quarter end frequency
QS	quarter start frequency
BQS	business quarter start frequency
A, Y	year end frequency
BA, BY	business year end frequency
AS, YS	year start frequency
BAS, BYS	business year start frequency
BH	business hour frequency
H	hourly frequency
T, min	minutely frequency
S	secondly frequency
L, ms	milliseconds
U, us	microseconds
N	nanoseconds

19.8.7 Combining Aliases

As we have seen previously, the alias and the offset instance are fungible in most functions:

```
In [200]: pd.date_range(start, periods=5, freq='B')
Out[200]: 
DatetimeIndex(['2011-01-03', '2011-01-04', '2011-01-05', '2011-01-06',
               '2011-01-07'],
              dtype='datetime64[ns]', freq='B')

In [201]: pd.date_range(start, periods=5, freq=BDay())
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2011-01-03', '2011-01-04', '2011-01-05', '2011-01-06',
               '2011-01-07'],
              dtype='datetime64[ns]', freq='B')
```

You can combine together day and intraday offsets:

```
In [202]: pd.date_range(start, periods=10, freq='2h20min')
Out[202]: 
DatetimeIndex(['2011-01-01 00:00:00', '2011-01-01 02:20:00',
               '2011-01-01 04:40:00', '2011-01-01 07:00:00',
               '2011-01-01 09:20:00', '2011-01-01 11:40:00',
               '2011-01-01 14:00:00', '2011-01-01 16:20:00',
               '2011-01-01 18:40:00', '2011-01-01 21:00:00'],
              dtype='datetime64[ns]', freq='140T')

In [203]: pd.date_range(start, periods=10, freq='1D10U')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex([       '2011-01-01 00:00:00', '2011-01-02 00:00:00.000010',
               '2011-01-03 00:00:00.000020', '2011-01-04 00:00:00.000030',
               '2011-01-05 00:00:00.000040', '2011-01-06 00:00:00.000050',
               '2011-01-07 00:00:00.000060', '2011-01-08 00:00:00.000070',
               '2011-01-09 00:00:00.000080', '2011-01-10 00:00:00.000090'],
              dtype='datetime64[ns]', freq='86400000010U')
```

19.8.8 Anchored Offsets

For some frequencies you can specify an anchoring suffix:

Alias	Description
W-SUN	weekly frequency (Sundays). Same as 'W'
W-MON	weekly frequency (Mondays)
W-TUE	weekly frequency (Tuesdays)
W-WED	weekly frequency (Wednesdays)
W-THU	weekly frequency (Thursdays)
W-FRI	weekly frequency (Fridays)
W-SAT	weekly frequency (Saturdays)
(B)Q(S)-DEC	quarterly frequency, year ends in December. Same as 'Q'
(B)Q(S)-JAN	quarterly frequency, year ends in January
(B)Q(S)-FEB	quarterly frequency, year ends in February
(B)Q(S)-MAR	quarterly frequency, year ends in March
(B)Q(S)-APR	quarterly frequency, year ends in April
(B)Q(S)-MAY	quarterly frequency, year ends in May
(B)Q(S)-JUN	quarterly frequency, year ends in June

Continued on next page

Table 19.2 – continued from previous page

Alias	Description
(B)Q(S)-JUL	quarterly frequency, year ends in July
(B)Q(S)-AUG	quarterly frequency, year ends in August
(B)Q(S)-SEP	quarterly frequency, year ends in September
(B)Q(S)-OCT	quarterly frequency, year ends in October
(B)Q(S)-NOV	quarterly frequency, year ends in November
(B)A(S)-DEC	annual frequency, anchored end of December. Same as 'A'
(B)A(S)-JAN	annual frequency, anchored end of January
(B)A(S)-FEB	annual frequency, anchored end of February
(B)A(S)-MAR	annual frequency, anchored end of March
(B)A(S)-APR	annual frequency, anchored end of April
(B)A(S)-MAY	annual frequency, anchored end of May
(B)A(S)-JUN	annual frequency, anchored end of June
(B)A(S)-JUL	annual frequency, anchored end of July
(B)A(S)-AUG	annual frequency, anchored end of August
(B)A(S)-SEP	annual frequency, anchored end of September
(B)A(S)-OCT	annual frequency, anchored end of October
(B)A(S)-NOV	annual frequency, anchored end of November

These can be used as arguments to `date_range`, `bdate_range`, constructors for `DatetimeIndex`, as well as various other timeseries-related functions in pandas.

19.8.9 Anchored Offset Semantics

For those offsets that are anchored to the start or end of specific frequency (`MonthEnd`, `MonthBegin`, `WeekEnd`, etc) the following rules apply to rolling forward and backwards.

When `n` is not 0, if the given date is not on an anchor point, it snapped to the next(previous) anchor point, and moved `|n|-1` additional steps forwards or backwards.

```
In [204]: pd.Timestamp('2014-01-02') + MonthBegin(n=1)
Out[204]: Timestamp('2014-02-01 00:00:00')

In [205]: pd.Timestamp('2014-01-02') + MonthEnd(n=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[205]: Timestamp('2014-01-31 00:00:00')

In [206]: pd.Timestamp('2014-01-02') - MonthBegin(n=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[206]:␣
↪Timestamp('2014-01-01 00:00:00')

In [207]: pd.Timestamp('2014-01-02') - MonthEnd(n=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2013-12-31 00:00:00')

In [208]: pd.Timestamp('2014-01-02') + MonthBegin(n=4)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-05-01 00:00:00')

In [209]: pd.Timestamp('2014-01-02') - MonthBegin(n=4)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2013-10-01 00:00:00')
```

If the given date *is* on an anchor point, it is moved `|n|` points forwards or backwards.

```
In [210]: pd.Timestamp('2014-01-01') + MonthBegin(n=1)
Out[210]: Timestamp('2014-02-01 00:00:00')

In [211]: pd.Timestamp('2014-01-31') + MonthEnd(n=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[211]: Timestamp('2014-02-28 00:00:00')

In [212]: pd.Timestamp('2014-01-01') - MonthBegin(n=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[212]:␣
↪Timestamp('2013-12-01 00:00:00')

In [213]: pd.Timestamp('2014-01-31') - MonthEnd(n=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2013-12-31 00:00:00')

In [214]: pd.Timestamp('2014-01-01') + MonthBegin(n=4)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-05-01 00:00:00')

In [215]: pd.Timestamp('2014-01-31') - MonthBegin(n=4)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2013-10-01 00:00:00')
```

For the case when `n=0`, the date is not moved if on an anchor point, otherwise it is rolled forward to the next anchor point.

```
In [216]: pd.Timestamp('2014-01-02') + MonthBegin(n=0)
Out[216]: Timestamp('2014-02-01 00:00:00')

In [217]: pd.Timestamp('2014-01-02') + MonthEnd(n=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[217]: Timestamp('2014-01-31 00:00:00')

In [218]: pd.Timestamp('2014-01-01') + MonthBegin(n=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[218]:␣
↪Timestamp('2014-01-01 00:00:00')

In [219]: pd.Timestamp('2014-01-31') + MonthEnd(n=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2014-01-31 00:00:00')
```

19.8.10 Holidays / Holiday Calendars

Holidays and calendars provide a simple way to define holiday rules to be used with `CustomBusinessDay` or in other analysis that requires a predefined set of holidays. The `AbstractHolidayCalendar` class provides all the necessary methods to return a list of holidays and only `rules` need to be defined in a specific holiday calendar class. Further, `start_date` and `end_date` class attributes determine over what date range holidays are generated. These should be overwritten on the `AbstractHolidayCalendar` class to have the range apply to all calendar subclasses. `USFederalHolidayCalendar` is the only calendar that exists and primarily serves as an example for developing other calendars.

For holidays that occur on fixed dates (e.g., US Memorial Day or July 4th) an observance rule determines when that holiday is observed if it falls on a weekend or some other non-observed day. Defined observance rules are:

Rule	Description
nearest_workday	move Saturday to Friday and Sunday to Monday
sunday_to_monday	move Sunday to following Monday
next_monday_or_tuesday	move Saturday to Monday and Sunday/Monday to Tuesday
previous_friday	move Saturday and Sunday to previous Friday”
next_monday	move Saturday and Sunday to following Monday

An example of how holidays and holiday calendars are defined:

```
In [220]: from pandas.tseries.holiday import Holiday, USMemorialDay,\
   .....:     AbstractHolidayCalendar, nearest_workday, MO
   .....:

In [221]: class ExampleCalendar(AbstractHolidayCalendar):
   .....:     rules = [
   .....:         USMemorialDay,
   .....:         Holiday('July 4th', month=7, day=4, observance=nearest_workday),
   .....:         Holiday('Columbus Day', month=10, day=1,
   .....:             offset=DateOffset(weekday=MO(2))), #same as 2*Week(weekday=2)
   .....:         ]
   .....:

In [222]: cal = ExampleCalendar()

In [223]: cal.holidays(datetime(2012, 1, 1), datetime(2012, 12, 31))
Out[223]: DatetimeIndex(['2012-05-28', '2012-07-04', '2012-10-08'], dtype=
↪'datetime64[ns]', freq=None)
```

Using this calendar, creating an index or doing offset arithmetic skips weekends and holidays (i.e., Memorial Day/July 4th). For example, the below defines a custom business day offset using the `ExampleCalendar`. Like any other offset, it can be used to create a `DatetimeIndex` or added to `datetime` or `Timestamp` objects.

```
In [224]: from pandas.tseries.offsets import CDay

In [225]: pd.DatetimeIndex(start='7/1/2012', end='7/10/2012',
   .....:     freq=CDay(calendar=cal)).to_pydatetime()
   .....:
Out[225]:
array([datetime.datetime(2012, 7, 2, 0, 0),
       datetime.datetime(2012, 7, 3, 0, 0),
       datetime.datetime(2012, 7, 5, 0, 0),
       datetime.datetime(2012, 7, 6, 0, 0),
       datetime.datetime(2012, 7, 9, 0, 0),
       datetime.datetime(2012, 7, 10, 0, 0)], dtype=object)

In [226]: offset = CustomBusinessDay(calendar=cal)

In [227]: datetime(2012, 5, 25) + offset
Out[227]: Timestamp('2012-05-29 00:00:00')

In [228]: datetime(2012, 7, 3) + offset
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[228]: Timestamp('2012-07-05 00:00:00')

In [229]: datetime(2012, 7, 3) + 2 * offset
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[229]:␣
↪Timestamp('2012-07-06 00:00:00')

In [230]: datetime(2012, 7, 6) + offset
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2012-07-09 00:00:00')
```

Ranges are defined by the `start_date` and `end_date` class attributes of `AbstractHolidayCalendar`. The defaults are below.

```
In [231]: AbstractHolidayCalendar.start_date
Out[231]: Timestamp('1970-01-01 00:00:00')

In [232]: AbstractHolidayCalendar.end_date
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[232]: Timestamp('2030-12-31 00:00:00')
```

These dates can be overwritten by setting the attributes as datetime/Timestamp/string.

```
In [233]: AbstractHolidayCalendar.start_date = datetime(2012, 1, 1)

In [234]: AbstractHolidayCalendar.end_date = datetime(2012, 12, 31)

In [235]: cal.holidays()
Out[235]: DatetimeIndex(['2012-05-28', '2012-07-04', '2012-10-08'], dtype=
↪'datetime64[ns]', freq=None)
```

Every calendar class is accessible by name using the `get_calendar` function which returns a holiday class instance. Any imported calendar class will automatically be available by this function. Also, `HolidayCalendarFactory` provides an easy interface to create calendars that are combinations of calendars or calendars with additional rules.

```
In [236]: from pandas.tseries.holiday import get_calendar, HolidayCalendarFactory,\
   .....:     USLaborDay
   .....:

In [237]: cal = get_calendar('ExampleCalendar')

In [238]: cal.rules
Out[238]: 
[Holiday: MemorialDay (month=5, day=31, offset=<DateOffset: kwds={'weekday': MO(-1)}>
↪),
 Holiday: July 4th (month=7, day=4, observance=<function nearest_workday at␣
↪0x131922e18>),
 Holiday: Columbus Day (month=10, day=1, offset=<DateOffset: kwds={'weekday': MO(+2)}>
↪)]

In [239]: new_cal = HolidayCalendarFactory('NewExampleCalendar', cal, USLaborDay)

In [240]: new_cal.rules
Out[240]: 
[Holiday: Labor Day (month=9, day=1, offset=<DateOffset: kwds={'weekday': MO(+1)}>),
 Holiday: MemorialDay (month=5, day=31, offset=<DateOffset: kwds={'weekday': MO(-1)}>
↪),
 Holiday: July 4th (month=7, day=4, observance=<function nearest_workday at␣
↪0x131922e18>),
 Holiday: Columbus Day (month=10, day=1, offset=<DateOffset: kwds={'weekday': MO(+2)}>
↪)]
```

19.9 Time Series-Related Instance Methods

19.9.1 Shifting / Lagging

One may want to *shift* or *lag* the values in a time series back and forward in time. The method for this is `shift`, which is available on all of the pandas objects.

```
In [241]: ts = ts[:5]

In [242]: ts.shift(1)
Out[242]:
2011-01-31         NaN
2011-02-28   -1.281247
2011-03-31   -0.727707
2011-04-29   -0.121306
2011-05-31   -0.097883
Freq: BM, dtype: float64
```

The shift method accepts an `freq` argument which can accept a `DateOffset` class or other `timedelta`-like object or also a *offset alias*:

```
In [243]: ts.shift(5, freq=offsets.BDay())
Out[243]:
2011-02-07   -1.281247
2011-03-07   -0.727707
2011-04-07   -0.121306
2011-05-06   -0.097883
2011-06-07    0.695775
dtype: float64

In [244]: ts.shift(5, freq='BM')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
2011-06-30   -1.281247
2011-07-29   -0.727707
2011-08-31   -0.121306
2011-09-30   -0.097883
2011-10-31    0.695775
Freq: BM, dtype: float64
```

Rather than changing the alignment of the data and the index, `DataFrame` and `Series` objects also have a `tshift` convenience method that changes all the dates in the index by a specified number of offsets:

```
In [245]: ts.tshift(5, freq='D')
Out[245]:
2011-02-05   -1.281247
2011-03-05   -0.727707
2011-04-05   -0.121306
2011-05-04   -0.097883
2011-06-05    0.695775
dtype: float64
```

Note that with `tshift`, the leading entry is no longer NaN because the data is not being realigned.

19.9.2 Frequency Conversion

The primary function for changing frequencies is the `asfreq` function. For a `DatetimeIndex`, this is basically just a thin, but convenient wrapper around `reindex` which generates a `date_range` and calls `reindex`.

```
In [246]: dr = pd.date_range('1/1/2010', periods=3, freq=3 * offsets.BDay())

In [247]: ts = pd.Series(randn(3), index=dr)

In [248]: ts
Out[248]:
2010-01-01    0.155932
2010-01-06    1.486218
2010-01-11   -2.148675
Freq: 3B, dtype: float64

In [249]: ts.asfreq(BDay())
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2010-01-01    0.155932
2010-01-04         NaN
2010-01-05         NaN
2010-01-06    1.486218
2010-01-07         NaN
2010-01-08         NaN
2010-01-11   -2.148675
Freq: B, dtype: float64
```

`asfreq` provides a further convenience so you can specify an interpolation method for any gaps that may appear after the frequency conversion

```
In [250]: ts.asfreq(BDay(), method='pad')
Out[250]:
2010-01-01    0.155932
2010-01-04    0.155932
2010-01-05    0.155932
2010-01-06    1.486218
2010-01-07    1.486218
2010-01-08    1.486218
2010-01-11   -2.148675
Freq: B, dtype: float64
```

19.9.3 Filling Forward / Backward

Related to `asfreq` and `reindex` is the `fillna` function documented in the *missing data section*.

19.9.4 Converting to Python Datetimes

`DatetimeIndex` can be converted to an array of Python native datetime.datetime objects using the `to_pydatetime` method.

19.10 Resampling

Warning: The interface to `.resample` has changed in 0.18.0 to be more groupby-like and hence more flexible. See the *whatsnew docs* for a comparison with prior versions.

Pandas has a simple, powerful, and efficient functionality for performing resampling operations during frequency conversion (e.g., converting secondly data into 5-minutely data). This is extremely common in, but not limited to, financial applications.

`.resample()` is a time-based groupby, followed by a reduction method on each of its groups. See some *cookbook examples* for some advanced strategies

Starting in version 0.18.1, the `resample()` function can be used directly from `DataFrameGroupBy` objects, see the *groupby docs*.

Note: `.resample()` is similar to using a `.rolling()` operation with a time-based offset, see a discussion *here*

19.10.1 Basics

```
In [251]: rng = pd.date_range('1/1/2012', periods=100, freq='S')

In [252]: ts = pd.Series(np.random.randint(0, 500, len(rng)), index=rng)

In [253]: ts.resample('5Min').sum()
Out[253]:
2012-01-01    25653
Freq: 5T, dtype: int64
```

The `resample` function is very flexible and allows you to specify many different parameters to control the frequency conversion and resampling operation.

Any function available via *dispatching* is available as a method of the returned object, including `sum`, `mean`, `std`, `sem`, `max`, `min`, `median`, `first`, `last`, `ohlc`:

```
In [254]: ts.resample('5Min').mean()
Out[254]:
2012-01-01    256.53
Freq: 5T, dtype: float64

In [255]: ts.resample('5Min').ohlc()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[255]:
            open  high  low  close
2012-01-01   296   496    6    449

In [256]: ts.resample('5Min').max()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-01-01    496
Freq: 5T, dtype: int64
```

For downsampling, `closed` can be set to 'left' or 'right' to specify which end of the interval is closed:

```
In [257]: ts.resample('5Min', closed='right').mean()
Out[257]:
2011-12-31 23:55:00    296.000000
2012-01-01 00:00:00    256.131313
Freq: 5T, dtype: float64

In [258]: ts.resample('5Min', closed='left').mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-01-01    256.53
Freq: 5T, dtype: float64
```

Parameters like `label` and `loffset` are used to manipulate the resulting labels. `label` specifies whether the result is labeled with the beginning or the end of the interval. `loffset` performs a time adjustment on the output labels.

```
In [259]: ts.resample('5Min').mean() # by default label='left'
Out[259]:
2012-01-01    256.53
Freq: 5T, dtype: float64

In [260]: ts.resample('5Min', label='left').mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[260]:
2012-01-01    256.53
Freq: 5T, dtype: float64

In [261]: ts.resample('5Min', label='left', loffset='1s').mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-01-01 00:00:01    256.53
dtype: float64
```

Note: The default values for `label` and `closed` is 'left' for all frequency offsets except for 'M', 'A', 'Q', 'BM', 'BA', 'BQ', and 'W' which all have a default of 'right'.

```
In [262]: rng2 = pd.date_range('1/1/2012', end='3/31/2012', freq='D')

In [263]: ts2 = pd.Series(range(len(rng2)), index=rng2)

# default: label='right', closed='right'
In [264]: ts2.resample('M').max()
Out[264]:
2012-01-31    30
2012-02-29    59
2012-03-31    90
Freq: M, dtype: int64

# default: label='left', closed='left'
In [265]: ts2.resample('SM').max()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[265]:␣
↪
2011-12-31    13
2012-01-15    29
2012-01-31    44
2012-02-15    58
2012-02-29    73
2012-03-15    89
2012-03-31    90
```

```
Freq: SM-15, dtype: int64

In [266]: ts2.resample('SM', label='right', closed='right').max()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-01-15    14.0
2012-01-31    30.0
2012-02-15    45.0
2012-02-29    59.0
2012-03-15    74.0
2012-03-31    90.0
2012-04-15     NaN
Freq: SM-15, dtype: float64
```

The `axis` parameter can be set to 0 or 1 and allows you to resample the specified axis for a `DataFrame`.

`kind` can be set to ‘timestamp’ or ‘period’ to convert the resulting index to/from timestamp and time span representations. By default `resample` retains the input representation.

`convention` can be set to ‘start’ or ‘end’ when resampling period data (detail below). It specifies how low frequency periods are converted to higher frequency periods.

19.10.2 Upsampling

For upsampling, you can specify a way to upsample and the `limit` parameter to interpolate over the gaps that are created:

```
# from secondly to every 250 milliseconds
In [267]: ts[:2].resample('250L').asfreq()
Out[267]:
2012-01-01 00:00:00.000    296.0
2012-01-01 00:00:00.250      NaN
2012-01-01 00:00:00.500      NaN
2012-01-01 00:00:00.750      NaN
2012-01-01 00:00:01.000    199.0
Freq: 250L, dtype: float64

In [268]: ts[:2].resample('250L').ffill()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-01-01 00:00:00.000    296
2012-01-01 00:00:00.250    296
2012-01-01 00:00:00.500    296
2012-01-01 00:00:00.750    296
2012-01-01 00:00:01.000    199
Freq: 250L, dtype: int64

In [269]: ts[:2].resample('250L').ffill(limit=2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-01-01 00:00:00.000    296.0
2012-01-01 00:00:00.250    296.0
2012-01-01 00:00:00.500    296.0
2012-01-01 00:00:00.750      NaN
2012-01-01 00:00:01.000    199.0
Freq: 250L, dtype: float64
```

19.10.3 Sparse Resampling

Sparse timeseries are ones where you have a lot fewer points relative to the amount of time you are looking to resample. Naively upsampling a sparse series can potentially generate lots of intermediate values. When you don't want to use a method to fill these values, e.g. `fill_method` is `None`, then intermediate values will be filled with `NaN`.

Since `resample` is a time-based groupby, the following is a method to efficiently resample only the groups that are not all `NaN`

```
In [270]: rng = pd.date_range('2014-1-1', periods=100, freq='D') + pd.Timedelta('1s')

In [271]: ts = pd.Series(range(100), index=rng)
```

If we want to resample to the full range of the series

```
In [272]: ts.resample('3T').sum()
Out[272]:
2014-01-01 00:00:00     0.0
2014-01-01 00:03:00     NaN
2014-01-01 00:06:00     NaN
2014-01-01 00:09:00     NaN
2014-01-01 00:12:00     NaN
2014-01-01 00:15:00     NaN
2014-01-01 00:18:00     NaN
                       ...
2014-04-09 23:42:00     NaN
2014-04-09 23:45:00     NaN
2014-04-09 23:48:00     NaN
2014-04-09 23:51:00     NaN
2014-04-09 23:54:00     NaN
2014-04-09 23:57:00     NaN
2014-04-10 00:00:00    99.0
Freq: 3T, Length: 47521, dtype: float64
```

We can instead only resample those groups where we have points as follows:

```
In [273]: from functools import partial

In [274]: from pandas.tseries.frequencies import to_offset

In [275]: def round(t, freq):
   .....:     freq = to_offset(freq)
   .....:     return pd.Timestamp((t.value // freq.delta.value) * freq.delta.value)
   .....:

In [276]: ts.groupby(partial(round, freq='3T')).sum()
Out[276]:
2014-01-01     0
2014-01-02     1
2014-01-03     2
2014-01-04     3
2014-01-05     4
2014-01-06     5
2014-01-07     6
              ..
2014-04-04    93
2014-04-05    94
2014-04-06    95
```

```
2014-04-07    96
2014-04-08    97
2014-04-09    98
2014-04-10    99
Length: 100, dtype: int64
```

19.10.4 Aggregation

Similar to the *aggregating API*, *groupby API*, and the *window functions API*, a `Resampler` can be selectively resampled.

Resampling a `DataFrame`, the default will be to act on all columns with the same function.

```
In [277]: df = pd.DataFrame(np.random.randn(1000, 3),
   .....:                   index=pd.date_range('1/1/2012', freq='S', periods=1000),
   .....:                   columns=['A', 'B', 'C'])
   .....:

In [278]: r = df.resample('3T')

In [279]: r.mean()
Out[279]:
                            A         B         C
2012-01-01 00:00:00 -0.038580 -0.085117 -0.024750
2012-01-01 00:03:00  0.052387 -0.061477  0.029548
2012-01-01 00:06:00  0.121377 -0.010630 -0.043691
2012-01-01 00:09:00 -0.106814 -0.053819  0.097222
2012-01-01 00:12:00  0.032560  0.080543  0.167380
2012-01-01 00:15:00  0.060486 -0.057602 -0.106213
```

We can select a specific column or columns using standard getitem.

```
In [280]: r['A'].mean()
Out[280]:
2012-01-01 00:00:00   -0.038580
2012-01-01 00:03:00    0.052387
2012-01-01 00:06:00    0.121377
2012-01-01 00:09:00   -0.106814
2012-01-01 00:12:00    0.032560
2012-01-01 00:15:00    0.060486
Freq: 3T, Name: A, dtype: float64

In [281]: r[['A','B']].mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                            A         B
2012-01-01 00:00:00 -0.038580 -0.085117
2012-01-01 00:03:00  0.052387 -0.061477
2012-01-01 00:06:00  0.121377 -0.010630
2012-01-01 00:09:00 -0.106814 -0.053819
2012-01-01 00:12:00  0.032560  0.080543
2012-01-01 00:15:00  0.060486 -0.057602
```

You can pass a list or dict of functions to do aggregation with, outputting a `DataFrame`:

```
In [282]: r['A'].agg([np.sum, np.mean, np.std])
Out[282]:
                           sum      mean       std
2012-01-01 00:00:00  -6.944481 -0.038580  0.985150
2012-01-01 00:03:00   9.429707  0.052387  1.078022
2012-01-01 00:06:00  21.847876  0.121377  0.996365
2012-01-01 00:09:00 -19.226593 -0.106814  0.914070
2012-01-01 00:12:00   5.860874  0.032560  1.100055
2012-01-01 00:15:00   6.048588  0.060486  1.001532
```

On a resampled `DataFrame`, you can pass a list of functions to apply to each column, which produces an aggregated result with a hierarchical index:

```
In [283]: r.agg([np.sum, np.mean])
Out[283]:
                             A                    B                    C  \
                           sum      mean        sum      mean        sum
2012-01-01 00:00:00  -6.944481 -0.038580 -15.320993 -0.085117  -4.454941
2012-01-01 00:03:00   9.429707  0.052387 -11.065916 -0.061477   5.318688
2012-01-01 00:06:00  21.847876  0.121377  -1.913420 -0.010630  -7.864429
2012-01-01 00:09:00 -19.226593 -0.106814  -9.687468 -0.053819  17.499920
2012-01-01 00:12:00   5.860874  0.032560  14.497725  0.080543  30.128432
2012-01-01 00:15:00   6.048588  0.060486  -5.760208 -0.057602 -10.621260


                         mean
2012-01-01 00:00:00 -0.024750
2012-01-01 00:03:00  0.029548
2012-01-01 00:06:00 -0.043691
2012-01-01 00:09:00  0.097222
2012-01-01 00:12:00  0.167380
2012-01-01 00:15:00 -0.106213
```

By passing a dict to `aggregate` you can apply a different aggregation to the columns of a `DataFrame`:

```
In [284]: r.agg({'A' : np.sum,
   .....:        'B' : lambda x: np.std(x, ddof=1)})
   .....:
Out[284]:
                             A         B
2012-01-01 00:00:00  -6.944481  1.087752
2012-01-01 00:03:00   9.429707  1.014552
2012-01-01 00:06:00  21.847876  0.954588
2012-01-01 00:09:00 -19.226593  1.027990
2012-01-01 00:12:00   5.860874  1.021503
2012-01-01 00:15:00   6.048588  1.004984
```

The function names can also be strings. In order for a string to be valid it must be implemented on the Resampled object

```
In [285]: r.agg({'A' : 'sum', 'B' : 'std'})
Out[285]:
                             A         B
2012-01-01 00:00:00  -6.944481  1.087752
2012-01-01 00:03:00   9.429707  1.014552
2012-01-01 00:06:00  21.847876  0.954588
2012-01-01 00:09:00 -19.226593  1.027990
2012-01-01 00:12:00   5.860874  1.021503
```

```
2012-01-01 00:15:00   6.048588  1.004984
```

Furthermore, you can also specify multiple aggregation functions for each column separately.

```
In [286]: r.agg({'A' : ['sum','std'], 'B' : ['mean','std'] })
Out[286]: 
                             A                   B          
                           sum       std      mean       std
2012-01-01 00:00:00  -6.944481  0.985150 -0.085117  1.087752
2012-01-01 00:03:00   9.429707  1.078022 -0.061477  1.014552
2012-01-01 00:06:00  21.847876  0.996365 -0.010630  0.954588
2012-01-01 00:09:00 -19.226593  0.914070 -0.053819  1.027990
2012-01-01 00:12:00   5.860874  1.100055  0.080543  1.021503
2012-01-01 00:15:00   6.048588  1.001532 -0.057602  1.004984
```

If a `DataFrame` does not have a datetimelike index, but instead you want to resample based on datetimelike column in the frame, it can passed to the `on` keyword.

```
In [287]: df = pd.DataFrame({'date': pd.date_range('2015-01-01', freq='W', periods=5),
   .....:                    'a': np.arange(5)},
   .....:                   index=pd.MultiIndex.from_arrays([
   .....:                            [1,2,3,4,5],
   .....:                            pd.date_range('2015-01-01', freq='W',␣
↪periods=5)],
   .....:                        names=['v','d']))
   .....: 

In [288]: df
Out[288]: 
              a       date
v d                       
1 2015-01-04  0 2015-01-04
2 2015-01-11  1 2015-01-11
3 2015-01-18  2 2015-01-18
4 2015-01-25  3 2015-01-25
5 2015-02-01  4 2015-02-01

In [289]: df.resample('M', on='date').sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
            a
date         
2015-01-31  6
2015-02-28  4
```

Similarly, if you instead want to resample by a datetimelike level of `MultiIndex`, its name or location can be passed to the `level` keyword.

```
In [290]: df.resample('M', level='d').sum()
Out[290]: 
            a
d            
2015-01-31  6
2015-02-28  4
```

19.11 Time Span Representation

Regular intervals of time are represented by `Period` objects in pandas while sequences of `Period` objects are collected in a `PeriodIndex`, which can be created with the convenience function `period_range`.

19.11.1 Period

A `Period` represents a span of time (e.g., a day, a month, a quarter, etc). You can specify the span via `freq` keyword using a frequency alias like below. Because `freq` represents a span of `Period`, it cannot be negative like "-3D".

```
In [291]: pd.Period('2012', freq='A-DEC')
Out[291]: Period('2012', 'A-DEC')

In [292]: pd.Period('2012-1-1', freq='D')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[292]: Period('2012-01-01', 'D')

In [293]: pd.Period('2012-1-1 19:00', freq='H')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[293]:␣
↪Period('2012-01-01 19:00', 'H')

In [294]: pd.Period('2012-1-1 19:00', freq='5H')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Period('2012-01-01 19:00', '5H')
```

Adding and subtracting integers from periods shifts the period by its own frequency. Arithmetic is not allowed between `Period` with different `freq` (span).

```
In [295]: p = pd.Period('2012', freq='A-DEC')

In [296]: p + 1
Out[296]: Period('2013', 'A-DEC')

In [297]: p - 3
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[297]: Period('2009', 'A-DEC')

In [298]: p = pd.Period('2012-01', freq='2M')

In [299]: p + 2
Out[299]: Period('2012-05', '2M')

In [300]: p - 1
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[300]: Period('2011-11', '2M')

In [301]: p == pd.Period('2012-01', freq='3M')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\------------------
↪---------------------------------------------------------
IncompatibleFrequency                     Traceback (most recent call last)
<ipython-input-301-ff54ce3238f5> in <module>()
----> 1 p == pd.Period('2012-01', freq='3M')

~/Envs/pandas-dev/lib/python3.6/site-packages/pandas/pandas/_libs/period.pyx in␣
↪pandas._libs.period._Period.__richcmp__()

IncompatibleFrequency: Input has different freq=3M from Period(freq=2M)
```

If `Period` freq is daily or higher (`D`, `H`, `T`, `S`, `L`, `U`, `N`), `offsets` and `timedelta`-like can be added if the result can

have the same freq. Otherwise, `ValueError` will be raised.

```
In [302]: p = pd.Period('2014-07-01 09:00', freq='H')

In [303]: p + Hour(2)
Out[303]: Period('2014-07-01 11:00', 'H')

In [304]: p + timedelta(minutes=120)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[304]: Period('2014-07-01 11:00', 'H')

In [305]: p + np.timedelta64(7200, 's')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[305]:␣
↪Period('2014-07-01 11:00', 'H')
```

```
In [1]: p + Minute(5)
Traceback
   ...
ValueError: Input has different freq from Period(freq=H)
```

If `Period` has other freqs, only the same `offsets` can be added. Otherwise, `ValueError` will be raised.

```
In [306]: p = pd.Period('2014-07', freq='M')

In [307]: p + MonthEnd(3)
Out[307]: Period('2014-10', 'M')
```

```
In [1]: p + MonthBegin(3)
Traceback
   ...
ValueError: Input has different freq from Period(freq=M)
```

Taking the difference of `Period` instances with the same frequency will return the number of frequency units between them:

```
In [308]: pd.Period('2012', freq='A-DEC') - pd.Period('2002', freq='A-DEC')
Out[308]: 10
```

19.11.2 PeriodIndex and period_range

Regular sequences of `Period` objects can be collected in a `PeriodIndex`, which can be constructed using the `period_range` convenience function:

```
In [309]: prng = pd.period_range('1/1/2011', '1/1/2012', freq='M')

In [310]: prng
Out[310]: 
PeriodIndex(['2011-01', '2011-02', '2011-03', '2011-04', '2011-05', '2011-06',
             '2011-07', '2011-08', '2011-09', '2011-10', '2011-11', '2011-12',
             '2012-01'],
            dtype='period[M]', freq='M')
```

The `PeriodIndex` constructor can also be used directly:

```
In [311]: pd.PeriodIndex(['2011-1', '2011-2', '2011-3'], freq='M')
Out[311]: PeriodIndex(['2011-01', '2011-02', '2011-03'], dtype='period[M]', freq='M')
```

Passing multiplied frequency outputs a sequence of `Period` which has multiplied span.

```
In [312]: pd.PeriodIndex(start='2014-01', freq='3M', periods=4)
Out[312]: PeriodIndex(['2014-01', '2014-04', '2014-07', '2014-10'], dtype='period[3M]
↪', freq='3M')
```

If `start` or `end` are `Period` objects, they will be used as anchor endpoints for a `PeriodIndex` with frequency matching that of the `PeriodIndex` constructor.

```
In [313]: pd.PeriodIndex(start=pd.Period('2017Q1', freq='Q'),
   .....:                end=pd.Period('2017Q2', freq='Q'), freq='M')
   .....:
Out[313]: PeriodIndex(['2017-03', '2017-04', '2017-05', '2017-06'], dtype='period[M]',
↪ freq='M')
```

Just like `DatetimeIndex`, a `PeriodIndex` can also be used to index pandas objects:

```
In [314]: ps = pd.Series(np.random.randn(len(prng)), prng)

In [315]: ps
Out[315]:
2011-01    0.258318
2011-02   -2.503700
2011-03   -0.303053
2011-04    0.270509
2011-05    1.004841
2011-06   -0.129044
2011-07   -1.406335
2011-08   -1.310412
2011-09    0.769439
2011-10   -0.542325
2011-11    2.010541
2011-12    1.001558
2012-01   -0.087453
Freq: M, dtype: float64
```

`PeriodIndex` supports addition and subtraction with the same rule as `Period`.

```
In [316]: idx = pd.period_range('2014-07-01 09:00', periods=5, freq='H')

In [317]: idx
Out[317]:
PeriodIndex(['2014-07-01 09:00', '2014-07-01 10:00', '2014-07-01 11:00',
             '2014-07-01 12:00', '2014-07-01 13:00'],
            dtype='period[H]', freq='H')

In [318]: idx + Hour(2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
PeriodIndex(['2014-07-01 11:00', '2014-07-01 12:00', '2014-07-01 13:00',
             '2014-07-01 14:00', '2014-07-01 15:00'],
            dtype='period[H]', freq='H')

In [319]: idx = pd.period_range('2014-07', periods=5, freq='M')

In [320]: idx
Out[320]: PeriodIndex(['2014-07', '2014-08', '2014-09', '2014-10', '2014-11'], dtype=
↪'period[M]', freq='M')
```

```
In [321]: idx + MonthEnd(3)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪PeriodIndex(['2014-10', '2014-11', '2014-12', '2015-01', '2015-02'], dtype=
↪'period[M]', freq='M')
```

`PeriodIndex` has its own dtype named `period`, refer to *Period Dtypes*.

19.11.3 Period Dtypes

New in version 0.19.0.

`PeriodIndex` has a custom `period` dtype. This is a pandas extension dtype similar to the *timezone aware dtype* (`datetime64[ns, tz]`).

The `period` dtype holds the `freq` attribute and is represented with `period[freq]` like `period[D]` or `period[M]`, using *frequency strings*.

```
In [322]: pi = pd.period_range('2016-01-01', periods=3, freq='M')

In [323]: pi
Out[323]: PeriodIndex(['2016-01', '2016-02', '2016-03'], dtype='period[M]', freq='M')

In [324]: pi.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[324]:␣
↪period[M]
```

The `period` dtype can be used in `.astype(...)`. It allows one to change the `freq` of a `PeriodIndex` like `.asfreq()` and convert a `DatetimeIndex` to `PeriodIndex` like `to_period()`:

```
# change monthly freq to daily freq
In [325]: pi.astype('period[D]')
Out[325]: PeriodIndex(['2016-01-31', '2016-02-29', '2016-03-31'], dtype='period[D]',␣
↪freq='D')

# convert to DatetimeIndex
In [326]: pi.astype('datetime64[ns]')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[32
↪DatetimeIndex(['2016-01-01', '2016-02-01', '2016-03-01'], dtype='datetime64[ns]',␣
↪freq='MS')

# convert to PeriodIndex
In [327]: dti = pd.date_range('2011-01-01', freq='M', periods=3)

In [328]: dti
Out[328]: DatetimeIndex(['2011-01-31', '2011-02-28', '2011-03-31'], dtype=
↪'datetime64[ns]', freq='M')

In [329]: dti.astype('period[M]')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪PeriodIndex(['2011-01', '2011-02', '2011-03'], dtype='period[M]', freq='M')
```

19.11.4 PeriodIndex Partial String Indexing

You can pass in dates and strings to `Series` and `DataFrame` with `PeriodIndex`, in the same manner as `DatetimeIndex`. For details, refer to *DatetimeIndex Partial String Indexing*.

```
In [330]: ps['2011-01']
Out[330]: 0.25831819727391592

In [331]: ps[datetime(2011, 12, 25):]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[331]:
2011-12    1.001558
2012-01   -0.087453
Freq: M, dtype: float64

In [332]: ps['10/31/2011':'12/31/2011']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2011-10   -0.542325
2011-11    2.010541
2011-12    1.001558
Freq: M, dtype: float64
```

Passing a string representing a lower frequency than `PeriodIndex` returns partial sliced data.

```
In [333]: ps['2011']
Out[333]:
2011-01    0.258318
2011-02   -2.503700
2011-03   -0.303053
2011-04    0.270509
2011-05    1.004841
2011-06   -0.129044
2011-07   -1.406335
2011-08   -1.310412
2011-09    0.769439
2011-10   -0.542325
2011-11    2.010541
2011-12    1.001558
Freq: M, dtype: float64

In [334]: dfp = pd.DataFrame(np.random.randn(600,1),
   .....:                    columns=['A'],
   .....:                    index=pd.period_range('2013-01-01 9:00', periods=600,␣
↪freq='T'))
   .....:

In [335]: dfp
Out[335]:
                         A
2013-01-01 09:00  0.005210
2013-01-01 09:01 -0.014385
2013-01-01 09:02 -0.212404
2013-01-01 09:03 -1.227760
2013-01-01 09:04 -0.809722
2013-01-01 09:05 -1.719723
2013-01-01 09:06 -0.808486
...                    ...
2013-01-01 18:53 -0.783098
2013-01-01 18:54  0.755005
2013-01-01 18:55 -1.116732
2013-01-01 18:56 -0.940692
2013-01-01 18:57  0.228536
2013-01-01 18:58  0.109472
```

```
2013-01-01 18:59  0.235414

[600 rows x 1 columns]

In [336]: dfp['2013-01-01 10H']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                         A
2013-01-01 10:00 -0.148998
2013-01-01 10:01  2.154810
2013-01-01 10:02 -1.605646
2013-01-01 10:03  0.021024
2013-01-01 10:04 -0.623737
2013-01-01 10:05  1.451612
2013-01-01 10:06  1.062463
...                    ...
2013-01-01 10:53  0.273119
2013-01-01 10:54 -0.994071
2013-01-01 10:55 -1.222179
2013-01-01 10:56 -1.167118
2013-01-01 10:57  0.262822
2013-01-01 10:58 -0.283786
2013-01-01 10:59  1.190726

[60 rows x 1 columns]
```

As with `DatetimeIndex`, the endpoints will be included in the result. The example below slices data starting from 10:00 to 11:59.

```
In [337]: dfp['2013-01-01 10H':'2013-01-01 11H']
Out[337]:
                         A
2013-01-01 10:00 -0.148998
2013-01-01 10:01  2.154810
2013-01-01 10:02 -1.605646
2013-01-01 10:03  0.021024
2013-01-01 10:04 -0.623737
2013-01-01 10:05  1.451612
2013-01-01 10:06  1.062463
...                    ...
2013-01-01 11:53 -1.477914
2013-01-01 11:54  0.594465
2013-01-01 11:55 -0.903243
2013-01-01 11:56  1.182131
2013-01-01 11:57  0.621345
2013-01-01 11:58 -0.996113
2013-01-01 11:59 -0.191659

[120 rows x 1 columns]
```

19.11.5 Frequency Conversion and Resampling with PeriodIndex

The frequency of `Period` and `PeriodIndex` can be converted via the `asfreq` method. Let's start with the fiscal year 2011, ending in December:

```
In [338]: p = pd.Period('2011', freq='A-DEC')

In [339]: p
Out[339]: Period('2011', 'A-DEC')
```

We can convert it to a monthly frequency. Using the `how` parameter, we can specify whether to return the starting or ending month:

```
In [340]: p.asfreq('M', how='start')
Out[340]: Period('2011-01', 'M')

In [341]: p.asfreq('M', how='end')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[341]: Period('2011-12', 'M')
```

The shorthands 's' and 'e' are provided for convenience:

```
In [342]: p.asfreq('M', 's')
Out[342]: Period('2011-01', 'M')

In [343]: p.asfreq('M', 'e')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[343]: Period('2011-12', 'M')
```

Converting to a "super-period" (e.g., annual frequency is a super-period of quarterly frequency) automatically returns the super-period that includes the input period:

```
In [344]: p = pd.Period('2011-12', freq='M')

In [345]: p.asfreq('A-NOV')
Out[345]: Period('2012', 'A-NOV')
```

Note that since we converted to an annual frequency that ends the year in November, the monthly period of December 2011 is actually in the 2012 A-NOV period. Period conversions with anchored frequencies are particularly useful for working with various quarterly data common to economics, business, and other fields. Many organizations define quarters relative to the month in which their fiscal year starts and ends. Thus, first quarter of 2011 could start in 2010 or a few months into 2011. Via anchored frequencies, pandas works for all quarterly frequencies `Q-JAN` through `Q-DEC`.

`Q-DEC` define regular calendar quarters:

```
In [346]: p = pd.Period('2012Q1', freq='Q-DEC')

In [347]: p.asfreq('D', 's')
Out[347]: Period('2012-01-01', 'D')

In [348]: p.asfreq('D', 'e')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[348]: Period('2012-03-31', 'D')
```

`Q-MAR` defines fiscal year end in March:

```
In [349]: p = pd.Period('2011Q4', freq='Q-MAR')

In [350]: p.asfreq('D', 's')
Out[350]: Period('2011-01-01', 'D')

In [351]: p.asfreq('D', 'e')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[351]: Period('2011-03-31', 'D')
```

19.12 Converting Between Representations

Timestamped data can be converted to PeriodIndex-ed data using `to_period` and vice-versa using `to_timestamp`:

```
In [352]: rng = pd.date_range('1/1/2012', periods=5, freq='M')

In [353]: ts = pd.Series(np.random.randn(len(rng)), index=rng)

In [354]: ts
Out[354]:
2012-01-31   -0.898547
2012-02-29   -1.332247
2012-03-31   -0.741645
2012-04-30    0.094321
2012-05-31   -0.438813
Freq: M, dtype: float64

In [355]: ps = ts.to_period()

In [356]: ps
Out[356]:
2012-01   -0.898547
2012-02   -1.332247
2012-03   -0.741645
2012-04    0.094321
2012-05   -0.438813
Freq: M, dtype: float64

In [357]: ps.to_timestamp()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
2012-01-01   -0.898547
2012-02-01   -1.332247
2012-03-01   -0.741645
2012-04-01    0.094321
2012-05-01   -0.438813
Freq: MS, dtype: float64
```

Remember that ‘s’ and ‘e’ can be used to return the timestamps at the start or end of the period:

```
In [358]: ps.to_timestamp('D', how='s')
Out[358]:
2012-01-01   -0.898547
2012-02-01   -1.332247
2012-03-01   -0.741645
2012-04-01    0.094321
2012-05-01   -0.438813
Freq: MS, dtype: float64
```

Converting between period and timestamp enables some convenient arithmetic functions to be used. In the following example, we convert a quarterly frequency with year ending in November to 9am of the end of the month following the quarter end:

```
In [359]: prng = pd.period_range('1990Q1', '2000Q4', freq='Q-NOV')

In [360]: ts = pd.Series(np.random.randn(len(prng)), prng)
```

```
In [361]: ts.index = (prng.asfreq('M', 'e') + 1).asfreq('H', 's') + 9

In [362]: ts.head()
Out[362]:
1990-03-01 09:00   -0.564874
1990-06-01 09:00   -1.426510
1990-09-01 09:00    1.295437
1990-12-01 09:00    1.124017
1991-03-01 09:00    0.840428
Freq: H, dtype: float64
```

19.13 Representing Out-of-Bounds Spans

If you have data that is outside of the `Timestamp` bounds, see *Timestamp limitations*, then you can use a `PeriodIndex` and/or `Series` of `Periods` to do computations.

```
In [363]: span = pd.period_range('1215-01-01', '1381-01-01', freq='D')

In [364]: span
Out[364]:
PeriodIndex(['1215-01-01', '1215-01-02', '1215-01-03', '1215-01-04',
             '1215-01-05', '1215-01-06', '1215-01-07', '1215-01-08',
             '1215-01-09', '1215-01-10',
             ...
             '1380-12-23', '1380-12-24', '1380-12-25', '1380-12-26',
             '1380-12-27', '1380-12-28', '1380-12-29', '1380-12-30',
             '1380-12-31', '1381-01-01'],
            dtype='period[D]', length=60632, freq='D')
```

To convert from an `int64` based YYYYMMDD representation.

```
In [365]: s = pd.Series([20121231, 20141130, 99991231])

In [366]: s
Out[366]:
0    20121231
1    20141130
2    99991231
dtype: int64

In [367]: def conv(x):
   .....:     return pd.Period(year = x // 10000, month = x//100 % 100, day = x%100,␣
↪freq='D')
   .....:

In [368]: s.apply(conv)
Out[368]:
0   2012-12-31
1   2014-11-30
2   9999-12-31
dtype: object

In [369]: s.apply(conv)[2]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[369]:␣
↪Period('9999-12-31', 'D')
```

These can easily be converted to a `PeriodIndex`

```
In [370]: span = pd.PeriodIndex(s.apply(conv))

In [371]: span
Out[371]: PeriodIndex(['2012-12-31', '2014-11-30', '9999-12-31'], dtype='period[D]',␣
↪freq='D')
```

19.14 Time Zone Handling

Pandas provides rich support for working with timestamps in different time zones using `pytz` and `dateutil` libraries. `dateutil` currently is only supported for fixed offset and tzfile zones. The default library is `pytz`. Support for `dateutil` is provided for compatibility with other applications e.g. if you use `dateutil` in other python packages.

19.14.1 Working with Time Zones

By default, pandas objects are time zone unaware:

```
In [372]: rng = pd.date_range('3/6/2012 00:00', periods=15, freq='D')

In [373]: rng.tz is None
Out[373]: True
```

To supply the time zone, you can use the `tz` keyword to `date_range` and other functions. Dateutil time zone strings are distinguished from `pytz` time zones by starting with `dateutil/`.

- In `pytz` you can find a list of common (and less common) time zones using `from pytz import common_timezones, all_timezones`.
- `dateutil` uses the OS timezones so there isn't a fixed list available. For common zones, the names are the same as `pytz`.

```
# pytz
In [374]: rng_pytz = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
   .....:                          tz='Europe/London')
   .....:

In [375]: rng_pytz.tz
Out[375]: <DstTzInfo 'Europe/London' LMT-1 day, 23:59:00 STD>

# dateutil
In [376]: rng_dateutil = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
   .....:                              tz='dateutil/Europe/London')
   .....:

In [377]: rng_dateutil.tz
Out[377]: tzfile('/usr/share/zoneinfo/Europe/London')

# dateutil - utc special case
In [378]: rng_utc = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
   .....:                         tz=dateutil.tz.tzutc())
   .....:
```

```
In [379]: rng_utc.tz
Out[379]: tzutc()
```

Note that the `UTC` timezone is a special case in `dateutil` and should be constructed explicitly as an instance of `dateutil.tz.tzutc`. You can also construct other timezones explicitly first, which gives you more control over which time zone is used:

```
# pytz
In [380]: tz_pytz = pytz.timezone('Europe/London')

In [381]: rng_pytz = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
   .....:                          tz=tz_pytz)
   .....:

In [382]: rng_pytz.tz == tz_pytz
Out[382]: True

# dateutil
In [383]: tz_dateutil = dateutil.tz.gettz('Europe/London')

In [384]: rng_dateutil = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
   .....:                              tz=tz_dateutil)
   .....:

In [385]: rng_dateutil.tz == tz_dateutil
Out[385]: True
```

Timestamps, like Python's `datetime.datetime` object can be either time zone naive or time zone aware. Naive time series and `DatetimeIndex` objects can be *localized* using `tz_localize`:

```
In [386]: ts = pd.Series(np.random.randn(len(rng)), rng)

In [387]: ts_utc = ts.tz_localize('UTC')

In [388]: ts_utc
Out[388]:
2012-03-06 00:00:00+00:00    0.037206
2012-03-07 00:00:00+00:00    2.313998
2012-03-08 00:00:00+00:00    1.458296
2012-03-09 00:00:00+00:00   -0.620431
2012-03-10 00:00:00+00:00   -0.000111
2012-03-11 00:00:00+00:00   -0.342783
2012-03-12 00:00:00+00:00   -0.664322
2012-03-13 00:00:00+00:00    0.654814
2012-03-14 00:00:00+00:00    1.550680
2012-03-15 00:00:00+00:00    0.174511
2012-03-16 00:00:00+00:00    1.360491
2012-03-17 00:00:00+00:00    0.799737
2012-03-18 00:00:00+00:00    0.449149
2012-03-19 00:00:00+00:00    0.111346
2012-03-20 00:00:00+00:00   -0.435531
Freq: D, dtype: float64
```

Again, you can explicitly construct the timezone object first. You can use the `tz_convert` method to convert pandas objects to convert tz-aware data to another time zone:

```
In [389]: ts_utc.tz_convert('US/Eastern')
Out[389]:
2012-03-05 19:00:00-05:00    0.037206
2012-03-06 19:00:00-05:00    2.313998
2012-03-07 19:00:00-05:00    1.458296
2012-03-08 19:00:00-05:00   -0.620431
2012-03-09 19:00:00-05:00   -0.000111
2012-03-10 19:00:00-05:00   -0.342783
2012-03-11 20:00:00-04:00   -0.664322
2012-03-12 20:00:00-04:00    0.654814
2012-03-13 20:00:00-04:00    1.550680
2012-03-14 20:00:00-04:00    0.174511
2012-03-15 20:00:00-04:00    1.360491
2012-03-16 20:00:00-04:00    0.799737
2012-03-17 20:00:00-04:00    0.449149
2012-03-18 20:00:00-04:00    0.111346
2012-03-19 20:00:00-04:00   -0.435531
Freq: D, dtype: float64
```

Warning: Be wary of conversions between libraries. For some zones `pytz` and `dateutil` have different definitions of the zone. This is more of a problem for unusual timezones than for 'standard' zones like `US/Eastern`.

Warning: Be aware that a timezone definition across versions of timezone libraries may not be considered equal. This may cause problems when working with stored data that is localized using one version and operated on with a different version. See *here* for how to handle such a situation.

Warning: It is incorrect to pass a timezone directly into the `datetime.datetime` constructor (e.g., `datetime.datetime(2011, 1, 1, tz=timezone('US/Eastern'))`. Instead, the datetime needs to be localized using the the localize method on the timezone.

Under the hood, all timestamps are stored in UTC. Scalar values from a `DatetimeIndex` with a time zone will have their fields (day, hour, minute) localized to the time zone. However, timestamps with the same UTC value are still considered to be equal even if they are in different time zones:

```
In [390]: rng_eastern = rng_utc.tz_convert('US/Eastern')

In [391]: rng_berlin = rng_utc.tz_convert('Europe/Berlin')

In [392]: rng_eastern[5]
Out[392]: Timestamp('2012-03-10 19:00:00-0500', tz='US/Eastern', freq='D')

In [393]: rng_berlin[5]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[393]:␣
↪Timestamp('2012-03-11 01:00:00+0100', tz='Europe/Berlin', freq='D')

In [394]: rng_eastern[5] == rng_berlin[5]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪True
```

Like `Series`, `DataFrame`, and `DatetimeIndex`, ``` Timestamp``s can be converted to other ```

`time zones using ``tz_convert:`

```
In [395]: rng_eastern[5]
Out[395]: Timestamp('2012-03-10 19:00:00-0500', tz='US/Eastern', freq='D')

In [396]: rng_berlin[5]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[396]:␣
↪Timestamp('2012-03-11 01:00:00+0100', tz='Europe/Berlin', freq='D')

In [397]: rng_eastern[5].tz_convert('Europe/Berlin')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timestamp('2012-03-11 01:00:00+0100', tz='Europe/Berlin')
```

Localization of `Timestamp` functions just like `DatetimeIndex` and `Series`:

```
In [398]: rng[5]
Out[398]: Timestamp('2012-03-11 00:00:00', freq='D')

In [399]: rng[5].tz_localize('Asia/Shanghai')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[399]: Timestamp('2012-03-11␣
↪00:00:00+0800', tz='Asia/Shanghai')
```

Operations between `Series` in different time zones will yield UTC `Series`, aligning the data on the UTC timestamps:

```
In [400]: eastern = ts_utc.tz_convert('US/Eastern')

In [401]: berlin = ts_utc.tz_convert('Europe/Berlin')

In [402]: result = eastern + berlin

In [403]: result
Out[403]: 
2012-03-06 00:00:00+00:00    0.074412
2012-03-07 00:00:00+00:00    4.627997
2012-03-08 00:00:00+00:00    2.916592
2012-03-09 00:00:00+00:00   -1.240863
2012-03-10 00:00:00+00:00   -0.000221
2012-03-11 00:00:00+00:00   -0.685566
2012-03-12 00:00:00+00:00   -1.328643
2012-03-13 00:00:00+00:00    1.309628
2012-03-14 00:00:00+00:00    3.101359
2012-03-15 00:00:00+00:00    0.349022
2012-03-16 00:00:00+00:00    2.720983
2012-03-17 00:00:00+00:00    1.599475
2012-03-18 00:00:00+00:00    0.898297
2012-03-19 00:00:00+00:00    0.222691
2012-03-20 00:00:00+00:00   -0.871062
Freq: D, dtype: float64

In [404]: result.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2012-03-06', '2012-03-07', '2012-03-08', '2012-03-09',
               '2012-03-10', '2012-03-11', '2012-03-12', '2012-03-13',
               '2012-03-14', '2012-03-15', '2012-03-16', '2012-03-17',
               '2012-03-18', '2012-03-19', '2012-03-20'],
              dtype='datetime64[ns, UTC]', freq='D')
```

To remove timezone from tz-aware `DatetimeIndex`, use `tz_localize(None)` or `tz_convert(None)`. `tz_localize(None)` will remove timezone holding local time representations. `tz_convert(None)` will remove timezone after converting to UTC time.

```
In [405]: didx = pd.DatetimeIndex(start='2014-08-01 09:00', freq='H', periods=10, tz=
↪'US/Eastern')

In [406]: didx
Out[406]: 
DatetimeIndex(['2014-08-01 09:00:00-04:00', '2014-08-01 10:00:00-04:00',
               '2014-08-01 11:00:00-04:00', '2014-08-01 12:00:00-04:00',
               '2014-08-01 13:00:00-04:00', '2014-08-01 14:00:00-04:00',
               '2014-08-01 15:00:00-04:00', '2014-08-01 16:00:00-04:00',
               '2014-08-01 17:00:00-04:00', '2014-08-01 18:00:00-04:00'],
              dtype='datetime64[ns, US/Eastern]', freq='H')

In [407]: didx.tz_localize(None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2014-08-01 09:00:00', '2014-08-01 10:00:00',
               '2014-08-01 11:00:00', '2014-08-01 12:00:00',
               '2014-08-01 13:00:00', '2014-08-01 14:00:00',
               '2014-08-01 15:00:00', '2014-08-01 16:00:00',
               '2014-08-01 17:00:00', '2014-08-01 18:00:00'],
              dtype='datetime64[ns]', freq='H')

In [408]: didx.tz_convert(None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2014-08-01 13:00:00', '2014-08-01 14:00:00',
               '2014-08-01 15:00:00', '2014-08-01 16:00:00',
               '2014-08-01 17:00:00', '2014-08-01 18:00:00',
               '2014-08-01 19:00:00', '2014-08-01 20:00:00',
               '2014-08-01 21:00:00', '2014-08-01 22:00:00'],
              dtype='datetime64[ns]', freq='H')

# tz_convert(None) is identical with tz_convert('UTC').tz_localize(None)
In [409]: didx.tz_convert('UCT').tz_localize(None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2014-08-01 13:00:00', '2014-08-01 14:00:00',
               '2014-08-01 15:00:00', '2014-08-01 16:00:00',
               '2014-08-01 17:00:00', '2014-08-01 18:00:00',
               '2014-08-01 19:00:00', '2014-08-01 20:00:00',
               '2014-08-01 21:00:00', '2014-08-01 22:00:00'],
              dtype='datetime64[ns]', freq='H')
```

19.14.2 Ambiguous Times when Localizing

In some cases, localize cannot determine the DST and non-DST hours when there are duplicates. This often happens when reading files or database records that simply duplicate the hours. Passing `ambiguous='infer'` (`infer_dst` argument in prior releases) into `tz_localize` will attempt to determine the right offset. Below the top example will fail as it contains ambiguous times and the bottom will infer the right offset.

```
In [410]: rng_hourly = pd.DatetimeIndex(['11/06/2011 00:00', '11/06/2011 01:00',
   .....:                                '11/06/2011 01:00', '11/06/2011 02:00',
```

```
  .....:                                  '11/06/2011 03:00'])
  .....:
```

This will fail as there are ambiguous times

```
In [2]: rng_hourly.tz_localize('US/Eastern')
AmbiguousTimeError: Cannot infer dst time from Timestamp('2011-11-06 01:00:00'), try␣
↪using the 'ambiguous' argument
```

Infer the ambiguous times

```
In [411]: rng_hourly_eastern = rng_hourly.tz_localize('US/Eastern', ambiguous='infer')

In [412]: rng_hourly_eastern.tolist()
Out[412]:
[Timestamp('2011-11-06 00:00:00-0400', tz='US/Eastern'),
 Timestamp('2011-11-06 01:00:00-0400', tz='US/Eastern'),
 Timestamp('2011-11-06 01:00:00-0500', tz='US/Eastern'),
 Timestamp('2011-11-06 02:00:00-0500', tz='US/Eastern'),
 Timestamp('2011-11-06 03:00:00-0500', tz='US/Eastern')]
```

In addition to 'infer', there are several other arguments supported. Passing an array-like of bools or 0s/1s where True represents a DST hour and False a non-DST hour, allows for distinguishing more than one DST transition (e.g., if you have multiple records in a database each with their own DST transition). Or passing 'NaT' will fill in transition times with not-a-time values. These methods are available in the `DatetimeIndex` constructor as well as `tz_localize`.

```
In [413]: rng_hourly_dst = np.array([1, 1, 0, 0, 0])

In [414]: rng_hourly.tz_localize('US/Eastern', ambiguous=rng_hourly_dst).tolist()
Out[414]:
[Timestamp('2011-11-06 00:00:00-0400', tz='US/Eastern'),
 Timestamp('2011-11-06 01:00:00-0400', tz='US/Eastern'),
 Timestamp('2011-11-06 01:00:00-0500', tz='US/Eastern'),
 Timestamp('2011-11-06 02:00:00-0500', tz='US/Eastern'),
 Timestamp('2011-11-06 03:00:00-0500', tz='US/Eastern')]

In [415]: rng_hourly.tz_localize('US/Eastern', ambiguous='NaT').tolist()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
[Timestamp('2011-11-06 00:00:00-0400', tz='US/Eastern'),
 NaT,
 NaT,
 Timestamp('2011-11-06 02:00:00-0500', tz='US/Eastern'),
 Timestamp('2011-11-06 03:00:00-0500', tz='US/Eastern')]

In [416]: didx = pd.DatetimeIndex(start='2014-08-01 09:00', freq='H', periods=10, tz=
↪'US/Eastern')

In [417]: didx
Out[417]:
DatetimeIndex(['2014-08-01 09:00:00-04:00', '2014-08-01 10:00:00-04:00',
               '2014-08-01 11:00:00-04:00', '2014-08-01 12:00:00-04:00',
               '2014-08-01 13:00:00-04:00', '2014-08-01 14:00:00-04:00',
               '2014-08-01 15:00:00-04:00', '2014-08-01 16:00:00-04:00',
               '2014-08-01 17:00:00-04:00', '2014-08-01 18:00:00-04:00'],
              dtype='datetime64[ns, US/Eastern]', freq='H')

In [418]: didx.tz_localize(None)
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2014-08-01 09:00:00', '2014-08-01 10:00:00',
               '2014-08-01 11:00:00', '2014-08-01 12:00:00',
               '2014-08-01 13:00:00', '2014-08-01 14:00:00',
               '2014-08-01 15:00:00', '2014-08-01 16:00:00',
               '2014-08-01 17:00:00', '2014-08-01 18:00:00'],
              dtype='datetime64[ns]', freq='H')

In [419]: didx.tz_convert(None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2014-08-01 13:00:00', '2014-08-01 14:00:00',
               '2014-08-01 15:00:00', '2014-08-01 16:00:00',
               '2014-08-01 17:00:00', '2014-08-01 18:00:00',
               '2014-08-01 19:00:00', '2014-08-01 20:00:00',
               '2014-08-01 21:00:00', '2014-08-01 22:00:00'],
              dtype='datetime64[ns]', freq='H')

# tz_convert(None) is identical with tz_convert('UTC').tz_localize(None)
In [420]: didx.tz_convert('UCT').tz_localize(None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
DatetimeIndex(['2014-08-01 13:00:00', '2014-08-01 14:00:00',
               '2014-08-01 15:00:00', '2014-08-01 16:00:00',
               '2014-08-01 17:00:00', '2014-08-01 18:00:00',
               '2014-08-01 19:00:00', '2014-08-01 20:00:00',
               '2014-08-01 21:00:00', '2014-08-01 22:00:00'],
              dtype='datetime64[ns]', freq='H')
```

19.14.3 TZ Aware Dtypes

New in version 0.17.0.

`Series/DatetimeIndex` with a timezone **naive** value are represented with a dtype of `datetime64[ns]`.

```
In [421]: s_naive = pd.Series(pd.date_range('20130101',periods=3))

In [422]: s_naive
Out[422]:
0   2013-01-01
1   2013-01-02
2   2013-01-03
dtype: datetime64[ns]
```

`Series/DatetimeIndex` with a timezone **aware** value are represented with a dtype of `datetime64[ns, tz]`.

```
In [423]: s_aware = pd.Series(pd.date_range('20130101',periods=3,tz='US/Eastern'))

In [424]: s_aware
Out[424]:
0   2013-01-01 00:00:00-05:00
1   2013-01-02 00:00:00-05:00
2   2013-01-03 00:00:00-05:00
dtype: datetime64[ns, US/Eastern]
```

Both of these `Series` can be manipulated via the `.dt` accessor, see *here*.

For example, to localize and convert a naive stamp to timezone aware.

```
In [425]: s_naive.dt.tz_localize('UTC').dt.tz_convert('US/Eastern')
Out[425]: 
0   2012-12-31 19:00:00-05:00
1   2013-01-01 19:00:00-05:00
2   2013-01-02 19:00:00-05:00
dtype: datetime64[ns, US/Eastern]
```

Further more you can `.astype(...)` timezone aware (and naive). This operation is effectively a localize AND convert on a naive stamp, and a convert on an aware stamp.

```
# localize and convert a naive timezone
In [426]: s_naive.astype('datetime64[ns, US/Eastern]')
Out[426]: 
0   2012-12-31 19:00:00-05:00
1   2013-01-01 19:00:00-05:00
2   2013-01-02 19:00:00-05:00
dtype: datetime64[ns, US/Eastern]

# make an aware tz naive
In [427]: s_aware.astype('datetime64[ns]')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2013-01-01 05:00:00
1   2013-01-02 05:00:00
2   2013-01-03 05:00:00
dtype: datetime64[ns]

# convert to a new timezone
In [428]: s_aware.astype('datetime64[ns, CET]')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2013-01-01 06:00:00+01:00
1   2013-01-02 06:00:00+01:00
2   2013-01-03 06:00:00+01:00
dtype: datetime64[ns, CET]
```

Note: Using the `.values` accessor on a `Series`, returns an numpy array of the data. These values are converted to UTC, as numpy does not currently support timezones (even though it is *printing* in the local timezone!).

```
In [429]: s_naive.values
Out[429]: 
array(['2013-01-01T00:00:00.000000000', '2013-01-02T00:00:00.000000000',
       '2013-01-03T00:00:00.000000000'], dtype='datetime64[ns]')

In [430]: s_aware.values
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
array(['2013-01-01T05:00:00.000000000', '2013-01-02T05:00:00.000000000',
       '2013-01-03T05:00:00.000000000'], dtype='datetime64[ns]')
```

Further note that once converted to a numpy array these would lose the tz tenor.

```
In [431]: pd.Series(s_aware.values)
Out[431]: 
```

```
0   2013-01-01 05:00:00
1   2013-01-02 05:00:00
2   2013-01-03 05:00:00
dtype: datetime64[ns]
```

However, these can be easily converted

```
In [432]: pd.Series(s_aware.values).dt.tz_localize('UTC').dt.tz_convert('US/Eastern')
Out[432]:
0   2013-01-01 00:00:00-05:00
1   2013-01-02 00:00:00-05:00
2   2013-01-03 00:00:00-05:00
dtype: datetime64[ns, US/Eastern]
```

CHAPTER

TWENTY

TIME DELTAS

Timedeltas are differences in times, expressed in difference units, e.g. days, hours, minutes, seconds. They can be both positive and negative.

`Timedelta` is a subclass of `datetime.timedelta`, and behaves in a similar manner, but allows compatibility with `np.timedelta64` types as well as a host of custom representation, parsing, and attributes.

20.1 Parsing

You can construct a `Timedelta` scalar through various arguments:

```
# strings
In [1]: pd.Timedelta('1 days')
Out[1]: Timedelta('1 days 00:00:00')

In [2]: pd.Timedelta('1 days 00:00:00')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[2]: Timedelta('1 days 00:00:00')

In [3]: pd.Timedelta('1 days 2 hours')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[3]:␣
↪Timedelta('1 days 02:00:00')

In [4]: pd.Timedelta('-1 days 2 min 3us')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('-2 days +23:57:59.999997')

# like datetime.timedelta
# note: these MUST be specified as keyword arguments
In [5]: pd.Timedelta(days=1, seconds=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('1 days 00:00:01')

# integers with a unit
In [6]: pd.Timedelta(1, unit='d')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('1 days 00:00:00')

# from a datetime.timedelta/np.timedelta64
In [7]: pd.Timedelta(datetime.timedelta(days=1, seconds=1))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('1 days 00:00:01')

In [8]: pd.Timedelta(np.timedelta64(1, 'ms'))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('0 days 00:00:00.001000')
```

```
# negative Timedeltas have this string repr
# to be more consistent with datetime.timedelta conventions
In [9]: pd.Timedelta('-1us')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('-1 days +23:59:59.999999')

# a NaT
In [10]: pd.Timedelta('nan')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪NaT

In [11]: pd.Timedelta('nat')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪NaT
```

DateOffsets (`Day, Hour, Minute, Second, Milli, Micro, Nano`) can also be used in construction.

```
In [12]: pd.Timedelta(Second(2))
Out[12]: Timedelta('0 days 00:00:02')
```

Further, operations among the scalars yield another scalar `Timedelta`.

```
In [13]: pd.Timedelta(Day(2)) + pd.Timedelta(Second(2)) + pd.Timedelta('00:00:00.
↪000123')
Out[13]: Timedelta('2 days 00:00:02.000123')
```

20.1.1 to_timedelta

Using the top-level `pd.to_timedelta`, you can convert a scalar, array, list, or Series from a recognized timedelta format / value into a `Timedelta` type. It will construct Series if the input is a Series, a scalar if the input is scalar-like, otherwise it will output a `TimedeltaIndex`.

You can parse a single string to a Timedelta:

```
In [14]: pd.to_timedelta('1 days 06:05:01.00003')
Out[14]: Timedelta('1 days 06:05:01.000030')

In [15]: pd.to_timedelta('15.5us')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[15]: Timedelta('0 days 00:00:00.
↪000015')
```

or a list/array of strings:

```
In [16]: pd.to_timedelta(['1 days 06:05:01.00003', '15.5us', 'nan'])
Out[16]: TimedeltaIndex(['1 days 06:05:01.000030', '0 days 00:00:00.000015', NaT],␣
↪dtype='timedelta64[ns]', freq=None)
```

The `unit` keyword argument specifies the unit of the Timedelta:

```
In [17]: pd.to_timedelta(np.arange(5), unit='s')
Out[17]: TimedeltaIndex(['00:00:00', '00:00:01', '00:00:02', '00:00:03', '00:00:04'],␣
↪dtype='timedelta64[ns]', freq=None)

In [18]: pd.to_timedelta(np.arange(5), unit='d')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪TimedeltaIndex(['0 days', '1 days', '2 days', '3 days', '4 days'], dtype=
↪'timedelta64[ns]', freq=None)
```

20.1.2 Timedelta limitations

Pandas represents `Timedeltas` in nanosecond resolution using 64 bit integers. As such, the 64 bit integer limits determine the `Timedelta` limits.

```
In [19]: pd.Timedelta.min
Out[19]: Timedelta('-106752 days +00:12:43.145224')

In [20]: pd.Timedelta.max
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[20]: Timedelta('106751 days␣
↪23:47:16.854775')
```

20.2 Operations

You can operate on Series/DataFrames and construct `timedelta64[ns]` Series through subtraction operations on `datetime64[ns]` Series, or `Timestamps`.

```
In [21]: s = pd.Series(pd.date_range('2012-1-1', periods=3, freq='D'))

In [22]: td = pd.Series([ pd.Timedelta(days=i) for i in range(3) ])

In [23]: df = pd.DataFrame(dict(A = s, B = td))

In [24]: df
Out[24]:
           A      B
0 2012-01-01 0 days
1 2012-01-02 1 days
2 2012-01-03 2 days

In [25]: df['C'] = df['A'] + df['B']

In [26]: df
Out[26]:
           A      B          C
0 2012-01-01 0 days 2012-01-01
1 2012-01-02 1 days 2012-01-03
2 2012-01-03 2 days 2012-01-05

In [27]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A      datetime64[ns]
B     timedelta64[ns]
C      datetime64[ns]
dtype: object

In [28]: s - s.max()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   -2 days
1   -1 days
2    0 days
```

```
dtype: timedelta64[ns]

In [29]: s - datetime.datetime(2011, 1, 1, 3, 5)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   364 days 20:55:00
1   365 days 20:55:00
2   366 days 20:55:00
dtype: timedelta64[ns]

In [30]: s + datetime.timedelta(minutes=5)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2012-01-01 00:05:00
1   2012-01-02 00:05:00
2   2012-01-03 00:05:00
dtype: datetime64[ns]

In [31]: s + Minute(5)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2012-01-01 00:05:00
1   2012-01-02 00:05:00
2   2012-01-03 00:05:00
dtype: datetime64[ns]

In [32]: s + Minute(5) + Milli(5)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2012-01-01 00:05:00.005
1   2012-01-02 00:05:00.005
2   2012-01-03 00:05:00.005
dtype: datetime64[ns]
```

Operations with scalars from a `timedelta64[ns]` series:

```
In [33]: y = s - s[0]

In [34]: y
Out[34]:
0   0 days
1   1 days
2   2 days
dtype: timedelta64[ns]
```

Series of timedeltas with `NaT` values are supported:

```
In [35]: y = s - s.shift()

In [36]: y
Out[36]:
0      NaT
1   1 days
2   1 days
dtype: timedelta64[ns]
```

Elements can be set to `NaT` using `np.nan` analogously to datetimes:

```
In [37]: y[1] = np.nan

In [38]: y
Out[38]:
0       NaT
1       NaT
2    1 days
dtype: timedelta64[ns]
```

Operands can also appear in a reversed order (a singular object operated with a Series):

```
In [39]: s.max() - s
Out[39]:
0   2 days
1   1 days
2   0 days
dtype: timedelta64[ns]

In [40]: datetime.datetime(2011, 1, 1, 3, 5) - s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[40]:
0   -365 days +03:05:00
1   -366 days +03:05:00
2   -367 days +03:05:00
dtype: timedelta64[ns]

In [41]: datetime.timedelta(minutes=5) + s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   2012-01-01 00:05:00
1   2012-01-02 00:05:00
2   2012-01-03 00:05:00
dtype: datetime64[ns]
```

`min, max` and the corresponding `idxmin, idxmax` operations are supported on frames:

```
In [42]: A = s - pd.Timestamp('20120101') - pd.Timedelta('00:05:05')

In [43]: B = s - pd.Series(pd.date_range('2012-1-2', periods=3, freq='D'))

In [44]: df = pd.DataFrame(dict(A=A, B=B))

In [45]: df
Out[45]:
                  A       B
0 -1 days +23:54:55 -1 days
1   0 days 23:54:55 -1 days
2   1 days 23:54:55 -1 days

In [46]: df.min()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A   -1 days +23:54:55
B   -1 days +00:00:00
dtype: timedelta64[ns]

In [47]: df.min(axis=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
0   -1 days
1   -1 days
2   -1 days
dtype: timedelta64[ns]

In [48]: df.idxmin()
\\\
```

You can also negate, multiply and use `abs` on `Timedeltas`:

```
In [57]: td1 = pd.Timedelta('-1 days 2 hours 3 seconds')

In [58]: td1
Out[58]: Timedelta('-2 days +21:59:57')

In [59]: -1 * td1
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[59]: Timedelta('1 days 02:00:03')

In [60]: - td1
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[60]:␣
↪Timedelta('1 days 02:00:03')

In [61]: abs(td1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('1 days 02:00:03')
```

20.3 Reductions

Numeric reduction operation for `timedelta64[ns]` will return `Timedelta` objects. As usual `NaT` are skipped during evaluation.

```
In [62]: y2 = pd.Series(pd.to_timedelta(['-1 days +00:00:05', 'nat', '-1 days␣
↪+00:00:05', '1 days']))

In [63]: y2
Out[63]:
0   -1 days +00:00:05
1                 NaT
2   -1 days +00:00:05
3     1 days 00:00:00
dtype: timedelta64[ns]

In [64]: y2.mean()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('-1 days +16:00:03.333333')

In [65]: y2.median()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('-1 days +00:00:05')

In [66]: y2.quantile(.1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('-1 days +00:00:05')

In [67]: y2.sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Timedelta('-1 days +00:00:10')
```

20.4 Frequency Conversion

Timedelta Series, `TimedeltaIndex`, and `Timedelta` scalars can be converted to other 'frequencies' by dividing by another timedelta, or by astyping to a specific timedelta type. These operations yield Series and propagate `NaT` ->

nan. Note that division by the numpy scalar is true division, while astyping is equivalent of floor division.

```
In [68]: td = pd.Series(pd.date_range('20130101', periods=4)) - \
   ....:      pd.Series(pd.date_range('20121201', periods=4))
   ....:

In [69]: td[2] += datetime.timedelta(minutes=5, seconds=3)

In [70]: td[3] = np.nan

In [71]: td
Out[71]:
0   31 days 00:00:00
1   31 days 00:00:00
2   31 days 00:05:03
3                NaT
dtype: timedelta64[ns]

# to days
In [72]: td / np.timedelta64(1, 'D')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    31.000000
1    31.000000
2    31.003507
3          NaN
dtype: float64

In [73]: td.astype('timedelta64[D]')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    31.0
1    31.0
2    31.0
3     NaN
dtype: float64

# to seconds
In [74]: td / np.timedelta64(1, 's')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    2678400.0
1    2678400.0
2    2678703.0
3          NaN
dtype: float64

In [75]: td.astype('timedelta64[s]')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    2678400.0
1    2678400.0
2    2678703.0
3          NaN
dtype: float64

# to months (these are constant months)
In [76]: td / np.timedelta64(1, 'M')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
0    1.018501
1    1.018501
2    1.018617
3         NaN
dtype: float64
```

Dividing or multiplying a `timedelta64[ns]` Series by an integer or integer Series yields another `timedelta64[ns]` dtypes Series.

```
In [77]: td * -1
Out[77]:
0   -31 days +00:00:00
1   -31 days +00:00:00
2   -32 days +23:54:57
3                  NaT
dtype: timedelta64[ns]

In [78]: td * pd.Series([1, 2, 3, 4])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   31 days 00:00:00
1   62 days 00:00:00
2   93 days 00:15:09
3                NaT
dtype: timedelta64[ns]
```

20.5 Attributes

You can access various components of the `Timedelta` or `TimedeltaIndex` directly using the attributes `days,seconds,microseconds,nanoseconds`. These are identical to the values returned by `datetime.timedelta`, in that, for example, the `.seconds` attribute represents the number of seconds >= 0 and < 1 day. These are signed according to whether the `Timedelta` is signed.

These operations can also be directly accessed via the `.dt` property of the `Series` as well.

Note: Note that the attributes are NOT the displayed values of the `Timedelta`. Use `.components` to retrieve the displayed values.

For a `Series`:

```
In [79]: td.dt.days
Out[79]:
0    31.0
1    31.0
2    31.0
3     NaN
dtype: float64

In [80]: td.dt.seconds
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[80]:
0      0.0
1      0.0
2    303.0
```

```
3      NaN
dtype: float64
```

You can access the value of the fields for a scalar `Timedelta` directly.

```
In [81]: tds = pd.Timedelta('31 days 5 min 3 sec')

In [82]: tds.days
Out[82]: 31

In [83]: tds.seconds
\\\\\\\\\\\\Out[83]: 303

In [84]: (-tds).seconds
\\\\\\\\\\\\\\\\\\\\\\\\\Out[84]: 86097
```

You can use the `.components` property to access a reduced form of the timedelta. This returns a `DataFrame` indexed similarly to the `Series`. These are the *displayed* values of the `Timedelta`.

```
In [85]: td.dt.components
Out[85]:
   days  hours  minutes  seconds  milliseconds  microseconds  nanoseconds
0  31.0    0.0      0.0      0.0           0.0           0.0          0.0
1  31.0    0.0      0.0      0.0           0.0           0.0          0.0
2  31.0    0.0      5.0      3.0           0.0           0.0          0.0
3   NaN    NaN      NaN      NaN           NaN           NaN          NaN

In [86]: td.dt.components.seconds
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    0.0
1    0.0
2    3.0
3    NaN
Name: seconds, dtype: float64
```

You can convert a `Timedelta` to an ISO 8601 Duration string with the `.isoformat` method

New in version 0.20.0.

```
In [87]: pd.Timedelta(days=6, minutes=50, seconds=3,
   ....:              milliseconds=10, microseconds=10,
   ....:              nanoseconds=12).isoformat()
   ....:
Out[87]: 'P6DT0H50M3.010010012S'
```

20.6 TimedeltaIndex

To generate an index with time delta, you can use either the `TimedeltaIndex` or the `timedelta_range` constructor.

Using `TimedeltaIndex` you can pass string-like, `Timedelta`, `timedelta`, or `np.timedelta64` objects. Passing `np.nan/pd.NaT/nat` will represent missing values.

```
In [88]: pd.TimedeltaIndex(['1 days', '1 days, 00:00:05',
   ....:                    np.timedelta64(2,'D'), datetime.timedelta(days=2,
↪seconds=2)])
```

```
   ....:
Out[88]:
TimedeltaIndex(['1 days 00:00:00', '1 days 00:00:05', '2 days 00:00:00',
                '2 days 00:00:02'],
               dtype='timedelta64[ns]', freq=None)
```

Similarly to `date_range`, you can construct regular ranges of a `TimedeltaIndex`:

```
In [89]: pd.timedelta_range(start='1 days', periods=5, freq='D')
Out[89]: TimedeltaIndex(['1 days', '2 days', '3 days', '4 days', '5 days'], dtype=
↪'timedelta64[ns]', freq='D')

In [90]: pd.timedelta_range(start='1 days', end='2 days', freq='30T')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
TimedeltaIndex(['1 days 00:00:00', '1 days 00:30:00', '1 days 01:00:00',
                '1 days 01:30:00', '1 days 02:00:00', '1 days 02:30:00',
                '1 days 03:00:00', '1 days 03:30:00', '1 days 04:00:00',
                '1 days 04:30:00', '1 days 05:00:00', '1 days 05:30:00',
                '1 days 06:00:00', '1 days 06:30:00', '1 days 07:00:00',
                '1 days 07:30:00', '1 days 08:00:00', '1 days 08:30:00',
                '1 days 09:00:00', '1 days 09:30:00', '1 days 10:00:00',
                '1 days 10:30:00', '1 days 11:00:00', '1 days 11:30:00',
                '1 days 12:00:00', '1 days 12:30:00', '1 days 13:00:00',
                '1 days 13:30:00', '1 days 14:00:00', '1 days 14:30:00',
                '1 days 15:00:00', '1 days 15:30:00', '1 days 16:00:00',
                '1 days 16:30:00', '1 days 17:00:00', '1 days 17:30:00',
                '1 days 18:00:00', '1 days 18:30:00', '1 days 19:00:00',
                '1 days 19:30:00', '1 days 20:00:00', '1 days 20:30:00',
                '1 days 21:00:00', '1 days 21:30:00', '1 days 22:00:00',
                '1 days 22:30:00', '1 days 23:00:00', '1 days 23:30:00',
                '2 days 00:00:00'],
               dtype='timedelta64[ns]', freq='30T')
```

20.6.1 Using the TimedeltaIndex

Similarly to other of the datetime-like indices, `DatetimeIndex` and `PeriodIndex`, you can use `TimedeltaIndex` as the index of pandas objects.

```
In [91]: s = pd.Series(np.arange(100),
   ....:               index=pd.timedelta_range('1 days', periods=100, freq='h'))
   ....:

In [92]: s
Out[92]:
1 days 00:00:00     0
1 days 01:00:00     1
1 days 02:00:00     2
1 days 03:00:00     3
1 days 04:00:00     4
1 days 05:00:00     5
1 days 06:00:00     6
                   ..
4 days 21:00:00    93
4 days 22:00:00    94
4 days 23:00:00    95
```

```
5 days 00:00:00    96
5 days 01:00:00    97
5 days 02:00:00    98
5 days 03:00:00    99
Freq: H, Length: 100, dtype: int64
```

Selections work similarly, with coercion on string-likes and slices:

```
In [93]: s['1 day':'2 day']
Out[93]:
1 days 00:00:00     0
1 days 01:00:00     1
1 days 02:00:00     2
1 days 03:00:00     3
1 days 04:00:00     4
1 days 05:00:00     5
1 days 06:00:00     6
                   ..
2 days 17:00:00    41
2 days 18:00:00    42
2 days 19:00:00    43
2 days 20:00:00    44
2 days 21:00:00    45
2 days 22:00:00    46
2 days 23:00:00    47
Freq: H, Length: 48, dtype: int64

In [94]: s['1 day 01:00:00']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪1

In [95]: s[pd.Timedelta('1 day 1h')]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪1
```

Furthermore you can use partial string selection and the range will be inferred:

```
In [96]: s['1 day':'1 day 5 hours']
Out[96]:
1 days 00:00:00    0
1 days 01:00:00    1
1 days 02:00:00    2
1 days 03:00:00    3
1 days 04:00:00    4
1 days 05:00:00    5
Freq: H, dtype: int64
```

20.6.2 Operations

Finally, the combination of `TimedeltaIndex` with `DatetimeIndex` allow certain combination operations that are NaT preserving:

```
In [97]: tdi = pd.TimedeltaIndex(['1 days', pd.NaT, '2 days'])

In [98]: tdi.tolist()
Out[98]: [Timedelta('1 days 00:00:00'), NaT, Timedelta('2 days 00:00:00')]
```

```
In [99]: dti = pd.date_range('20130101', periods=3)

In [100]: dti.tolist()
Out[100]:
[Timestamp('2013-01-01 00:00:00', freq='D'),
 Timestamp('2013-01-02 00:00:00', freq='D'),
 Timestamp('2013-01-03 00:00:00', freq='D')]

In [101]: (dti + tdi).tolist()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[Timestamp('2013-01-02 00:00:00'), NaT, Timestamp('2013-01-05 00:00:00')]

In [102]: (dti - tdi).tolist()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[Timestamp('2012-12-31 00:00:00'), NaT, Timestamp('2013-01-01 00:00:00')]
```

20.6.3 Conversions

Similarly to frequency conversion on a `Series` above, you can convert these indices to yield another Index.

```
In [103]: tdi / np.timedelta64(1,'s')
Out[103]: Float64Index([86400.0, nan, 172800.0], dtype='float64')

In [104]: tdi.astype('timedelta64[s]')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[104]:␣
↪Float64Index([86400.0, nan, 172800.0], dtype='float64')
```

Scalars type ops work as well. These can potentially return a *different* type of index.

```
# adding or timedelta and date -> datelike
In [105]: tdi + pd.Timestamp('20130101')
Out[105]: DatetimeIndex(['2013-01-02', 'NaT', '2013-01-03'], dtype='datetime64[ns]',␣
↪freq=None)

# subtraction of a date and a timedelta -> datelike
# note that trying to subtract a date from a Timedelta will raise an exception
In [106]: (pd.Timestamp('20130101') - tdi).tolist()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[
↪[Timestamp('2012-12-31 00:00:00'), NaT, Timestamp('2012-12-30 00:00:00')]

# timedelta + timedelta -> timedelta
In [107]: tdi + pd.Timedelta('10 days')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪TimedeltaIndex(['11 days', NaT, '12 days'], dtype='timedelta64[ns]', freq=None)

# division can result in a Timedelta if the divisor is an integer
In [108]: tdi / 2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪TimedeltaIndex(['0 days 12:00:00', NaT, '1 days 00:00:00'], dtype='timedelta64[ns]',
↪ freq=None)

# or a Float64Index if the divisor is a Timedelta
In [109]: tdi / tdi[0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Float64Index([1.0, nan, 2.0], dtype='float64')
```

20.7 Resampling

Similar to *timeseries resampling*, we can resample with a `TimedeltaIndex`.

```
In [110]: s.resample('D').mean()
Out[110]:
1 days    11.5
2 days    35.5
3 days    59.5
4 days    83.5
5 days    97.5
Freq: D, dtype: float64
```

CHAPTER

TWENTYONE

CATEGORICAL DATA

This is an introduction to pandas categorical data type, including a short comparison with R's `factor`.

Categoricals are a pandas data type, which correspond to categorical variables in statistics: a variable, which can take on only a limited, and usually fixed, number of possible values (*categories*; *levels* in R). Examples are gender, social class, blood types, country affiliations, observation time or ratings via Likert scales.

In contrast to statistical categorical variables, categorical data might have an order (e.g. 'strongly agree' vs 'agree' or 'first observation' vs. 'second observation'), but numerical operations (additions, divisions, ...) are not possible.

All values of categorical data are either in *categories* or *np.nan*. Order is defined by the order of *categories*, not lexical order of the values. Internally, the data structure consists of a *categories* array and an integer array of *codes* which point to the real value in the *categories* array.

The categorical data type is useful in the following cases:

- A string variable consisting of only a few different values. Converting such a string variable to a categorical variable will save some memory, see *here*.
- The lexical order of a variable is not the same as the logical order ("one", "two", "three"). By converting to a categorical and specifying an order on the categories, sorting and min/max will use the logical order instead of the lexical order, see *here*.
- As a signal to other python libraries that this column should be treated as a categorical variable (e.g. to use suitable statistical methods or plot types).

See also the *API docs on categoricals*.

21.1 Object Creation

Categorical *Series* or columns in a *DataFrame* can be created in several ways:

By specifying `dtype="category"` when constructing a *Series*:

```
In [1]: s = pd.Series(["a","b","c","a"], dtype="category")

In [2]: s
Out[2]:
0    a
1    b
2    c
3    a
dtype: category
Categories (3, object): [a, b, c]
```

By converting an existing *Series* or column to a `category` dtype:

```
In [3]: df = pd.DataFrame({"A":["a","b","c","a"]})

In [4]: df["B"] = df["A"].astype('category')

In [5]: df
Out[5]:
   A  B
0  a  a
1  b  b
2  c  c
3  a  a
```

By using some special functions:

```
In [6]: df = pd.DataFrame({'value': np.random.randint(0, 100, 20)})

In [7]: labels = [ "{0} - {1}".format(i, i + 9) for i in range(0, 100, 10) ]

In [8]: df['group'] = pd.cut(df.value, range(0, 105, 10), right=False, labels=labels)

In [9]: df.head(10)
Out[9]:
   value    group
0     65  60 - 69
1     49  40 - 49
2     56  50 - 59
3     43  40 - 49
4     43  40 - 49
5     91  90 - 99
6     32  30 - 39
7     87  80 - 89
8     36  30 - 39
9      8    0 - 9
```

See *documentation* for `cut()`.

By passing a `pandas.Categorical` object to a *Series* or assigning it to a *DataFrame*.

```
In [10]: raw_cat = pd.Categorical(["a","b","c","a"], categories=["b","c","d"],
   ....:                          ordered=False)
   ....:

In [11]: s = pd.Series(raw_cat)

In [12]: s
Out[12]:
0    NaN
1      b
2      c
3    NaN
dtype: category
Categories (3, object): [b, c, d]

In [13]: df = pd.DataFrame({"A":["a","b","c","a"]})

In [14]: df["B"] = raw_cat
```

```
In [15]: df
Out[15]:
   A    B
0  a  NaN
1  b    b
2  c    c
3  a  NaN
```

Anywhere above we passed a keyword `dtype='category'`, we used the default behavior of

1. categories are inferred from the data
2. categories are unordered.

To control those behaviors, instead of passing `'category'`, use an instance of *CategoricalDtype*.

```
In [16]: from pandas.api.types import CategoricalDtype

In [17]: s = pd.Series(["a", "b", "c", "a"])

In [18]: cat_type = CategoricalDtype(categories=["b", "c", "d"],
   ....:                             ordered=True)
   ....:

In [19]: s_cat = s.astype(cat_type)

In [20]: s_cat
Out[20]:
0    NaN
1      b
2      c
3    NaN
dtype: category
Categories (3, object): [b < c < d]
```

Categorical data has a specific `category` *dtype*:

```
In [21]: df.dtypes
Out[21]:
A      object
B    category
dtype: object
```

Note: In contrast to R's *factor* function, categorical data is not converting input values to strings and categories will end up the same data type as the original values.

Note: In contrast to R's *factor* function, there is currently no way to assign/change labels at creation time. Use *categories* to change the categories after creation time.

To get back to the original Series or *numpy* array, use `Series.astype(original_dtype)` or `np.asarray(categorical)`:

```
In [22]: s = pd.Series(["a","b","c","a"])

In [23]: s
```

```
Out[23]:
0    a
1    b
2    c
3    a
dtype: object

In [24]: s2 = s.astype('category')

In [25]: s2
Out[25]:
0    a
1    b
2    c
3    a
dtype: category
Categories (3, object): [a, b, c]

In [26]: s2.astype(str)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[26]:␣
↪
0    a
1    b
2    c
3    a
dtype: object

In [27]: np.asarray(s2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪array(['a', 'b', 'c', 'a'], dtype=object)
```

If you have already *codes* and *categories*, you can use the *from_codes()* constructor to save the factorize step during normal constructor mode:

```
In [28]: splitter = np.random.choice([0,1], 5, p=[0.5,0.5])

In [29]: s = pd.Series(pd.Categorical.from_codes(splitter, categories=["train", "test
↪"]))
```

21.2 CategoricalDtype

Changed in version 0.21.0.

A categorical's type is fully described by

1. `categories`: a sequence of unique values and no missing values
2. `ordered`: a boolean

This information can be stored in a *CategoricalDtype*. The `categories` argument is optional, which implies that the actual categories should be inferred from whatever is present in the data when the *pandas.Categorical* is created. The categories are assumed to be unordered by default.

```
In [30]: from pandas.api.types import CategoricalDtype

In [31]: CategoricalDtype(['a', 'b', 'c'])
Out[31]: CategoricalDtype(categories=['a', 'b', 'c'], ordered=False)
```

```
In [32]: CategoricalDtype(['a', 'b', 'c'], ordered=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[32]:␣
↪CategoricalDtype(categories=['a', 'b', 'c'], ordered=True)

In [33]: CategoricalDtype()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪CategoricalDtype(categories=None, ordered=False)
```

A *`CategoricalDtype`* can be used in any place pandas expects a *dtype*. For example *`pandas.read_csv()`*, *`pandas.DataFrame.astype()`*, or in the Series constructor.

Note: As a convenience, you can use the string `'category'` in place of a *`CategoricalDtype`* when you want the default behavior of the categories being unordered, and equal to the set values present in the array. In other words, `dtype='category'` is equivalent to `dtype=CategoricalDtype()`.

21.2.1 Equality Semantics

Two instances of *`CategoricalDtype`* compare equal whenever they have the same categories and orderedness. When comparing two unordered categoricals, the order of the `categories` is not considered

```
In [34]: c1 = CategoricalDtype(['a', 'b', 'c'], ordered=False)

# Equal, since order is not considered when ordered=False
In [35]: c1 == CategoricalDtype(['b', 'c', 'a'], ordered=False)
Out[35]: True

# Unequal, since the second CategoricalDtype is ordered
In [36]: c1 == CategoricalDtype(['a',  'b', 'c'], ordered=True)
\\\\\\\\\\\\\\Out[36]: False
```

All instances of `CategoricalDtype` compare equal to the string `'category'`

```
In [37]: c1 == 'category'
Out[37]: True
```

Warning: Since `dtype='category'` is essentially `CategoricalDtype(None, False)`, and since all instances `CategoricalDtype` compare equal to `'category'`, all instances of `CategoricalDtype` compare equal to a `CategoricalDtype(None, False)`, regardless of `categories` or `ordered`.

21.3 Description

Using `.describe()` on categorical data will produce similar output to a *Series* or *DataFrame* of type `string`.

```
In [38]: cat = pd.Categorical(["a", "c", "c", np.nan], categories=["b", "a", "c"])

In [39]: df = pd.DataFrame({"cat":cat, "s":["a", "c", "c", np.nan]})

In [40]: df.describe()
Out[40]:
```

```
       cat  s
count    3  3
unique   2  2
top      c  c
freq     2  2

In [41]: df["cat"].describe()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[41]:␣
↪
count     3
unique    2
top       c
freq      2
Name: cat, dtype: object
```

21.4 Working with categories

Categorical data has a *categories* and a *ordered* property, which list their possible values and whether the ordering matters or not. These properties are exposed as `s.cat.categories` and `s.cat.ordered`. If you don't manually specify categories and ordering, they are inferred from the passed in values.

```
In [42]: s = pd.Series(["a","b","c","a"], dtype="category")

In [43]: s.cat.categories
Out[43]: Index(['a', 'b', 'c'], dtype='object')

In [44]: s.cat.ordered
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[44]: False
```

It's also possible to pass in the categories in a specific order:

```
In [45]: s = pd.Series(pd.Categorical(["a","b","c","a"], categories=["c","b","a"]))

In [46]: s.cat.categories
Out[46]: Index(['c', 'b', 'a'], dtype='object')

In [47]: s.cat.ordered
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[47]: False
```

Note: New categorical data are NOT automatically ordered. You must explicitly pass `ordered=True` to indicate an ordered `Categorical`.

Note: The result of `Series.unique()` is not always the same as `Series.cat.categories`, because `Series.unique()` has a couple of guarantees, namely that it returns categories in the order of appearance, and it only includes values that are actually present.

```
In [48]: s = pd.Series(list('babc')).astype(CategoricalDtype(list('abcd')))

In [49]: s
Out[49]:
0    b
1    a
```

```
2    b
3    c
dtype: category
Categories (4, object): [a, b, c, d]

# categories
In [50]: s.cat.categories
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[50]:␣
↪Index(['a', 'b', 'c', 'd'], dtype='object')

# uniques
In [51]: s.unique()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
[b, a, c]
Categories (3, object): [b, a, c]
```

21.4.1 Renaming categories

Renaming categories is done by assigning new values to the `Series.cat.categories` property or by using the `Categorical.rename_categories()` method:

```
In [52]: s = pd.Series(["a","b","c","a"], dtype="category")

In [53]: s
Out[53]:
0    a
1    b
2    c
3    a
dtype: category
Categories (3, object): [a, b, c]

In [54]: s.cat.categories = ["Group %s" % g for g in s.cat.categories]

In [55]: s
Out[55]:
0    Group a
1    Group b
2    Group c
3    Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]

In [56]: s.cat.rename_categories([1,2,3])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    2
2    3
3    1
dtype: category
Categories (3, int64): [1, 2, 3]

In [57]: s
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    Group a
1    Group b
2    Group c
3    Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]

# You can also pass a dict-like object to map the renaming
In [58]: s.cat.rename_categories({1: 'x', 2: 'y', 3: 'z'})
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    Group a
1    Group b
2    Group c
3    Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]

In [59]: s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    Group a
1    Group b
2    Group c
3    Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]
```

Note: In contrast to R's *factor*, categorical data can have categories of other types than string.

Note: Be aware that assigning new categories is an inplace operations, while most other operation under `Series.cat` per default return a new Series of dtype *category*.

Categories must be unique or a *ValueError* is raised:

```
In [60]: try:
   ....:     s.cat.categories = [1,1,1]
   ....: except ValueError as e:
   ....:     print("ValueError: " + str(e))
   ....:
ValueError: Categorical categories must be unique
```

Categories must also not be `NaN` or a *ValueError* is raised:

```
In [61]: try:
   ....:     s.cat.categories = [1,2,np.nan]
   ....: except ValueError as e:
   ....:     print("ValueError: " + str(e))
   ....:
ValueError: Categorial categories cannot be null
```

21.4.2 Appending new categories

Appending categories can be done by using the `Categorical.add_categories()` method:

```
In [62]: s = s.cat.add_categories([4])

In [63]: s.cat.categories
Out[63]: Index(['Group a', 'Group b', 'Group c', 4], dtype='object')

In [64]: s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[64]:
0    Group a
1    Group b
2    Group c
3    Group a
dtype: category
Categories (4, object): [Group a, Group b, Group c, 4]
```

21.4.3 Removing categories

Removing categories can be done by using the `Categorical.remove_categories()` method. Values which are removed are replaced by `np.nan`.:

```
In [65]: s = s.cat.remove_categories([4])

In [66]: s
Out[66]:
0    Group a
1    Group b
2    Group c
3    Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]
```

21.4.4 Removing unused categories

Removing unused categories can also be done:

```
In [67]: s = pd.Series(pd.Categorical(["a","b","a"], categories=["a","b","c","d"]))

In [68]: s
Out[68]:
0    a
1    b
2    a
dtype: category
Categories (4, object): [a, b, c, d]

In [69]: s.cat.remove_unused_categories()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[69]:␣
↪
0    a
1    b
2    a
```

```
dtype: category
Categories (2, object): [a, b]
```

21.4.5 Setting categories

If you want to do remove and add new categories in one step (which has some speed advantage), or simply set the categories to a predefined scale, use `Categorical.set_categories()`.

```
In [70]: s = pd.Series(["one","two","four", "-"], dtype="category")

In [71]: s
Out[71]:
0     one
1     two
2    four
3       -
dtype: category
Categories (4, object): [-, four, one, two]

In [72]: s = s.cat.set_categories(["one","two","three","four"])

In [73]: s
Out[73]:
0     one
1     two
2    four
3     NaN
dtype: category
Categories (4, object): [one, two, three, four]
```

Note: Be aware that `Categorical.set_categories()` cannot know whether some category is omitted intentionally or because it is misspelled or (under Python3) due to a type difference (e.g., numpys S1 dtype and python strings). This can result in surprising behaviour!

21.5 Sorting and Order

If categorical data is ordered (`s.cat.ordered == True`), then the order of the categories has a meaning and certain operations are possible. If the categorical is unordered, `.min()/.max()` will raise a *TypeError*.

```
In [74]: s = pd.Series(pd.Categorical(["a","b","c","a"], ordered=False))

In [75]: s.sort_values(inplace=True)

In [76]: s = pd.Series(["a","b","c","a"]).astype(
   ....:     CategoricalDtype(ordered=True)
   ....: )
   ....:

In [77]: s.sort_values(inplace=True)

In [78]: s
Out[78]:
```

```
0    a
3    a
1    b
2    c
dtype: category
Categories (3, object): [a < b < c]

In [79]: s.min(), s.max()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[79]:␣
↪('a', 'c')
```

You can set categorical data to be ordered by using `as_ordered()` or unordered by using `as_unordered()`. These will by default return a *new* object.

```
In [80]: s.cat.as_ordered()
Out[80]:
0    a
3    a
1    b
2    c
dtype: category
Categories (3, object): [a < b < c]

In [81]: s.cat.as_unordered()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[81]:␣
↪
0    a
3    a
1    b
2    c
dtype: category
Categories (3, object): [a, b, c]
```

Sorting will use the order defined by categories, not any lexical order present on the data type. This is even true for strings and numeric data:

```
In [82]: s = pd.Series([1,2,3,1], dtype="category")

In [83]: s = s.cat.set_categories([2,3,1], ordered=True)

In [84]: s
Out[84]:
0    1
1    2
2    3
3    1
dtype: category
Categories (3, int64): [2 < 3 < 1]

In [85]: s.sort_values(inplace=True)

In [86]: s
Out[86]:
1    2
2    3
0    1
3    1
dtype: category
```

```
Categories (3, int64): [2 < 3 < 1]

In [87]: s.min(), s.max()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[87]:␣
↪(2, 1)
```

21.5.1 Reordering

Reordering the categories is possible via the `Categorical.reorder_categories()` and the `Categorical.set_categories()` methods. For `Categorical.reorder_categories()`, all old categories must be included in the new categories and no new categories are allowed. This will necessarily make the sort order the same as the categories order.

```
In [88]: s = pd.Series([1,2,3,1], dtype="category")

In [89]: s = s.cat.reorder_categories([2,3,1], ordered=True)

In [90]: s
Out[90]:
0    1
1    2
2    3
3    1
dtype: category
Categories (3, int64): [2 < 3 < 1]

In [91]: s.sort_values(inplace=True)

In [92]: s
Out[92]:
1    2
2    3
0    1
3    1
dtype: category
Categories (3, int64): [2 < 3 < 1]

In [93]: s.min(), s.max()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[93]:␣
↪(2, 1)
```

Note: Note the difference between assigning new categories and reordering the categories: the first renames categories and therefore the individual values in the *Series*, but if the first position was sorted last, the renamed value will still be sorted last. Reordering means that the way values are sorted is different afterwards, but not that individual values in the *Series* are changed.

Note: If the *Categorical* is not ordered, `Series.min()` and `Series.max()` will raise `TypeError`. Numeric operations like `+`, `-`, `*`, `/` and operations based on them (e.g. `Series.median()`, which would need to compute the mean between two values if the length of an array is even) do not work and raise a `TypeError`.

21.5.2 Multi Column Sorting

A categorical dtyped column will participate in a multi-column sort in a similar manner to other columns. The ordering of the categorical is determined by the `categories` of that column.

```
In [94]: dfs = pd.DataFrame({'A' : pd.Categorical(list('bbeebbaa'), categories=['e','a
↪','b'], ordered=True),
   ....:                     'B' : [1,2,1,2,2,1,2,1] })
   ....:

In [95]: dfs.sort_values(by=['A', 'B'])
Out[95]:
   A  B
2  e  1
3  e  2
7  a  1
6  a  2
0  b  1
5  b  1
1  b  2
4  b  2
```

Reordering the `categories` changes a future sort.

```
In [96]: dfs['A'] = dfs['A'].cat.reorder_categories(['a','b','e'])

In [97]: dfs.sort_values(by=['A','B'])
Out[97]:
   A  B
7  a  1
6  a  2
0  b  1
5  b  1
1  b  2
4  b  2
2  e  1
3  e  2
```

21.6 Comparisons

Comparing categorical data with other objects is possible in three cases:

- comparing equality (== and !=) to a list-like object (list, Series, array, ...) of the same length as the categorical data.
- all comparisons (==, !=, >, >=, <, and <=) of categorical data to another categorical Series, when `ordered==True` and the *categories* are the same.
- all comparisons of a categorical data to a scalar.

All other comparisons, especially "non-equality" comparisons of two categoricals with different categories or a categorical with any list-like object, will raise a TypeError.

Note: Any "non-equality" comparisons of categorical data with a *Series*, *np.array*, *list* or categorical data with different categories or ordering will raise an *TypeError* because custom categories ordering could be interpreted in two

ways: one with taking into account the ordering and one without.

```
In [98]: cat = pd.Series([1,2,3]).astype(
   ....:     CategoricalDtype([3, 2, 1], ordered=True)
   ....: )
   ....:

In [99]: cat_base = pd.Series([2,2,2]).astype(
   ....:     CategoricalDtype([3, 2, 1], ordered=True)
   ....: )
   ....:

In [100]: cat_base2 = pd.Series([2,2,2]).astype(
   .....:     CategoricalDtype(ordered=True)
   .....: )
   .....:

In [101]: cat
Out[101]:
0    1
1    2
2    3
dtype: category
Categories (3, int64): [3 < 2 < 1]

In [102]: cat_base
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[102]:␣
↪
0    2
1    2
2    2
dtype: category
Categories (3, int64): [3 < 2 < 1]

In [103]: cat_base2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    2
1    2
2    2
dtype: category
Categories (1, int64): [2]
```

Comparing to a categorical with the same categories and ordering or to a scalar works:

```
In [104]: cat > cat_base
Out[104]:
0     True
1    False
2    False
dtype: bool

In [105]: cat > 2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[105]:
0     True
1    False
2    False
dtype: bool
```

Equality comparisons work with any list-like object of same length and scalars:

```
In [106]: cat == cat_base
Out[106]:
0    False
1     True
2    False
dtype: bool

In [107]: cat == np.array([1,2,3])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[107]:
0    True
1    True
2    True
dtype: bool

In [108]: cat == 2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    False
1     True
2    False
dtype: bool
```

This doesn’t work because the categories are not the same:

```
In [109]: try:
   .....:     cat > cat_base2
   .....: except TypeError as e:
   .....:      print("TypeError: " + str(e))
   .....:
TypeError: Categoricals can only be compared if 'categories' are the same. Categories␣
↪are different lengths
```

If you want to do a “non-equality” comparison of a categorical series with a list-like object which is not categorical data, you need to be explicit and convert the categorical data back to the original values:

```
In [110]: base = np.array([1,2,3])

In [111]: try:
   .....:     cat > base
   .....: except TypeError as e:
   .....:      print("TypeError: " + str(e))
   .....:
TypeError: Cannot compare a Categorical for op __gt__ with type <class 'numpy.ndarray
↪'>.
If you want to compare values, use 'np.asarray(cat) <op> other'.

In [112]: np.asarray(cat) > base
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪array([False, False, False], dtype=bool)
```

When you compare two unordered categoricals with the same categories, the order is not considered:

```
In [113]: c1 = pd.Categorical(['a', 'b'], categories=['a', 'b'], ordered=False)

In [114]: c2 = pd.Categorical(['a', 'b'], categories=['b', 'a'], ordered=False)
```

```
In [115]: c1 == c2
Out[115]: array([ True,  True], dtype=bool)
```

21.7 Operations

Apart from `Series.min()`, `Series.max()` and `Series.mode()`, the following operations are possible with categorical data:

Series methods like *Series.value_counts()* will use all categories, even if some categories are not present in the data:

```
In [116]: s = pd.Series(pd.Categorical(["a","b","c","c"], categories=["c","a","b","d
↪"]))

In [117]: s.value_counts()
Out[117]:
c    2
b    1
a    1
d    0
dtype: int64
```

Groupby will also show "unused" categories:

```
In [118]: cats = pd.Categorical(["a","b","b","b","c","c","c"], categories=["a","b","c
↪","d"])

In [119]: df = pd.DataFrame({"cats":cats,"values":[1,2,2,2,3,4,5]})

In [120]: df.groupby("cats").mean()
Out[120]:
      values
cats
a        1.0
b        2.0
c        4.0
d        NaN

In [121]: cats2 = pd.Categorical(["a","a","b","b"], categories=["a","b","c"])

In [122]: df2 = pd.DataFrame({"cats":cats2,"B":["c","d","c","d"], "values":[1,2,3,4]})

In [123]: df2.groupby(["cats","B"]).mean()
Out[123]:
        values
cats B
a    c     1.0
     d     2.0
b    c     3.0
     d     4.0
c    c     NaN
     d     NaN
```

Pivot tables:

```
In [124]: raw_cat = pd.Categorical(["a","a","b","b"], categories=["a","b","c"])

In [125]: df = pd.DataFrame({"A":raw_cat,"B":["c","d","c","d"], "values":[1,2,3,4]})

In [126]: pd.pivot_table(df, values='values', index=['A', 'B'])
Out[126]: 
     values
A B        
a c     1.0
  d     2.0
b c     3.0
  d     4.0
c c     NaN
  d     NaN
```

21.8 Data munging

The optimized pandas data access methods `.loc`, `.iloc`, `.at`, and `.iat`, work as normal. The only difference is the return type (for getting) and that only values already in *categories* can be assigned.

21.8.1 Getting

If the slicing operation returns either a *DataFrame* or a column of type *Series*, the `category` dtype is preserved.

```
In [127]: idx = pd.Index(["h","i","j","k","l","m","n",])

In [128]: cats = pd.Series(["a","b","b","b","c","c","c"], dtype="category", index=idx)

In [129]: values= [1,2,2,2,3,4,5]

In [130]: df = pd.DataFrame({"cats":cats,"values":values}, index=idx)

In [131]: df.iloc[2:4,:]
Out[131]: 
  cats  values
j    b       2
k    b       2

In [132]: df.iloc[2:4,:].dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[132]: 
cats      category
values       int64
dtype: object

In [133]: df.loc["h":"j","cats"]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
h    a
i    b
j    b
Name: cats, dtype: category
Categories (3, object): [a, b, c]

In [134]: df[df["cats"] == "b"]
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
  cats  values
i    b       2
j    b       2
k    b       2
```

An example where the category type is not preserved is if you take one single row: the resulting *Series* is of dtype `object`:

```
# get the complete "h" row as a Series
In [135]: df.loc["h", :]
Out[135]:
cats      a
values    1
Name: h, dtype: object
```

Returning a single item from categorical data will also return the value, not a categorical of length "1".

```
In [136]: df.iat[0,0]
Out[136]: 'a'

In [137]: df["cats"].cat.categories = ["x","y","z"]

In [138]: df.at["h","cats"] # returns a string
Out[138]: 'x'
```

Note: This is a difference to R's *factor* function, where `factor(c(1,2,3))[1]` returns a single value *factor*.

To get a single value *Series* of type `category` pass in a list with a single value:

```
In [139]: df.loc[["h"],"cats"]
Out[139]:
h    x
Name: cats, dtype: category
Categories (3, object): [x, y, z]
```

21.8.2 String and datetime accessors

New in version 0.17.1.

The accessors `.dt` and `.str` will work if the `s.cat.categories` are of an appropriate type:

```
In [140]: str_s = pd.Series(list('aabb'))

In [141]: str_cat = str_s.astype('category')

In [142]: str_cat
Out[142]:
0    a
1    a
2    b
3    b
dtype: category
Categories (2, object): [a, b]
```

```
In [143]: str_cat.str.contains("a")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[143]:␣
↪
0     True
1     True
2    False
3    False
dtype: bool

In [144]: date_s = pd.Series(pd.date_range('1/1/2015', periods=5))

In [145]: date_cat = date_s.astype('category')

In [146]: date_cat
Out[146]:
0   2015-01-01
1   2015-01-02
2   2015-01-03
3   2015-01-04
4   2015-01-05
dtype: category
Categories (5, datetime64[ns]): [2015-01-01, 2015-01-02, 2015-01-03, 2015-01-04, 2015-
↪01-05]

In [147]: date_cat.dt.day
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    2
2    3
3    4
4    5
dtype: int64
```

Note: The returned `Series` (or `DataFrame`) is of the same type as if you used the `.str.<method>` / `.dt.<method>` on a `Series` of that type (and not of type `category`!).

That means, that the returned values from methods and properties on the accessors of a `Series` and the returned values from methods and properties on the accessors of this `Series` transformed to one of type *category* will be equal:

```
In [148]: ret_s = str_s.str.contains("a")

In [149]: ret_cat = str_cat.str.contains("a")

In [150]: ret_s.dtype == ret_cat.dtype
Out[150]: True

In [151]: ret_s == ret_cat
\\\\\\\\\\\\\\\Out[151]:
0    True
1    True
2    True
3    True
dtype: bool
```

Note: The work is done on the `categories` and then a new `Series` is constructed. This has some performance implication if you have a `Series` of type string, where lots of elements are repeated (i.e. the number of unique elements in the `Series` is a lot smaller than the length of the `Series`). In this case it can be faster to convert the original `Series` to one of type `category` and use `.str.<method>` or `.dt.<property>` on that.

21.8.3 Setting

Setting values in a categorical column (or *Series*) works as long as the value is included in the *categories*:

```
In [152]: idx = pd.Index(["h","i","j","k","l","m","n"])

In [153]: cats = pd.Categorical(["a","a","a","a","a","a","a"], categories=["a","b"])

In [154]: values = [1,1,1,1,1,1,1]

In [155]: df = pd.DataFrame({"cats":cats,"values":values}, index=idx)

In [156]: df.iloc[2:4,:] = [["b",2],["b",2]]

In [157]: df
Out[157]: 
  cats  values
h    a       1
i    a       1
j    b       2
k    b       2
l    a       1
m    a       1
n    a       1

In [158]: try:
   .....:     df.iloc[2:4,:] = [["c",3],["c",3]]
   .....: except ValueError as e:
   .....:     print("ValueError: " + str(e))
   .....: 
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Cannot setitem on a Categorical with a new category, set the categories first
```

Setting values by assigning categorical data will also check that the *categories* match:

```
In [159]: df.loc["j":"k","cats"] = pd.Categorical(["a","a"], categories=["a","b"])

In [160]: df
Out[160]: 
  cats  values
h    a       1
i    a       1
j    a       2
k    a       2
l    a       1
m    a       1
n    a       1

In [161]: try:
   .....:     df.loc["j":"k","cats"] = pd.Categorical(["b","b"], categories=["a","b",
↪"c"])
```

```
   .....: except ValueError as e:
   .....:     print("ValueError: " + str(e))
   .....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Cannot set a Categorical with another, without identical categories
```

Assigning a *Categorical* to parts of a column of other types will use the values:

```
In [162]: df = pd.DataFrame({"a":[1,1,1,1,1], "b":["a","a","a","a","a"]})

In [163]: df.loc[1:2,"a"] = pd.Categorical(["b","b"], categories=["a","b"])

In [164]: df.loc[2:3,"b"] = pd.Categorical(["b","b"], categories=["a","b"])

In [165]: df
Out[165]:
   a  b
0  1  a
1  b  a
2  b  b
3  1  b
4  1  a

In [166]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[166]:
a    object
b    object
dtype: object
```

21.8.4 Merging

You can concat two *DataFrames* containing categorical data together, but the categories of these categoricals need to be the same:

```
In [167]: cat = pd.Series(["a","b"], dtype="category")

In [168]: vals = [1,2]

In [169]: df = pd.DataFrame({"cats":cat, "vals":vals})

In [170]: res = pd.concat([df,df])

In [171]: res
Out[171]:
  cats  vals
0    a     1
1    b     2
0    a     1
1    b     2

In [172]: res.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[172]:
cats    category
vals       int64
dtype: object
```

In this case the categories are not the same and so an error is raised:

```
In [173]: df_different = df.copy()

In [174]: df_different["cats"].cat.categories = ["c","d"]

In [175]: try:
   .....:     pd.concat([df,df_different])
   .....: except ValueError as e:
   .....:     print("ValueError: " + str(e))
   .....:
```

The same applies to `df.append(df_different)`.

See also the section on *merge dtypes* for notes about preserving merge dtypes and performance.

21.8.5 Unioning

New in version 0.19.0.

If you want to combine categoricals that do not necessarily have the same categories, the `union_categoricals` function will combine a list-like of categoricals. The new categories will be the union of the categories being combined.

```
In [176]: from pandas.api.types import union_categoricals

In [177]: a = pd.Categorical(["b", "c"])

In [178]: b = pd.Categorical(["a", "b"])

In [179]: union_categoricals([a, b])
Out[179]:
[b, c, a, b]
Categories (3, object): [b, c, a]
```

By default, the resulting categories will be ordered as they appear in the data. If you want the categories to be lexsorted, use `sort_categories=True` argument.

```
In [180]: union_categoricals([a, b], sort_categories=True)
Out[180]:
[b, c, a, b]
Categories (3, object): [a, b, c]
```

`union_categoricals` also works with the "easy" case of combining two categoricals of the same categories and order information (e.g. what you could also `append` for).

```
In [181]: a = pd.Categorical(["a", "b"], ordered=True)

In [182]: b = pd.Categorical(["a", "b", "a"], ordered=True)

In [183]: union_categoricals([a, b])
Out[183]:
[a, b, a, b, a]
Categories (2, object): [a < b]
```

The below raises `TypeError` because the categories are ordered and not identical.

```
In [1]: a = pd.Categorical(["a", "b"], ordered=True)
In [2]: b = pd.Categorical(["a", "b", "c"], ordered=True)
```

```
In [3]: union_categoricals([a, b])
Out[3]:
TypeError: to union ordered Categoricals, all categories must be the same
```

New in version 0.20.0.

Ordered categoricals with different categories or orderings can be combined by using the `ignore_ordered=True` argument.

```
In [184]: a = pd.Categorical(["a", "b", "c"], ordered=True)

In [185]: b = pd.Categorical(["c", "b", "a"], ordered=True)

In [186]: union_categoricals([a, b], ignore_order=True)
Out[186]:
[a, b, c, c, b, a]
Categories (3, object): [a, b, c]
```

`union_categoricals` also works with a `CategoricalIndex`, or `Series` containing categorical data, but note that the resulting array will always be a plain `Categorical`

```
In [187]: a = pd.Series(["b", "c"], dtype='category')

In [188]: b = pd.Series(["a", "b"], dtype='category')

In [189]: union_categoricals([a, b])
Out[189]:
[b, c, a, b]
Categories (3, object): [b, c, a]
```

Note: `union_categoricals` may recode the integer codes for categories when combining categoricals. This is likely what you want, but if you are relying on the exact numbering of the categories, be aware.

```
In [190]: c1 = pd.Categorical(["b", "c"])

In [191]: c2 = pd.Categorical(["a", "b"])

In [192]: c1
Out[192]:
[b, c]
Categories (2, object): [b, c]

# "b" is coded to 0
In [193]: c1.codes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[193]: array([0, 1], dtype=int8)

In [194]: c2
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[194]:␣
↪
[a, b]
Categories (2, object): [a, b]

# "b" is coded to 1
In [195]: c2.codes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪array([0, 1], dtype=int8)
```

```
In [196]: c = union_categoricals([c1, c2])

In [197]: c
Out[197]:
[b, c, a, b]
Categories (3, object): [b, c, a]

# "b" is coded to 0 throughout, same as c1, different from c2
In [198]: c.codes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[198]: array([0, 1, 2,␣
↪0], dtype=int8)
```

21.8.6 Concatenation

This section describes concatenations specific to `category` dtype. See *Concatenating objects* for general description.

By default, `Series` or `DataFrame` concatenation which contains the same categories results in `category` dtype, otherwise results in `object` dtype. Use `.astype` or `union_categoricals` to get `category` result.

```
# same categories
In [199]: s1 = pd.Series(['a', 'b'], dtype='category')

In [200]: s2 = pd.Series(['a', 'b', 'a'], dtype='category')

In [201]: pd.concat([s1, s2])
Out[201]:
0    a
1    b
0    a
1    b
2    a
dtype: category
Categories (2, object): [a, b]

# different categories
In [202]: s3 = pd.Series(['b', 'c'], dtype='category')

In [203]: pd.concat([s1, s3])
Out[203]:
0    a
1    b
0    b
1    c
dtype: object

In [204]: pd.concat([s1, s3]).astype('category')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[204]:
0    a
1    b
0    b
1    c
dtype: category
Categories (3, object): [a, b, c]

In [205]: union_categoricals([s1.values, s3.values])
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
[a, b, b, c]
Categories (3, object): [a, b, c]
```

Following table summarizes the results of `Categoricals` related concatenations.

arg1	arg2	result
category	category (identical categories)	category
category	category (different categories, both not ordered)	object (dtype is inferred)
category	category (different categories, either one is ordered)	object (dtype is inferred)
category	not category	object (dtype is inferred)

21.9 Getting Data In/Out

You can write data that contains `category` dtypes to a `HDFStore`. See *here* for an example and caveats.

It is also possible to write data to and reading data from *Stata* format files. See *here* for an example and caveats.

Writing to a CSV file will convert the data, effectively removing any information about the categorical (categories and ordering). So if you read back the CSV file you have to convert the relevant columns back to *category* and assign the right categories and categories ordering.

```
In [206]: s = pd.Series(pd.Categorical(['a', 'b', 'b', 'a', 'a', 'd']))

# rename the categories
In [207]: s.cat.categories = ["very good", "good", "bad"]

# reorder the categories and add missing categories
In [208]: s = s.cat.set_categories(["very bad", "bad", "medium", "good", "very good"])

In [209]: df = pd.DataFrame({"cats":s, "vals":[1,2,3,4,5,6]})

In [210]: csv = StringIO()

In [211]: df.to_csv(csv)

In [212]: df2 = pd.read_csv(StringIO(csv.getvalue()))

In [213]: df2.dtypes
Out[213]: 
Unnamed: 0     int64
cats          object
vals           int64
dtype: object

In [214]: df2["cats"]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[214]:␣
↪
0    very good
1         good
2         good
3    very good
4    very good
5          bad
Name: cats, dtype: object
```

```
# Redo the category
In [215]: df2["cats"] = df2["cats"].astype("category")

In [216]: df2["cats"].cat.set_categories(["very bad", "bad", "medium", "good", "very␣
↪good"],
   .....:                                  inplace=True)
   .....:

In [217]: df2.dtypes
Out[217]:
Unnamed: 0       int64
cats          category
vals             int64
dtype: object

In [218]: df2["cats"]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[218
↪
0    very good
1         good
2         good
3    very good
4    very good
5          bad
Name: cats, dtype: category
Categories (5, object): [very bad, bad, medium, good, very good]
```

The same holds for writing to a SQL database with `to_sql`.

21.10 Missing Data

pandas primarily uses the value *np.nan* to represent missing data. It is by default not included in computations. See the *Missing Data section*.

Missing values should **not** be included in the Categorical's `categories`, only in the `values`. Instead, it is understood that NaN is different, and is always a possibility. When working with the Categorical's `codes`, missing values will always have a code of `-1`.

```
In [219]: s = pd.Series(["a", "b", np.nan, "a"], dtype="category")

# only two categories
In [220]: s
Out[220]:
0      a
1      b
2    NaN
3      a
dtype: category
Categories (2, object): [a, b]

In [221]: s.cat.codes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[22
↪
0    0
1    1
```

```
2   -1
3    0
dtype: int8
```

Methods for working with missing data, e.g. `isna()`, `fillna()`, `dropna()`, all work normally:

```
In [222]: s = pd.Series(["a", "b", np.nan], dtype="category")

In [223]: s
Out[223]:
0      a
1      b
2    NaN
dtype: category
Categories (2, object): [a, b]

In [224]: pd.isna(s)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[224]:␣
↪
0    False
1    False
2     True
dtype: bool

In [225]: s.fillna("a")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    a
1    b
2    a
dtype: category
Categories (2, object): [a, b]
```

21.11 Differences to R's *factor*

The following differences to R's factor functions can be observed:

- R's *levels* are named *categories*
- R's *levels* are always of type string, while *categories* in pandas can be of any dtype.
- It's not possible to specify labels at creation time. Use `s.cat.rename_categories(new_labels)` afterwards.
- In contrast to R's *factor* function, using categorical data as the sole input to create a new categorical series will *not* remove unused categories but create a new categorical series which is equal to the passed in one!
- R allows for missing values to be included in its *levels* (pandas' *categories*). Pandas does not allow *NaN* categories, but missing values can still be in the *values*.

21.12 Gotchas

21.12.1 Memory Usage

The memory usage of a `Categorical` is proportional to the number of categories plus the length of the data. In contrast, an `object` dtype is a constant times the length of the data.

```
In [226]: s = pd.Series(['foo','bar']*1000)

# object dtype
In [227]: s.nbytes
Out[227]: 16000

# category dtype
In [228]: s.astype('category').nbytes
\\\\\\\\\\\\\\\\Out[228]: 2016
```

Note: If the number of categories approaches the length of the data, the `Categorical` will use nearly the same or more memory than an equivalent `object` dtype representation.

```
In [229]: s = pd.Series(['foo%04d' % i for i in range(2000)])

# object dtype
In [230]: s.nbytes
Out[230]: 16000

# category dtype
In [231]: s.astype('category').nbytes
\\\\\\\\\\\\\\\\Out[231]: 20000
```

21.12.2 *Categorical* is not a *numpy* array

Currently, categorical data and the underlying *Categorical* is implemented as a python object and not as a low-level *numpy* array dtype. This leads to some problems.

numpy itself doesn't know about the new *dtype*:

```
In [232]: try:
   .....:     np.dtype("category")
   .....: except TypeError as e:
   .....:     print("TypeError: " + str(e))
   .....:
TypeError: data type "category" not understood

In [233]: dtype = pd.Categorical(["a"]).dtype

In [234]: try:
   .....:     np.dtype(dtype)
   .....: except TypeError as e:
   .....:      print("TypeError: " + str(e))
   .....:
TypeError: data type not understood
```

Dtype comparisons work:

```
In [235]: dtype == np.str_
Out[235]: False

In [236]: np.str_ == dtype
\\\\\\\\\\\\\\\\Out[236]: False
```

To check if a Series contains Categorical data, use `hasattr(s, 'cat')`:

```
In [237]: hasattr(pd.Series(['a'], dtype='category'), 'cat')
Out[237]: True

In [238]: hasattr(pd.Series(['a']), 'cat')
\\\\\\\\\\\\\\\Out[238]: False
```

Using *numpy* functions on a *Series* of type `category` should not work as *Categoricals* are not numeric data (even in the case that `.categories` is numeric).

```
In [239]: s = pd.Series(pd.Categorical([1,2,3,4]))

In [240]: try:
   .....:     np.sum(s)
   .....: except TypeError as e:
   .....:      print("TypeError: " + str(e))
   .....:
TypeError: Categorical cannot perform the operation sum
```

Note: If such a function works, please file a bug at https://github.com/pandas-dev/pandas!

21.12.3 dtype in apply

Pandas currently does not preserve the dtype in apply functions: If you apply along rows you get a *Series* of `object` *dtype* (same as getting a row -> getting one element will return a basic type) and applying along columns will also convert to object.

```
In [241]: df = pd.DataFrame({"a":[1,2,3,4],
   .....:                    "b":["a","b","c","d"],
   .....:                    "cats":pd.Categorical([1,2,3,2])})
   .....:

In [242]: df.apply(lambda row: type(row["cats"]), axis=1)
Out[242]:
0    <class 'int'>
1    <class 'int'>
2    <class 'int'>
3    <class 'int'>
dtype: object

In [243]: df.apply(lambda col: col.dtype, axis=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a       object
b       object
```

```
cats    object
dtype: object
```

21.12.4 Categorical Index

`CategoricalIndex` is a type of index that is useful for supporting indexing with duplicates. This is a container around a `Categorical` and allows efficient indexing and storage of an index with a large number of duplicated elements. See the *advanced indexing docs* for a more detailed explanation.

Setting the index will create a `CategoricalIndex`

```
In [244]: cats = pd.Categorical([1,2,3,4], categories=[4,2,3,1])

In [245]: strings = ["a","b","c","d"]

In [246]: values = [4,2,3,1]

In [247]: df = pd.DataFrame({"strings":strings, "values":values}, index=cats)

In [248]: df.index
Out[248]: CategoricalIndex([1, 2, 3, 4], categories=[4, 2, 3, 1], ordered=False,␣
↪dtype='category')

# This now sorts by the categories order
In [249]: df.sort_index()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Ou
↪
  strings  values
4       d       1
2       b       2
3       c       3
1       a       4
```

21.12.5 Side Effects

Constructing a *Series* from a *Categorical* will not copy the input *Categorical*. This means that changes to the *Series* will in most cases change the original *Categorical*:

```
In [250]: cat = pd.Categorical([1,2,3,10], categories=[1,2,3,4,10])

In [251]: s = pd.Series(cat, name="cat")

In [252]: cat
Out[252]: 
[1, 2, 3, 10]
Categories (5, int64): [1, 2, 3, 4, 10]

In [253]: s.iloc[0:2] = 10

In [254]: cat
Out[254]: 
[10, 10, 3, 10]
Categories (5, int64): [1, 2, 3, 4, 10]

In [255]: df = pd.DataFrame(s)
```

```
In [256]: df["cat"].cat.categories = [1,2,3,4,5]

In [257]: cat
Out[257]:
[5, 5, 3, 5]
Categories (5, int64): [1, 2, 3, 4, 5]
```

Use `copy=True` to prevent such a behaviour or simply don't reuse *Categoricals*:

```
In [258]: cat = pd.Categorical([1,2,3,10], categories=[1,2,3,4,10])

In [259]: s = pd.Series(cat, name="cat", copy=True)

In [260]: cat
Out[260]:
[1, 2, 3, 10]
Categories (5, int64): [1, 2, 3, 4, 10]

In [261]: s.iloc[0:2] = 10

In [262]: cat
Out[262]:
[1, 2, 3, 10]
Categories (5, int64): [1, 2, 3, 4, 10]
```

Note: This also happens in some cases when you supply a *numpy* array instead of a *Categorical*: using an int array (e.g. `np.array([1,2,3,4])`) will exhibit the same behaviour, while using a string array (e.g. `np.array(["a","b","c","a"])`) will not.

CHAPTER

TWENTYTWO

VISUALIZATION

We use the standard convention for referencing the matplotlib API:

```
In [1]: import matplotlib.pyplot as plt
```

We provide the basics in pandas to easily create decent looking plots. See the *ecosystem* section for visualization libraries that go beyond the basics documented here.

Note: All calls to `np.random` are seeded with 123456.

22.1 Basic Plotting: `plot`

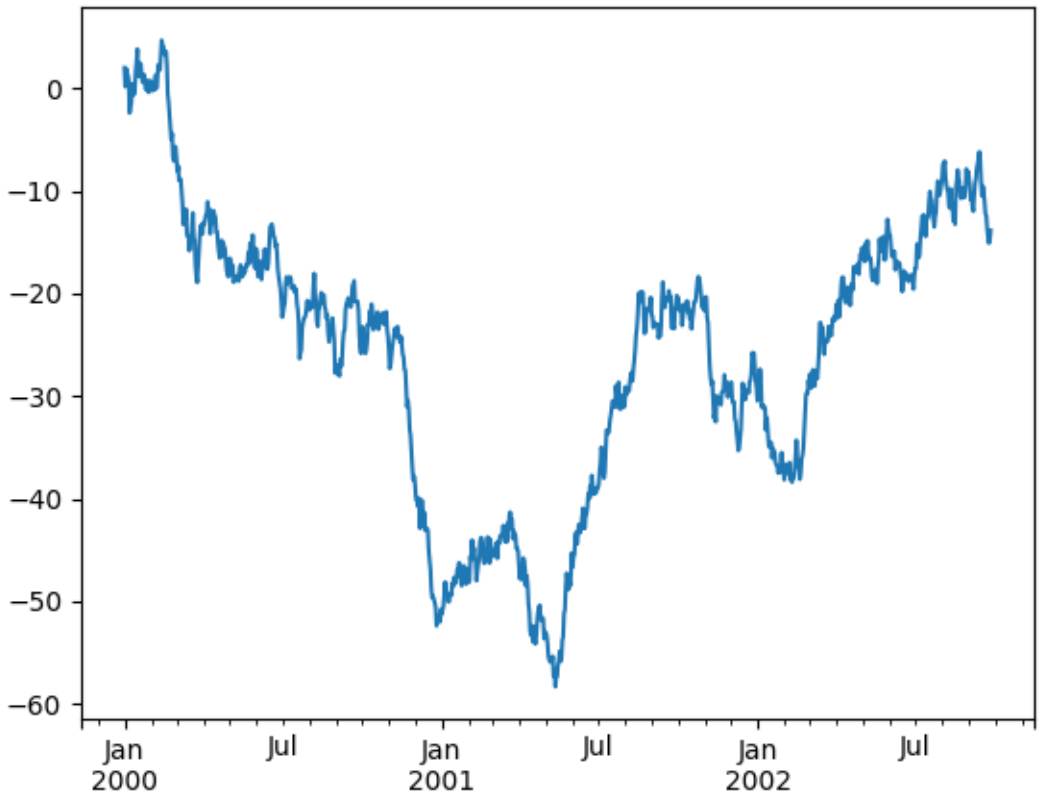
See the *cookbook* for some advanced strategies

The `plot` method on Series and DataFrame is just a simple wrapper around `plt.plot()`:

```
In [2]: ts = pd.Series(np.random.randn(1000), index=pd.date_range('1/1/2000',␣
↪periods=1000))

In [3]: ts = ts.cumsum()

In [4]: ts.plot()
Out[4]: <matplotlib.axes._subplots.AxesSubplot at 0x128f4bcc0>
```



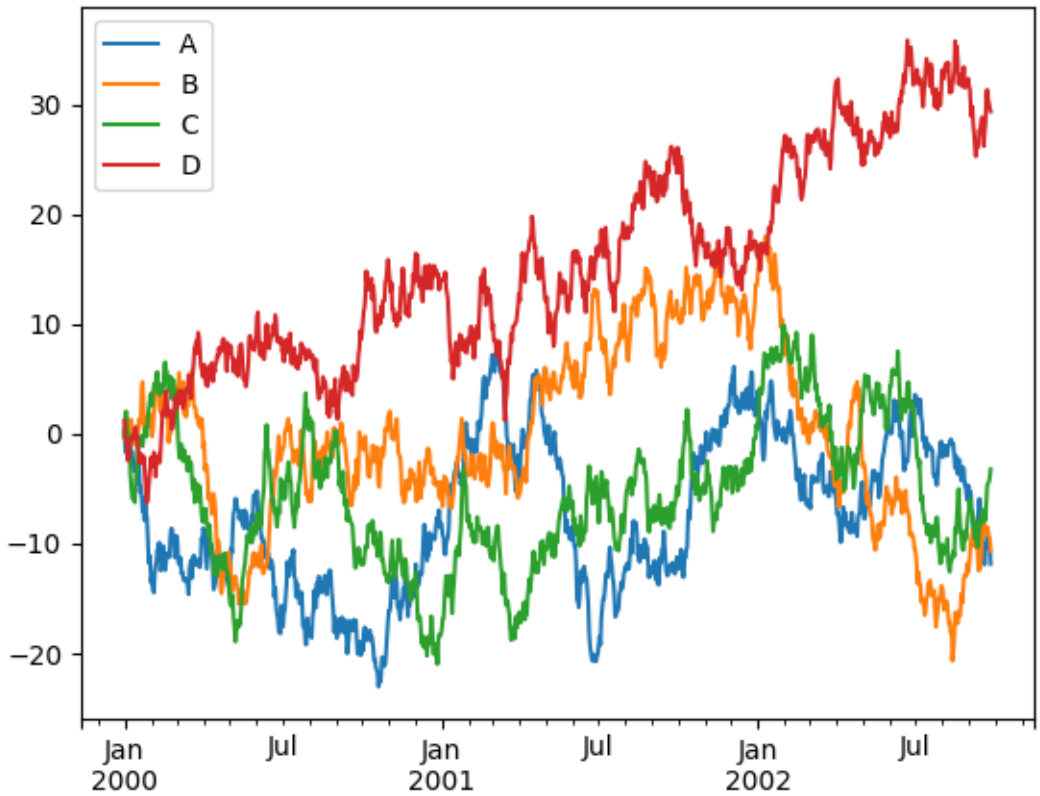
If the index consists of dates, it calls `gcf().autofmt_xdate()` to try to format the x-axis nicely as per above.

On DataFrame, *`plot()`* is a convenience to plot all of the columns with labels:

```
In [5]: df = pd.DataFrame(np.random.randn(1000, 4), index=ts.index, columns=list('ABCD
↪'))

In [6]: df = df.cumsum()

In [7]: plt.figure(); df.plot();
```

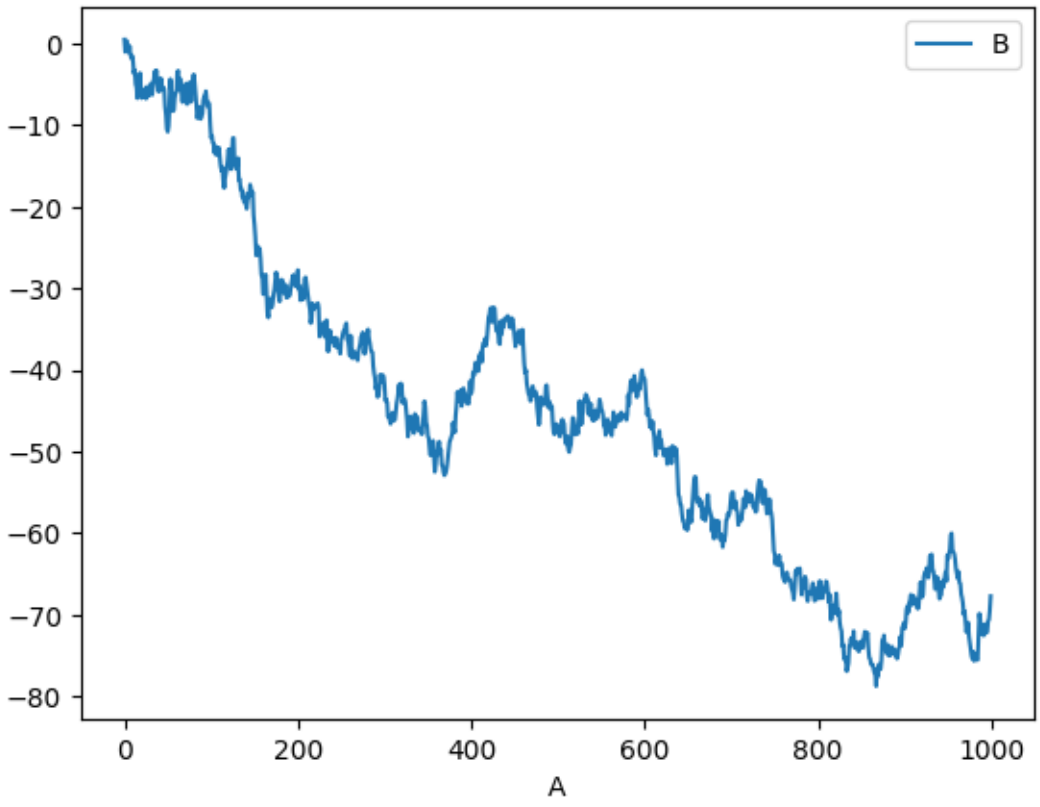


You can plot one column versus another using the *x* and *y* keywords in `plot()`:

```
In [8]: df3 = pd.DataFrame(np.random.randn(1000, 2), columns=['B', 'C']).cumsum()

In [9]: df3['A'] = pd.Series(list(range(len(df))))

In [10]: df3.plot(x='A', y='B')
Out[10]: <matplotlib.axes._subplots.AxesSubplot at 0x128bed5f8>
```



Note: For more formatting and styling options, see *below*.

22.2 Other Plots

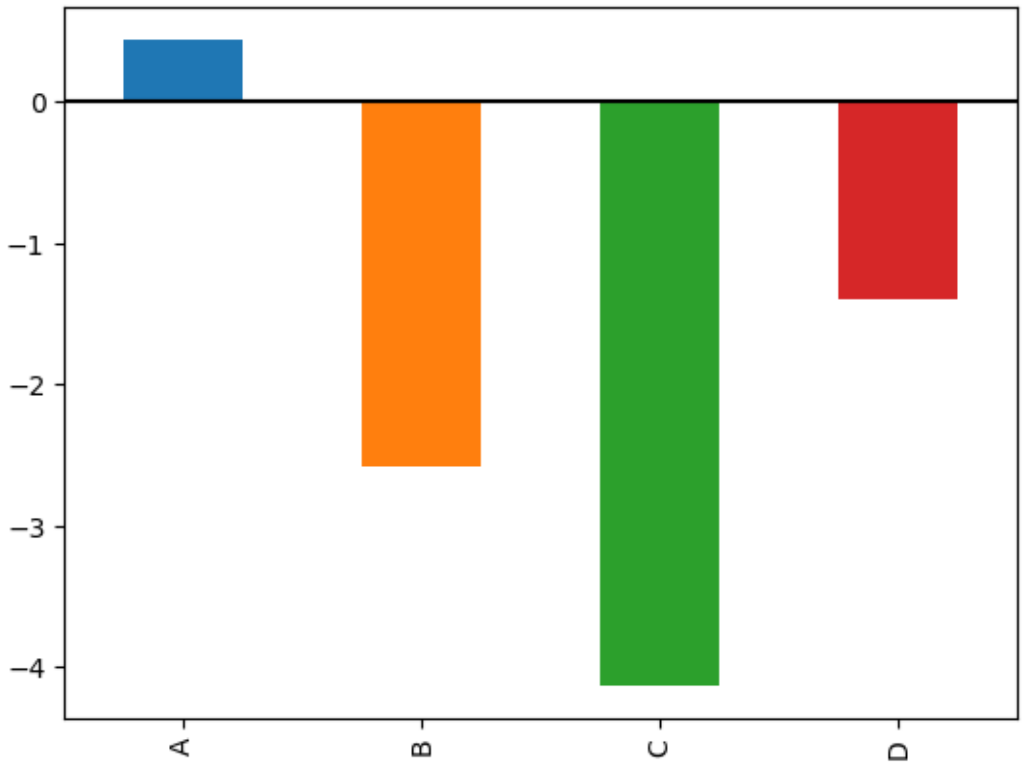
Plotting methods allow for a handful of plot styles other than the default Line plot. These methods can be provided as the `kind` keyword argument to *`plot()`*. These include:

- *'bar'* or *'barh'* for bar plots
- *'hist'* for histogram
- *'box'* for boxplot
- *'kde'* or `'density'` for density plots
- *'area'* for area plots
- *'scatter'* for scatter plots
- *'hexbin'* for hexagonal bin plots
- *'pie'* for pie plots

For example, a bar plot can be created the following way:

```
In [11]: plt.figure();

In [12]: df.iloc[5].plot(kind='bar');
```



New in version 0.17.0.

You can also create these other plots using the methods `DataFrame.plot.<kind>` instead of providing the `kind` keyword argument. This makes it easier to discover plot methods and the specific arguments they use:

```
In [13]: df = pd.DataFrame()

In [14]: df.plot.<TAB>
df.plot.area     df.plot.barh     df.plot.density  df.plot.hist     df.plot.line
↪df.plot.scatter
df.plot.bar      df.plot.box      df.plot.hexbin   df.plot.kde      df.plot.pie
```

In addition to these `kind` s, there are the *DataFrame.hist()*, and *DataFrame.boxplot()* methods, which use a separate interface.

Finally, there are several *plotting functions* in `pandas.plotting` that take a `Series` or `DataFrame` as an argument. These include:

- *Scatter Matrix*
- *Andrews Curves*
- *Parallel Coordinates*
- *Lag Plot*
- *Autocorrelation Plot*
- *Bootstrap Plot*
- *RadViz*

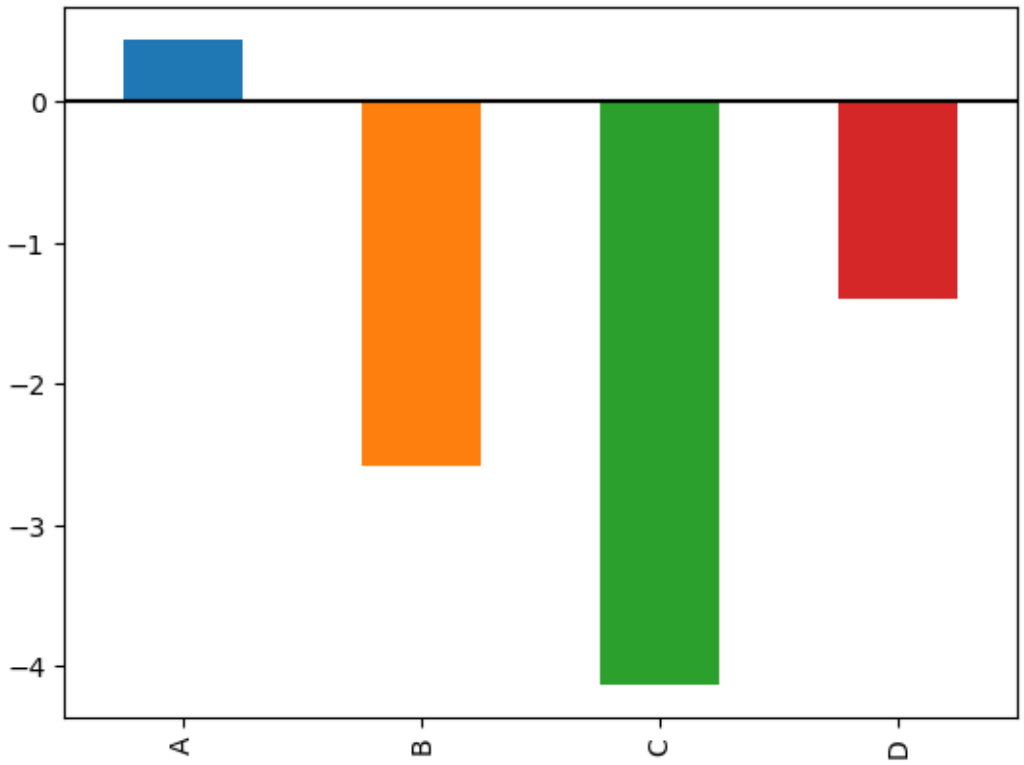
Plots may also be adorned with *errorbars* or *tables*.

22.2.1 Bar plots

For labeled, non-time series data, you may wish to produce a bar plot:

```
In [15]: plt.figure();

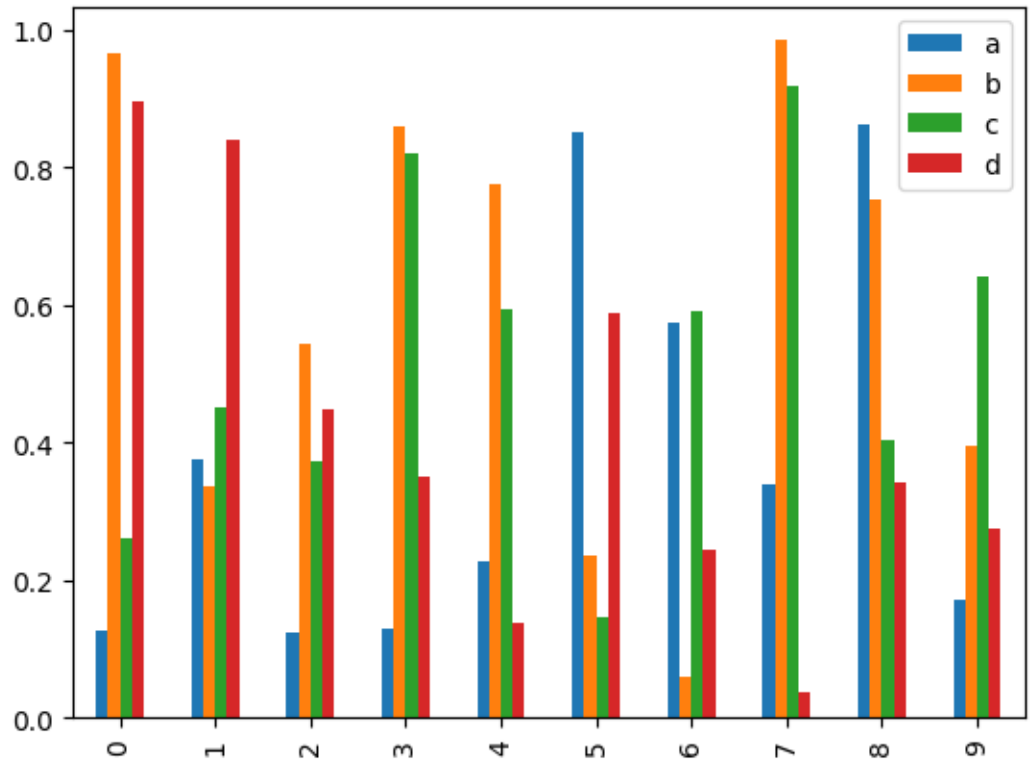
In [16]: df.iloc[5].plot.bar(); plt.axhline(0, color='k')
Out[16]: <matplotlib.lines.Line2D at 0x120654be0>
```



Calling a DataFrame's `plot.bar()` method produces a multiple bar plot:

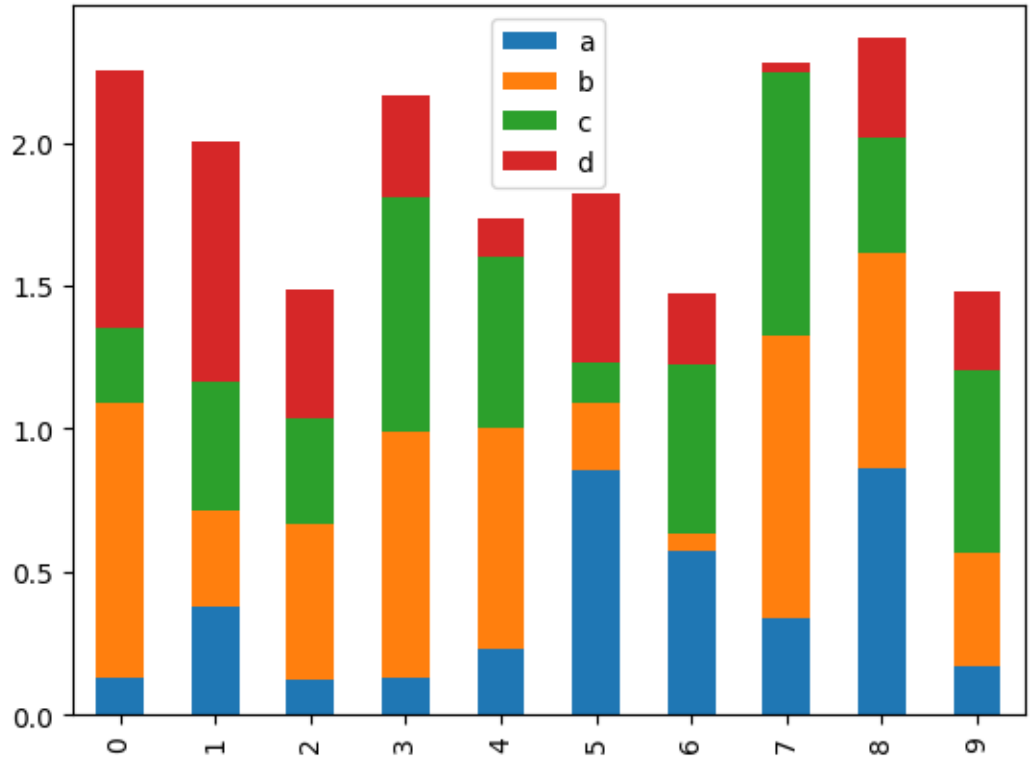
```
In [17]: df2 = pd.DataFrame(np.random.rand(10, 4), columns=['a', 'b', 'c', 'd'])

In [18]: df2.plot.bar();
```



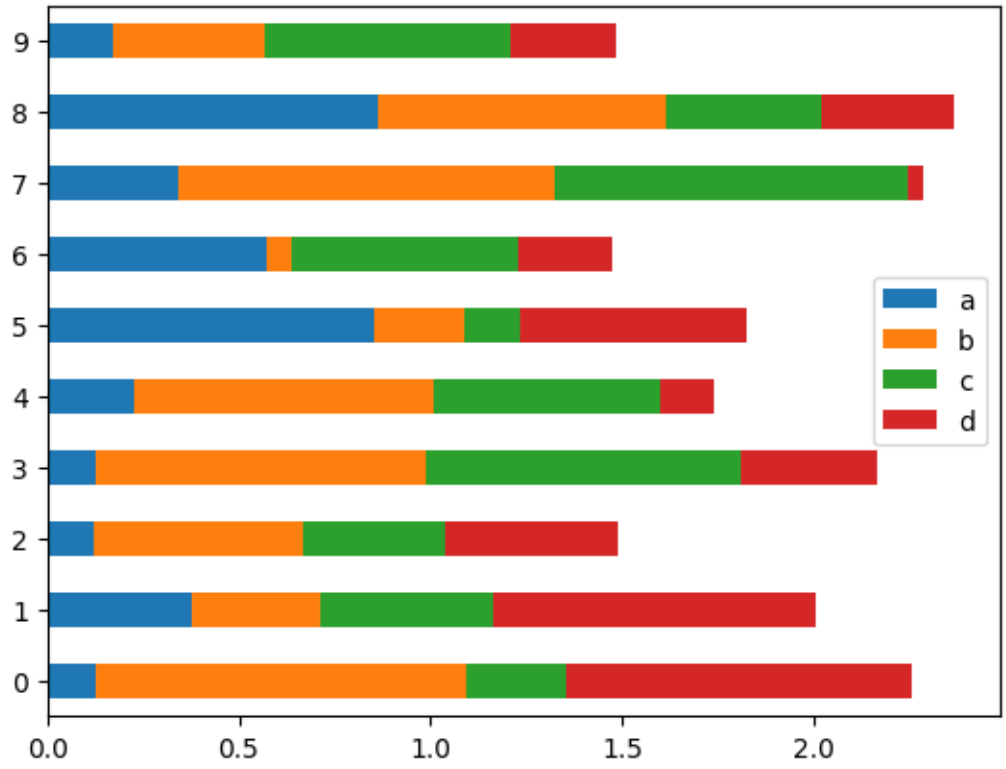
To produce a stacked bar plot, pass `stacked=True`:

```
In [19]: df2.plot.bar(stacked=True);
```



To get horizontal bar plots, use the `barh` method:

```
In [20]: df2.plot.barh(stacked=True);
```



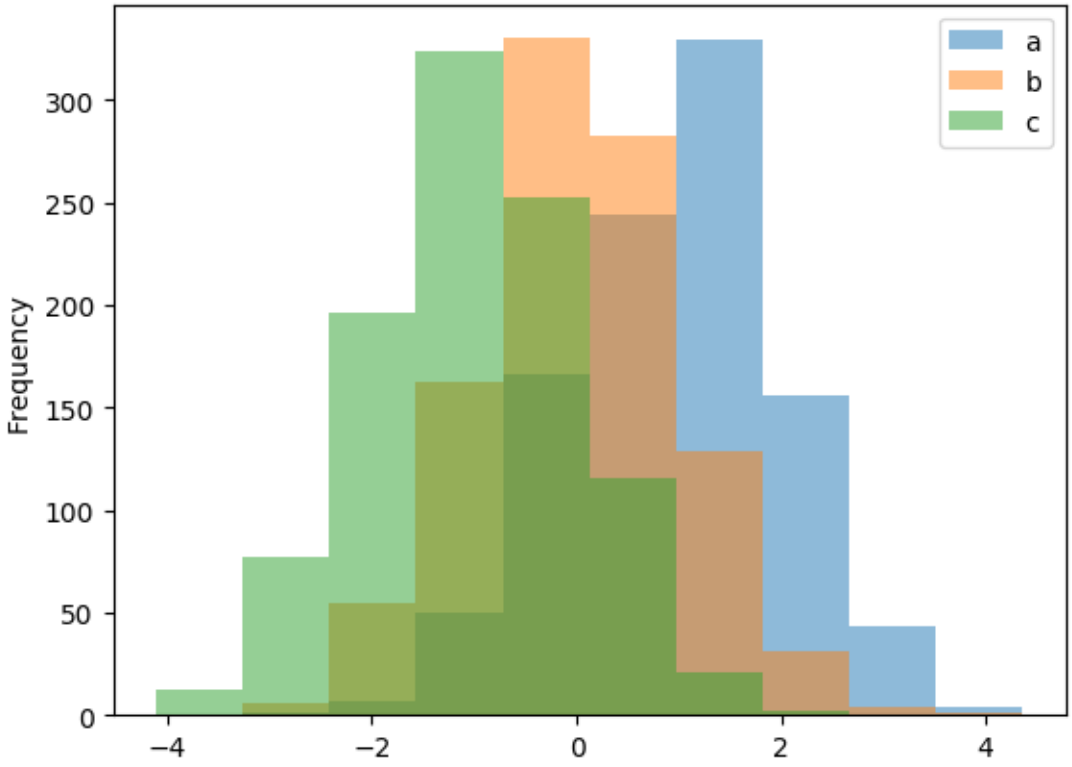
22.2.2 Histograms

Histogram can be drawn by using the *`DataFrame.plot.hist()`* and *`Series.plot.hist()`* methods.

```
In [21]: df4 = pd.DataFrame({'a': np.random.randn(1000) + 1, 'b': np.random.
↪randn(1000),
   ....:                     'c': np.random.randn(1000) - 1}, columns=['a', 'b', 'c'])
   ....:

In [22]: plt.figure();

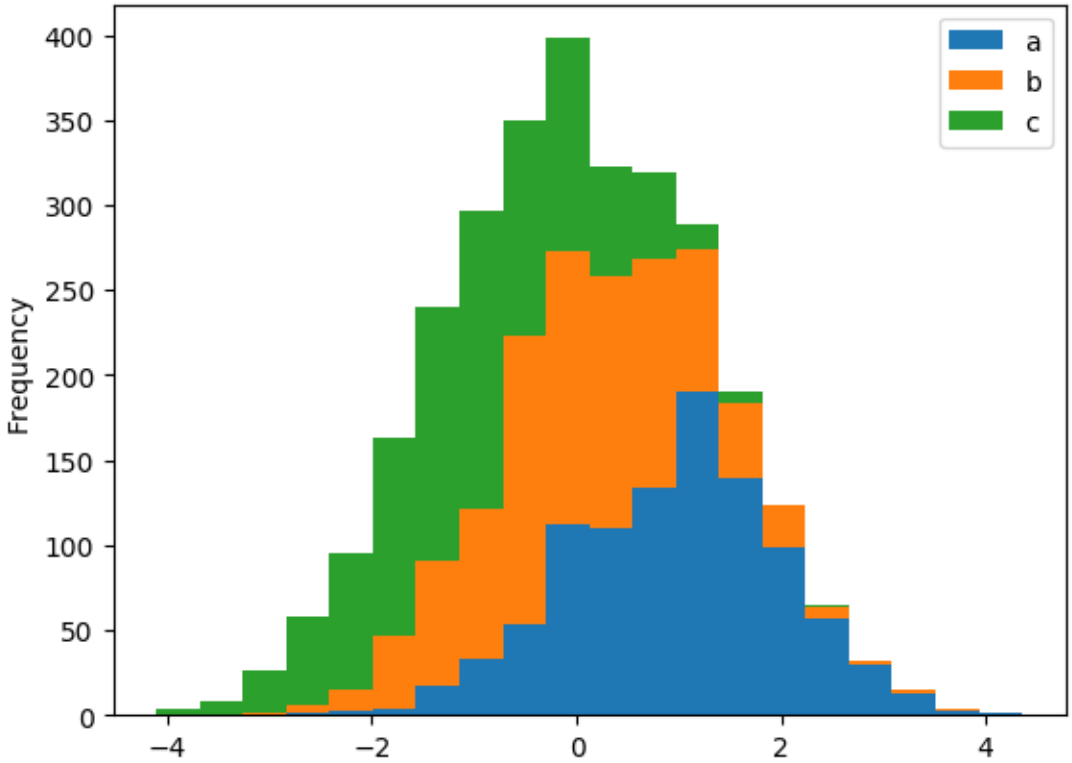
In [23]: df4.plot.hist(alpha=0.5)
Out[23]: <matplotlib.axes._subplots.AxesSubplot at 0x1150fb6a0>
```



Histogram can be stacked by `stacked=True`. Bin size can be changed by `bins` keyword.

```
In [24]: plt.figure();

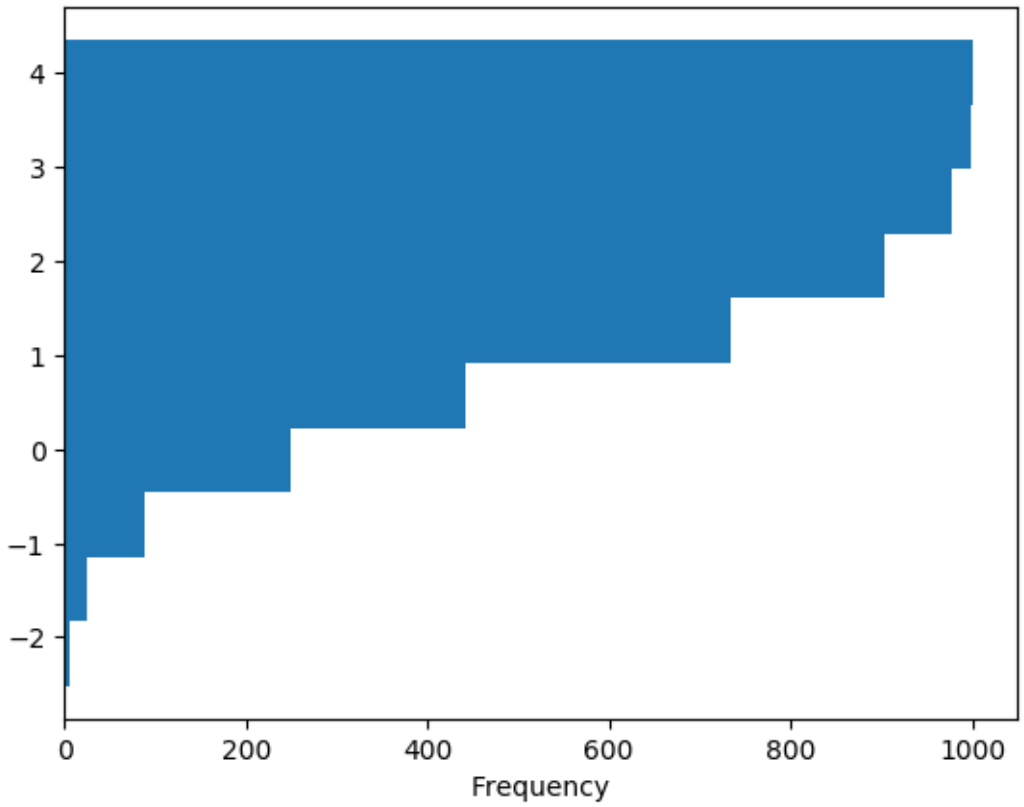
In [25]: df4.plot.hist(stacked=True, bins=20)
Out[25]: <matplotlib.axes._subplots.AxesSubplot at 0x12d400eb8>
```



You can pass other keywords supported by matplotlib `hist`. For example, horizontal and cumulative histogram can be drawn by `orientation='horizontal'` and `cumulative=True`.

```
In [26]: plt.figure();

In [27]: df4['a'].plot.hist(orientation='horizontal', cumulative=True)
Out[27]: <matplotlib.axes._subplots.AxesSubplot at 0x128ea3da0>
```

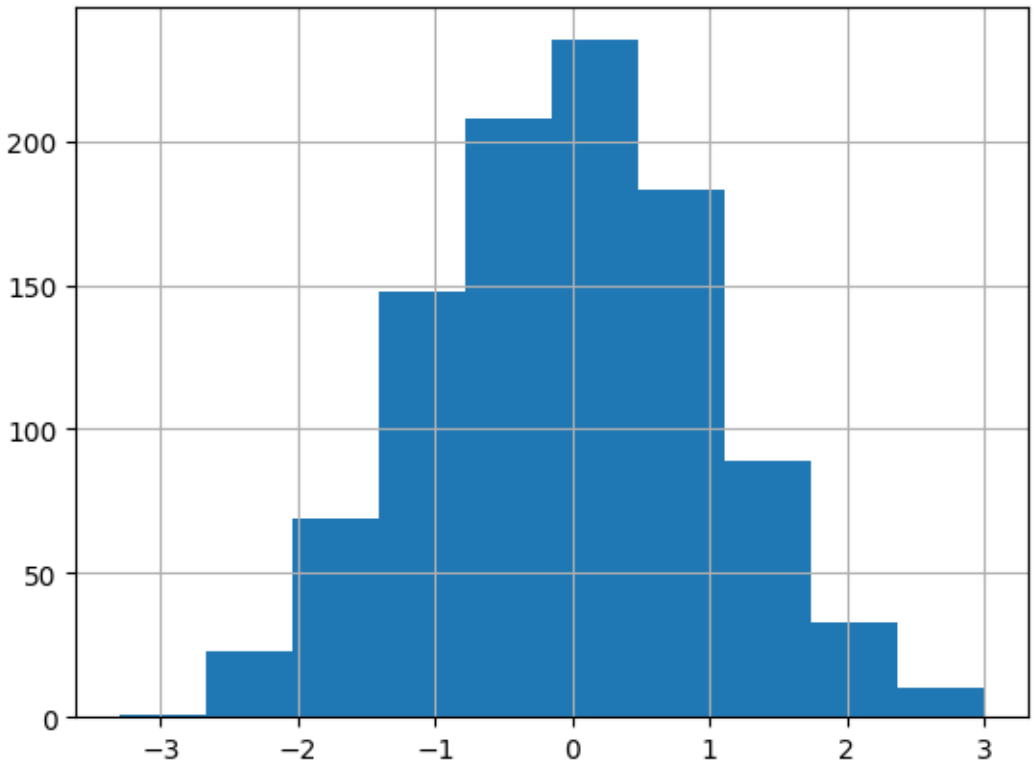


See the `hist` method and the matplotlib hist documentation for more.

The existing interface `DataFrame.hist` to plot histogram still can be used.

```
In [28]: plt.figure();

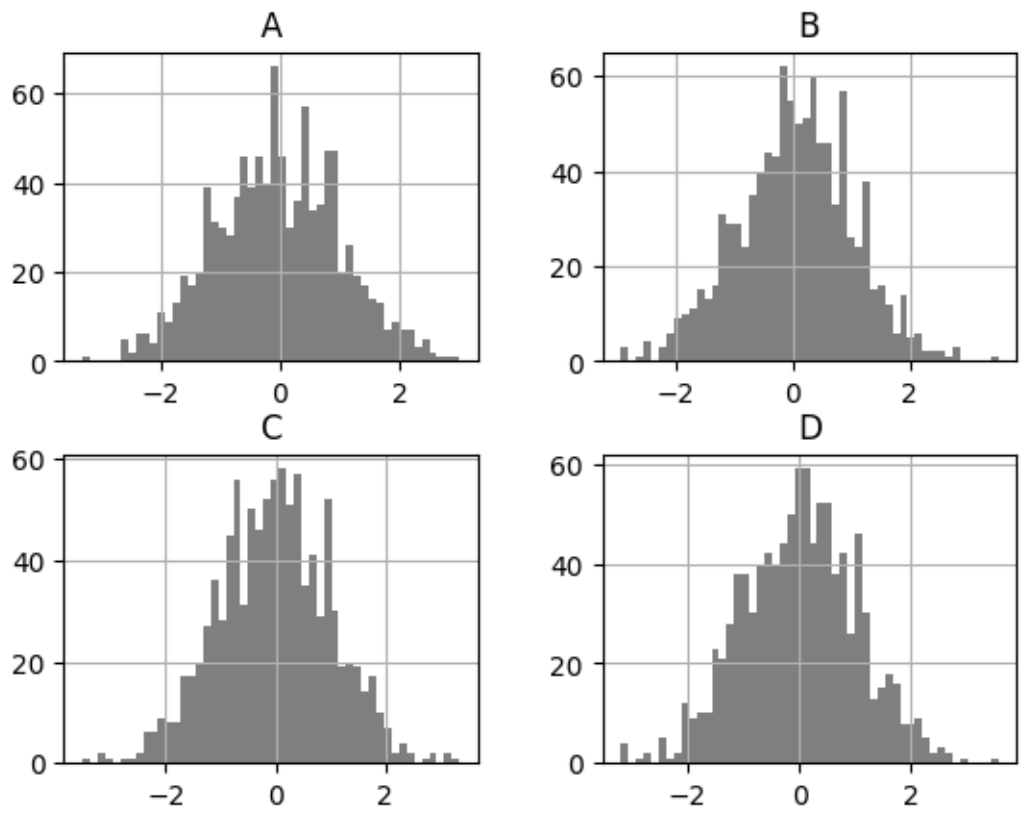
In [29]: df['A'].diff().hist()
Out[29]: <matplotlib.axes._subplots.AxesSubplot at 0x12ee45a20>
```



`DataFrame.hist()` plots the histograms of the columns on multiple subplots:

```
In [30]: plt.figure()
Out[30]: <matplotlib.figure.Figure at 0x12b6df208>

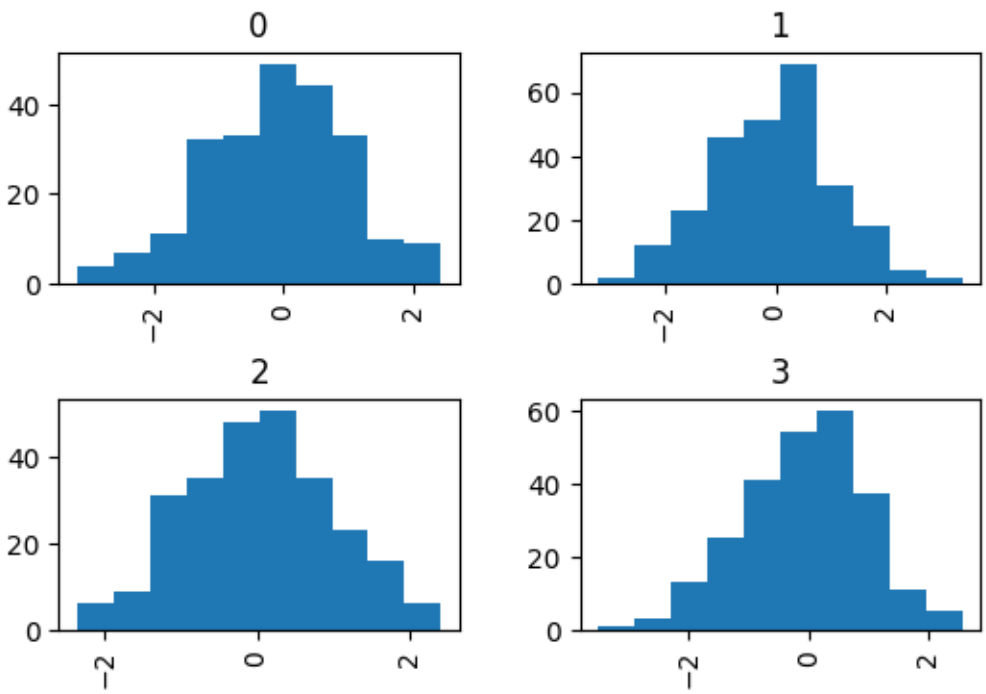
In [31]: df.diff().hist(color='k', alpha=0.5, bins=50)
\\\
```



The `by` keyword can be specified to plot grouped histograms:

```
In [32]: data = pd.Series(np.random.randn(1000))

In [33]: data.hist(by=np.random.randint(0, 4, 1000), figsize=(6, 4))
Out[33]:
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x12a7855c0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x12616ea58>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x12a173908>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x12a41ef28>]], dtype=object)
```



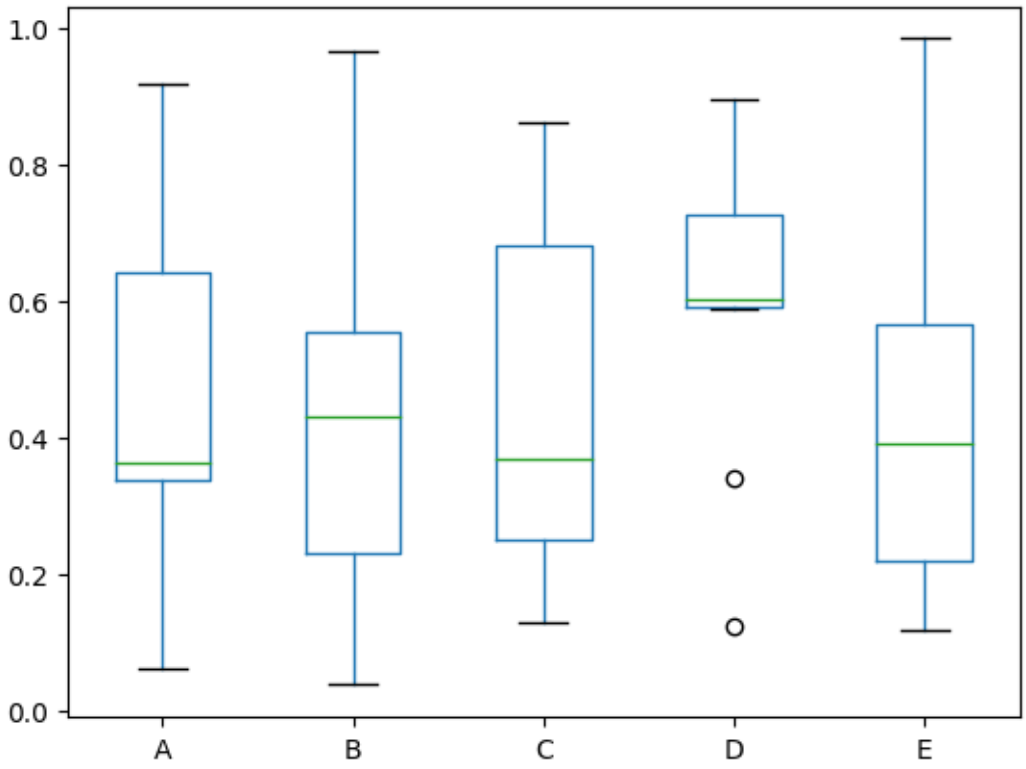
22.2.3 Box Plots

Boxplot can be drawn calling `Series.plot.box()` and `DataFrame.plot.box()`, or `DataFrame.boxplot()` to visualize the distribution of values within each column.

For instance, here is a boxplot representing five trials of 10 observations of a uniform random variable on [0,1).

```
In [34]: df = pd.DataFrame(np.random.rand(10, 5), columns=['A', 'B', 'C', 'D', 'E'])

In [35]: df.plot.box()
Out[35]: <matplotlib.axes._subplots.AxesSubplot at 0x128eb0080>
```



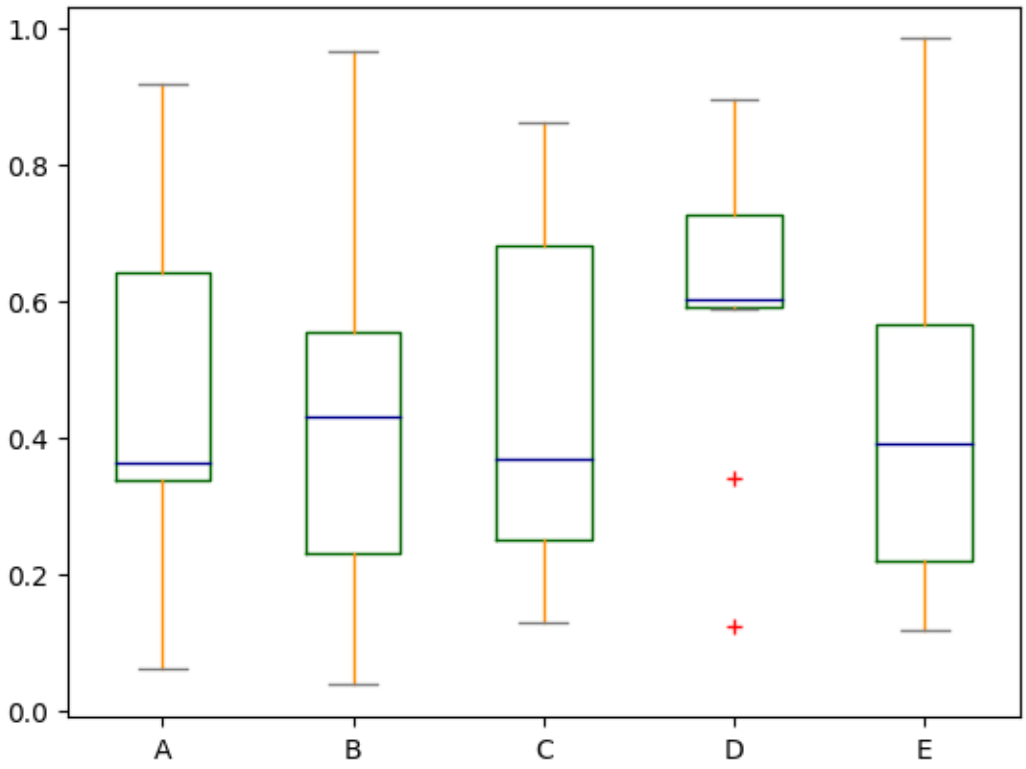
Boxplot can be colorized by passing `color` keyword. You can pass a `dict` whose keys are `boxes`, `whiskers`, `medians` and `caps`. If some keys are missing in the `dict`, default colors are used for the corresponding artists. Also, boxplot has `sym` keyword to specify fliers style.

When you pass other type of arguments via `color` keyword, it will be directly passed to matplotlib for all the `boxes`, `whiskers`, `medians` and `caps` colorization.

The colors are applied to every boxes to be drawn. If you want more complicated colorization, you can get each drawn artists by passing *return_type*.

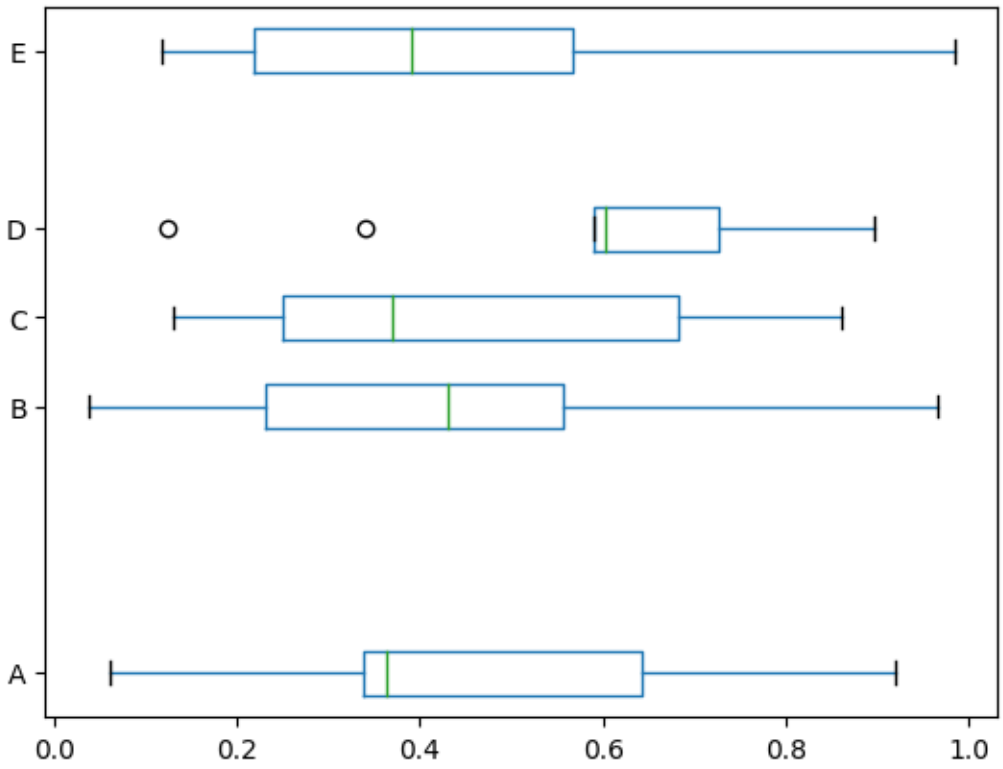
```
In [36]: color = dict(boxes='DarkGreen', whiskers='DarkOrange',
    ....:               medians='DarkBlue', caps='Gray')
    ....:

In [37]: df.plot.box(color=color, sym='r+')
Out[37]: <matplotlib.axes._subplots.AxesSubplot at 0x1279f08d0>
```



Also, you can pass other keywords supported by matplotlib `boxplot`. For example, horizontal and custom-positioned boxplot can be drawn by `vert=False` and `positions` keywords.

```
In [38]: df.plot.box(vert=False, positions=[1, 4, 5, 6, 8])
Out[38]: <matplotlib.axes._subplots.AxesSubplot at 0x13134c7b8>
```



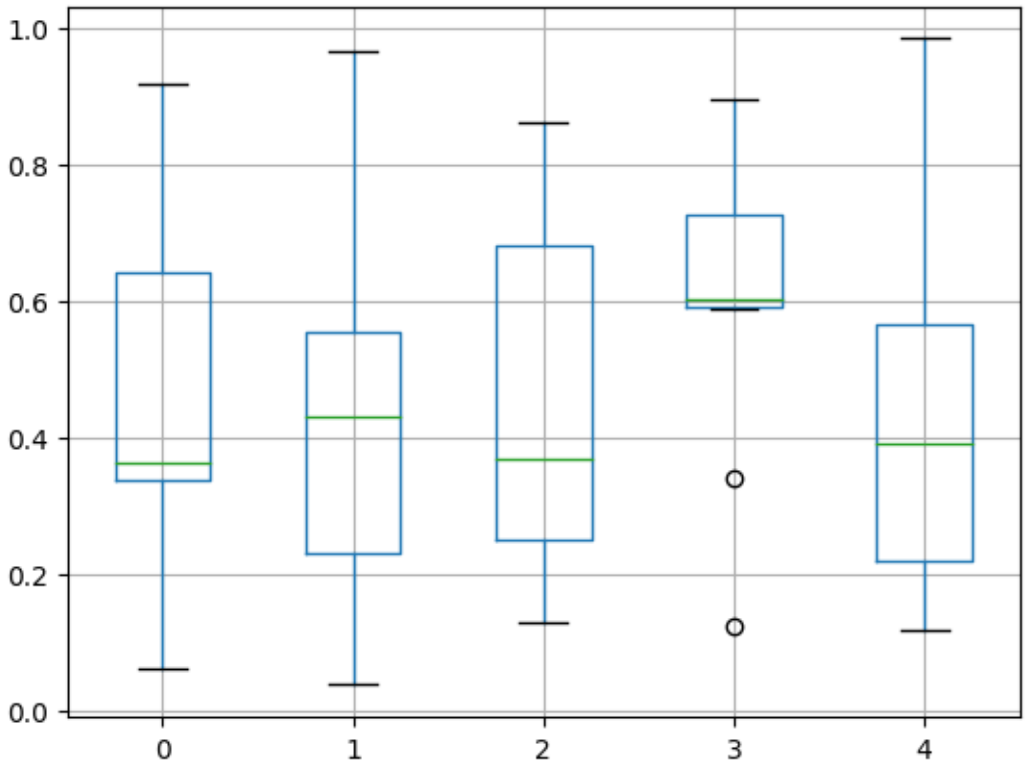
See the `boxplot` method and the matplotlib boxplot documentation for more.

The existing interface `DataFrame.boxplot` to plot boxplot still can be used.

```
In [39]: df = pd.DataFrame(np.random.rand(10,5))

In [40]: plt.figure();

In [41]: bp = df.boxplot()
```



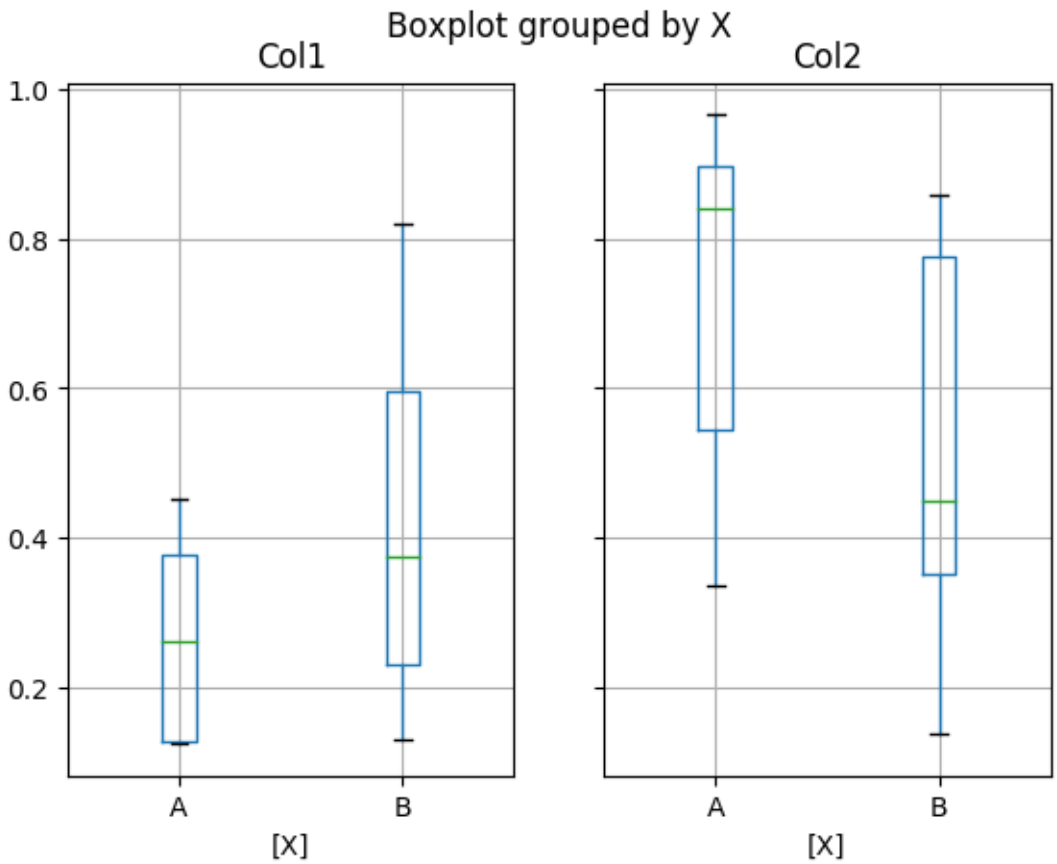
You can create a stratified boxplot using the `by` keyword argument to create groupings. For instance,

```
In [42]: df = pd.DataFrame(np.random.rand(10,2), columns=['Col1', 'Col2'] )

In [43]: df['X'] = pd.Series(['A','A','A','A','A','B','B','B','B','B'])

In [44]: plt.figure();

In [45]: bp = df.boxplot(by='X')
```



You can also pass a subset of columns to plot, as well as group by multiple columns:

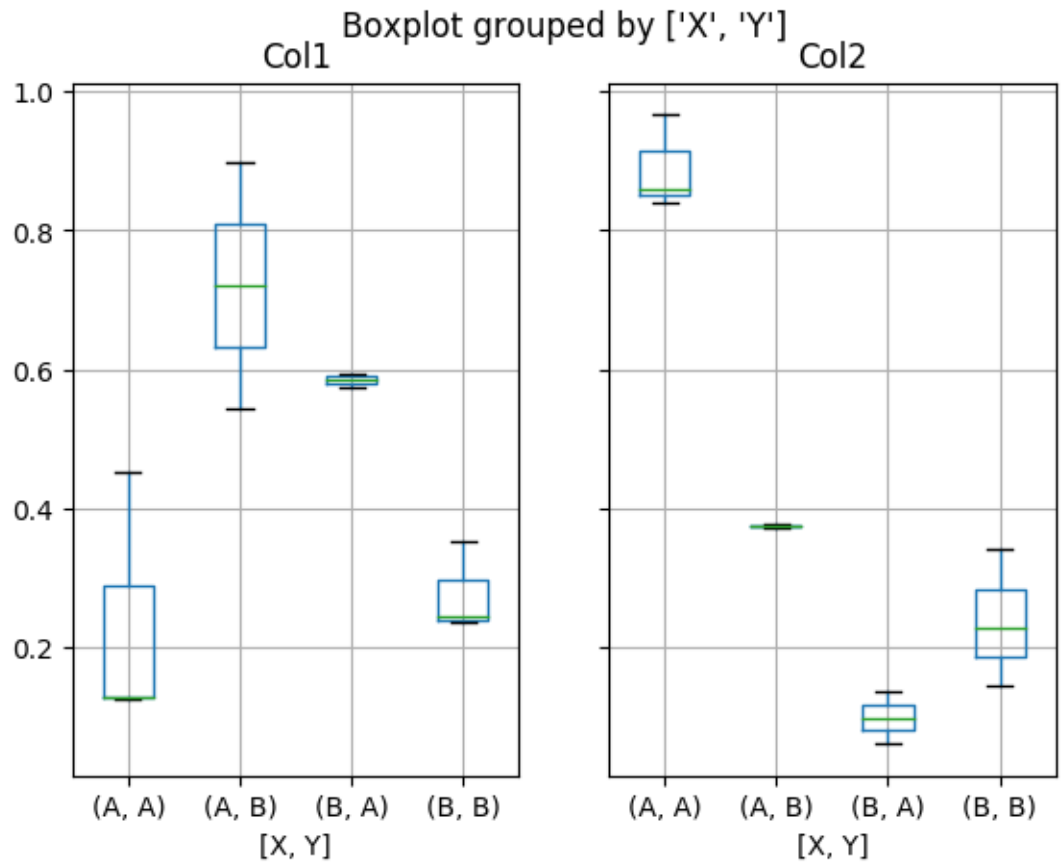
```
In [46]: df = pd.DataFrame(np.random.rand(10,3), columns=['Col1', 'Col2', 'Col3'])

In [47]: df['X'] = pd.Series(['A','A','A','A','A','B','B','B','B','B'])

In [48]: df['Y'] = pd.Series(['A','B','A','B','A','B','A','B','A','B'])

In [49]: plt.figure();

In [50]: bp = df.boxplot(column=['Col1','Col2'], by=['X','Y'])
```



Warning: The default changed from `'dict'` to `'axes'` in version 0.19.0.

In `boxplot`, the return type can be controlled by the `return_type`, keyword. The valid choices are `{"axes", "dict", "both", None}`. Faceting, created by `DataFrame.boxplot` with the `by` keyword, will affect the output type as well:

`return_type=`	Faceted	Output type
`None`	No	axes
`None`	Yes	2-D ndarray of axes
`'axes'`	No	axes
`'axes'`	Yes	Series of axes
`'dict'`	No	dict of artists
`'dict'`	Yes	Series of dicts of artists
`'both'`	No	namedtuple
`'both'`	Yes	Series of namedtuples

`Groupby.boxplot` always returns a Series of `return_type`.

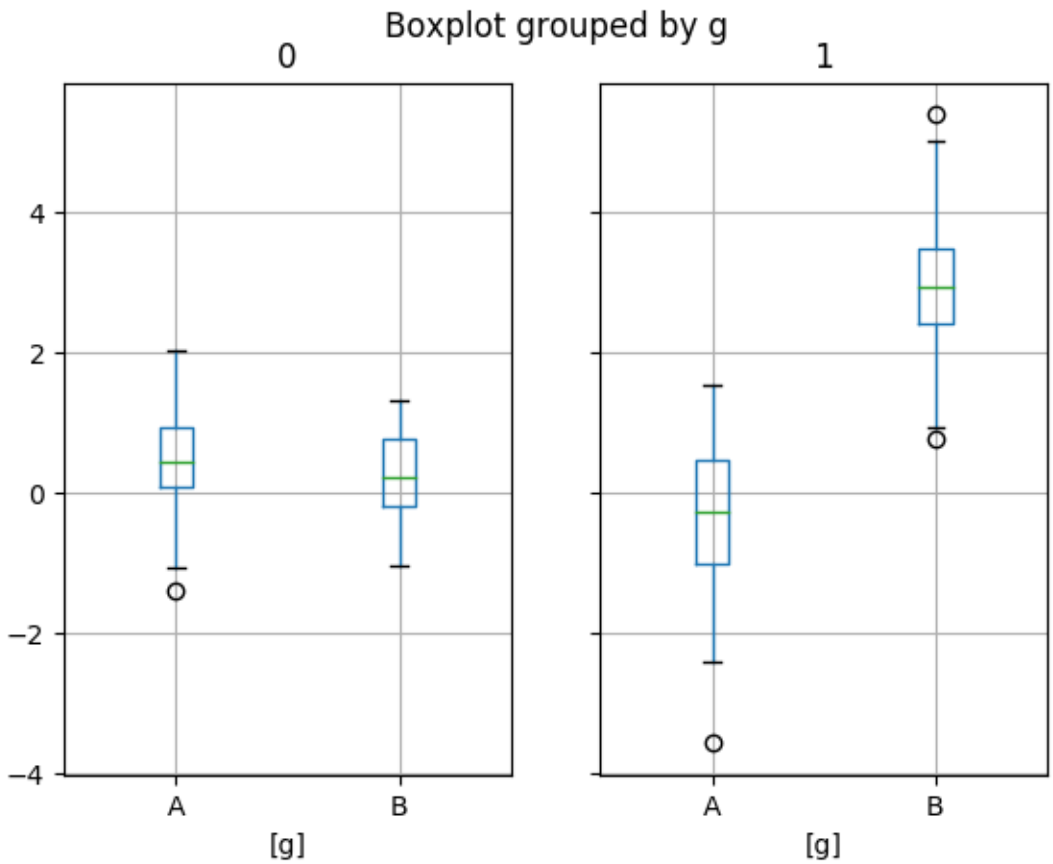
```
In [51]: np.random.seed(1234)

In [52]: df_box = pd.DataFrame(np.random.randn(50, 2))

In [53]: df_box['g'] = np.random.choice(['A', 'B'], size=50)

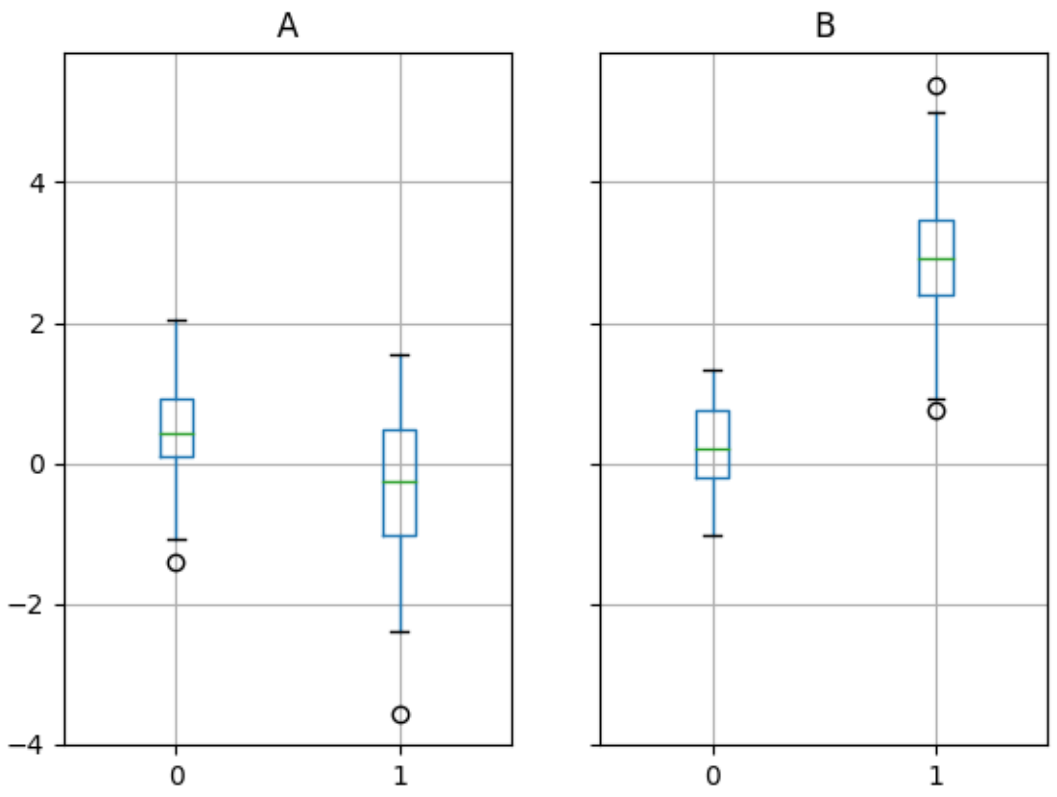
In [54]: df_box.loc[df_box['g'] == 'B', 1] += 3
```

```
In [55]: bp = df_box.boxplot(by='g')
```



Compare to:

```
In [56]: bp = df_box.groupby('g').boxplot()
```



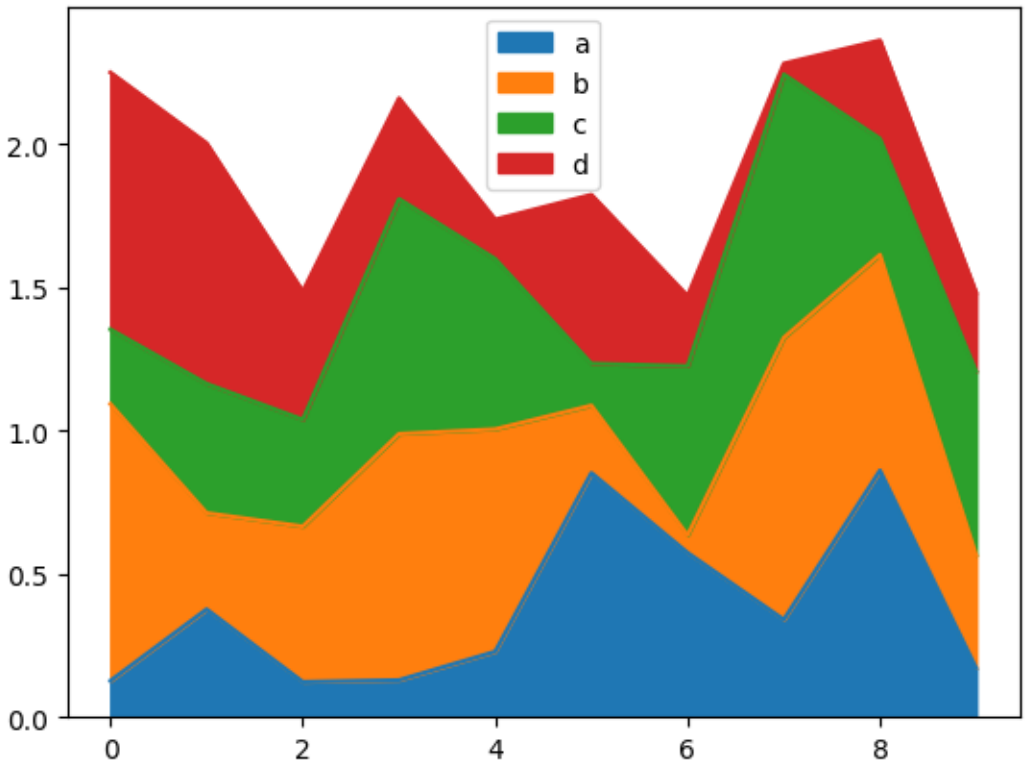
22.2.4 Area Plot

You can create area plots with `Series.plot.area()` and `DataFrame.plot.area()`. Area plots are stacked by default. To produce stacked area plot, each column must be either all positive or all negative values.

When input data contains *NaN*, it will be automatically filled by 0. If you want to drop or fill by different values, use `dataframe.dropna()` or `dataframe.fillna()` before calling *plot*.

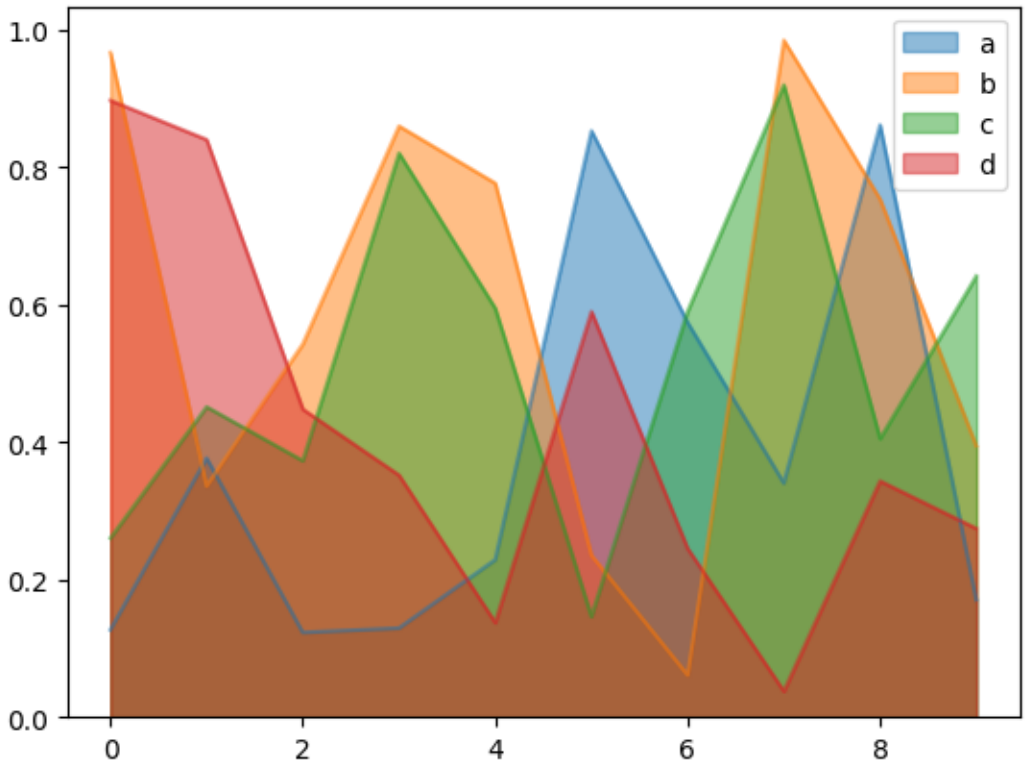
```
In [57]: df = pd.DataFrame(np.random.rand(10, 4), columns=['a', 'b', 'c', 'd'])

In [58]: df.plot.area();
```



To produce an unstacked plot, pass `stacked=False`. Alpha value is set to 0.5 unless otherwise specified:

```
In [59]: df.plot.area(stacked=False);
```

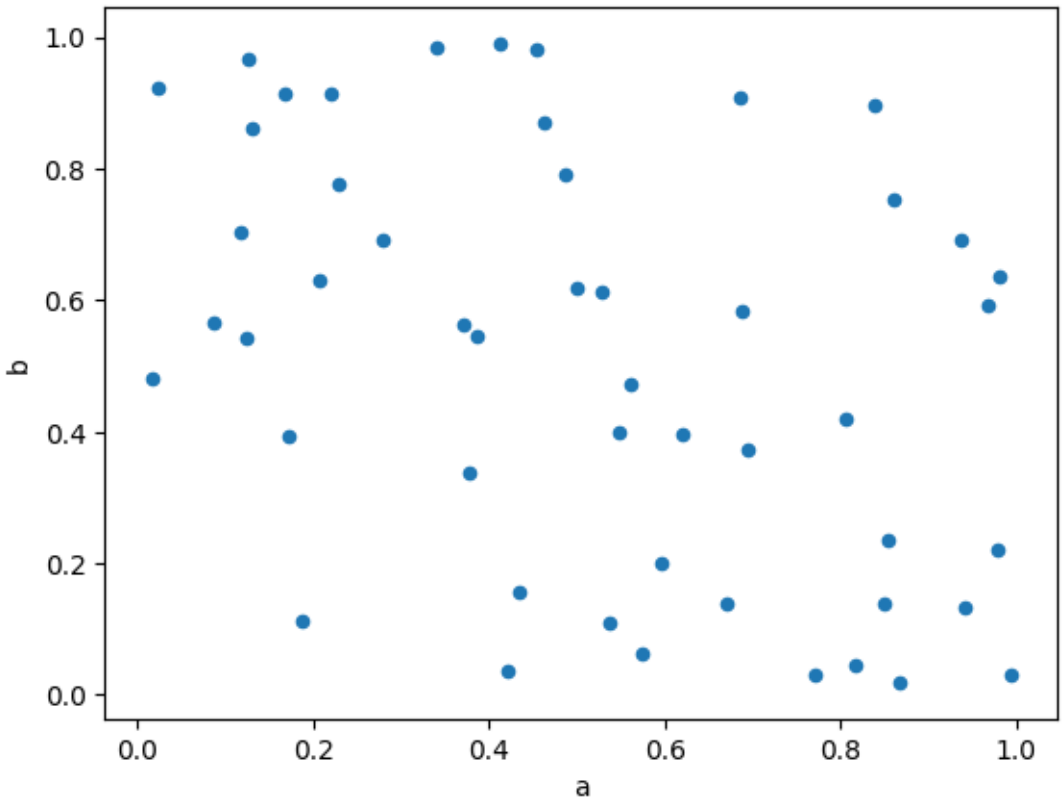


22.2.5 Scatter Plot

Scatter plot can be drawn by using the `DataFrame.plot.scatter()` method. Scatter plot requires numeric columns for x and y axis. These can be specified by `x` and `y` keywords each.

```
In [60]: df = pd.DataFrame(np.random.rand(50, 4), columns=['a', 'b', 'c', 'd'])

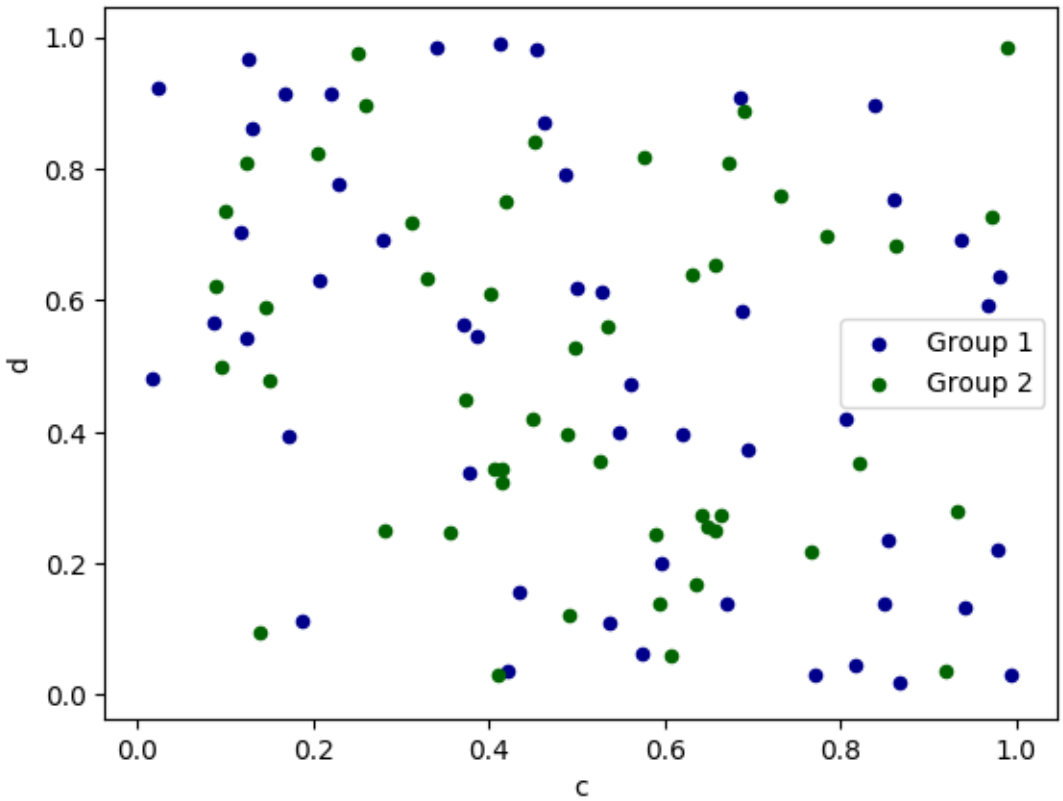
In [61]: df.plot.scatter(x='a', y='b');
```



To plot multiple column groups in a single axes, repeat `plot` method specifying target `ax`. It is recommended to specify `color` and `label` keywords to distinguish each groups.

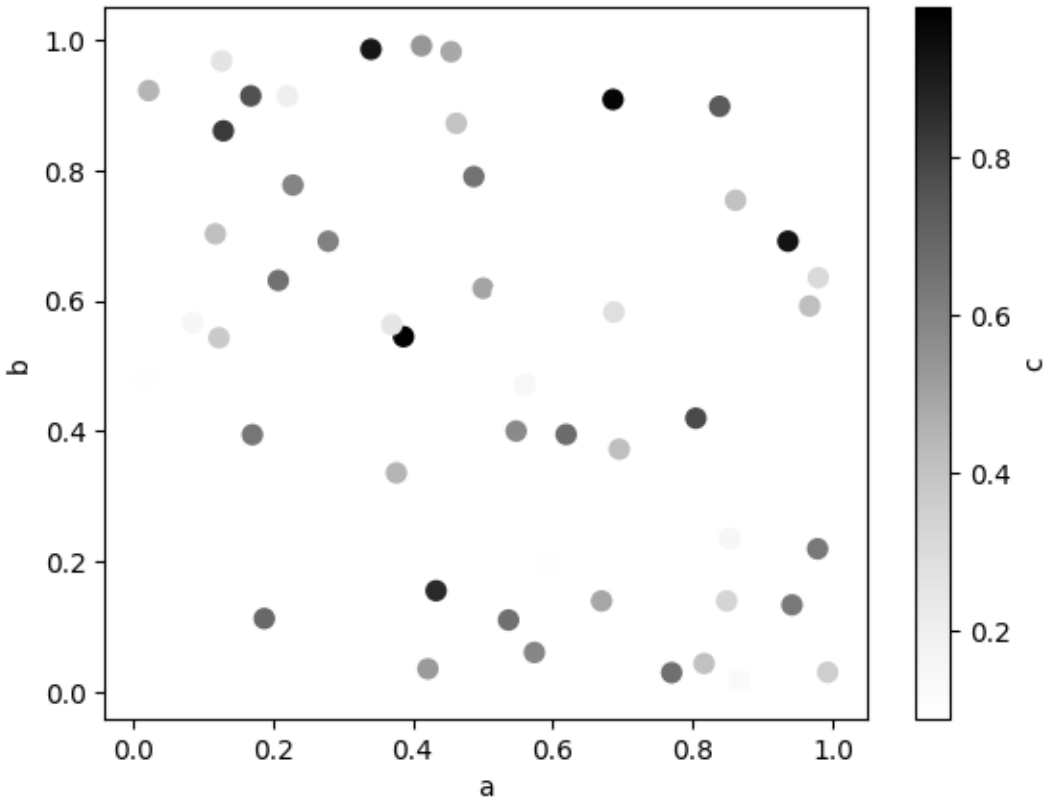
```
In [62]: ax = df.plot.scatter(x='a', y='b', color='DarkBlue', label='Group 1');

In [63]: df.plot.scatter(x='c', y='d', color='DarkGreen', label='Group 2', ax=ax);
```



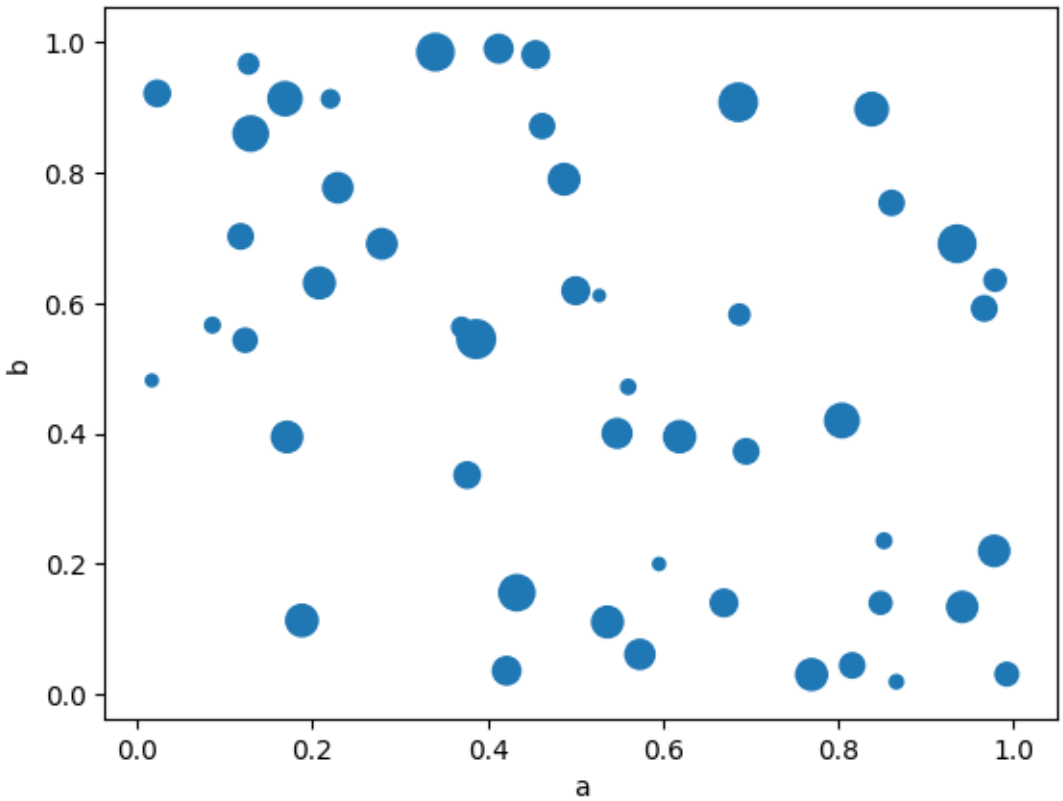
The keyword `c` may be given as the name of a column to provide colors for each point:

```
In [64]: df.plot.scatter(x='a', y='b', c='c', s=50);
```



You can pass other keywords supported by matplotlib `scatter`. Below example shows a bubble chart using a dataframe column values as bubble size.

```
In [65]: df.plot.scatter(x='a', y='b', s=df['c']*200);
```



See the `scatter` method and the matplotlib scatter documentation for more.

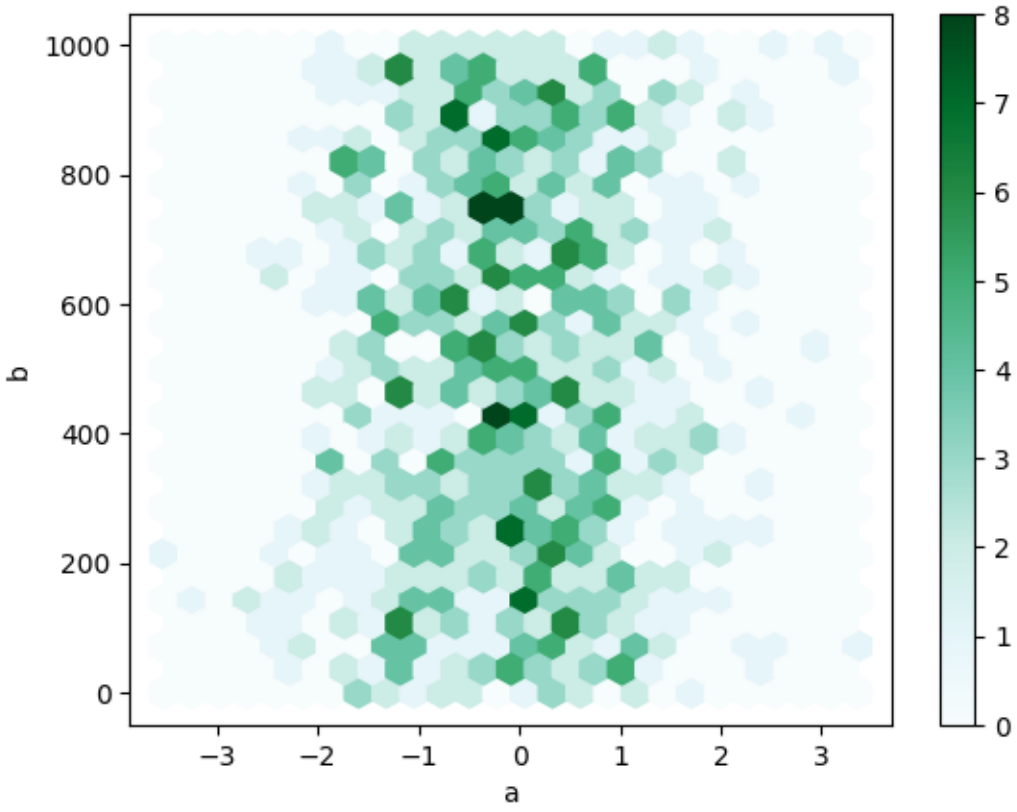
22.2.6 Hexagonal Bin Plot

You can create hexagonal bin plots with *`DataFrame.plot.hexbin()`*. Hexbin plots can be a useful alternative to scatter plots if your data are too dense to plot each point individually.

```
In [66]: df = pd.DataFrame(np.random.randn(1000, 2), columns=['a', 'b'])

In [67]: df['b'] = df['b'] + np.arange(1000)

In [68]: df.plot.hexbin(x='a', y='b', gridsize=25)
Out[68]: <matplotlib.axes._subplots.AxesSubplot at 0x12cdb8588>
```



A useful keyword argument is `gridsize`; it controls the number of hexagons in the x-direction, and defaults to 100. A larger `gridsize` means more, smaller bins.

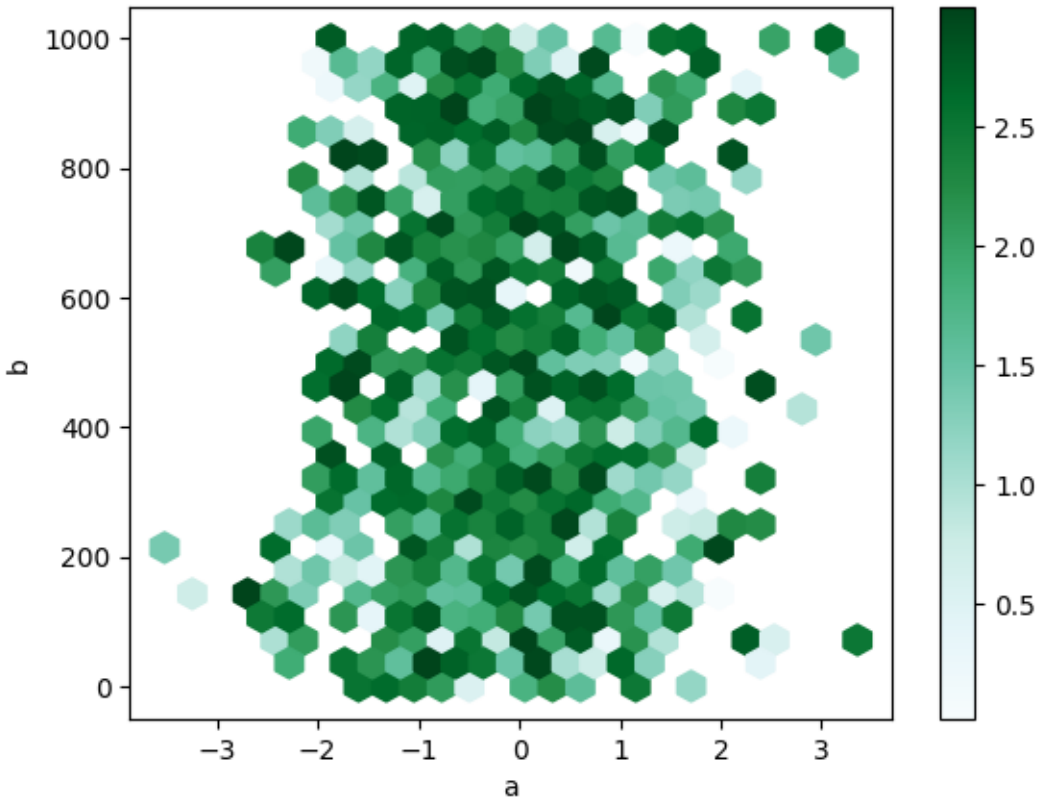
By default, a histogram of the counts around each `(x, y)` point is computed. You can specify alternative aggregations by passing values to the `C` and `reduce_C_function` arguments. `C` specifies the value at each `(x, y)` point and `reduce_C_function` is a function of one argument that reduces all the values in a bin to a single number (e.g. `mean`, `max`, `sum`, `std`). In this example the positions are given by columns `a` and `b`, while the value is given by column `z`. The bins are aggregated with numpy's `max` function.

```
In [69]: df = pd.DataFrame(np.random.randn(1000, 2), columns=['a', 'b'])

In [70]: df['b'] = df['b'] = df['b'] + np.arange(1000)

In [71]: df['z'] = np.random.uniform(0, 3, 1000)

In [72]: df.plot.hexbin(x='a', y='b', C='z', reduce_C_function=np.max,
   ....:         gridsize=25)
   ....:
Out[72]: <matplotlib.axes._subplots.AxesSubplot at 0x12df6f978>
```



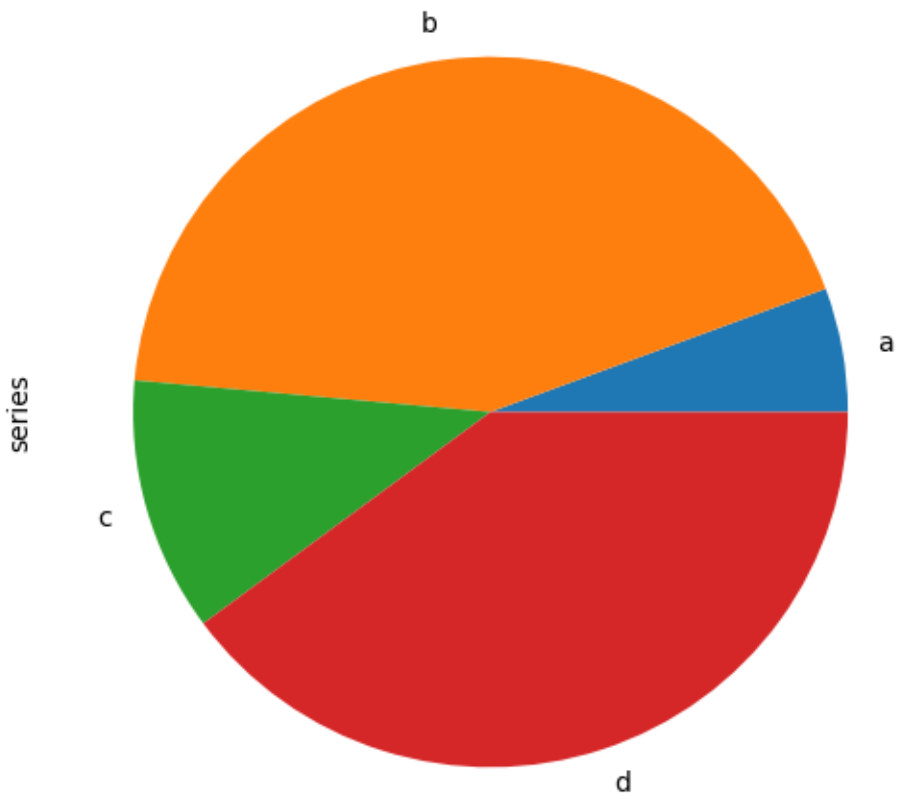
See the `hexbin` method and the matplotlib hexbin documentation for more.

22.2.7 Pie plot

You can create a pie plot with *`DataFrame.plot.pie()`* or *`Series.plot.pie()`*. If your data includes any `NaN`, they will be automatically filled with 0. A `ValueError` will be raised if there are any negative values in your data.

```
In [73]: series = pd.Series(3 * np.random.rand(4), index=['a', 'b', 'c', 'd'], name=
↪'series')

In [74]: series.plot.pie(figsize=(6, 6))
Out[74]: <matplotlib.axes._subplots.AxesSubplot at 0x12da00438>
```

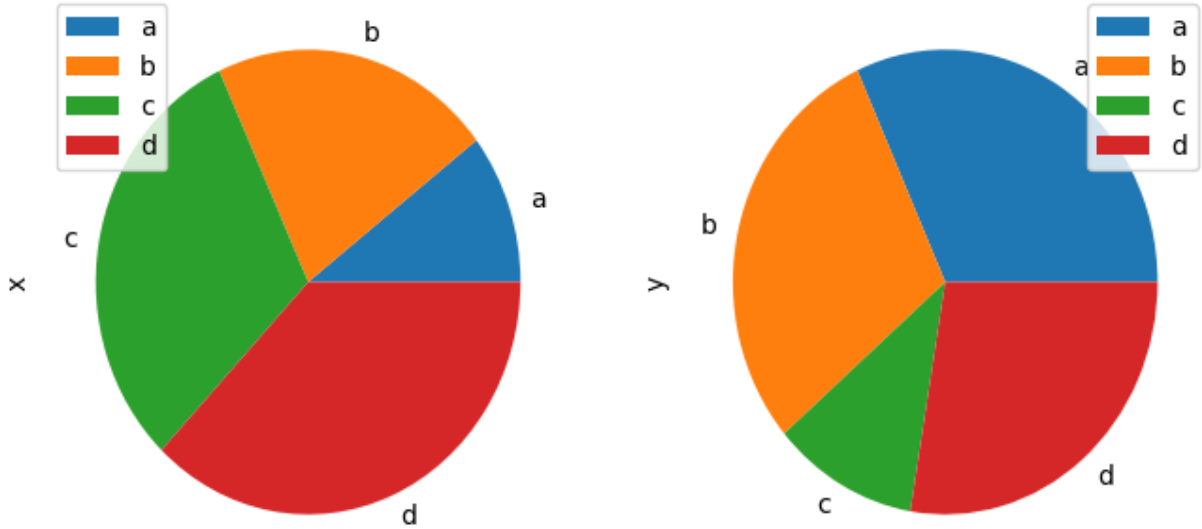


For pie plots it's best to use square figures, one's with an equal aspect ratio. You can create the figure with equal width and height, or force the aspect ratio to be equal after plotting by calling `ax.set_aspect('equal')` on the returned `axes` object.

Note that pie plot with *DataFrame* requires that you either specify a target column by the `y` argument or `subplots=True`. When `y` is specified, pie plot of selected column will be drawn. If `subplots=True` is specified, pie plots for each column are drawn as subplots. A legend will be drawn in each pie plots by default; specify `legend=False` to hide it.

```
In [75]: df = pd.DataFrame(3 * np.random.rand(4, 2), index=['a', 'b', 'c', 'd'],␣
↪columns=['x', 'y'])

In [76]: df.plot.pie(subplots=True, figsize=(8, 4))
Out[76]:
array([<matplotlib.axes._subplots.AxesSubplot object at 0x128f2bf60>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x127ebcc50>], dtype=object)
```

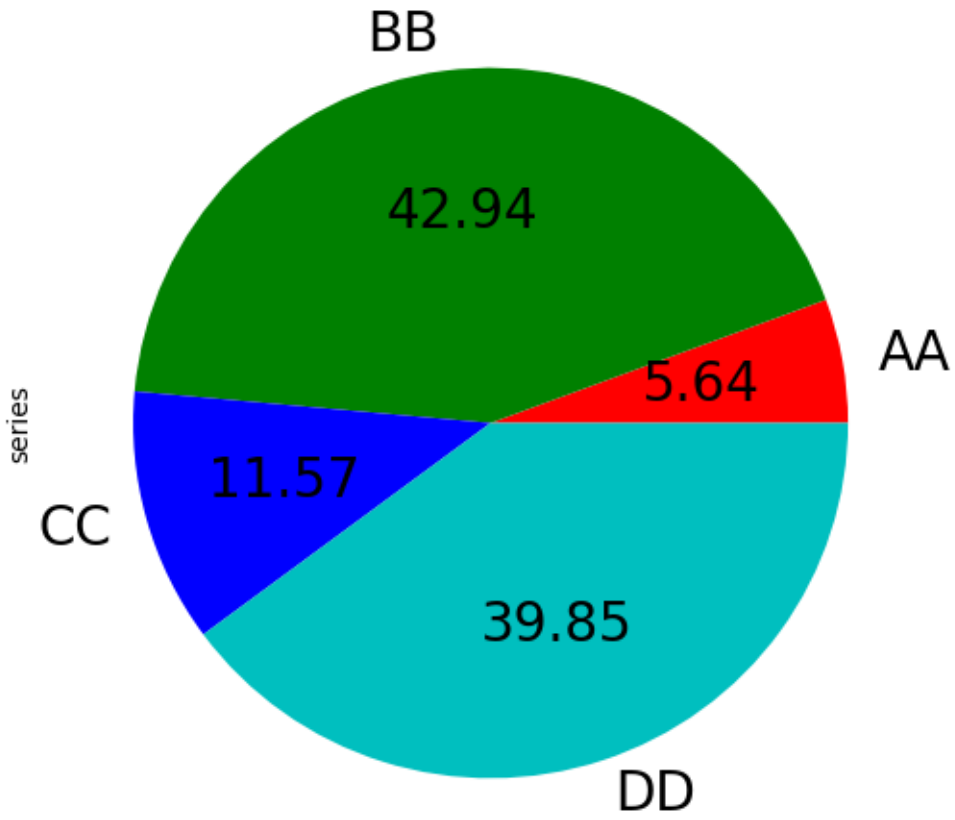


You can use the `labels` and `colors` keywords to specify the labels and colors of each wedge.

> **Warning:** Most pandas plots use the the `label` and `color` arguments (note the lack of "s" on those). To be consistent with `matplotlib.pyplot.pie()` you must use `labels` and `colors`.

If you want to hide wedge labels, specify `labels=None`. If `fontsize` is specified, the value will be applied to wedge labels. Also, other keywords supported by `matplotlib.pyplot.pie()` can be used.

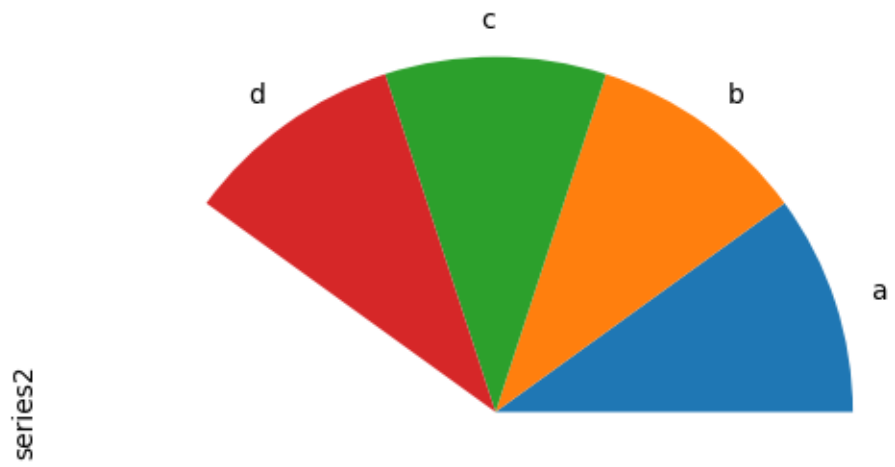
```
In [77]: series.plot.pie(labels=['AA', 'BB', 'CC', 'DD'], colors=['r', 'g', 'b', 'c'],
   ....:                 autopct='%.2f', fontsize=20, figsize=(6, 6))
   ....:
Out[77]: <matplotlib.axes._subplots.AxesSubplot at 0x12cdb8b38>
```



If you pass values whose sum total is less than 1.0, matplotlib draws a semicircle.

```
In [78]: series = pd.Series([0.1] * 4, index=['a', 'b', 'c', 'd'], name='series2')

In [79]: series.plot.pie(figsize=(6, 6))
Out[79]: <matplotlib.axes._subplots.AxesSubplot at 0x128f2b908>
```



See the matplotlib pie documentation for more.

22.3 Plotting with Missing Data

Pandas tries to be pragmatic about plotting DataFrames or Series that contain missing data. Missing values are dropped, left out, or filled depending on the plot type.

Plot Type	NaN Handling
Line	Leave gaps at NaNs
Line (stacked)	Fill 0's
Bar	Fill 0's
Scatter	Drop NaNs
Histogram	Drop NaNs (column-wise)
Box	Drop NaNs (column-wise)
Area	Fill 0's
KDE	Drop NaNs (column-wise)
Hexbin	Drop NaNs
Pie	Fill 0's

If any of these defaults are not what you want, or if you want to be explicit about how missing values are handled, consider using `fillna()` or `dropna()` before plotting.

22.4 Plotting Tools

These functions can be imported from `pandas.plotting` and take a *Series* or *DataFrame* as an argument.

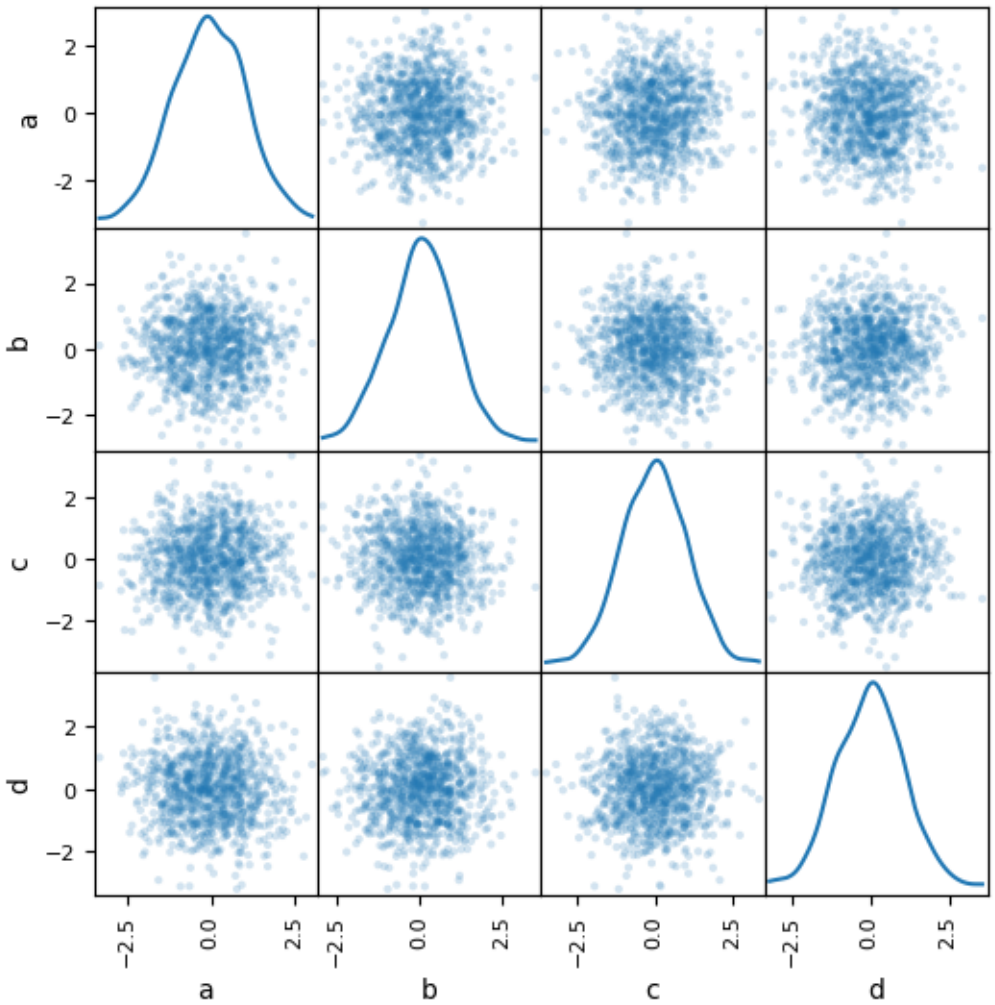
22.4.1 Scatter Matrix Plot

You can create a scatter plot matrix using the `scatter_matrix` method in `pandas.plotting`:

```
In [80]: from pandas.plotting import scatter_matrix

In [81]: df = pd.DataFrame(np.random.randn(1000, 4), columns=['a', 'b', 'c', 'd'])

In [82]: scatter_matrix(df, alpha=0.2, figsize=(6, 6), diagonal='kde')
Out[82]:
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x128dd3470>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x12d75d898>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x12d787630>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x1299fe860>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x12997c0f0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x12997c128>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x12da681d0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x1291a2a20>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x12da2a8d0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x127a748d0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x131116940>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x12914e940>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x1266b2940>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x12d6e4400>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x12d82d470>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x128d07470>]], dtype=object)
```

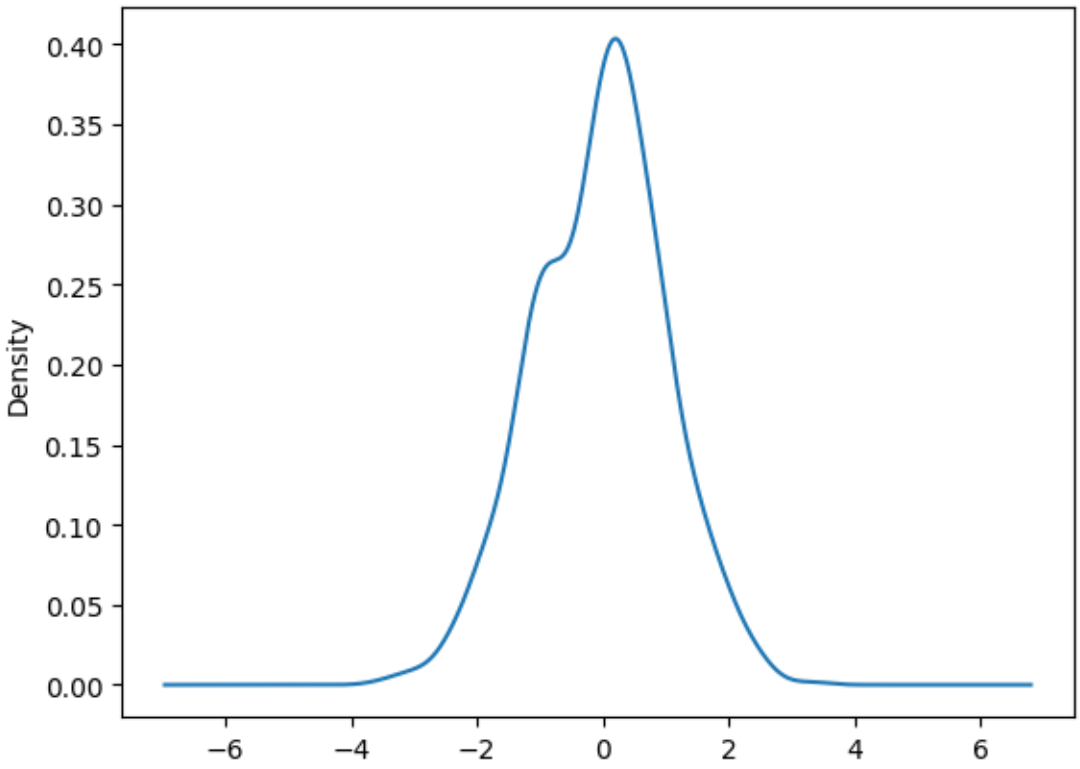


22.4.2 Density Plot

You can create density plots using the `Series.plot.kde()` and `DataFrame.plot.kde()` methods.

```
In [83]: ser = pd.Series(np.random.randn(1000))

In [84]: ser.plot.kde()
Out[84]: <matplotlib.axes._subplots.AxesSubplot at 0x12a98acf8>
```



22.4.3 Andrews Curves

Andrews curves allow one to plot multivariate data as a large number of curves that are created using the attributes of samples as coefficients for Fourier series. By coloring these curves differently for each class it is possible to visualize data clustering. Curves belonging to samples of the same class will usually be closer together and form larger structures.

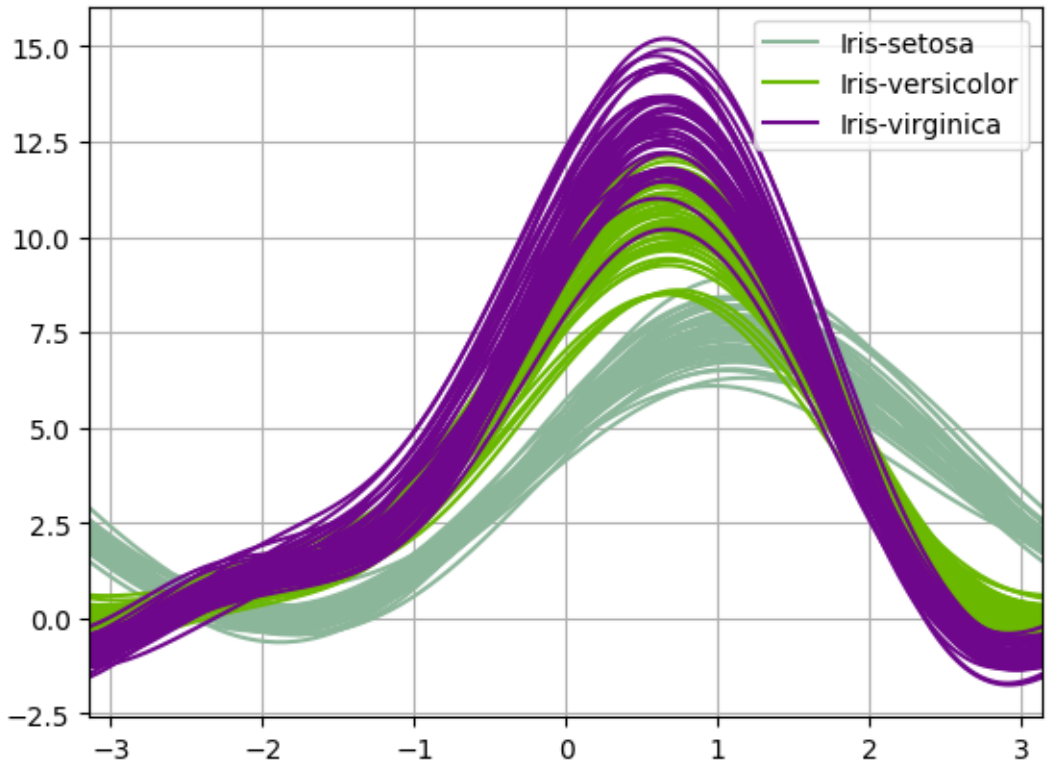
Note: The "Iris" dataset is available here.

```
In [85]: from pandas.plotting import andrews_curves

In [86]: data = pd.read_csv('data/iris.data')

In [87]: plt.figure()
Out[87]: <matplotlib.figure.Figure at 0x128db1470>

In [88]: andrews_curves(data, 'Name')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[88]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x12e27ed68>
```



22.4.4 Parallel Coordinates

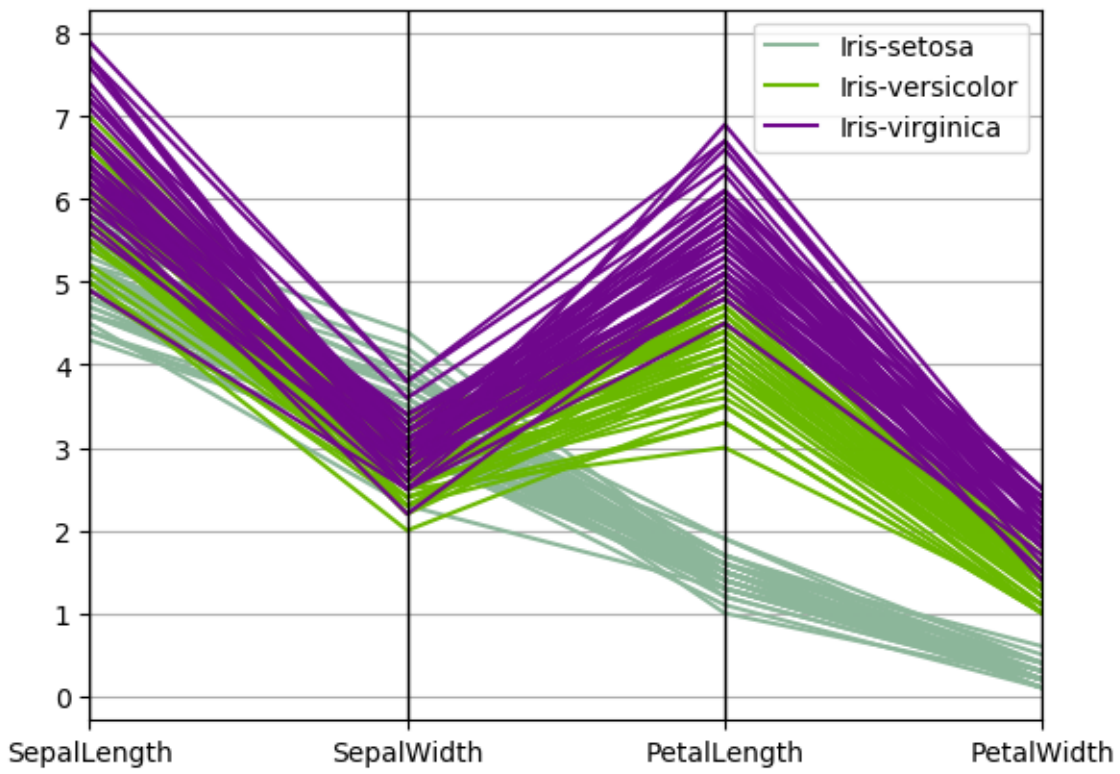
Parallel coordinates is a plotting technique for plotting multivariate data. It allows one to see clusters in data and to estimate other statistics visually. Using parallel coordinates points are represented as connected line segments. Each vertical line represents one attribute. One set of connected line segments represents one data point. Points that tend to cluster will appear closer together.

```
In [89]: from pandas.plotting import parallel_coordinates

In [90]: data = pd.read_csv('data/iris.data')

In [91]: plt.figure()
Out[91]: <matplotlib.figure.Figure at 0x12e2ef4a8>

In [92]: parallel_coordinates(data, 'Name')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[92]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x12aa8bf60>
```



22.4.5 Lag Plot

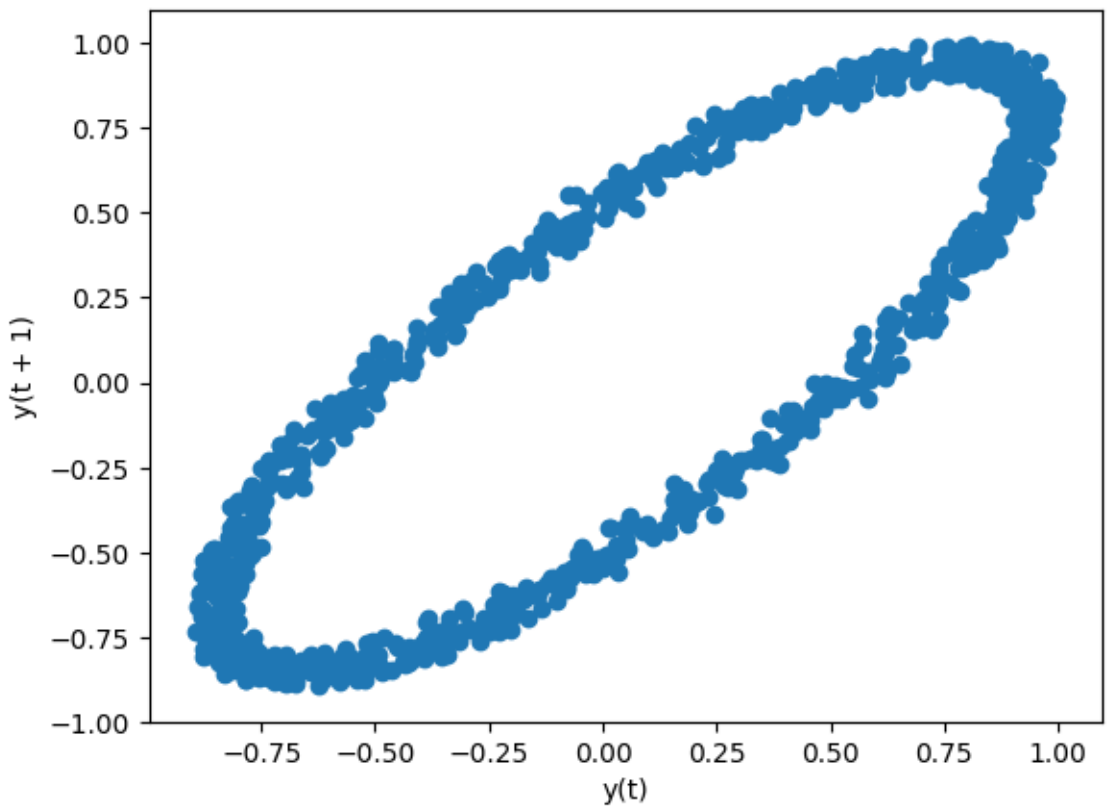
Lag plots are used to check if a data set or time series is random. Random data should not exhibit any structure in the lag plot. Non-random structure implies that the underlying data are not random.

```
In [93]: from pandas.plotting import lag_plot

In [94]: plt.figure()
Out[94]: <matplotlib.figure.Figure at 0x12e27e0f0>

In [95]: data = pd.Series(0.1 * np.random.rand(1000) +
   ....:     0.9 * np.sin(np.linspace(-99 * np.pi, 99 * np.pi, num=1000)))
   ....:

In [96]: lag_plot(data)
Out[96]: <matplotlib.axes._subplots.AxesSubplot at 0x12a294940>
```



22.4.6 Autocorrelation Plot

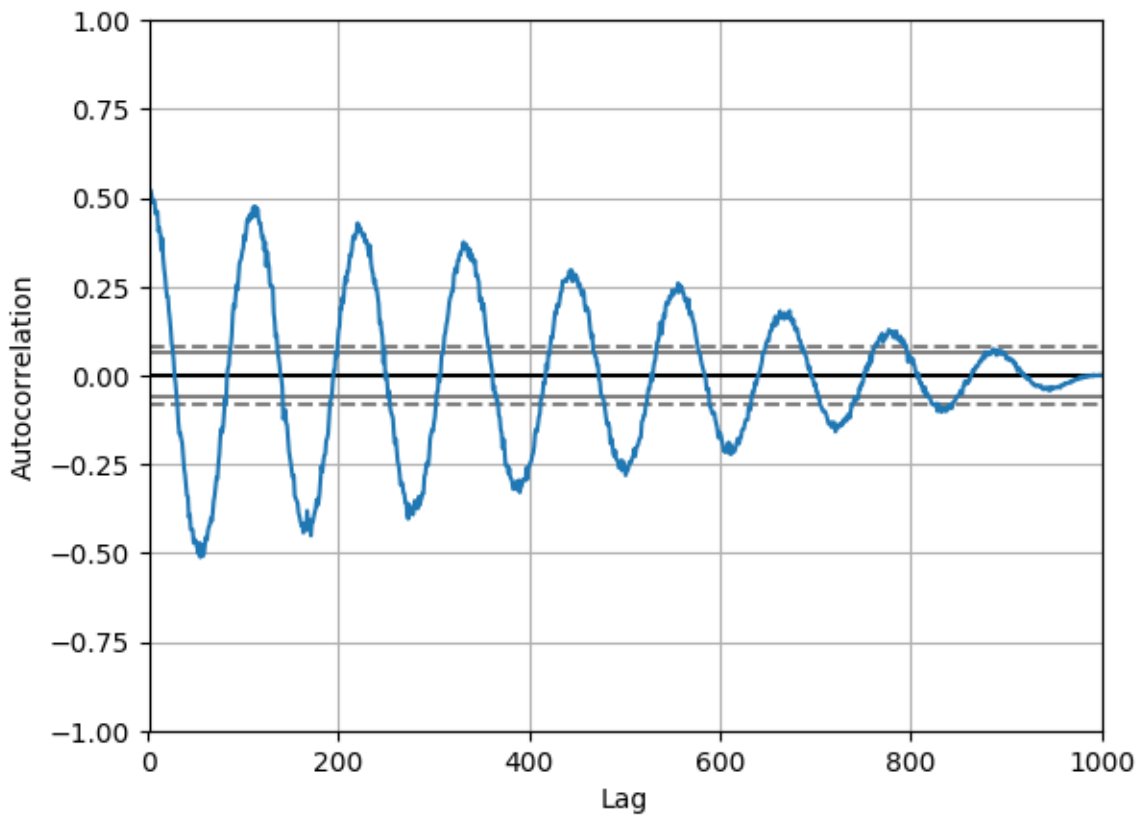
Autocorrelation plots are often used for checking randomness in time series. This is done by computing autocorrelations for data values at varying time lags. If time series is random, such autocorrelations should be near zero for any and all time-lag separations. If time series is non-random then one or more of the autocorrelations will be significantly non-zero. The horizontal lines displayed in the plot correspond to 95% and 99% confidence bands. The dashed line is 99% confidence band.

```
In [97]: from pandas.plotting import autocorrelation_plot

In [98]: plt.figure()
Out[98]: <matplotlib.figure.Figure at 0x12a218550>

In [99]: data = pd.Series(0.7 * np.random.rand(1000) +
   ....:     0.3 * np.sin(np.linspace(-9 * np.pi, 9 * np.pi, num=1000)))
   ....:

In [100]: autocorrelation_plot(data)
Out[100]: <matplotlib.axes._subplots.AxesSubplot at 0x12e31b278>
```



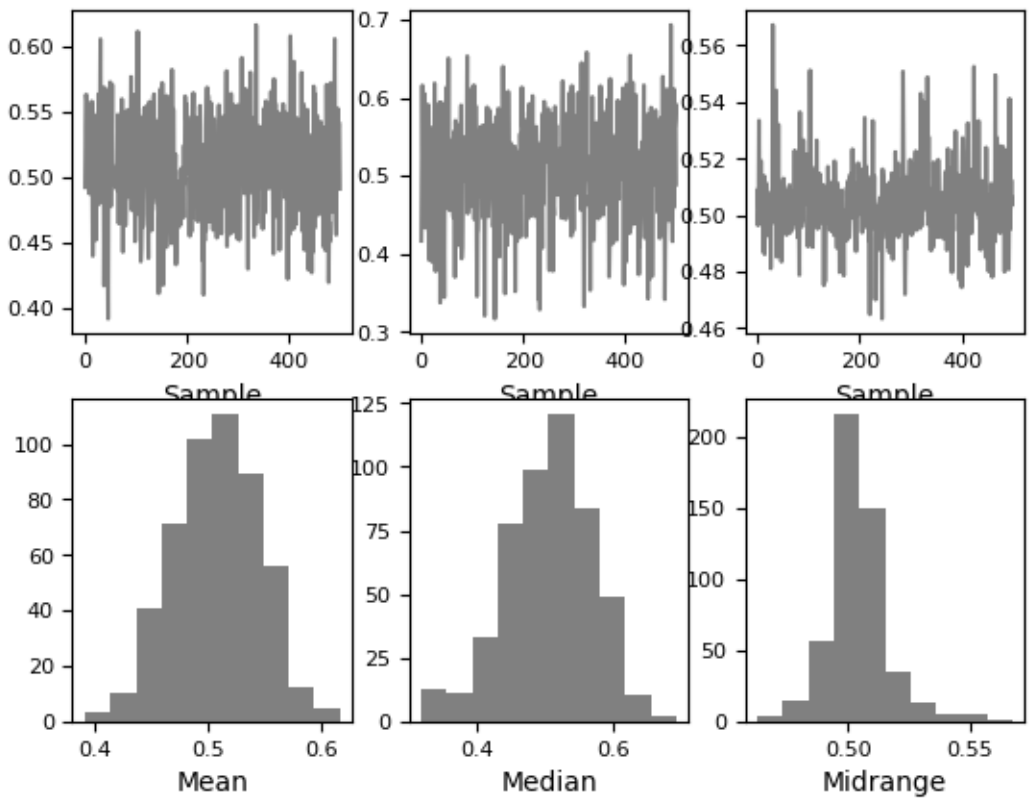
22.4.7 Bootstrap Plot

Bootstrap plots are used to visually assess the uncertainty of a statistic, such as mean, median, midrange, etc. A random subset of a specified size is selected from a data set, the statistic in question is computed for this subset and the process is repeated a specified number of times. Resulting plots and histograms are what constitutes the bootstrap plot.

```
In [101]: from pandas.plotting import bootstrap_plot

In [102]: data = pd.Series(np.random.rand(1000))

In [103]: bootstrap_plot(data, size=50, samples=500, color='grey')
Out[103]: <matplotlib.figure.Figure at 0x1255c7a58>
```



22.4.8 RadViz

RadViz is a way of visualizing multi-variate data. It is based on a simple spring tension minimization algorithm. Basically you set up a bunch of points in a plane. In our case they are equally spaced on a unit circle. Each point represents a single attribute. You then pretend that each sample in the data set is attached to each of these points by a spring, the stiffness of which is proportional to the numerical value of that attribute (they are normalized to unit interval). The point in the plane, where our sample settles to (where the forces acting on our sample are at an equilibrium) is where a dot representing our sample will be drawn. Depending on which class that sample belongs it will be colored differently.

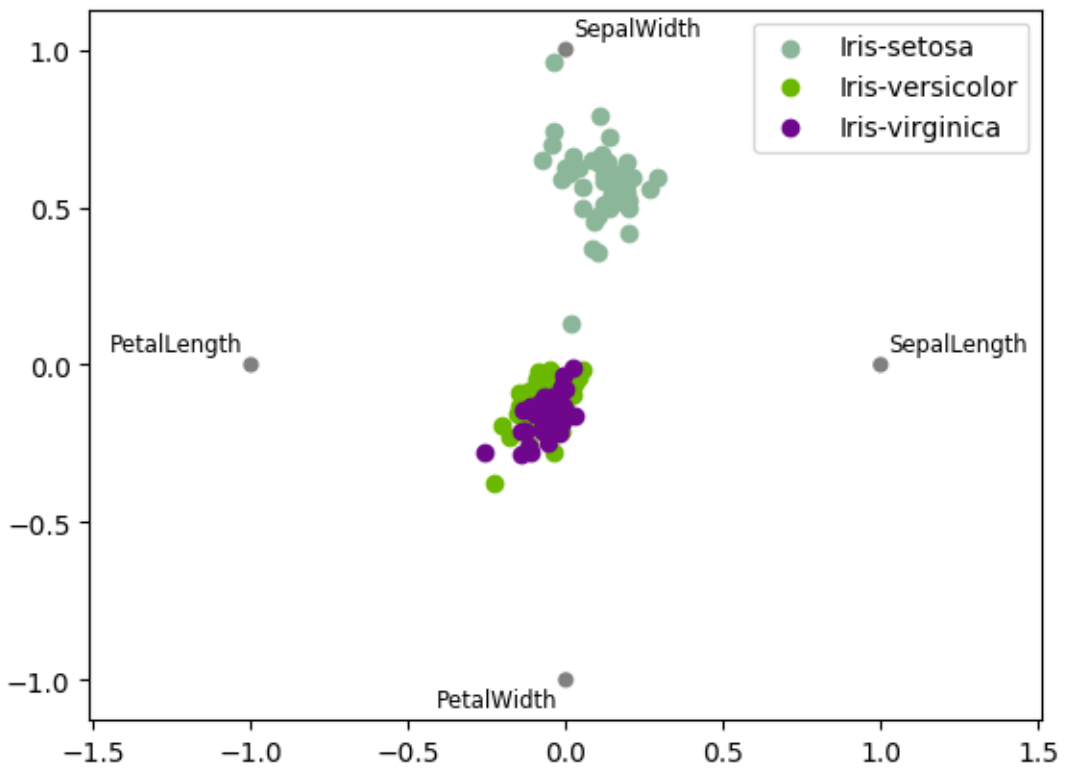
Note: The "Iris" dataset is available here.

```
In [104]: from pandas.plotting import radviz

In [105]: data = pd.read_csv('data/iris.data')

In [106]: plt.figure()
Out[106]: <matplotlib.figure.Figure at 0x127ae4898>

In [107]: radviz(data, 'Name')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[107]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x12dbe79b0>
```



22.5 Plot Formatting

22.5.1 Setting the plot style

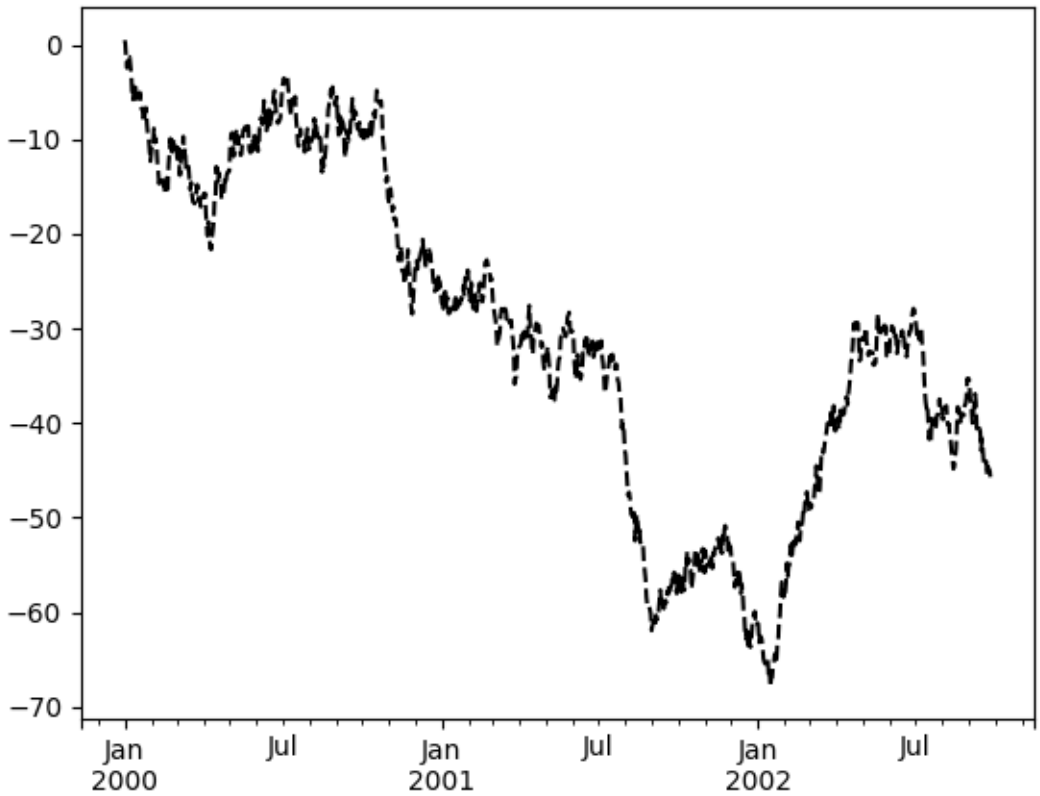
From version 1.5 and up, matplotlib offers a range of preconfigured plotting styles. Setting the style can be used to easily give plots the general look that you want. Setting the style is as easy as calling `matplotlib.style.use(my_plot_style)` before creating your plot. For example you could do `matplotlib.style.use('ggplot')` for ggplot-style plots.

You can see the various available style names at `matplotlib.style.available` and it's very easy to try them out.

22.5.2 General plot style arguments

Most plotting methods have a set of keyword arguments that control the layout and formatting of the returned plot:

```
In [108]: plt.figure(); ts.plot(style='k--', label='Series');
```



For each kind of plot (e.g. *line*, *bar*, *scatter*) any additional arguments keywords are passed along to the corresponding matplotlib function (`ax.plot()`, `ax.bar()`, `ax.scatter()`). These can be used to control additional styling, beyond what pandas provides.

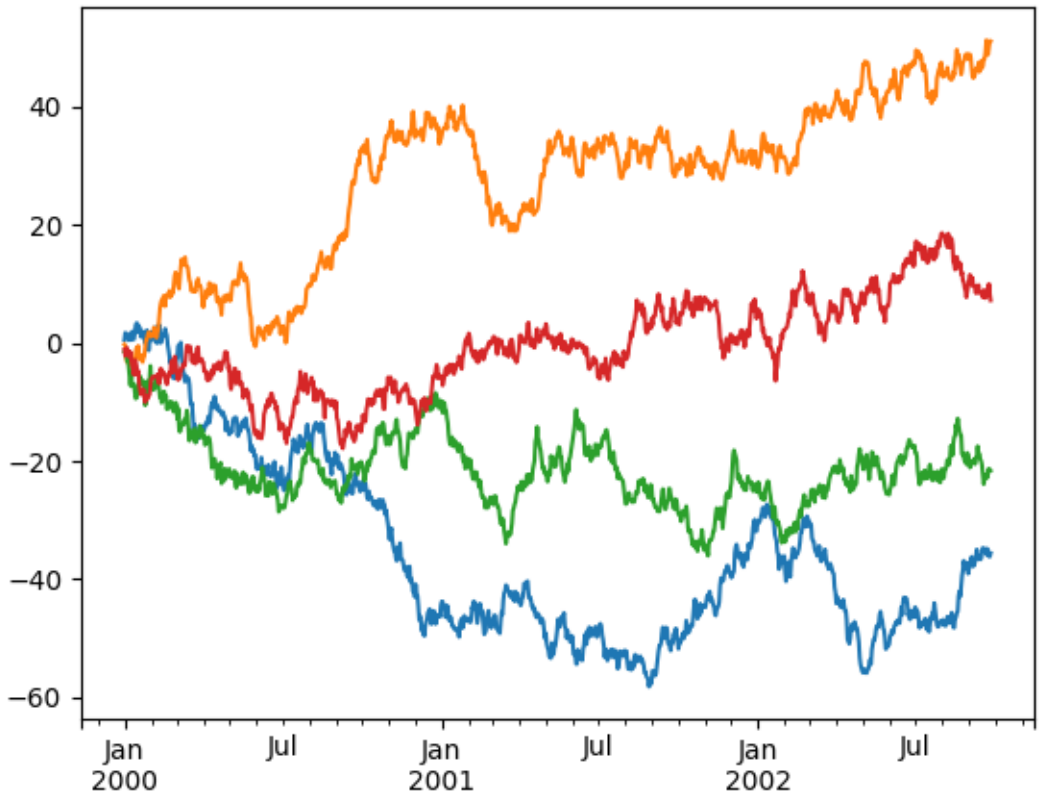
22.5.3 Controlling the Legend

You may set the `legend` argument to `False` to hide the legend, which is shown by default.

```
In [109]: df = pd.DataFrame(np.random.randn(1000, 4), index=ts.index, columns=list(
↪'ABCD'))

In [110]: df = df.cumsum()

In [111]: df.plot(legend=False)
Out[111]: <matplotlib.axes._subplots.AxesSubplot at 0x128f9b7b8>
```



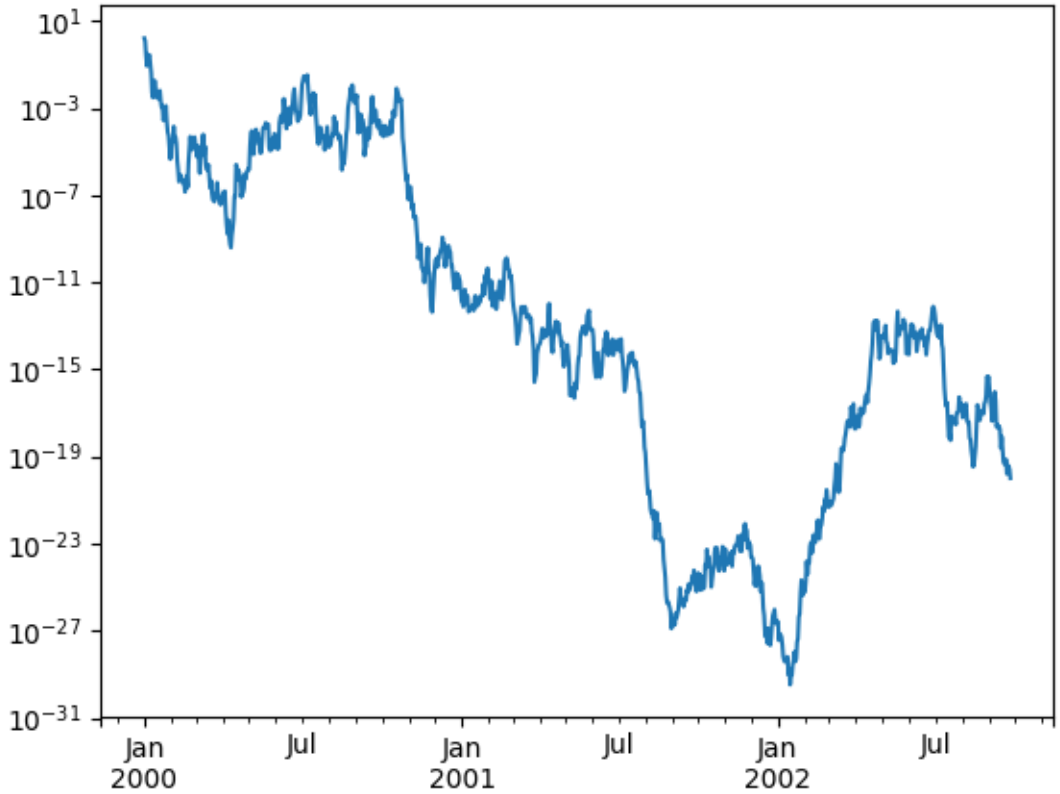
22.5.4 Scales

You may pass `logy` to get a log-scale Y axis.

```
In [112]: ts = pd.Series(np.random.randn(1000), index=pd.date_range('1/1/2000',␣
↪periods=1000))

In [113]: ts = np.exp(ts.cumsum())

In [114]: ts.plot(logy=True)
Out[114]: <matplotlib.axes._subplots.AxesSubplot at 0x1299f2ac8>
```



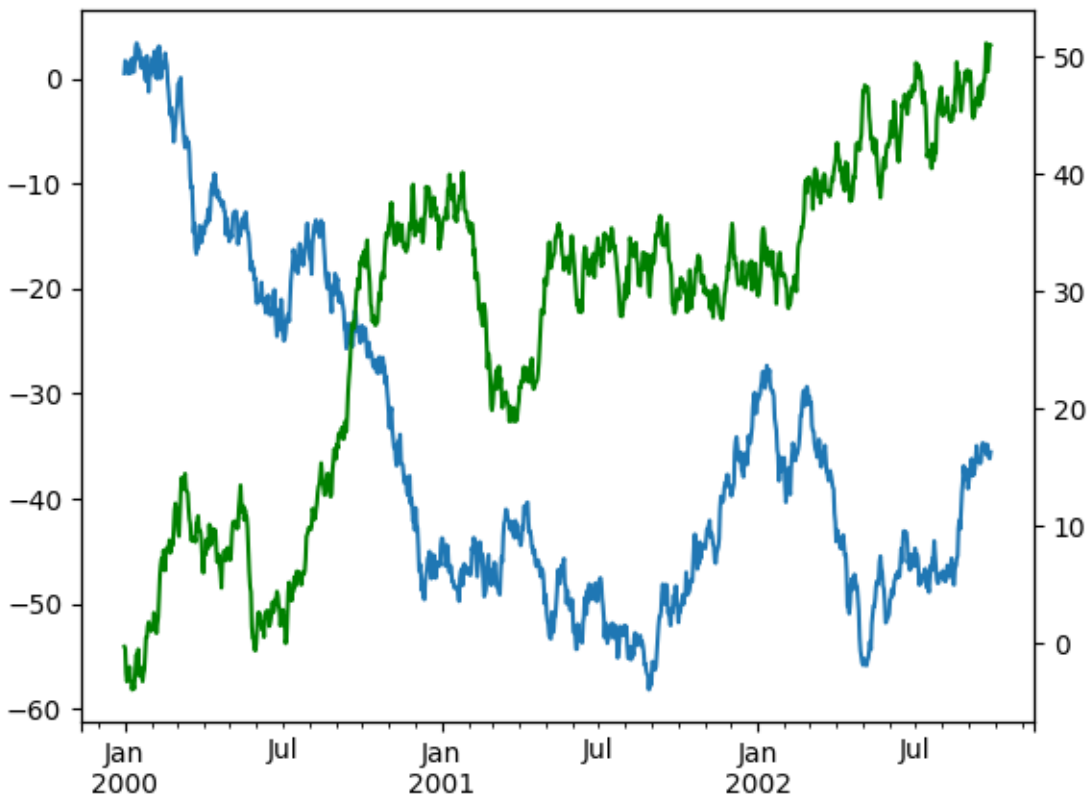
See also the `logx` and `loglog` keyword arguments.

22.5.5 Plotting on a Secondary Y-axis

To plot data on a secondary y-axis, use the `secondary_y` keyword:

```
In [115]: df.A.plot()
Out[115]: <matplotlib.axes._subplots.AxesSubplot at 0x120619d30>

In [116]: df.B.plot(secondary_y=True, style='g')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[116]:
↪<matplotlib.axes._subplots.AxesSubplot at 0x12d6b59b0>
```



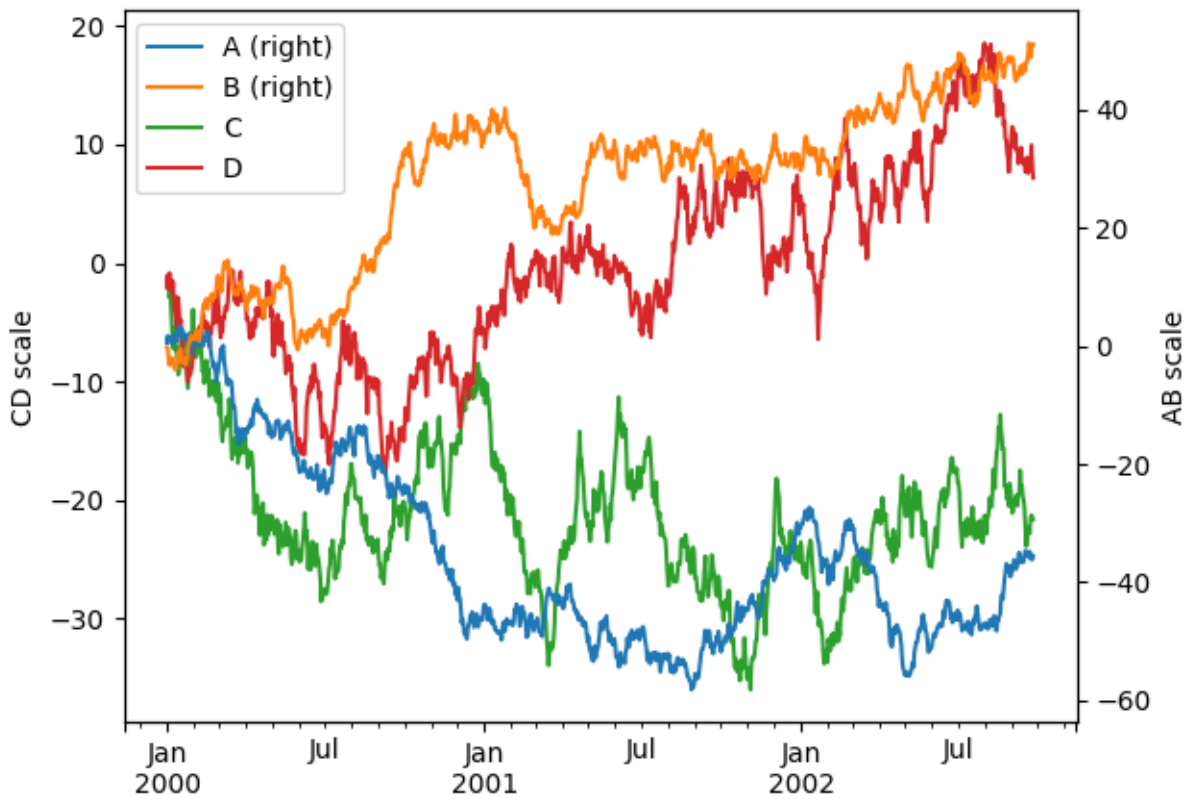
To plot some columns in a DataFrame, give the column names to the `secondary_y` keyword:

```
In [117]: plt.figure()
Out[117]: <matplotlib.figure.Figure at 0x12de88710>

In [118]: ax = df.plot(secondary_y=['A', 'B'])

In [119]: ax.set_ylabel('CD scale')
Out[119]: Text(0,0.5,'CD scale')

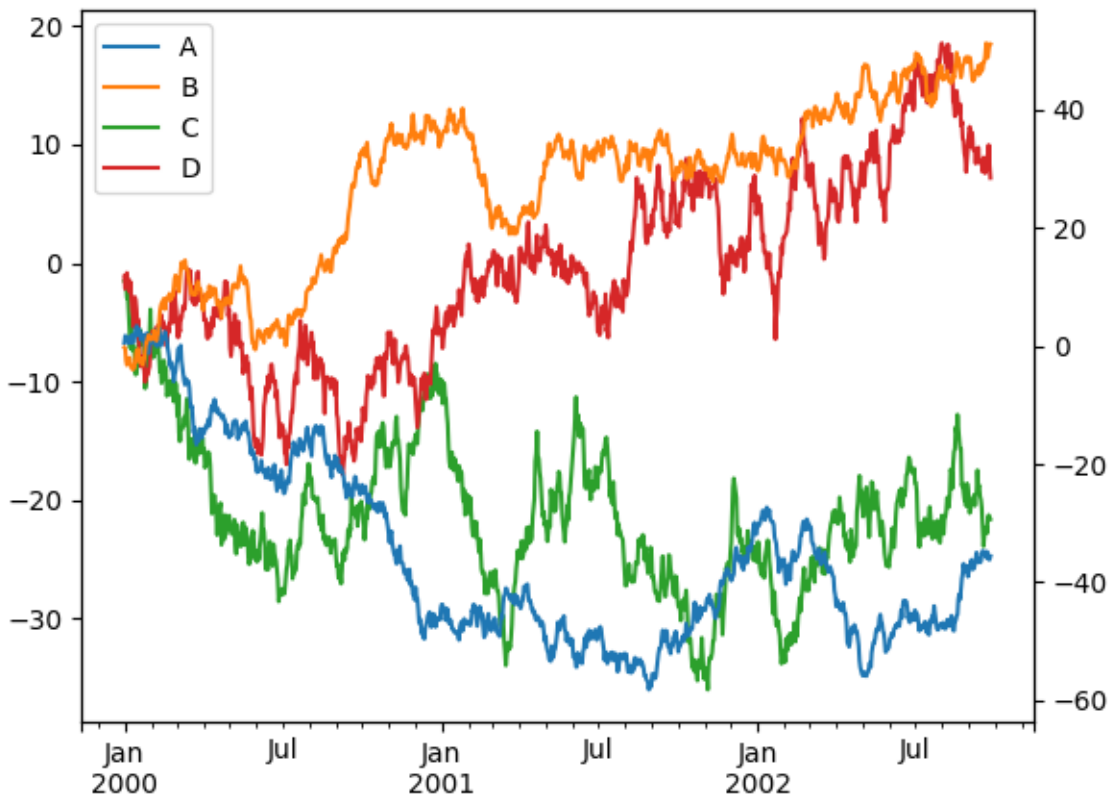
In [120]: ax.right_ax.set_ylabel('AB scale')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[120]: Text(0,0.5,'AB scale')
```



Note that the columns plotted on the secondary y-axis is automatically marked with "(right)" in the legend. To turn off the automatic marking, use the `mark_right=False` keyword:

```
In [121]: plt.figure()
Out[121]: <matplotlib.figure.Figure at 0x12d261e80>

In [122]: df.plot(secondary_y=['A', 'B'], mark_right=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[122]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x129918978>
```



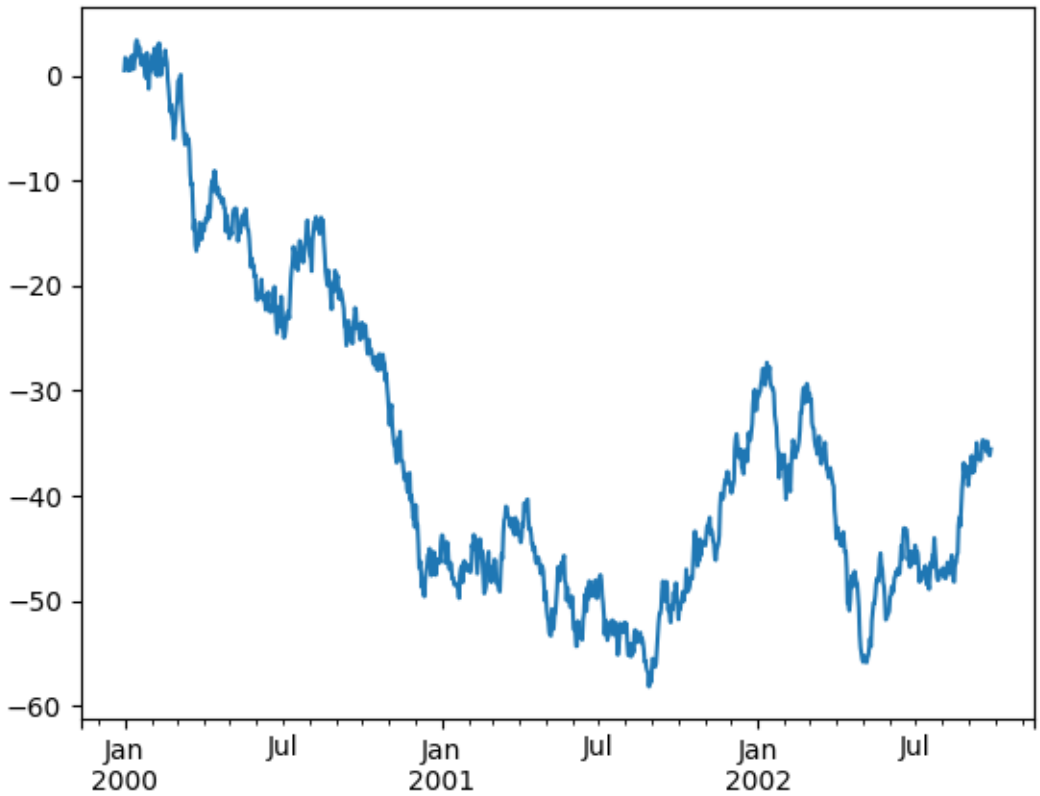
22.5.6 Suppressing Tick Resolution Adjustment

pandas includes automatic tick resolution adjustment for regular frequency time-series data. For limited cases where pandas cannot infer the frequency information (e.g., in an externally created `twinx`), you can choose to suppress this behavior for alignment purposes.

Here is the default behavior, notice how the x-axis tick labelling is performed:

```
In [123]: plt.figure()
Out[123]: <matplotlib.figure.Figure at 0x12ed98cf8>

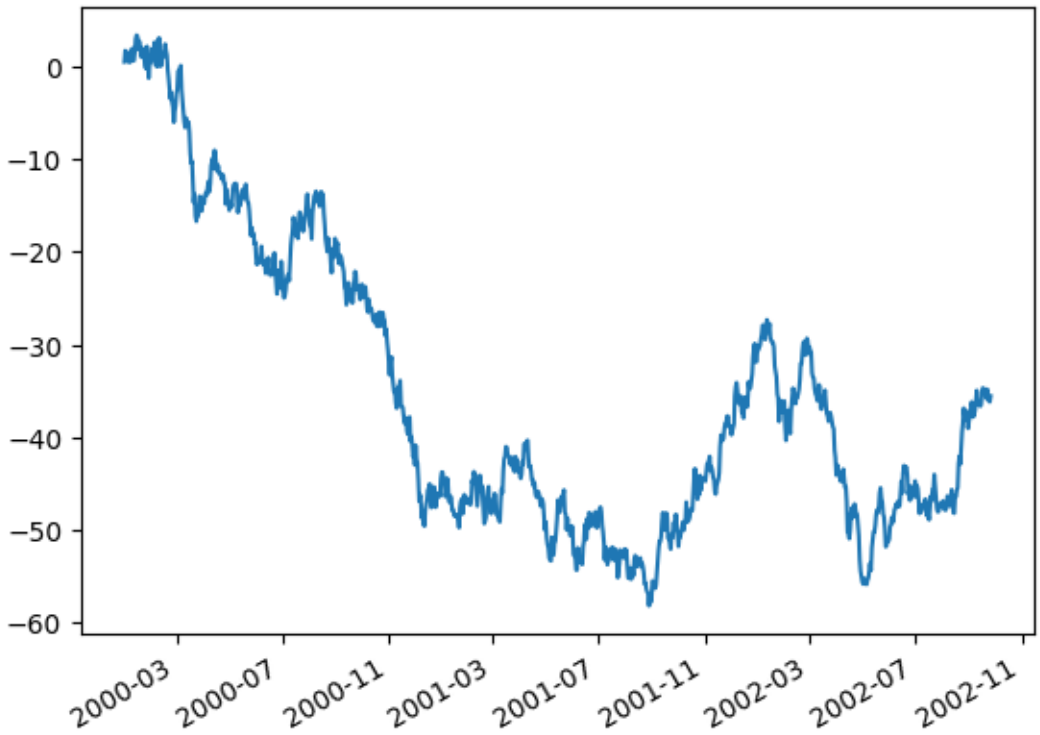
In [124]: df.A.plot()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[124]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x13106dda0>
```



Using the `x_compat` parameter, you can suppress this behavior:

```
In [125]: plt.figure()
Out[125]: <matplotlib.figure.Figure at 0x12edb0ba8>

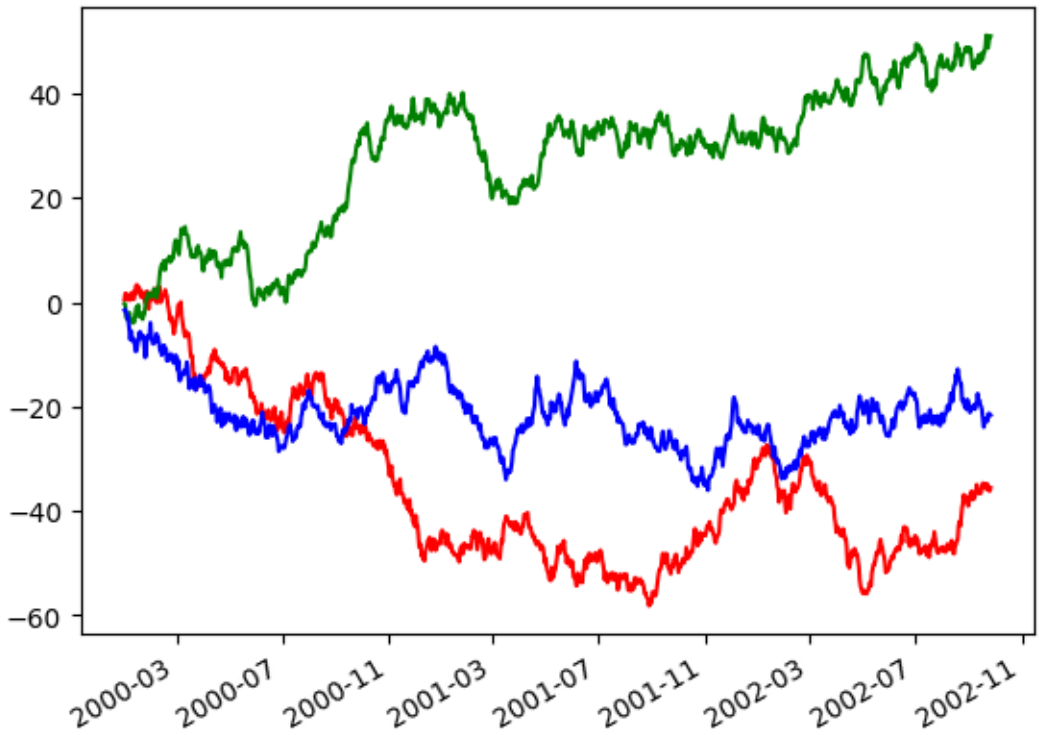
In [126]: df.A.plot(x_compat=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[126]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x12ec991d0>
```



If you have more than one plot that needs to be suppressed, the `use` method in `pandas.plotting.plot_params` can be used in a *with statement*:

```
In [127]: plt.figure()
Out[127]: <matplotlib.figure.Figure at 0x12ec98198>

In [128]: with pd.plotting.plot_params.use('x_compat', True):
   .....:     df.A.plot(color='r')
   .....:     df.B.plot(color='g')
   .....:     df.C.plot(color='b')
   .....:
```



22.5.7 Automatic Date Tick Adjustment

New in version 0.20.0.

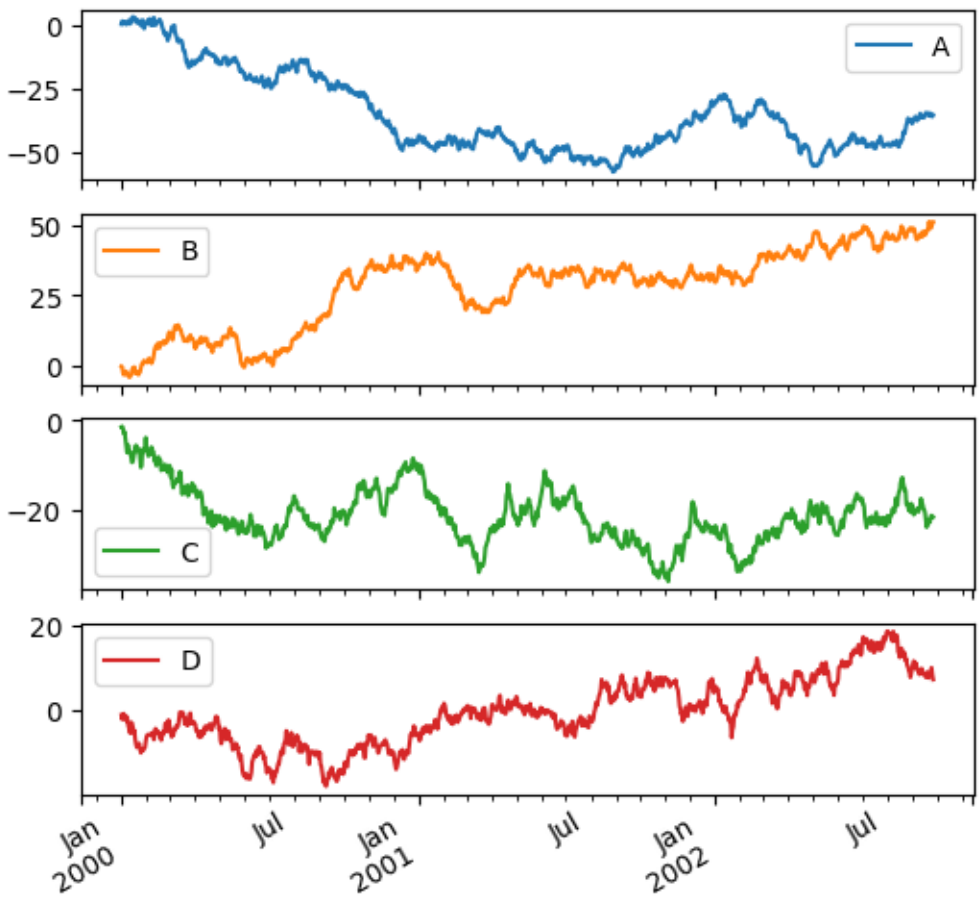
`TimedeltaIndex` now uses the native matplotlib tick locator methods, it is useful to call the automatic date tick adjustment from matplotlib for figures whose ticklabels overlap.

See the `autofmt_xdate` method and the matplotlib documentation for more.

22.5.8 Subplots

Each Series in a DataFrame can be plotted on a different axis with the `subplots` keyword:

```
In [129]: df.plot(subplots=True, figsize=(6, 6));
```

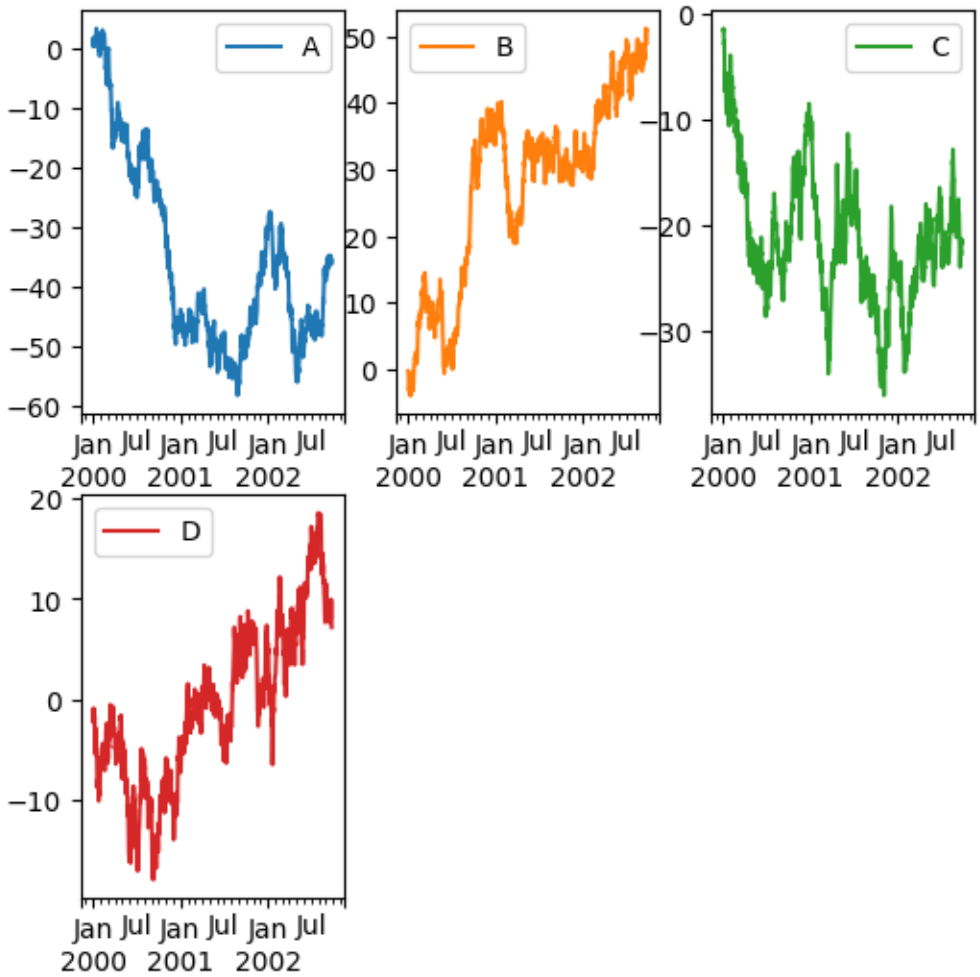


22.5.9 Using Layout and Targeting Multiple Axes

The layout of subplots can be specified by `layout` keyword. It can accept `(rows, columns)`. The `layout` keyword can be used in `hist` and `boxplot` also. If input is invalid, `ValueError` will be raised.

The number of axes which can be contained by rows x columns specified by `layout` must be larger than the number of required subplots. If layout can contain more axes than required, blank axes are not drawn. Similar to a numpy array's `reshape` method, you can use `-1` for one dimension to automatically calculate the number of rows or columns needed, given the other.

```
In [130]: df.plot(subplots=True, layout=(2, 3), figsize=(6, 6), sharex=False);
```



The above example is identical to using

```
In [131]: df.plot(subplots=True, layout=(2, -1), figsize=(6, 6), sharex=False);
```

The required number of columns (3) is inferred from the number of series to plot and the given number of rows (2).

Also, you can pass multiple axes created beforehand as list-like via `ax` keyword. This allows to use more complicated layout. The passed axes must be the same number as the subplots being drawn.

When multiple axes are passed via `ax` keyword, `layout`, `sharex` and `sharey` keywords don't affect to the output. You should explicitly pass `sharex=False` and `sharey=False`, otherwise you will see a warning.

```
In [132]: fig, axes = plt.subplots(4, 4, figsize=(6, 6));

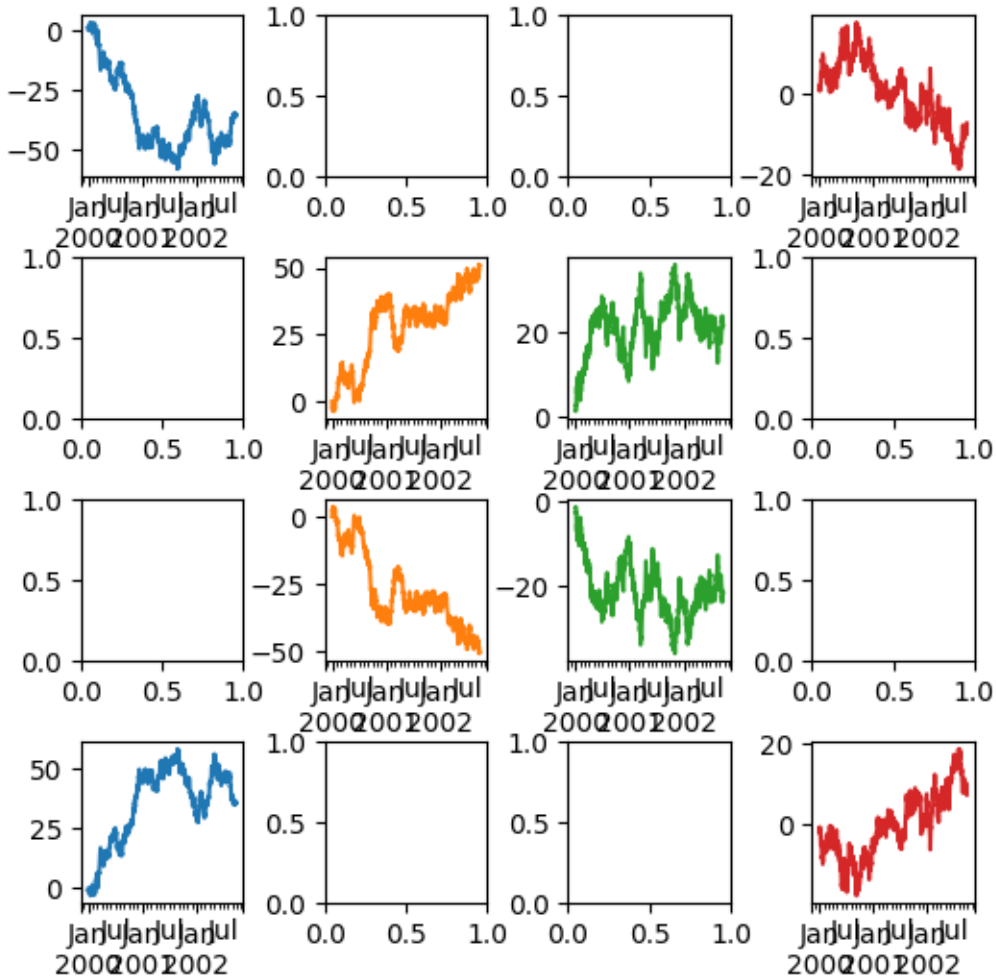
In [133]: plt.subplots_adjust(wspace=0.5, hspace=0.5);

In [134]: target1 = [axes[0][0], axes[1][1], axes[2][2], axes[3][3]]

In [135]: target2 = [axes[3][0], axes[2][1], axes[1][2], axes[0][3]]

In [136]: df.plot(subplots=True, ax=target1, legend=False, sharex=False,␣
↪sharey=False);

In [137]: (-df).plot(subplots=True, ax=target2, legend=False, sharex=False,␣
↪sharey=False);
```



Another option is passing an `ax` argument to *`Series.plot()`* to plot on a particular axis:

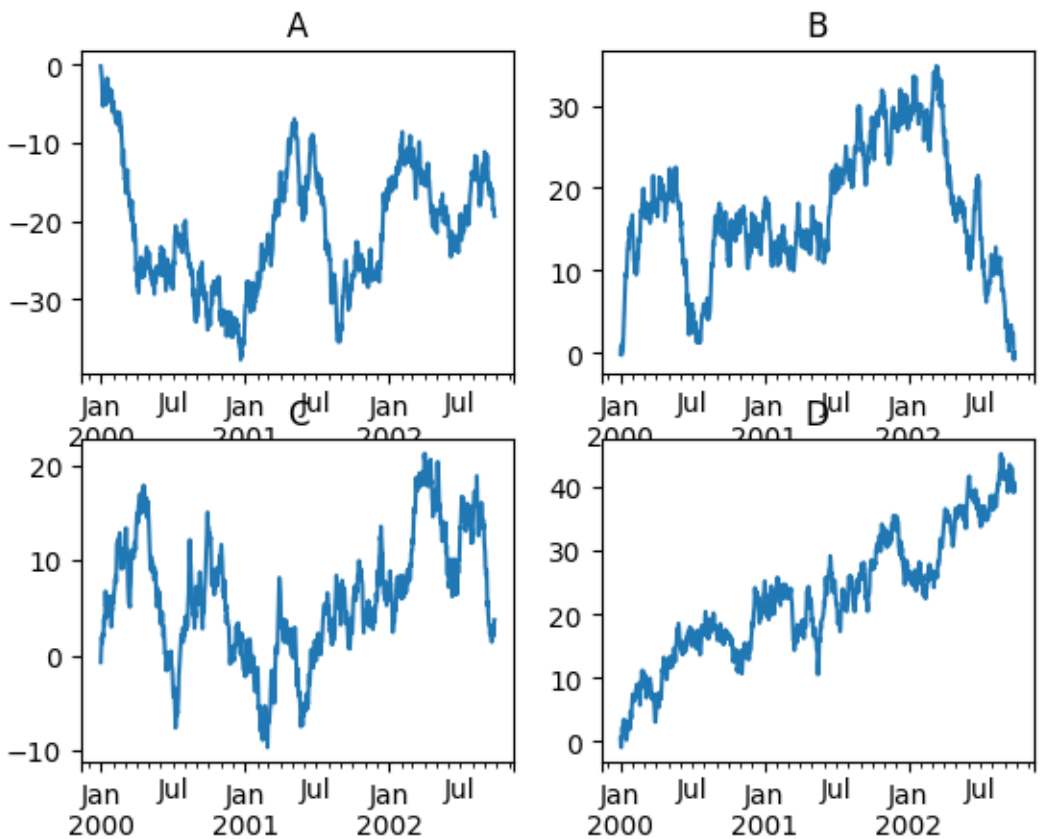
```
In [138]: fig, axes = plt.subplots(nrows=2, ncols=2)

In [139]: df['A'].plot(ax=axes[0,0]); axes[0,0].set_title('A');

In [140]: df['B'].plot(ax=axes[0,1]); axes[0,1].set_title('B');

In [141]: df['C'].plot(ax=axes[1,0]); axes[1,0].set_title('C');

In [142]: df['D'].plot(ax=axes[1,1]); axes[1,1].set_title('D');
```



22.5.10 Plotting With Error Bars

Plotting with error bars is now supported in the `DataFrame.plot()` and `Series.plot()`

Horizontal and vertical errorbars can be supplied to the `xerr` and `yerr` keyword arguments to `plot()`. The error values can be specified using a variety of formats.

- As a `DataFrame` or `dict` of errors with column names matching the `columns` attribute of the plotting `DataFrame` or matching the `name` attribute of the `Series`
- As a `str` indicating which of the columns of plotting `DataFrame` contain the error values
- As raw values (`list`, `tuple`, or `np.ndarray`). Must be the same length as the plotting `DataFrame`/`Series`

Asymmetrical error bars are also supported, however raw error values must be provided in this case. For a `M` length `Series`, a `Mx2` array should be provided indicating lower and upper (or left and right) errors. For a `MxN` `DataFrame`, asymmetrical errors should be in a `Mx2xN` array.

Here is an example of one way to easily plot group means with standard deviations from the raw data.

```
# Generate the data
In [143]: ix3 = pd.MultiIndex.from_arrays([['a', 'a', 'a', 'a', 'b', 'b', 'b', 'b'], [
↪'foo', 'foo', 'bar', 'bar', 'foo', 'foo', 'bar', 'bar']], names=['letter', 'word'])

In [144]: df3 = pd.DataFrame({'data1': [3, 2, 4, 3, 2, 4, 3, 2], 'data2': [6, 5, 7, 5,
↪ 4, 5, 6, 5]}, index=ix3)
```

```
# Group by index labels and take the means and standard deviations for each group
In [145]: gp3 = df3.groupby(level=('letter', 'word'))

In [146]: means = gp3.mean()

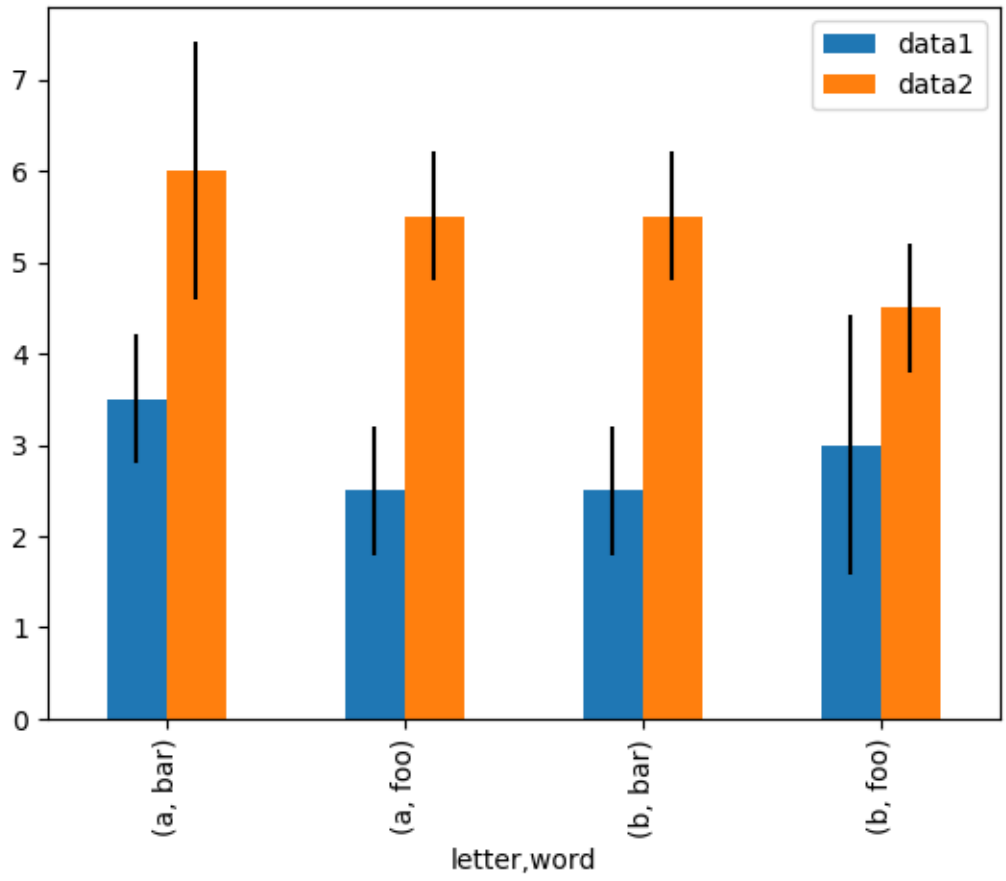
In [147]: errors = gp3.std()

In [148]: means
Out[148]: 
             data1  data2
letter word              
a      bar     3.5    6.0
       foo     2.5    5.5
b      bar     2.5    5.5
       foo     3.0    4.5

In [149]: errors
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                data1     data2
letter word                    
a      bar   0.707107  1.414214
       foo   0.707107  0.707107
b      bar   0.707107  0.707107
       foo   1.414214  0.707107

# Plot
In [150]: fig, ax = plt.subplots()

In [151]: means.plot.bar(yerr=errors, ax=ax)
Out[151]: <matplotlib.axes._subplots.AxesSubplot at 0x1364c3c50>
```



22.5.11 Plotting Tables

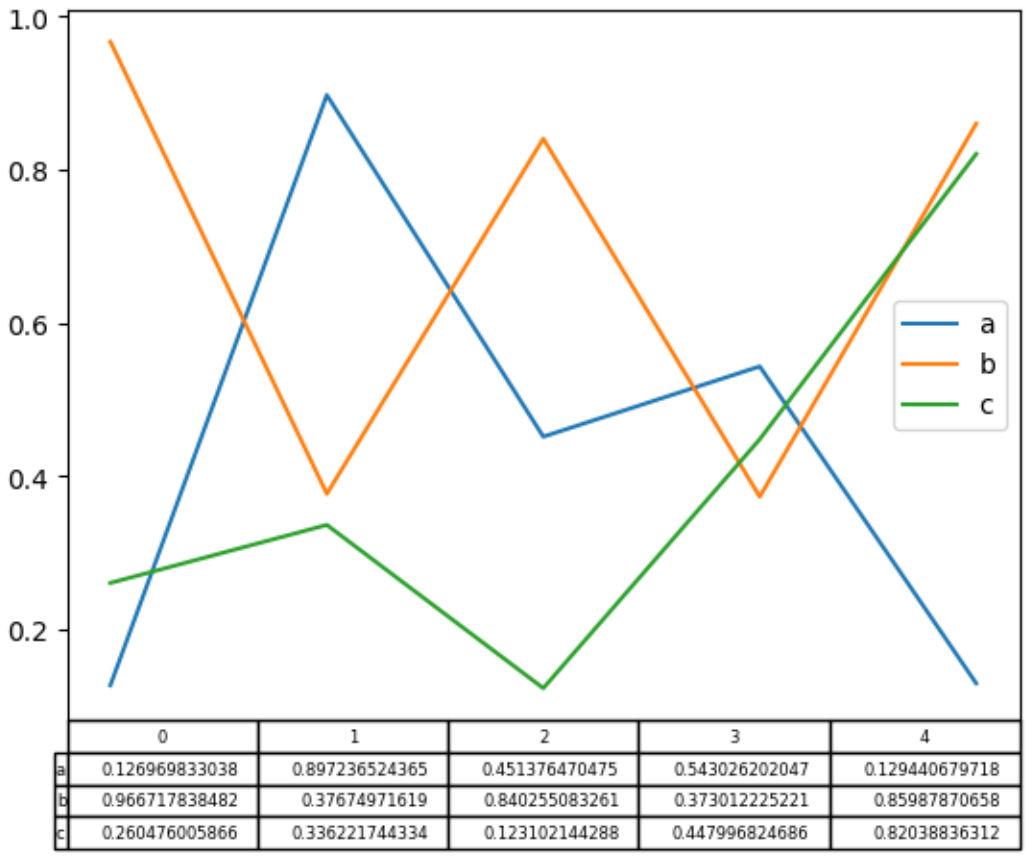
Plotting with matplotlib table is now supported in *DataFrame.plot()* and *Series.plot()* with a `table` keyword. The `table` keyword can accept `bool`, *DataFrame* or *Series*. The simple way to draw a table is to specify `table=True`. Data will be transposed to meet matplotlib's default layout.

```
In [152]: fig, ax = plt.subplots(1, 1)

In [153]: df = pd.DataFrame(np.random.rand(5, 3), columns=['a', 'b', 'c'])

In [154]: ax.get_xaxis().set_visible(False)    # Hide Ticks

In [155]: df.plot(table=True, ax=ax)
Out[155]: <matplotlib.axes._subplots.AxesSubplot at 0x133634a58>
```

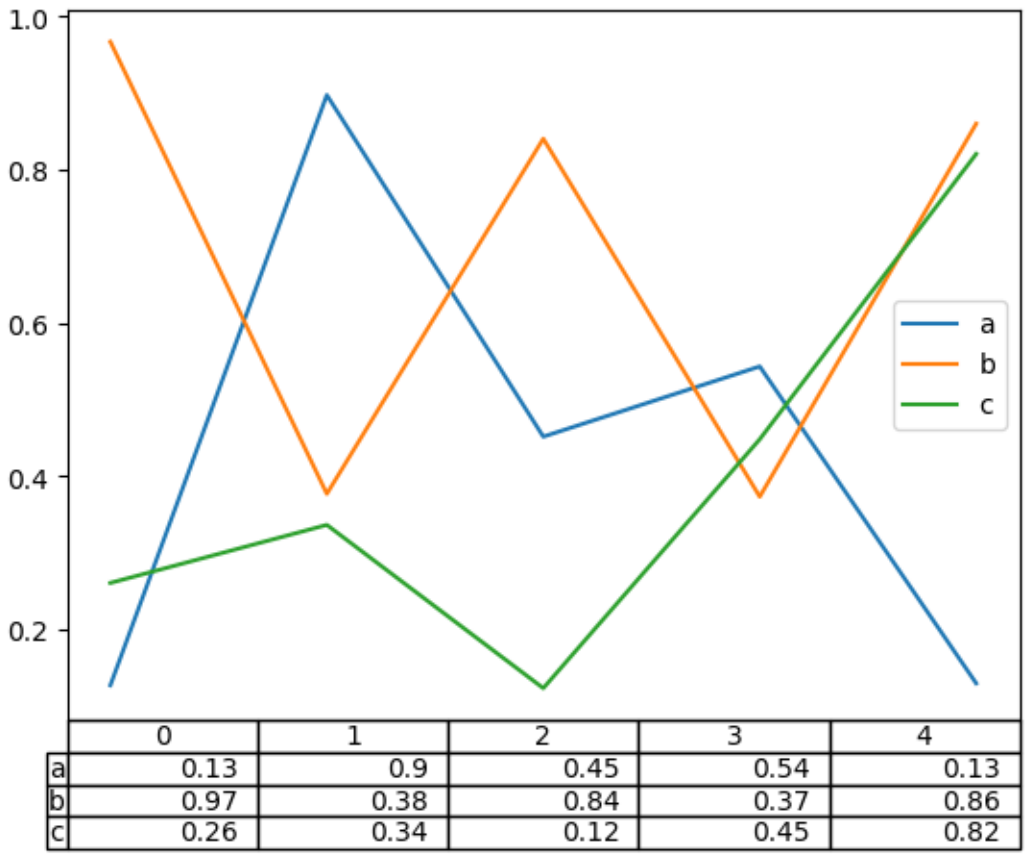


Also, you can pass different *DataFrame* or *Series* for `table` keyword. The data will be drawn as displayed in print method (not transposed automatically). If required, it should be transposed manually as below example.

```
In [156]: fig, ax = plt.subplots(1, 1)

In [157]: ax.get_xaxis().set_visible(False)    # Hide Ticks

In [158]: df.plot(table=np.round(df.T, 2), ax=ax)
Out[158]: <matplotlib.axes._subplots.AxesSubplot at 0x136543cc0>
```



	0	1	2	3	4
a	0.13	0.9	0.45	0.54	0.13
b	0.97	0.38	0.84	0.37	0.86
c	0.26	0.34	0.12	0.45	0.82

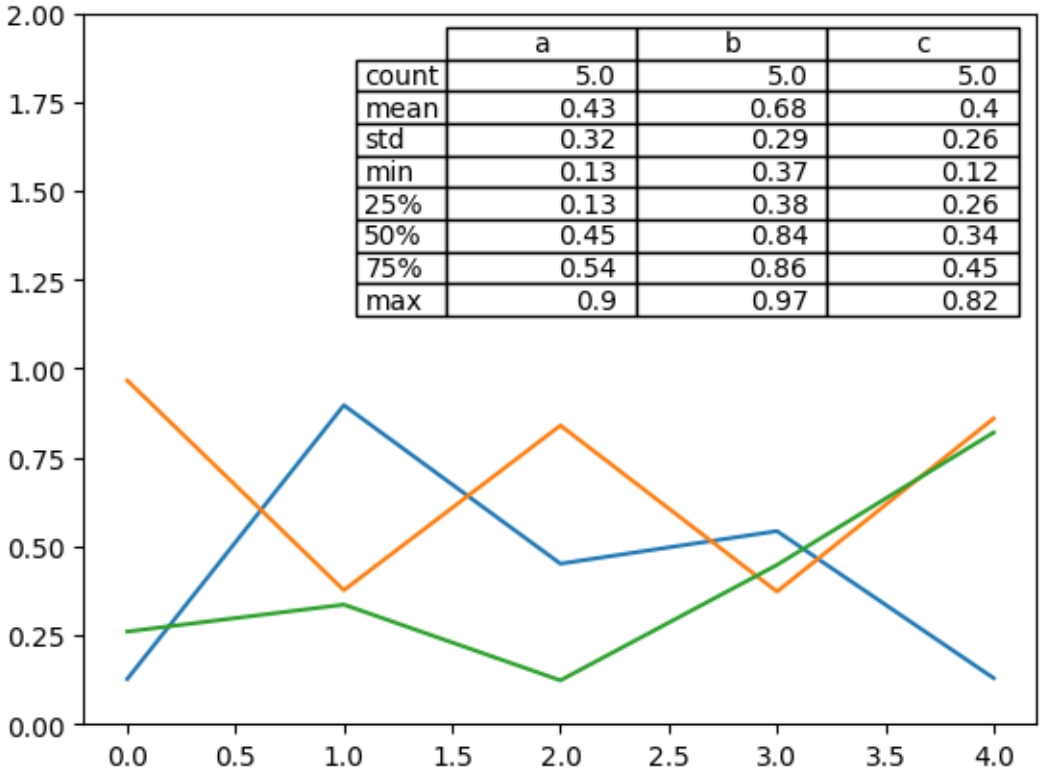
Finally, there is a helper function `pandas.plotting.table` to create a table from *`DataFrame`* and *`Series`*, and add it to an `matplotlib.Axes`. This function can accept keywords which matplotlib table has.

```
In [159]: from pandas.plotting import table

In [160]: fig, ax = plt.subplots(1, 1)

In [161]: table(ax, np.round(df.describe(), 2),
   .....:       loc='upper right', colWidths=[0.2, 0.2, 0.2])
   .....:
Out[161]: <matplotlib.table.Table at 0x1295b7a58>

In [162]: df.plot(ax=ax, ylim=(0, 2), legend=None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[162]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x12d52f470>
```



	a	b	c
count	5.0	5.0	5.0
mean	0.43	0.68	0.4
std	0.32	0.29	0.26
min	0.13	0.37	0.12
25%	0.13	0.38	0.26
50%	0.45	0.84	0.34
75%	0.54	0.86	0.45
max	0.9	0.97	0.82

Note: You can get table instances on the axes using `axes.tables` property for further decorations. See the matplotlib table documentation for more.

22.5.12 Colormaps

A potential issue when plotting a large number of columns is that it can be difficult to distinguish some series due to repetition in the default colors. To remedy this, DataFrame plotting supports the use of the `colormap=` argument, which accepts either a Matplotlib colormap or a string that is a name of a colormap registered with Matplotlib. A visualization of the default matplotlib colormaps is available here.

As matplotlib does not directly support colormaps for line-based plots, the colors are selected based on an even spacing determined by the number of columns in the DataFrame. There is no consideration made for background color, so some colormaps will produce lines that are not easily visible.

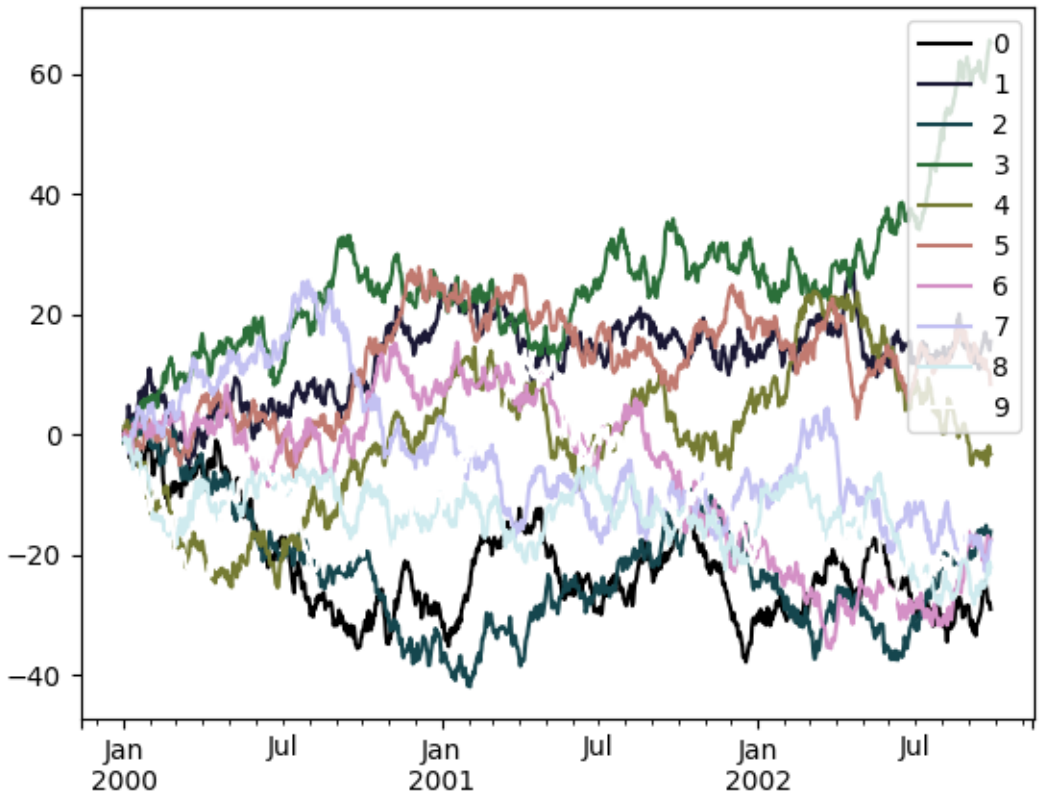
To use the cubehelix colormap, we can simply pass `'cubehelix'` to `colormap=`

```
In [163]: df = pd.DataFrame(np.random.randn(1000, 10), index=ts.index)

In [164]: df = df.cumsum()

In [165]: plt.figure()
Out[165]: <matplotlib.figure.Figure at 0x1295c48d0>

In [166]: df.plot(colormap='cubehelix')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[166]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x115d0fba8>
```

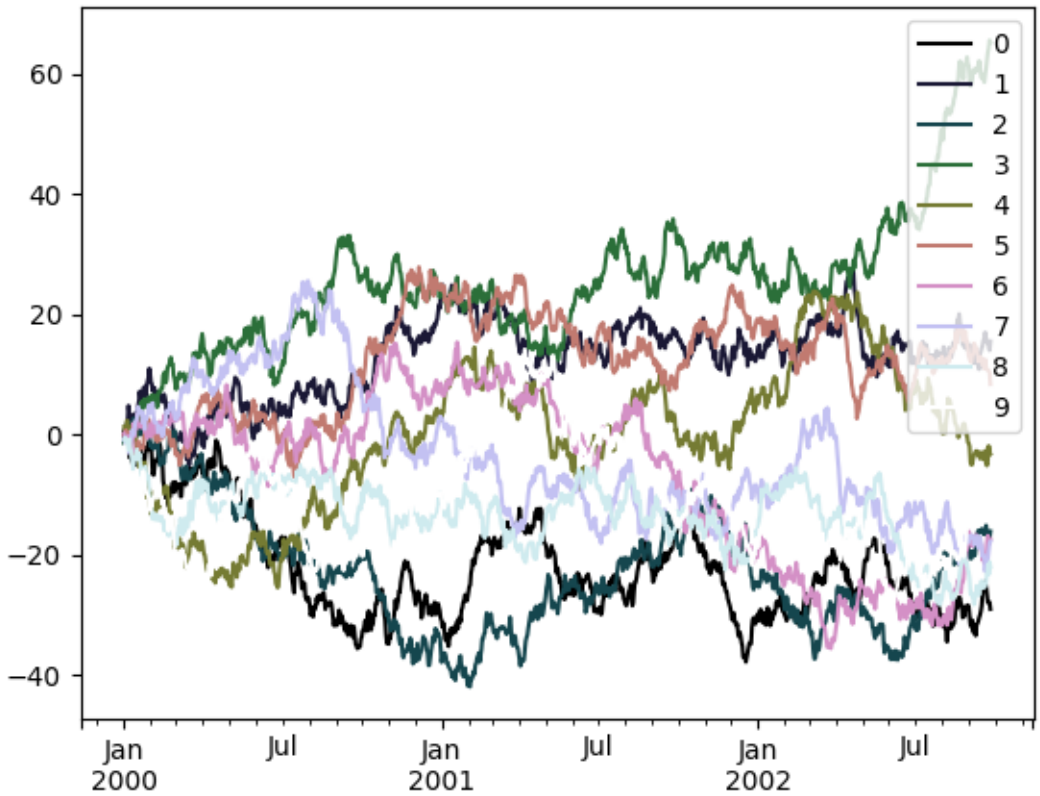


or we can pass the colormap itself

```
In [167]: from matplotlib import cm

In [168]: plt.figure()
Out[168]: <matplotlib.figure.Figure at 0x115ce9cf8>

In [169]: df.plot(colormap=cm.cubehelix)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[169]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x12d1efbe0>
```



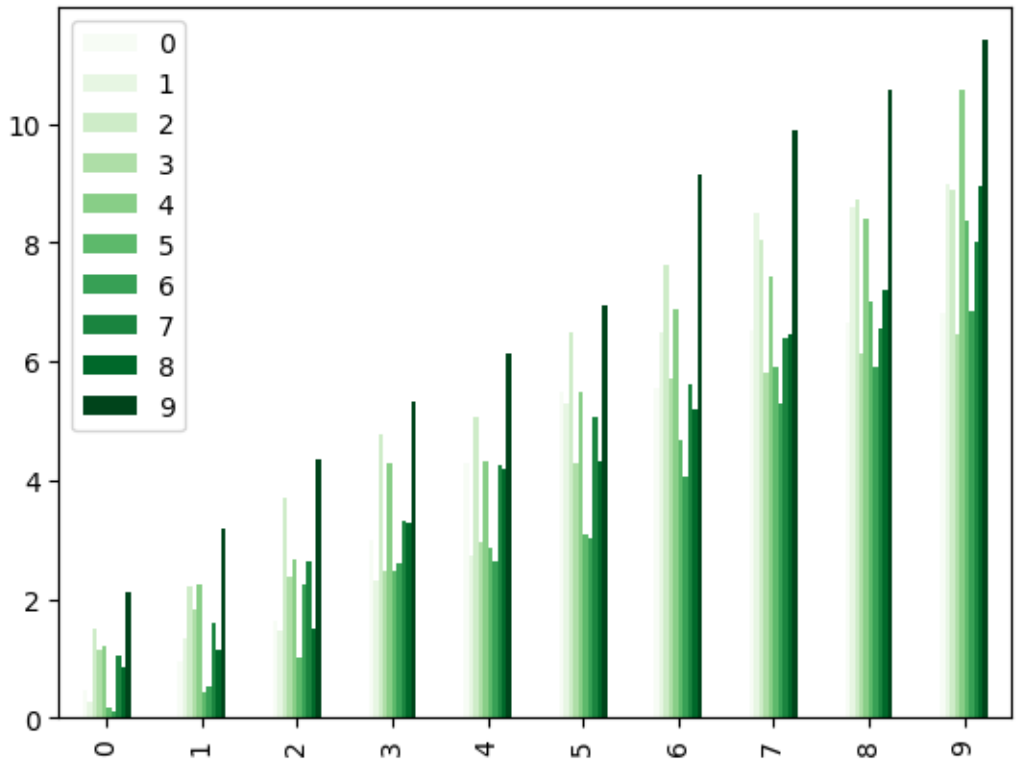
Colormaps can also be used other plot types, like bar charts:

```
In [170]: dd = pd.DataFrame(np.random.randn(10, 10)).applymap(abs)

In [171]: dd = dd.cumsum()

In [172]: plt.figure()
Out[172]: <matplotlib.figure.Figure at 0x12eb384e0>

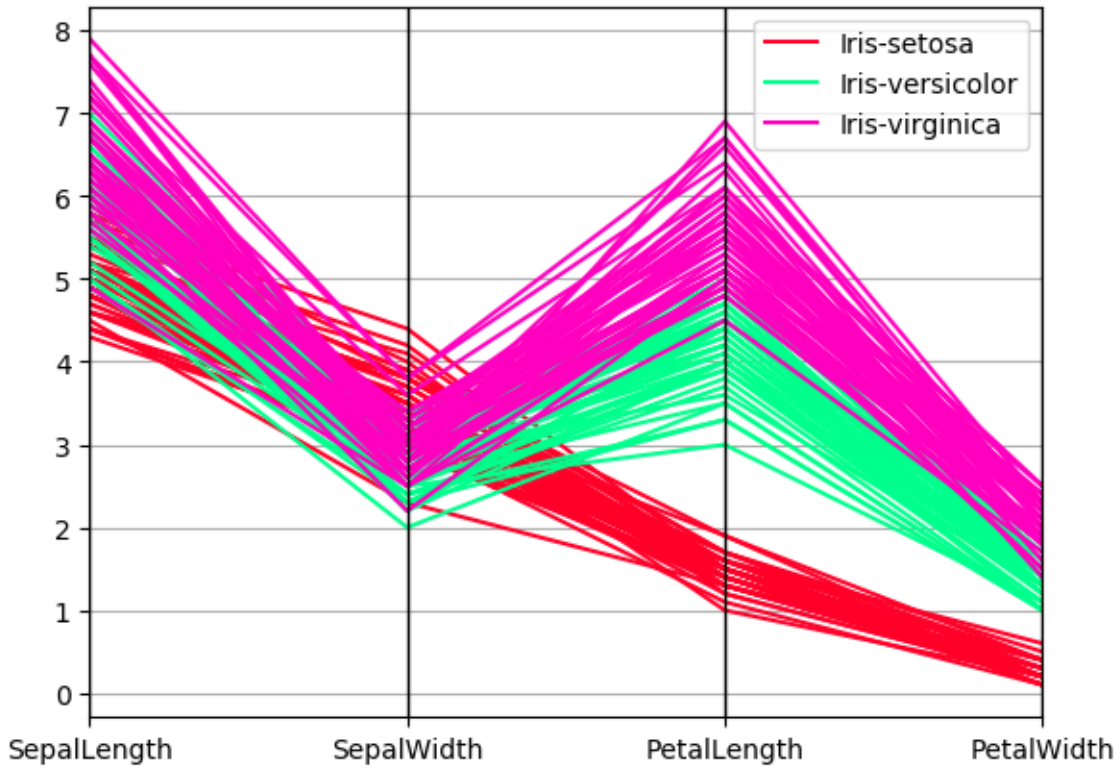
In [173]: dd.plot.bar(colormap='Greens')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[173]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x12a0287b8>
```



Parallel coordinates charts:

```
In [174]: plt.figure()
Out[174]: <matplotlib.figure.Figure at 0x115d0f400>

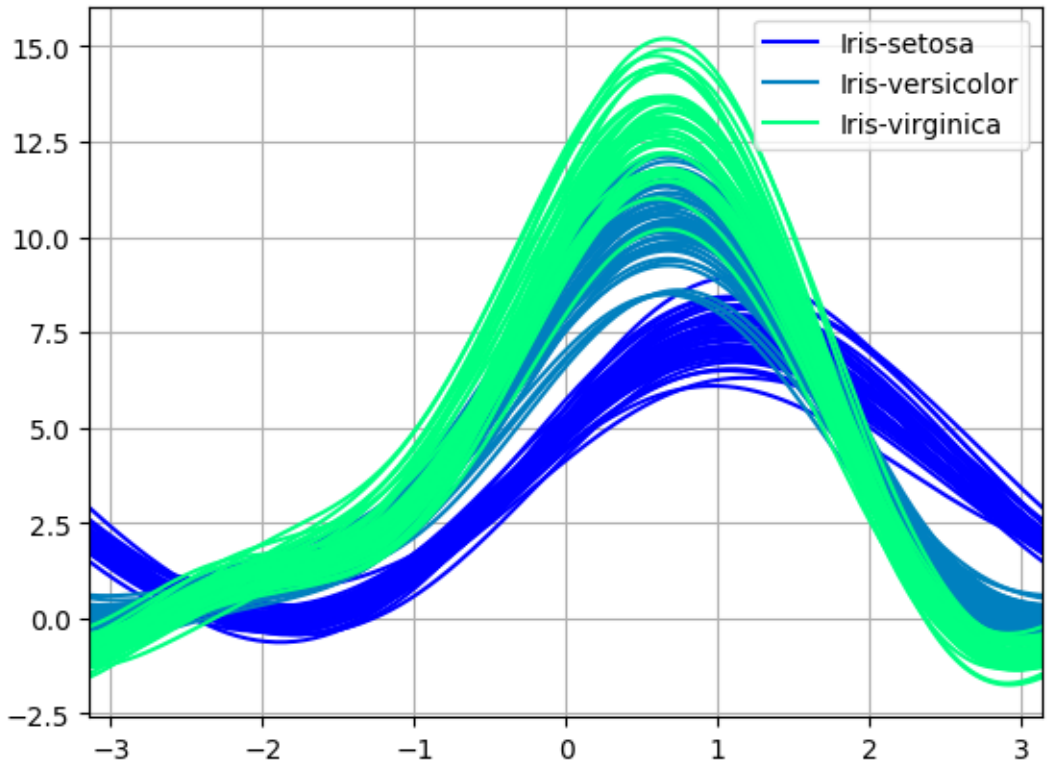
In [175]: parallel_coordinates(data, 'Name', colormap='gist_rainbow')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[175]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x12365ac18>
```



Andrews curves charts:

```
In [176]: plt.figure()
Out[176]: <matplotlib.figure.Figure at 0x115d0f048>

In [177]: andrews_curves(data, 'Name', colormap='winter')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[177]: <matplotlib.axes._
↪subplots.AxesSubplot at 0x12a4dd1d0>
```



22.6 Plotting directly with matplotlib

In some situations it may still be preferable or necessary to prepare plots directly with matplotlib, for instance when a certain type of plot or customization is not (yet) supported by pandas. Series and DataFrame objects behave like arrays and can therefore be passed directly to matplotlib functions without explicit casts.

pandas also automatically registers formatters and locators that recognize date indices, thereby extending date and time support to practically all plot types available in matplotlib. Although this formatting does not provide the same level of refinement you would get when plotting via pandas, it can be faster when plotting a large number of points.

```
In [178]: price = pd.Series(np.random.randn(150).cumsum(),
   .....:                   index=pd.date_range('2000-1-1', periods=150, freq='B'))
   .....:

In [179]: ma = price.rolling(20).mean()

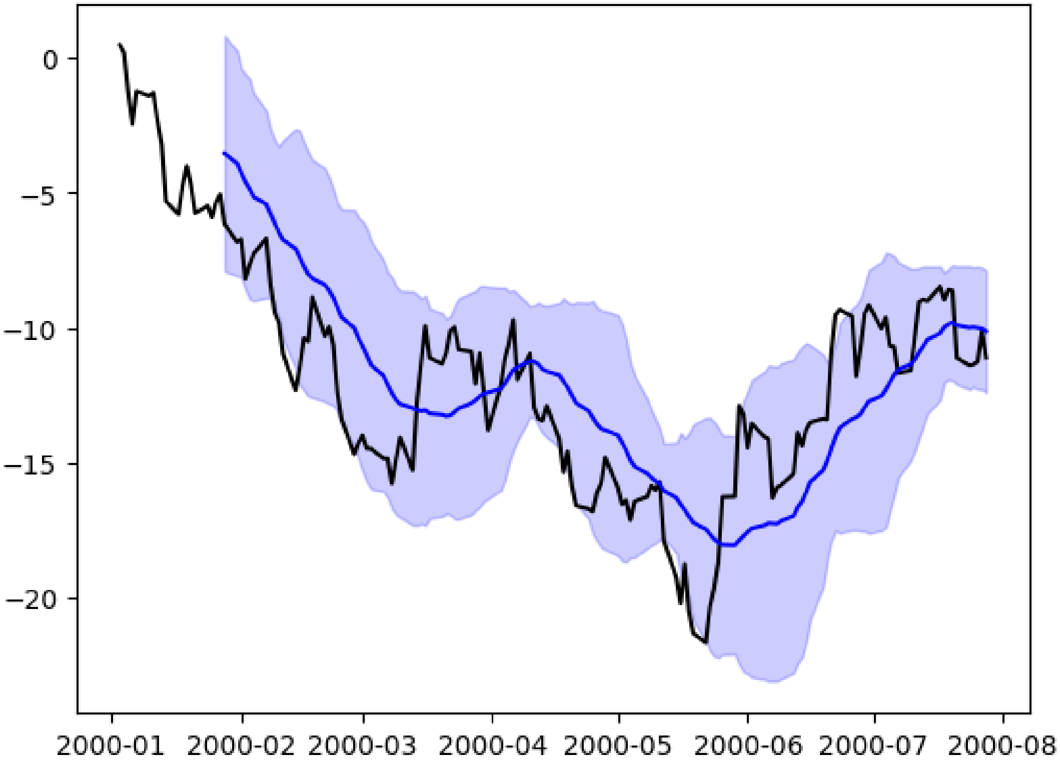
In [180]: mstd = price.rolling(20).std()

In [181]: plt.figure()
Out[181]: <matplotlib.figure.Figure at 0x128ee9080>

In [182]: plt.plot(price.index, price, 'k')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[182]: [<matplotlib.lines.
↪Line2D at 0x1292f6668>]

In [183]: plt.plot(ma.index, ma, 'b')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[<matplotlib.lines.Line2D at 0x129a1bf28>]
```

```
In [184]: plt.fill_between(mstd.index, ma-2*mstd, ma+2*mstd, color='b', alpha=0.2)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪<matplotlib.collections.PolyCollection at 0x12db7d710>
```



22.7 Trellis plotting interface

Warning: The `rplot` trellis plotting interface has been **removed**. Please use external packages like seaborn for similar but more refined functionality and refer to our 0.18.1 documentation here for how to convert to using it.

CHAPTER

TWENTYTHREE

STYLING

New in version 0.17.1

Provisional: This is a new feature and still under development. We'll be adding features and possibly making breaking changes in future releases. We'd love to hear your feedback.

This document is written as a Jupyter Notebook, and can be viewed or downloaded here.

You can apply **conditional formatting**, the visual styling of a DataFrame depending on the data within, by using the `DataFrame.style` property. This is a property that returns a `Styler` object, which has useful methods for formatting and displaying DataFrames.

The styling is accomplished using CSS. You write "style functions" that take scalars, `DataFrame`s or `Series`, and return *like-indexed* DataFrames or Series with CSS `"attribute: value"` pairs for the values. These functions can be incrementally passed to the `Styler` which collects the styles before rendering.

23.1 Building Styles

Pass your style functions into one of the following methods:

- `Styler.applymap`: elementwise
- `Styler.apply`: column-/row-/table-wise

Both of those methods take a function (and some other keyword arguments) and applies your function to the DataFrame in a certain way. `Styler.applymap` works through the DataFrame elementwise. `Styler.apply` passes each column or row into your DataFrame one-at-a-time or the entire table at once, depending on the `axis` keyword argument. For columnwise use `axis=0`, rowwise use `axis=1`, and for the entire table at once use `axis=None`.

For `Styler.applymap` your function should take a scalar and return a single string with the CSS attribute-value pair.

For `Styler.apply` your function should take a Series or DataFrame (depending on the axis parameter), and return a Series or DataFrame with an identical shape where each value is a string with a CSS attribute-value pair.

Let's see some examples.

```
In [2]: import pandas as pd
        import numpy as np

        np.random.seed(24)
        df = pd.DataFrame({'A': np.linspace(1, 10, 10)})
        df = pd.concat([df, pd.DataFrame(np.random.randn(10, 4), columns=list('BCDE'))],
                       axis=1)
        df.iloc[0, 2] = np.nan
```

Here's a boring example of rendering a DataFrame, without any (visible) styles:

```
In [3]: df.style
```

```
Out[3]: <pandas.io.formats.style.Styler at 0x10654ee80>
```

Note: The `DataFrame.style` attribute is a property that returns a `Styler` object. `Styler` has a `_repr_html_` method defined on it so they are rendered automatically. If you want the actual HTML back for further processing or for writing to file call the `.render()` method which returns a string.

The above output looks very similar to the standard DataFrame HTML representation. But we've done some work behind the scenes to attach CSS classes to each cell. We can view these by calling the `.render` method.

```
In [4]: df.style.highlight_null().render().split('\n')[:10]
```

```
Out[4]: ['<style  type="text/css" >',
         '    #T_a298eba8_bb2c_11e7_bd17_186590cd1c87row0_col2 {',
         '            background-color:  red;',
         '        }</style>  ',
         '<table id="T_a298eba8_bb2c_11e7_bd17_186590cd1c87" > ',
         '<thead>    <tr> ',
         '        <th class="blank level0" ></th> ',
         '        <th class="col_heading level0 col0" >A</th> ',
         '        <th class="col_heading level0 col1" >B</th> ',
         '        <th class="col_heading level0 col2" >C</th> ']
```

The `row0_col2` is the identifier for that particular cell. We've also prepended each row/column identifier with a UUID unique to each DataFrame so that the style from one doesn't collide with the styling from another within the same notebook or page (you can set the `uuid` if you'd like to tie together the styling of two DataFrames).

When writing style functions, you take care of producing the CSS attribute / value pairs you want. Pandas matches those up with the CSS classes that identify each cell.

Let's write a simple style function that will color negative numbers red and positive numbers black.

```
In [5]: def color_negative_red(val):
            """
            Takes a scalar and returns a string with
            the css property `'color: red'` for negative
            strings, black otherwise.
            """
            color = 'red' if val < 0 else 'black'
            return 'color: %s' % color
```

In this case, the cell's style depends only on it's own value. That means we should use the `Styler.applymap` method which works elementwise.

```
In [6]: s = df.style.applymap(color_negative_red)
        s
```

```
Out[6]: <pandas.io.formats.style.Styler at 0x103c04eb8>
```

Notice the similarity with the standard `df.applymap`, which operates on DataFrames elementwise. We want you to be able to reuse your existing knowledge of how to interact with DataFrames.

Notice also that our function returned a string containing the CSS attribute and value, separated by a colon just like in a `<style>` tag. This will be a common theme.

Finally, the input shapes matched. `Styler.applymap` calls the function on each scalar input, and the function returns a scalar output.

Now suppose you wanted to highlight the maximum value in each column. We can't use `.applymap` anymore since that operated elementwise. Instead, we'll turn to `.apply` which operates columnwise (or rowwise using the `axis` keyword). Later on we'll see that something like `highlight_max` is already defined on `Styler` so you wouldn't need to write this yourself.

```
In [7]: def highlight_max(s):
            '''
            highlight the maximum in a Series yellow.
            '''
            is_max = s == s.max()
            return ['background-color: yellow' if v else '' for v in is_max]
```

```
In [8]: df.style.apply(highlight_max)
```

```
Out[8]: <pandas.io.formats.style.Styler at 0x103c2e048>
```

In this case the input is a `Series`, one column at a time. Notice that the output shape of `highlight_max` matches the input shape, an array with `len(s)` items.

We encourage you to use method chains to build up a style piecewise, before finally rending at the end of the chain.

```
In [9]: df.style.\
            applymap(color_negative_red).\
            apply(highlight_max)
```

```
Out[9]: <pandas.io.formats.style.Styler at 0x103c28400>
```

Above we used `Styler.apply` to pass in each column one at a time.

Debugging Tip: If you're having trouble writing your style function, try just passing it into DataFrame.apply. Internally, Styler.apply uses DataFrame.apply so the result should be the same.

What if you wanted to highlight just the maximum value in the entire table? Use `.apply(function, axis=None)` to indicate that your function wants the entire table, not one column or row at a time. Let's try that next.

We'll rewrite our `highlight-max` to handle either Series (from `.apply(axis=0 or 1)`) or DataFrames (from `.apply(axis=None)`). We'll also allow the color to be adjustable, to demonstrate that `.apply`, and `.applymap` pass along keyword arguments.

```
In [10]: def highlight_max(data, color='yellow'):
             '''
             highlight the maximum in a Series or DataFrame
             '''
             attr = 'background-color: {}'.format(color)
             if data.ndim == 1:  # Series from .apply(axis=0) or axis=1
                 is_max = data == data.max()
                 return [attr if v else '' for v in is_max]
             else:  # from .apply(axis=None)
                 is_max = data == data.max().max()
                 return pd.DataFrame(np.where(is_max, attr, ''),
                                     index=data.index, columns=data.columns)
```

When using `Styler.apply(func, axis=None)`, the function must return a DataFrame with the same index and column labels.

```
In [11]: df.style.apply(highlight_max, color='darkorange', axis=None)
```

```
Out[11]: <pandas.io.formats.style.Styler at 0x103c344a8>
```

23.1.1 Building Styles Summary

Style functions should return strings with one or more CSS `attribute: value` delimited by semicolons. Use

- `Styler.applymap(func)` for elementwise styles
- `Styler.apply(func, axis=0)` for columnwise styles
- `Styler.apply(func, axis=1)` for rowwise styles

- `Styler.apply(func, axis=None)` for tablewise styles

And crucially the input and output shapes of `func` must match. If `x` is the input then `func(x).shape == x.shape`.

23.2 Finer Control: Slicing

Both `Styler.apply`, and `Styler.applymap` accept a `subset` keyword. This allows you to apply styles to specific rows or columns, without having to code that logic into your `style` function.

The value passed to `subset` behaves simlar to slicing a DataFrame.

- A scalar is treated as a column label
- A list (or series or numpy array)
- A tuple is treated as `(row_indexer, column_indexer)`

Consider using `pd.IndexSlice` to construct the tuple for the last one.

```
In [12]: df.style.apply(highlight_max, subset=['B', 'C', 'D'])
```

```
Out[12]: <pandas.io.formats.style.Styler at 0x103c2e208>
```

For row and column slicing, any valid indexer to `.loc` will work.

```
In [13]: df.style.applymap(color_negative_red,
                           subset=pd.IndexSlice[2:5, ['B', 'D']])
```

```
Out[13]: <pandas.io.formats.style.Styler at 0x103c2e6d8>
```

Only label-based slicing is supported right now, not positional.

If your style function uses a `subset` or `axis` keyword argument, consider wrapping your function in a `functools.partial`, partialing out that keyword.

```
my_func2 = functools.partial(my_func, subset=42)
```

23.3 Finer Control: Display Values

We distinguish the *display* value from the *actual* value in `Styler`. To control the display value, the text is printed in each cell, use `Styler.format`. Cells can be formatted according to a format spec string or a callable that takes a single value and returns a string.

```
In [14]: df.style.format("{:.2%}")
```

```
Out[14]: <pandas.io.formats.style.Styler at 0x103c2e5c0>
```

Use a dictionary to format specific columns.

```
In [15]: df.style.format({'B': "{:0<4.0f}", 'D': '{:+.2f}'})
```

```
Out[15]: <pandas.io.formats.style.Styler at 0x103c2e908>
```

Or pass in a callable (or dictionary of callables) for more flexible handling.

```
In [16]: df.style.format({"B": lambda x: "±{:.2f}".format(abs(x))})
```

```
Out[16]: <pandas.io.formats.style.Styler at 0x103c2edd8>
```

23.4 Builtin Styles

Finally, we expect certain styling functions to be common enough that we've included a few "built-in" to the `Styler`, so you don't have to write them yourself.

```
In [17]: df.style.highlight_null(null_color='red')
```

```
Out[17]: <pandas.io.formats.style.Styler at 0x103c2e7b8>
```

You can create "heatmaps" with the `background_gradient` method. These require matplotlib, and we'll use Seaborn to get a nice colormap.

```
In [18]: import seaborn as sns

         cm = sns.light_palette("green", as_cmap=True)

         s = df.style.background_gradient(cmap=cm)
         s
```

```
/Users/taugspurger/Envs/pandas-dev/lib/python3.6/site-packages/matplotlib/colors.py:489: RuntimeWarni
  np.copyto(xa, -1, where=xa < 0.0)
```

```
Out[18]: <pandas.io.formats.style.Styler at 0x10531c438>
```

`Styler.background_gradient` takes the keyword arguments `low` and `high`. Roughly speaking these extend the range of your data by `low` and `high` percent so that when we convert the colors, the colormap's entire range isn't used. This is useful so that you can actually read the text still.

```
In [19]: # Uses the full color range
         df.loc[:4].style.background_gradient(cmap='viridis')
```

```
/Users/taugspurger/Envs/pandas-dev/lib/python3.6/site-packages/matplotlib/colors.py:489: RuntimeWarni
  np.copyto(xa, -1, where=xa < 0.0)
```

```
Out[19]: <pandas.io.formats.style.Styler at 0x103c2e5f8>
```

```
In [20]: # Compress the color range
         (df.loc[:4]
             .style
             .background_gradient(cmap='viridis', low=.5, high=0)
             .highlight_null('red'))
```

```
/Users/taugspurger/Envs/pandas-dev/lib/python3.6/site-packages/matplotlib/colors.py:489: RuntimeWarni
  np.copyto(xa, -1, where=xa < 0.0)
```

```
Out[20]: <pandas.io.formats.style.Styler at 0x10a091f28>
```

There's also `.highlight_min` and `.highlight_max`.

```
In [21]: df.style.highlight_max(axis=0)
```

```
Out[21]: <pandas.io.formats.style.Styler at 0x10a091cc0>
```

Use `Styler.set_properties` when the style doesn't actually depend on the values.

```
In [22]: df.style.set_properties(**{'background-color': 'black',
                                    'color': 'lawngreen',
                                    'border-color': 'white'})
```

```
Out[22]: <pandas.io.formats.style.Styler at 0x10a15b320>
```

23.4.1 Bar charts

You can include "bar charts" in your DataFrame.

```
In [23]: df.style.bar(subset=['A', 'B'], color='#d65f5f')
```

```
Out[23]: <pandas.io.formats.style.Styler at 0x10a091b00>
```

New in version 0.20.0 is the ability to customize further the bar chart: You can now have the `df.style.bar` be centered on zero or midpoint value (in addition to the already existing way of having the min value at the left side of the cell), and you can pass a list of `[color_negative, color_positive]`.

Here's how you can change the above with the new `align='mid'` option:

```
In [24]: df.style.bar(subset=['A', 'B'], align='mid', color=['#d65f5f', '#5fba7d'])
```

```
Out[24]: <pandas.io.formats.style.Styler at 0x10a224278>
```

The following example aims to give a highlight of the behavior of the new align options:

```
In [25]: import pandas as pd
         from IPython.display import HTML

         # Test series
         test1 = pd.Series([-100,-60,-30,-20], name='All Negative')
         test2 = pd.Series([10,20,50,100], name='All Positive')
         test3 = pd.Series([-10,-5,0,90], name='Both Pos and Neg')

         head = """
         <table>
             <thead>
                 <th>Align</th>
                 <th>All Negative</th>
                 <th>All Positive</th>
                 <th>Both Neg and Pos</th>
             </thead>
             </tbody>

         """

         aligns = ['left','zero','mid']
         for align in aligns:
             row = "<tr><th>{}</th>".format(align)
             for serie in [test1,test2,test3]:
                 s = serie.copy()
                 s.name=''
                 row += "<td>{}</td>".format(s.to_frame().style.bar(align=align,
                                                                    color=['#d65f5f', '#5fba7d'],
                                                                    width=100).render()) #testn['wid
             row += '</tr>'
             head += row

         head+= """
         </tbody>
         </table>"""


         HTML(head)
```

```
Out[25]: <IPython.core.display.HTML object>
```

23.5 Sharing Styles

Say you have a lovely style built up for a DataFrame, and now you want to apply the same style to a second DataFrame. Export the style with `df1.style.export`, and import it on the second DataFrame with `df1.style.set`

```
In [26]: df2 = -df
         style1 = df.style.applymap(color_negative_red)
         style1
```

```
Out[26]: <pandas.io.formats.style.Styler at 0x10a21ce48>
```

```
In [27]: style2 = df2.style
         style2.use(style1.export())
         style2
```

```
Out[27]: <pandas.io.formats.style.Styler at 0x10a257eb8>
```

Notice that you're able share the styles even though they're data aware. The styles are re-evaluated on the new DataFrame they've been `used` upon.

23.6 Other Options

You've seen a few methods for data-driven styling. `Styler` also provides a few other options for styles that don't depend on the data.

- precision
- captions
- table-wide styles

Each of these can be specified in two ways:

- A keyword argument to `Styler.__init__`
- A call to one of the `.set_` methods, e.g. `.set_caption`

The best method to use depends on the context. Use the `Styler` constructor when building many styled DataFrames that should all share the same properties. For interactive use, the `.set_` methods are more convenient.

23.6.1 Precision

You can control the precision of floats using pandas' regular `display.precision` option.

```
In [28]: with pd.option_context('display.precision', 2):
             html = (df.style
                       .applymap(color_negative_red)
                       .apply(highlight_max))
         html
```

```
Out[28]: <pandas.io.formats.style.Styler at 0x10a22fda0>
```

Or through a `set_precision` method.

```
In [29]: df.style\
           .applymap(color_negative_red)\
           .apply(highlight_max)\
           .set_precision(2)
```

```
Out[29]: <pandas.io.formats.style.Styler at 0x10a2576a0>
```

Setting the precision only affects the printed number; the full-precision values are always passed to your style functions. You can always use `df.round(2).style` if you'd prefer to round from the start.

23.6.2 Captions

Regular table captions can be added in a few ways.

```
In [30]: df.style.set_caption('Colormaps, with a caption.')\
             .background_gradient(cmap=cm)
```

```
/Users/taugspurger/Envs/pandas-dev/lib/python3.6/site-packages/matplotlib/colors.py:489: RuntimeWarn
  np.copyto(xa, -1, where=xa < 0.0)
```

```
Out[30]: <pandas.io.formats.style.Styler at 0x10a22ff28>
```

23.6.3 Table Styles

The next option you have are "table styles". These are styles that apply to the table as a whole, but don't look at the data. Certain sytlings, including pseudo-selectors like `:hover` can only be used this way.

```
In [31]: from IPython.display import HTML

         def hover(hover_color="#ffff99"):
             return dict(selector="tr:hover",
                         props=[("background-color", "%s" % hover_color)])

         styles = [
             hover(),
             dict(selector="th", props=[("font-size", "150%"),
                                        ("text-align", "center")]),
             dict(selector="caption", props=[("caption-side", "bottom")])
         ]
         html = (df.style.set_table_styles(styles)
                   .set_caption("Hover to highlight."))
         html
```

```
Out[31]: <pandas.io.formats.style.Styler at 0x103c2ef98>
```

`table_styles` should be a list of dictionaries. Each dictionary should have the `selector` and `props` keys. The value for `selector` should be a valid CSS selector. Recall that all the styles are already attached to an `id`, unique to each `Styler`. This selector is in addition to that `id`. The value for `props` should be a list of tuples of `('attribute', 'value')`.

`table_styles` are extremely flexible, but not as fun to type out by hand. We hope to collect some useful ones either in pandas, or preferable in a new package that *builds on top* the tools here.

23.6.4 CSS Classes

Certain CSS classes are attached to cells.

- Index and Column names include `index_name` and `level<k>` where `k` is its level in a MultiIndex
- Index label cells include
- `row_heading`
- `row<n>` where `n` is the numeric position of the row
- `level<k>` where `k` is the level in a MultiIndex

- Column label cells include
- `col_heading`
- `col<n>` where `n` is the numeric position of the column
- `level<k>` where `k` is the level in a MultiIndex
- Blank cells include `blank`
- Data cells include `data`

23.6.5 Limitations

- DataFrame only `(use Series.to_frame().style)`
- The index and columns must be unique
- No large repr, and performance isn't great; this is intended for summary DataFrames
- You can only style the *values*, not the index or columns
- You can only apply styles, you can't insert new HTML entities

Some of these will be addressed in the future.

23.6.6 Terms

- Style function: a function that's passed into `Styler.apply` or `Styler.applymap` and returns values like `'css attribute: value'`
- Builtin style functions: style functions that are methods on `Styler`
- table style: a dictionary with the two keys `selector` and `props`. `selector` is the CSS selector that `props` will apply to. `props` is a list of `(attribute, value)` tuples. A list of table styles passed into `Styler`.

23.7 Fun stuff

Here are a few interesting examples.

`Styler` interacts pretty well with widgets. If you're viewing this online instead of running the notebook yourself, you're missing out on interactively adjusting the color palette.

```
In [32]: from IPython.html import widgets
         @widgets.interact
         def f(h_neg=(0, 359, 1), h_pos=(0, 359), s=(0., 99.9), l=(0., 99.9)):
             return df.style.background_gradient(
                 cmap=sns.palettes.diverging_palette(h_neg=h_neg, h_pos=h_pos, s=s, l=l,
                                                     as_cmap=True)
             )
```

```
/Users/taugspurger/Envs/pandas-dev/lib/python3.6/site-packages/matplotlib/colors.py:489: RuntimeWarni
  np.copyto(xa, -1, where=xa < 0.0)
```

```
<pandas.io.formats.style.Styler at 0x10a15b748>
```

```
In [33]: def magnify():
             return [dict(selector="th",
                          props=[("font-size", "4pt")]),
                     dict(selector="td",
```

```
                        props=[('padding', "0em 0em")]),
                    dict(selector="th:hover",
                        props=[("font-size", "12pt")]),
                    dict(selector="tr:hover td:hover",
                        props=[('max-width', '200px'),
                               ('font-size', '12pt')])
        ]
```

```
In [34]: np.random.seed(25)
         cmap = cmap=sns.diverging_palette(5, 250, as_cmap=True)
         bigdf = pd.DataFrame(np.random.randn(20, 25)).cumsum()

         bigdf.style.background_gradient(cmap, axis=1)\
             .set_properties(**{'max-width': '80px', 'font-size': '1pt'})\
             .set_caption("Hover to magnify")\
             .set_precision(2)\
             .set_table_styles(magnify())
```

```
Out[34]: <pandas.io.formats.style.Styler at 0x10a22f5c0>
```

23.8 Export to Excel

New in version 0.20.0

Experimental: This is a new feature and still under development. We'll be adding features and possibly making breaking changes in future releases. We'd love to hear your feedback.

Some support is available for exporting styled `DataFrames` to Excel worksheets using the `OpenPyXL` engine. CSS2.2 properties handled include:

- `background-color`
- `border-style`, `border-width`, `border-color` and their {`top`, `right`, `bottom`, `left` variants}
- `color`
- `font-family`
- `font-style`
- `font-weight`
- `text-align`
- `text-decoration`
- `vertical-align`
- `white-space: nowrap`

Only CSS2 named colors and hex colors of the form `#rgb` or `#rrggbb` are currently supported.

```
In [35]: df.style.\
             applymap(color_negative_red).\
             apply(highlight_max).\
             to_excel('styled.xlsx', engine='openpyxl')
```

A screenshot of the output:

	A	B	C	D	E	F
1		A	B	C	D	E
2	0	1	1.329212		-0.31628	-0.99081
3	1	2	-1.070816	-1.438713	0.564417	0.295722
4	2	3	-1.626404	0.219565	0.678805	1.889273
5	3	4	0.961538	0.104011	-0.481165	0.850229
6	4	5	1.453425	1.057737	0.165562	0.515018
7	5	6	-1.336936	0.562861	1.392855	-0.063328
8	6	7	0.121668	1.207603	-0.00204	1.627796
9	7	8	0.354493	1.037528	-0.385684	0.519818
10	8	9	1.686583	-1.325963	1.428984	-2.089354
11	9	10	-0.12982	0.631523	-0.586538	0.29072

Fig. 23.1: Excel spreadsheet with styled DataFrame

23.9 Extensibility

The core of pandas is, and will remain, its "high-performance, easy-to-use data structures". With that in mind, we hope that `DataFrame.style` accomplishes two goals

- Provide an API that is pleasing to use interactively and is "good enough" for many tasks
- Provide the foundations for dedicated libraries to build on

If you build a great library on top of this, let us know and we'll link to it.

23.9.1 Subclassing

If the default template doesn't quite suit your needs, you can subclass Styler and extend or override the template. We'll show an example of extending the default template to insert a custom header before each table.

```
In [36]: from jinja2 import Environment, ChoiceLoader, FileSystemLoader
         from IPython.display import HTML
         from pandas.io.formats.style import Styler
```

```
In [37]: %mkdir templates
```

This next cell writes the custom template. We extend the template `html.tpl`, which comes with pandas.

```
In [38]: %%file templates/myhtml.tpl
         {% extends "html.tpl" %}
         {% block table %}
         <h1>{{ table_title|default("My Table") }}</h1>
         {{ super() }}
         {% endblock table %}
```

```
Writing templates/myhtml.tpl
```

Now that we've created a template, we need to set up a subclass of `Styler` that knows about it.

```
In [39]: class MyStyler(Styler):
             env = Environment(
                 loader=ChoiceLoader([
                     FileSystemLoader("templates"),  # contains ours
                     Styler.loader,  # the default
                 ])
             )
             template = env.get_template("myhtml.tpl")
```

Notice that we include the original loader in our environment's loader. That's because we extend the original template, so the Jinja environment needs to be able to find it.

Now we can use that custom styler. It's `__init__` takes a DataFrame.

```
In [40]: MyStyler(df)

Out[40]: <__main__.MyStyler at 0x10c66fe10>
```

Our custom template accepts a `table_title` keyword. We can provide the value in the `.render` method.

```
In [41]: HTML(MyStyler(df).render(table_title="Extending Example"))

Out[41]: <IPython.core.display.HTML object>
```

For convenience, we provide the `Styler.from_custom_template` method that does the same as the custom subclass.

```
In [42]: EasyStyler = Styler.from_custom_template("templates", "myhtml.tpl")
         EasyStyler(df)

Out[42]: <pandas.io.formats.style.Styler.from_custom_template.<locals>.MyStyler at 0x10c66fdd8>
```

Here's the template structure:

```
In [43]: with open("template_structure.html") as f:
             structure = f.read()

         HTML(structure)

Out[43]: <IPython.core.display.HTML object>
```

See the template in the GitHub repo for more details.

CHAPTER

TWENTYFOUR

IO TOOLS (TEXT, CSV, HDF5, ...)

The pandas I/O API is a set of top level `reader` functions accessed like `pd.read_csv()` that generally return a `pandas` object. The corresponding `writer` functions are object methods that are accessed like `df.to_csv()`

Format Type	Data Description	Reader	Writer
text	CSV	*read_csv*	*to_csv*
text	JSON	*read_json*	*to_json*
text	HTML	*read_html*	*to_html*
text	Local clipboard	*read_clipboard*	*to_clipboard*
binary	MS Excel	*read_excel*	*to_excel*
binary	HDF5 Format	*read_hdf*	*to_hdf*
binary	Feather Format	*read_feather*	*to_feather*
binary	Parquet Format	*read_parquet*	*to_parquet*
binary	Msgpack	*read_msgpack*	*to_msgpack*
binary	Stata	*read_stata*	*to_stata*
binary	SAS	*read_sas*	
binary	Python Pickle Format	*read_pickle*	*to_pickle*
SQL	SQL	*read_sql*	*to_sql*
SQL	Google Big Query	*read_gbq*	*to_gbq*

Here is an informal performance comparison for some of these IO methods.

Note: For examples that use the `StringIO` class, make sure you import it according to your Python version, i.e. `from StringIO import StringIO` for Python 2 and `from io import StringIO` for Python 3.

24.1 CSV & Text files

The two workhorse functions for reading text files (a.k.a. flat files) are *`read_csv()`* and *`read_table()`*. They both use the same parsing code to intelligently convert tabular data into a DataFrame object. See the *cookbook* for some advanced strategies.

24.1.1 Parsing options

`read_csv()` and *`read_table()`* accept the following arguments:

24.1.1.1 Basic

filepath_or_buffer [various] Either a path to a file (a `str`, `pathlib.Path`, or `py._path.local.LocalPath`), URL (including http, ftp, and S3 locations), or any object with a `read()` method (such as an open file or `StringIO`).

sep [str, defaults to `','` for *`read_csv()`*, `\t` for *`read_table()`*] Delimiter to use. If sep is `None`, the C engine cannot automatically detect the separator, but the Python parsing engine can, meaning the latter will be used and automatically detect the separator by Python's builtin sniffer tool, `csv.Sniffer`. In addition, separators longer than 1 character and different from `'\s+'` will be interpreted as regular expressions and will also force the use of the Python parsing engine. Note that regex delimiters are prone to ignoring quoted data. Regex example: `'\\r\\t'`.

delimiter [str, default `None`] Alternative argument name for sep.

delim_whitespace [boolean, default False] Specifies whether or not whitespace (e.g. `' '` or `'\t'`) will be used as the delimiter. Equivalent to setting `sep='\s+'`. If this option is set to True, nothing should be passed in for the `delimiter` parameter.

New in version 0.18.1: support for the Python parser.

24.1.1.2 Column and Index Locations and Names

header [int or list of ints, default `'infer'`] Row number(s) to use as the column names, and the start of the data. Default behavior is as if `header=0` if no `names` passed, otherwise as if `header=None`. Explicitly pass `header=0` to be able to replace existing names. The header can be a list of ints that specify row locations for a multi-index on the columns e.g. `[0,1,3]`. Intervening rows that are not specified will be skipped (e.g. 2 in this example is skipped). Note that this parameter ignores commented lines and empty lines if `skip_blank_lines=True`, so header=0 denotes the first line of data rather than the first line of the file.

names [array-like, default `None`] List of column names to use. If file contains no header row, then you should explicitly pass `header=None`. Duplicates in this list will cause

> a `UserWarning` to be issued.

index_col [int or sequence or `False`, default `None`] Column to use as the row labels of the DataFrame. If a sequence is given, a MultiIndex is used. If you have a malformed file with delimiters at the end of each line, you might consider `index_col=False` to force pandas to *not* use the first column as the index (row names).

usecols [array-like or callable, default `None`] Return a subset of the columns. If array-like, all elements must either be positional (i.e. integer indices into the document columns) or strings that correspond to column names provided either by the user in *names* or inferred from the document header row(s). For example, a valid array-like *usecols* parameter would be [0, 1, 2] or ['foo', 'bar', 'baz'].

If callable, the callable function will be evaluated against the column names, returning names where the callable function evaluates to True:

```
In [1]: data = 'col1,col2,col3\na,b,1\na,b,2\nc,d,3'

In [2]: pd.read_csv(StringIO(data))
Out[2]:
  col1 col2  col3
0    a    b     1
1    a    b     2
2    c    d     3

In [3]: pd.read_csv(StringIO(data), usecols=lambda x: x.upper() in ['COL1', 'COL3
↪'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[3]:␣
↪
```

```
  col1  col3
0    a     1
1    a     2
2    c     3
```

Using this parameter results in much faster parsing time and lower memory usage.

as_recarray [boolean, default `False`] Deprecated since version 0.18.2: Please call `pd.read_csv(...).to_records()` instead.

Return a NumPy recarray instead of a DataFrame after parsing the data. If set to `True`, this option takes precedence over the `squeeze` parameter. In addition, as row indices are not available in such a format, the `index_col` parameter will be ignored.

squeeze [boolean, default `False`] If the parsed data only contains one column then return a Series.

prefix [str, default `None`] Prefix to add to column numbers when no header, e.g. 'X' for X0, X1, ...

mangle_dupe_cols [boolean, default `True`] Duplicate columns will be specified as 'X.0'...'X.N', rather than 'X'...'X'. Passing in False will cause data to be overwritten if there are duplicate names in the columns.

24.1.1.3 General Parsing Configuration

dtype [Type name or dict of column -> type, default `None`] Data type for data or columns. E.g. `{'a': np.float64, 'b': np.int32}` (unsupported with `engine='python'`). Use *str* or *object* to preserve and not interpret dtype.

New in version 0.20.0: support for the Python parser.

engine [{`'c'`, `'python'`}] Parser engine to use. The C engine is faster while the python engine is currently more feature-complete.

converters [dict, default `None`] Dict of functions for converting values in certain columns. Keys can either be integers or column labels.

true_values [list, default `None`] Values to consider as `True`.

false_values [list, default `None`] Values to consider as `False`.

skipinitialspace [boolean, default `False`] Skip spaces after delimiter.

skiprows [list-like or integer, default `None`] Line numbers to skip (0-indexed) or number of lines to skip (int) at the start of the file.

If callable, the callable function will be evaluated against the row indices, returning True if the row should be skipped and False otherwise:

```
In [4]: data = 'col1,col2,col3\na,b,1\na,b,2\nc,d,3'

In [5]: pd.read_csv(StringIO(data))
Out[5]:
  col1 col2  col3
0    a    b     1
1    a    b     2
2    c    d     3

In [6]: pd.read_csv(StringIO(data), skiprows=lambda x: x % 2 != 0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[6]:␣
↪
  col1 col2  col3
0    a    b     2
```

skipfooter [int, default `0`] Number of lines at bottom of file to skip (unsupported with engine='c').

skip_footer [int, default `0`] Deprecated since version 0.19.0: Use the `skipfooter` parameter instead, as they are identical

nrows [int, default `None`] Number of rows of file to read. Useful for reading pieces of large files.

low_memory [boolean, default `True`] Internally process the file in chunks, resulting in lower memory use while parsing, but possibly mixed type inference. To ensure no mixed types either set `False`, or specify the type with the `dtype` parameter. Note that the entire file is read into a single DataFrame regardless, use the `chunksize` or `iterator` parameter to return the data in chunks. (Only valid with C parser)

buffer_lines [int, default None] Deprecated since version 0.19.0: Argument removed because its value is not respected by the parser

compact_ints [boolean, default False] Deprecated since version 0.19.0: Argument moved to `pd.to_numeric`

If `compact_ints` is `True`, then for any column that is of integer dtype, the parser will attempt to cast it as the smallest integer `dtype` possible, either signed or unsigned depending on the specification from the `use_unsigned` parameter.

use_unsigned [boolean, default False] Deprecated since version 0.18.2: Argument moved to `pd.to_numeric`

If integer columns are being compacted (i.e. `compact_ints=True`), specify whether the column should be compacted to the smallest signed or unsigned integer dtype.

memory_map [boolean, default False] If a filepath is provided for `filepath_or_buffer`, map the file object directly onto memory and access the data directly from there. Using this option can improve performance because there is no longer any I/O overhead.

24.1.1.4 NA and Missing Data Handling

na_values [scalar, str, list-like, or dict, default `None`] Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. See *na values const* below for a list of the values interpreted as NaN by default.

keep_default_na [boolean, default `True`] If na_values are specified and keep_default_na is `False` the default NaN values are overridden, otherwise they're appended to.

na_filter [boolean, default `True`] Detect missing value markers (empty strings and the value of na_values). In data without any NAs, passing `na_filter=False` can improve the performance of reading a large file.

verbose [boolean, default `False`] Indicate number of NA values placed in non-numeric columns.

skip_blank_lines [boolean, default `True`] If `True`, skip over blank lines rather than interpreting as NaN values.

24.1.1.5 Datetime Handling

parse_dates [boolean or list of ints or names or list of lists or dict, default `False`.]

- If `True` -> try parsing the index.
- If `[1, 2, 3]` -> try parsing columns 1, 2, 3 each as a separate date column.
- If `[[1, 3]]` -> combine columns 1 and 3 and parse as a single date column.
- If `{'foo' : [1, 3]}` -> parse columns 1, 3 as date and call result 'foo'. A fast-path exists for iso8601-formatted dates.

infer_datetime_format [boolean, default `False`] If `True` and parse_dates is enabled for a column, attempt to infer the datetime format to speed up the processing.

keep_date_col [boolean, default `False`] If `True` and parse_dates specifies combining multiple columns then keep the original columns.

date_parser [function, default `None`] Function to use for converting a sequence of string columns to an array of datetime instances. The default uses `dateutil.parser.parser` to do the conversion. Pandas will try to call date_parser in three different ways, advancing to the next if an exception occurs: 1) Pass one or more arrays (as defined by parse_dates) as arguments; 2) concatenate (row-wise) the string values from the columns defined by parse_dates into a single array and pass that; and 3) call date_parser once for each row using one or more strings (corresponding to the columns defined by parse_dates) as arguments.

dayfirst [boolean, default `False`] DD/MM format dates, international and European format.

24.1.1.6 Iteration

iterator [boolean, default `False`] Return *TextFileReader* object for iteration or getting chunks with `get_chunk()`.

chunksize [int, default `None`] Return *TextFileReader* object for iteration. See *iterating and chunking* below.

24.1.1.7 Quoting, Compression, and File Format

compression [{`'infer'`, `'gzip'`, `'bz2'`, `'zip'`, `'xz'`, `None`}, default `'infer'`] For on-the-fly decompression of on-disk data. If 'infer', then use gzip, bz2, zip, or xz if filepath_or_buffer is a string ending in '.gz', '.bz2', '.zip', or '.xz', respectively, and no decompression otherwise. If using 'zip', the ZIP file must contain only one data file to be read in. Set to `None` for no decompression.

New in version 0.18.1: support for 'zip' and 'xz' compression.

thousands [str, default `None`] Thousands separator.

decimal [str, default `'.'`] Character to recognize as decimal point. E.g. use `','` for European data.

float_precision [string, default None] Specifies which converter the C engine should use for floating-point values. The options are `None` for the ordinary converter, `high` for the high-precision converter, and `round_trip` for the round-trip converter.

lineterminator [str (length 1), default `None`] Character to break file into lines. Only valid with C parser.

quotechar [str (length 1)] The character used to denote the start and end of a quoted item. Quoted items can include the delimiter and it will be ignored.

quoting [int or `csv.QUOTE_*` instance, default `0`] Control field quoting behavior per `csv.QUOTE_*` constants. Use one of `QUOTE_MINIMAL` (0), `QUOTE_ALL` (1), `QUOTE_NONNUMERIC` (2) or `QUOTE_NONE` (3).

doublequote [boolean, default `True`] When `quotechar` is specified and `quoting` is not `QUOTE_NONE`, indicate whether or not to interpret two consecutive `quotechar` elements **inside** a field as a single `quotechar` element.

escapechar [str (length 1), default `None`] One-character string used to escape delimiter when quoting is `QUOTE_NONE`.

comment [str, default `None`] Indicates remainder of line should not be parsed. If found at the beginning of a line, the line will be ignored altogether. This parameter must be a single character. Like empty lines (as long as `skip_blank_lines=True`), fully commented lines are ignored by the parameter *header* but not by *skiprows*. For example, if `comment='#'`, parsing '#empty\na,b,c\n1,2,3' with *header=0* will result in 'a,b,c' being treated as the header.

encoding [str, default `None`] Encoding to use for UTF when reading/writing (e.g. `'utf-8'`). List of Python standard encodings.

dialect [str or `csv.Dialect` instance, default `None`] If provided, this parameter will override values (default or not) for the following parameters: *delimiter*, *doublequote*, *escapechar*, *skipinitialspace*, *quotechar*, and *quoting*. If it is necessary to override values, a ParserWarning will be issued. See `csv.Dialect` documentation for more details.

tupleize_cols [boolean, default `False`]

> Deprecated since version 0.21.0.
>
> This argument will be removed and will always convert to MultiIndex

Leave a list of tuples on columns as is (default is to convert to a MultiIndex on the columns).

24.1.1.8 Error Handling

error_bad_lines [boolean, default `True`] Lines with too many fields (e.g. a csv line with too many commas) will by default cause an exception to be raised, and no DataFrame will be returned. If `False`, then these “bad lines” will dropped from the DataFrame that is returned. See *bad lines* below.

warn_bad_lines [boolean, default `True`] If error_bad_lines is `False`, and warn_bad_lines is `True`, a warning for each “bad line” will be output.

24.1.2 Specifying column data types

You can indicate the data type for the whole DataFrame or individual columns:

```
In [7]: data = 'a,b,c\n1,2,3\n4,5,6\n7,8,9'

In [8]: print(data)
a,b,c
1,2,3
4,5,6
7,8,9

In [9]: df = pd.read_csv(StringIO(data), dtype=object)

In [10]: df
Out[10]:
   a  b  c
0  1  2  3
1  4  5  6
2  7  8  9

In [11]: df['a'][0]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[11]: '1'

In [12]: df = pd.read_csv(StringIO(data), dtype={'b': object, 'c': np.float64})

In [13]: df.dtypes
Out[13]:
a       int64
b      object
c     float64
dtype: object
```

Fortunately, `pandas` offers more than one way to ensure that your column(s) contain only one `dtype`. If you’re unfamiliar with these concepts, you can see *here* to learn more about dtypes, and *here* to learn more about `object` conversion in `pandas`.

For instance, you can use the `converters` argument of *read_csv()*:

```
In [14]: data = "col_1\n1\n2\n'A'\n4.22"

In [15]: df = pd.read_csv(StringIO(data), converters={'col_1':str})

In [16]: df
Out[16]:
  col_1
0     1
1     2
2   'A'
3  4.22

In [17]: df['col_1'].apply(type).value_counts()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[17]:
<class 'str'>    4
Name: col_1, dtype: int64
```

Or you can use the *to_numeric()* function to coerce the dtypes after reading in the data,

```
In [18]: df2 = pd.read_csv(StringIO(data))

In [19]: df2['col_1'] = pd.to_numeric(df2['col_1'], errors='coerce')

In [20]: df2
Out[20]:
   col_1
0   1.00
1   2.00
2    NaN
3   4.22

In [21]: df2['col_1'].apply(type).value_counts()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[21]:
<class 'float'>    4
Name: col_1, dtype: int64
```

which would convert all valid parsing to floats, leaving the invalid parsing as `NaN`.

Ultimately, how you deal with reading in columns containing mixed dtypes depends on your specific needs. In the case above, if you wanted to `NaN` out the data anomalies, then *to_numeric()* is probably your best option. However, if you wanted for all the data to be coerced, no matter the type, then using the `converters` argument of *read_csv()* would certainly be worth trying.

New in version 0.20.0: support for the Python parser.

The `dtype` option is supported by the 'python' engine

Note: In some cases, reading in abnormal data with columns containing mixed dtypes will result in an inconsistent dataset. If you rely on pandas to infer the dtypes of your columns, the parsing engine will go and infer the dtypes for different chunks of the data, rather than the whole dataset at once. Consequently, you can end up with column(s) with mixed dtypes. For example,

```
In [22]: df = pd.DataFrame({'col_1': list(range(500000)) + ['a', 'b'] +␣
↪list(range(500000))})

In [23]: df.to_csv('foo.csv')
```

```
In [24]: mixed_df = pd.read_csv('foo.csv')

In [25]: mixed_df['col_1'].apply(type).value_counts()
Out[25]: 
<class 'int'>    737858
<class 'str'>    262144
Name: col_1, dtype: int64

In [26]: mixed_df['col_1'].dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[26]:␣
↪dtype('O')
```

will result with *mixed_df* containing an `int` dtype for certain chunks of the column, and `str` for others due to the mixed dtypes from the data that was read in. It is important to note that the overall column will be marked with a `dtype` of `object`, which is used for columns with mixed dtypes.

24.1.3 Specifying Categorical dtype

New in version 0.19.0.

`Categorical` columns can be parsed directly by specifying `dtype='category'` or `dtype=CategoricalDtype(categories, ordered)`.

```
In [27]: data = 'col1,col2,col3\na,b,1\na,b,2\nc,d,3'

In [28]: pd.read_csv(StringIO(data))
Out[28]: 
  col1 col2  col3
0    a    b     1
1    a    b     2
2    c    d     3

In [29]: pd.read_csv(StringIO(data)).dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[29]:␣
↪
col1    object
col2    object
col3     int64
dtype: object

In [30]: pd.read_csv(StringIO(data), dtype='category').dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
col1    category
col2    category
col3    category
dtype: object
```

Individual columns can be parsed as a `Categorical` using a dict specification

```
In [31]: pd.read_csv(StringIO(data), dtype={'col1': 'category'}).dtypes
Out[31]: 
col1    category
col2      object
```

```
col3       int64
dtype: object
```

New in version 0.21.0.

Specifying `dtype='cateogry'` will result in an unordered `Categorical` whose `categories` are the unique values observed in the data. For more control on the categories and order, create a *`CategoricalDtype`* ahead of time, and pass that for that column's `dtype`.

```
In [32]: from pandas.api.types import CategoricalDtype

In [33]: dtype = CategoricalDtype(['d', 'c', 'b', 'a'], ordered=True)

In [34]: pd.read_csv(StringIO(data), dtype={'col1': dtype}).dtypes
Out[34]:
col1    category
col2      object
col3       int64
dtype: object
```

When using `dtype=CategoricalDtype`, "unexpected" values outside of `dtype.categories` are treated as missing values.

```
In [35]: dtype = CategoricalDtype(['a', 'b', 'd'])  # No 'c'

In [36]: pd.read_csv(StringIO(data), dtype={'col1': dtype}).col1
Out[36]:
0      a
1      a
2    NaN
Name: col1, dtype: category
Categories (3, object): [a, b, d]
```

This matches the behavior of `Categorical.set_categories()`.

Note: With `dtype='category'`, the resulting categories will always be parsed as strings (object dtype). If the categories are numeric they can be converted using the *`to_numeric()`* function, or as appropriate, another converter such as *`to_datetime()`*.

When `dtype` is a `CategoricalDtype` with homogenous `categories` (all numeric, all datetimes, etc.), the conversion is done automatically.

```
In [37]: df = pd.read_csv(StringIO(data), dtype='category')

In [38]: df.dtypes
Out[38]:
col1    category
col2    category
col3    category
dtype: object

In [39]: df['col3']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[39]:
0    1
1    2
2    3
Name: col3, dtype: category
```

```
Categories (3, object): [1, 2, 3]

In [40]: df['col3'].cat.categories = pd.to_numeric(df['col3'].cat.categories)

In [41]: df['col3']
Out[41]:
0    1
1    2
2    3
Name: col3, dtype: category
Categories (3, int64): [1, 2, 3]
```

24.1.4 Naming and Using Columns

24.1.4.1 Handling column names

A file may or may not have a header row. pandas assumes the first row should be used as the column names:

```
In [42]: data = 'a,b,c\n1,2,3\n4,5,6\n7,8,9'

In [43]: print(data)
a,b,c
1,2,3
4,5,6
7,8,9

In [44]: pd.read_csv(StringIO(data))
\\\\\\\\\\\\\\\\\\\\\\\\Out[44]:
   a  b  c
0  1  2  3
1  4  5  6
2  7  8  9
```

By specifying the `names` argument in conjunction with `header` you can indicate other names to use and whether or not to throw away the header row (if any):

```
In [45]: print(data)
a,b,c
1,2,3
4,5,6
7,8,9

In [46]: pd.read_csv(StringIO(data), names=['foo', 'bar', 'baz'], header=0)
\\\\\\\\\\\\\\\\\\\\\\\\Out[46]:
   foo  bar  baz
0    1    2    3
1    4    5    6
2    7    8    9

In [47]: pd.read_csv(StringIO(data), names=['foo', 'bar', 'baz'], header=None)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
  foo bar baz
0   a   b   c
1   1   2   3
```

```
2   4   5   6
3   7   8   9
```

If the header is in a row other than the first, pass the row number to `header`. This will skip the preceding rows:

```
In [48]: data = 'skip this skip it\na,b,c\n1,2,3\n4,5,6\n7,8,9'

In [49]: pd.read_csv(StringIO(data), header=1)
Out[49]:
   a  b  c
0  1  2  3
1  4  5  6
2  7  8  9
```

24.1.5 Duplicate names parsing

If the file or header contains duplicate names, pandas by default will deduplicate these names so as to prevent data overwrite:

```
In [50]: data = 'a,b,a\n0,1,2\n3,4,5'

In [51]: pd.read_csv(StringIO(data))
Out[51]:
   a  b  a.1
0  0  1    2
1  3  4    5
```

There is no more duplicate data because `mangle_dupe_cols=True` by default, which modifies a series of duplicate columns 'X'...'X' to become 'X.0'...'X.N'. If `mangle_dupe_cols =False`, duplicate data can arise:

```
In [2]: data = 'a,b,a\n0,1,2\n3,4,5'
In [3]: pd.read_csv(StringIO(data), mangle_dupe_cols=False)
Out[3]:
   a  b  a
0  2  1  2
1  5  4  5
```

To prevent users from encountering this problem with duplicate data, a `ValueError` exception is raised if `mangle_dupe_cols != True`:

```
In [2]: data = 'a,b,a\n0,1,2\n3,4,5'
In [3]: pd.read_csv(StringIO(data), mangle_dupe_cols=False)
...
ValueError: Setting mangle_dupe_cols=False is not supported yet
```

24.1.5.1 Filtering columns (`usecols`)

The `usecols` argument allows you to select any subset of the columns in a file, either using the column names, position numbers or a callable:

New in version 0.20.0: support for callable *usecols* arguments

```
In [52]: data = 'a,b,c,d\n1,2,3,foo\n4,5,6,bar\n7,8,9,baz'

In [53]: pd.read_csv(StringIO(data))
```

```
Out[53]:
   a  b  c    d
0  1  2  3  foo
1  4  5  6  bar
2  7  8  9  baz

In [54]: pd.read_csv(StringIO(data), usecols=['b', 'd'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[54]:
   b    d
0  2  foo
1  5  bar
2  8  baz

In [55]: pd.read_csv(StringIO(data), usecols=[0, 2, 3])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  c    d
0  1  3  foo
1  4  6  bar
2  7  9  baz

In [56]: pd.read_csv(StringIO(data), usecols=lambda x: x.upper() in ['A', 'C'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  c
0  1  3
1  4  6
2  7  9
```

The `usecols` argument can also be used to specify which columns not to use in the final result:

```
In [57]: pd.read_csv(StringIO(data), usecols=lambda x: x not in ['a', 'c'])
Out[57]:
   b    d
0  2  foo
1  5  bar
2  8  baz
```

In this case, the callable is specifying that we exclude the “a” and “c” columns from the output.

24.1.6 Comments and Empty Lines

24.1.6.1 Ignoring line comments and empty lines

If the `comment` parameter is specified, then completely commented lines will be ignored. By default, completely blank lines will be ignored as well.

```
In [58]: data = '\na,b,c\n  \n# commented line\n1,2,3\n\n4,5,6'

In [59]: print(data)

a,b,c

# commented line
1,2,3

```

```
4,5,6

In [60]: pd.read_csv(StringIO(data), comment='#')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[60]:
   a  b  c
0  1  2  3
1  4  5  6
```

If `skip_blank_lines=False`, then `read_csv` will not ignore blank lines:

```
In [61]: data = 'a,b,c\n\n1,2,3\n\n\n4,5,6'

In [62]: pd.read_csv(StringIO(data), skip_blank_lines=False)
Out[62]:
     a    b    c
0  NaN  NaN  NaN
1  1.0  2.0  3.0
2  NaN  NaN  NaN
3  NaN  NaN  NaN
4  4.0  5.0  6.0
```

Warning: The presence of ignored lines might create ambiguities involving line numbers; the parameter `header` uses row numbers (ignoring commented/empty lines), while `skiprows` uses line numbers (including commented/empty lines):

```
In [63]: data = '#comment\na,b,c\nA,B,C\n1,2,3'

In [64]: pd.read_csv(StringIO(data), comment='#', header=1)
Out[64]:
   A  B  C
0  1  2  3

In [65]: data = 'A,B,C\n#comment\na,b,c\n1,2,3'

In [66]: pd.read_csv(StringIO(data), comment='#', skiprows=2)
Out[66]:
   a  b  c
0  1  2  3
```

If both `header` and `skiprows` are specified, `header` will be relative to the end of `skiprows`. For example:

```
In [67]: data = '# empty\n# second empty line\n# third empty' \

In [67]: 'line\nX,Y,Z\n1,2,3\nA,B,C\n1,2.,4.\n5.,NaN,10.0'

In [68]: print(data)
# empty
# second empty line
# third emptyline
X,Y,Z
1,2,3
A,B,C
1,2.,4.
5.,NaN,10.0

In [69]: pd.read_csv(StringIO(data), comment='#', skiprows=4, header=1)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[69]:␣
↪
     A    B     C
0  1.0  2.0   4.0
1  5.0  NaN  10.0
```

24.1.6.2 Comments

Sometimes comments or meta data may be included in a file:

```
In [70]: print(open('tmp.csv').read())
ID,level,category
Patient1,123000,x # really unpleasant
Patient2,23000,y # wouldn't take his medicine
Patient3,1234018,z # awesome
```

By default, the parser includes the comments in the output:

```
In [71]: df = pd.read_csv('tmp.csv')

In [72]: df
Out[72]:
         ID    level                        category
0  Patient1   123000           x # really unpleasant
1  Patient2    23000  y # wouldn't take his medicine
2  Patient3  1234018                     z # awesome
```

We can suppress the comments using the `comment` keyword:

```
In [73]: df = pd.read_csv('tmp.csv', comment='#')

In [74]: df
Out[74]:
         ID    level category
0  Patient1   123000       x
1  Patient2    23000       y
2  Patient3  1234018       z
```

24.1.7 Dealing with Unicode Data

The `encoding` argument should be used for encoded unicode data, which will result in byte strings being decoded to unicode in the result:

```
In [75]: data = b'word,length\nTr\xc3\xa4umen,7\nGr\xc3\xbc\xc3\x9fe,5'.decode('utf8
↪').encode('latin-1')

In [76]: df = pd.read_csv(BytesIO(data), encoding='latin-1')

In [77]: df
Out[77]:
      word  length
0  Träumen       7
1    Grüße       5

In [78]: df['word'][1]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[78]: 'Grüße'
```

Some formats which encode all characters as multiple bytes, like UTF-16, won't parse correctly at all without specifying the encoding. Full list of Python standard encodings

24.1.8 Index columns and trailing delimiters

If a file has one more column of data than the number of column names, the first column will be used as the DataFrame's row names:

```
In [79]: data = 'a,b,c\n4,apple,bat,5.7\n8,orange,cow,10'

In [80]: pd.read_csv(StringIO(data))
Out[80]:
        a    b     c
4   apple  bat   5.7
8  orange  cow  10.0
```

```
In [81]: data = 'index,a,b,c\n4,apple,bat,5.7\n8,orange,cow,10'

In [82]: pd.read_csv(StringIO(data), index_col=0)
Out[82]:
            a    b     c
index
4       apple  bat   5.7
8      orange  cow  10.0
```

Ordinarily, you can achieve this behavior using the `index_col` option.

There are some exception cases when a file has been prepared with delimiters at the end of each data line, confusing the parser. To explicitly disable the index column inference and discard the last column, pass `index_col=False`:

```
In [83]: data = 'a,b,c\n4,apple,bat,\n8,orange,cow,'

In [84]: print(data)
a,b,c
4,apple,bat,
8,orange,cow,

In [85]: pd.read_csv(StringIO(data))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[85]:
        a    b    c
4   apple  bat NaN
8  orange  cow NaN

In [86]: pd.read_csv(StringIO(data), index_col=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a       b    c
0  4   apple  bat
1  8  orange  cow
```

If a subset of data is being parsed using the `usecols` option, the `index_col` specification is based on that subset, not the original data.

```
In [87]: data = 'a,b,c\n4,apple,bat,\n8,orange,cow,'

In [88]: print(data)
a,b,c
4,apple,bat,
8,orange,cow,

In [89]: pd.read_csv(StringIO(data), usecols=['b', 'c'])
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[89]:
     b   c
4  bat NaN
8  cow NaN

In [90]: pd.read_csv(StringIO(data), usecols=['b', 'c'], index_col=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[90]:
     b   c
4  bat NaN
8  cow NaN
```

24.1.9 Date Handling

24.1.9.1 Specifying Date Columns

To better facilitate working with datetime data, *`read_csv()`* and *`read_table()`* use the keyword arguments `parse_dates` and `date_parser` to allow users to specify a variety of columns and date/time formats to turn the input text data into `datetime` objects.

The simplest case is to just pass in `parse_dates=True`:

```
# Use a column as an index, and parse it as dates.
In [91]: df = pd.read_csv('foo.csv', index_col=0, parse_dates=True)

In [92]: df
Out[92]:
            A  B  C
date
2009-01-01  a  1  2
2009-01-02  b  3  4
2009-01-03  c  4  5

# These are python datetime objects
In [93]: df.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪DatetimeIndex(['2009-01-01', '2009-01-02', '2009-01-03'], dtype='datetime64[ns]',␣
↪name='date', freq=None)
```

It is often the case that we may want to store date and time data separately, or store various date fields separately. the `parse_dates` keyword can be used to specify a combination of columns to parse the dates and/or times from.

You can specify a list of column lists to `parse_dates`, the resulting date columns will be prepended to the output (so as to not affect the existing column order) and the new column names will be the concatenation of the component column names:

```
In [94]: print(open('tmp.csv').read())
KORD,19990127, 19:00:00, 18:56:00, 0.8100
KORD,19990127, 20:00:00, 19:56:00, 0.0100
KORD,19990127, 21:00:00, 20:56:00, -0.5900
KORD,19990127, 21:00:00, 21:18:00, -0.9900
KORD,19990127, 22:00:00, 21:56:00, -0.5900
KORD,19990127, 23:00:00, 22:56:00, -0.5900

In [95]: df = pd.read_csv('tmp.csv', header=None, parse_dates=[[1, 2], [1, 3]])

In [96]: df
```

```
Out[96]:
                  1_2                 1_3     0     4
0 1999-01-27 19:00:00 1999-01-27 18:56:00  KORD  0.81
1 1999-01-27 20:00:00 1999-01-27 19:56:00  KORD  0.01
2 1999-01-27 21:00:00 1999-01-27 20:56:00  KORD -0.59
3 1999-01-27 21:00:00 1999-01-27 21:18:00  KORD -0.99
4 1999-01-27 22:00:00 1999-01-27 21:56:00  KORD -0.59
5 1999-01-27 23:00:00 1999-01-27 22:56:00  KORD -0.59
```

By default the parser removes the component date columns, but you can choose to retain them via the `keep_date_col` keyword:

```
In [97]: df = pd.read_csv('tmp.csv', header=None, parse_dates=[[1, 2], [1, 3]],
   ....:                  keep_date_col=True)
   ....:

In [98]: df
Out[98]:
                  1_2                 1_3     0         1          2  \
0 1999-01-27 19:00:00 1999-01-27 18:56:00  KORD  19990127   19:00:00
1 1999-01-27 20:00:00 1999-01-27 19:56:00  KORD  19990127   20:00:00
2 1999-01-27 21:00:00 1999-01-27 20:56:00  KORD  19990127   21:00:00
3 1999-01-27 21:00:00 1999-01-27 21:18:00  KORD  19990127   21:00:00
4 1999-01-27 22:00:00 1999-01-27 21:56:00  KORD  19990127   22:00:00
5 1999-01-27 23:00:00 1999-01-27 22:56:00  KORD  19990127   23:00:00

           3     4
0   18:56:00  0.81
1   19:56:00  0.01
2   20:56:00 -0.59
3   21:18:00 -0.99
4   21:56:00 -0.59
5   22:56:00 -0.59
```

Note that if you wish to combine multiple columns into a single date column, a nested list must be used. In other words, `parse_dates=[1, 2]` indicates that the second and third columns should each be parsed as separate date columns while `parse_dates=[[1, 2]]` means the two columns should be parsed into a single column.

You can also use a dict to specify custom name columns:

```
In [99]: date_spec = {'nominal': [1, 2], 'actual': [1, 3]}

In [100]: df = pd.read_csv('tmp.csv', header=None, parse_dates=date_spec)

In [101]: df
Out[101]:
              nominal              actual     0     4
0 1999-01-27 19:00:00 1999-01-27 18:56:00  KORD  0.81
1 1999-01-27 20:00:00 1999-01-27 19:56:00  KORD  0.01
2 1999-01-27 21:00:00 1999-01-27 20:56:00  KORD -0.59
3 1999-01-27 21:00:00 1999-01-27 21:18:00  KORD -0.99
4 1999-01-27 22:00:00 1999-01-27 21:56:00  KORD -0.59
5 1999-01-27 23:00:00 1999-01-27 22:56:00  KORD -0.59
```

It is important to remember that if multiple text columns are to be parsed into a single date column, then a new column is prepended to the data. The *index_col* specification is based off of this new set of columns rather than the original data columns:

```
In [102]: date_spec = {'nominal': [1, 2], 'actual': [1, 3]}

In [103]: df = pd.read_csv('tmp.csv', header=None, parse_dates=date_spec,
   .....:                  index_col=0) #index is the nominal column
   .....:

In [104]: df
Out[104]:
                                actual     0     4
nominal
1999-01-27 19:00:00 1999-01-27 18:56:00  KORD  0.81
1999-01-27 20:00:00 1999-01-27 19:56:00  KORD  0.01
1999-01-27 21:00:00 1999-01-27 20:56:00  KORD -0.59
1999-01-27 21:00:00 1999-01-27 21:18:00  KORD -0.99
1999-01-27 22:00:00 1999-01-27 21:56:00  KORD -0.59
1999-01-27 23:00:00 1999-01-27 22:56:00  KORD -0.59
```

Note: If a column or index contains an unparseable date, the entire column or index will be returned unaltered as an object data type. For non-standard datetime parsing, use `to_datetime()` after `pd.read_csv`.

Note: read_csv has a fast_path for parsing datetime strings in iso8601 format, e.g "2000-01-01T00:01:02+00:00" and similar variations. If you can arrange for your data to store datetimes in this format, load times will be significantly faster, ~20x has been observed.

Note: When passing a dict as the *parse_dates* argument, the order of the columns prepended is not guaranteed, because *dict* objects do not impose an ordering on their keys. On Python 2.7+ you may use *collections.OrderedDict* instead of a regular *dict* if this matters to you. Because of this, when using a dict for 'parse_dates' in conjunction with the *index_col* argument, it's best to specify *index_col* as a column label rather then as an index on the resulting frame.

24.1.9.2 Date Parsing Functions

Finally, the parser allows you to specify a custom `date_parser` function to take full advantage of the flexibility of the date parsing API:

```
In [105]: import pandas.io.date_converters as conv

In [106]: df = pd.read_csv('tmp.csv', header=None, parse_dates=date_spec,
   .....:                  date_parser=conv.parse_date_time)
   .....:

In [107]: df
Out[107]:
               nominal               actual     0     4
0 1999-01-27 19:00:00 1999-01-27 18:56:00  KORD  0.81
1 1999-01-27 20:00:00 1999-01-27 19:56:00  KORD  0.01
2 1999-01-27 21:00:00 1999-01-27 20:56:00  KORD -0.59
3 1999-01-27 21:00:00 1999-01-27 21:18:00  KORD -0.99
4 1999-01-27 22:00:00 1999-01-27 21:56:00  KORD -0.59
5 1999-01-27 23:00:00 1999-01-27 22:56:00  KORD -0.59
```

Pandas will try to call the `date_parser` function in three different ways. If an exception is raised, the next one is tried:

1. `date_parser` is first called with one or more arrays as arguments, as defined using *parse_dates* (e.g., `date_parser(['2013', '2013'], ['1', '2'])`)
2. If #1 fails, `date_parser` is called with all the columns concatenated row-wise into a single array (e.g., `date_parser(['2013 1', '2013 2'])`)
3. If #2 fails, `date_parser` is called once for every row with one or more string arguments from the columns indicated with *parse_dates* (e.g., `date_parser('2013', '1')` for the first row, `date_parser('2013', '2')` for the second, etc.)

Note that performance-wise, you should try these methods of parsing dates in order:

1. Try to infer the format using `infer_datetime_format=True` (see section below)
2. If you know the format, use `pd.to_datetime()`: `date_parser=lambda x: pd.to_datetime(x, format=...)`
3. If you have a really non-standard format, use a custom `date_parser` function. For optimal performance, this should be vectorized, i.e., it should accept arrays as arguments.

You can explore the date parsing functionality in `date_converters.py` and add your own. We would love to turn this module into a community supported set of date/time parsers. To get you started, `date_converters.py` contains functions to parse dual date and time columns, year/month/day columns, and year/month/day/hour/minute/second columns. It also contains a `generic_parser` function so you can curry it with a function that deals with a single date rather than the entire array.

24.1.9.3 Inferring Datetime Format

If you have `parse_dates` enabled for some or all of your columns, and your datetime strings are all formatted the same way, you may get a large speed up by setting `infer_datetime_format=True`. If set, pandas will attempt to guess the format of your datetime strings, and then use a faster means of parsing the strings. 5-10x parsing speeds have been observed. pandas will fallback to the usual parsing if either the format cannot be guessed or the format that was guessed cannot properly parse the entire column of strings. So in general, `infer_datetime_format` should not have any negative consequences if enabled.

Here are some examples of datetime strings that can be guessed (All representing December 30th, 2011 at 00:00:00)

- "20111230"
- "2011/12/30"
- "20111230 00:00:00"
- "12/30/2011 00:00:00"
- "30/Dec/2011 00:00:00"
- "30/December/2011 00:00:00"

`infer_datetime_format` is sensitive to `dayfirst`. With `dayfirst=True`, it will guess "01/12/2011" to be December 1st. With `dayfirst=False` (default) it will guess "01/12/2011" to be January 12th.

```
# Try to infer the format for the index column
In [108]: df = pd.read_csv('foo.csv', index_col=0, parse_dates=True,
   .....:                  infer_datetime_format=True)
   .....:

In [109]: df
Out[109]:
```

```
            A  B  C
date
2009-01-01  a  1  2
2009-01-02  b  3  4
2009-01-03  c  4  5
```

24.1.9.4 International Date Formats

While US date formats tend to be MM/DD/YYYY, many international formats use DD/MM/YYYY instead. For convenience, a `dayfirst` keyword is provided:

```
In [110]: print(open('tmp.csv').read())
date,value,cat
1/6/2000,5,a
2/6/2000,10,b
3/6/2000,15,c

In [111]: pd.read_csv('tmp.csv', parse_dates=[0])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[111]:
        date  value cat
0 2000-01-06      5   a
1 2000-02-06     10   b
2 2000-03-06     15   c

In [112]: pd.read_csv('tmp.csv', dayfirst=True, parse_dates=[0])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
        date  value cat
0 2000-06-01      5   a
1 2000-06-02     10   b
2 2000-06-03     15   c
```

24.1.10 Specifying method for floating-point conversion

The parameter `float_precision` can be specified in order to use a specific floating-point converter during parsing with the C engine. The options are the ordinary converter, the high-precision converter, and the round-trip converter (which is guaranteed to round-trip values after writing to a file). For example:

```
In [113]: val = '0.3066101993807095471566981359501369297504425048828125'

In [114]: data = 'a,b,c\n1,2,{0}'.format(val)

In [115]: abs(pd.read_csv(StringIO(data), engine='c', float_precision=None)['c'][0] -␣
↪float(val))
Out[115]: 1.1102230246251565e-16

In [116]: abs(pd.read_csv(StringIO(data), engine='c', float_precision='high')['c'][0]␣
↪- float(val))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[116]: 5.5511151231257827e-17

In [117]: abs(pd.read_csv(StringIO(data), engine='c', float_precision='round_trip')['c
↪'][0] - float(val))
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[117]: 0.0
```

24.1.11 Thousand Separators

For large numbers that have been written with a thousands separator, you can set the `thousands` keyword to a string of length 1 so that integers will be parsed correctly:

By default, numbers with a thousands separator will be parsed as strings

```
In [118]: print(open('tmp.csv').read())
ID|level|category
Patient1|123,000|x
Patient2|23,000|y
Patient3|1,234,018|z

In [119]: df = pd.read_csv('tmp.csv', sep='|')

In [120]: df
Out[120]:
         ID      level category
0  Patient1    123,000        x
1  Patient2     23,000        y
2  Patient3  1,234,018        z

In [121]: df.level.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪dtype('O')
```

The `thousands` keyword allows integers to be parsed correctly

```
In [122]: print(open('tmp.csv').read())
ID|level|category
Patient1|123,000|x
Patient2|23,000|y
Patient3|1,234,018|z

In [123]: df = pd.read_csv('tmp.csv', sep='|', thousands=',')

In [124]: df
Out[124]:
         ID    level category
0  Patient1   123000        x
1  Patient2    23000        y
2  Patient3  1234018        z

In [125]: df.level.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪dtype('int64')
```

24.1.12 NA Values

To control which values are parsed as missing values (which are signified by `NaN`), specifiy a string in `na_values`. If you specify a list of strings, then all values in it are considered to be missing values. If you specify a number (a `float`, like `5.0` or an `integer` like `5`), the corresponding equivalent values will also imply a missing value (in this case effectively `[5.0,5]` are recognized as `NaN`.

To completely override the default values that are recognized as missing, specify `keep_default_na=False`. The default `NaN` recognized values are `['-1.#IND', '1.#QNAN', '1.#IND', '-1.#QNAN', '#N/A`

`N/A', '#N/A', 'N/A', 'n/a', 'NA', '#NA', 'NULL', 'null', 'NaN', '-NaN', 'nan', '-nan', ''].`

```
read_csv(path, na_values=[5])
```

the default values, in addition to `5` , `5.0` when interpreted as numbers are recognized as `NaN`

```
read_csv(path, keep_default_na=False, na_values=[""])
```

only an empty field will be `NaN`

```
read_csv(path, keep_default_na=False, na_values=["NA", "0"])
```

only `NA` and `0` as strings are `NaN`

```
read_csv(path, na_values=["Nope"])
```

the default values, in addition to the string `"Nope"` are recognized as `NaN`

24.1.13 Infinity

`inf` like values will be parsed as `np.inf` (positive infinity), and `-inf` as `-np.inf` (negative infinity). These will ignore the case of the value, meaning `Inf`, will also be parsed as `np.inf`.

24.1.14 Returning Series

Using the `squeeze` keyword, the parser will return output with a single column as a `Series`:

```
In [126]: print(open('tmp.csv').read())
level
Patient1,123000
Patient2,23000
Patient3,1234018

In [127]: output =  pd.read_csv('tmp.csv', squeeze=True)

In [128]: output
Out[128]: 
Patient1     123000
Patient2      23000
Patient3    1234018
Name: level, dtype: int64

In [129]: type(output)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out
↪pandas.core.series.Series
```

24.1.15 Boolean values

The common values `True`, `False`, `TRUE`, and `FALSE` are all recognized as boolean. Sometime you would want to recognize some other values as being boolean. To do this use the `true_values` and `false_values` options:

```
In [130]: data= 'a,b,c\n1,Yes,2\n3,No,4'

In [131]: print(data)
a,b,c
1,Yes,2
3,No,4

In [132]: pd.read_csv(StringIO(data))
\\\\\\\\\\\\\\\\\\\\\Out[132]:
   a    b  c
0  1  Yes  2
1  3   No  4

In [133]: pd.read_csv(StringIO(data), true_values=['Yes'], false_values=['No'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[133]:
   a      b  c
0  1   True  2
1  3  False  4
```

24.1.16 Handling “bad” lines

Some files may have malformed lines with too few fields or too many. Lines with too few fields will have NA values filled in the trailing fields. Lines with too many will cause an error by default:

```
In [27]: data = 'a,b,c\n1,2,3\n4,5,6,7\n8,9,10'

In [28]: pd.read_csv(StringIO(data))
---------------------------------------------------------------------------
ParserError                              Traceback (most recent call last)
ParserError: Error tokenizing data. C error: Expected 3 fields in line 3, saw 4
```

You can elect to skip bad lines:

```
In [29]: pd.read_csv(StringIO(data), error_bad_lines=False)
Skipping line 3: expected 3 fields, saw 4

Out[29]:
   a  b   c
0  1  2   3
1  8  9  10
```

You can also use the `usecols` parameter to eliminate extraneous column data that appear in some lines but not others:

```
In [30]: pd.read_csv(StringIO(data), usecols=[0, 1, 2])

 Out[30]:
    a  b   c
 0  1  2   3
 1  4  5   6
 2  8  9  10
```

24.1.17 Dialect

The `dialect` keyword gives greater flexibility in specifying the file format. By default it uses the Excel dialect but you can specify either the dialect name or a `csv.Dialect` instance.

Suppose you had data with unenclosed quotes:

```
In [134]: print(data)
label1,label2,label3
index1,"a,c,e
index2,b,d,f
```

By default, `read_csv` uses the Excel dialect and treats the double quote as the quote character, which causes it to fail when it finds a newline before it finds the closing double quote.

We can get around this using `dialect`

```
In [135]: dia = csv.excel()

In [136]: dia.quoting = csv.QUOTE_NONE

In [137]: pd.read_csv(StringIO(data), dialect=dia)
Out[137]:
       label1 label2 label3
index1     "a      c      e
index2      b      d      f
```

All of the dialect options can be specified separately by keyword arguments:

```
In [138]: data = 'a,b,c~1,2,3~4,5,6'

In [139]: pd.read_csv(StringIO(data), lineterminator='~')
Out[139]:
   a  b  c
0  1  2  3
1  4  5  6
```

Another common dialect option is `skipinitialspace`, to skip any whitespace after a delimiter:

```
In [140]: data = 'a, b, c\n1, 2, 3\n4, 5, 6'

In [141]: print(data)
a, b, c
1, 2, 3
4, 5, 6

In [142]: pd.read_csv(StringIO(data), skipinitialspace=True)
\\\\\\\\\\\\\\\\\\\\\\\\Out[142]:
   a  b  c
0  1  2  3
1  4  5  6
```

The parsers make every attempt to "do the right thing" and not be very fragile. Type inference is a pretty big deal. So if a column can be coerced to integer dtype without altering the contents, it will do so. Any non-numeric columns will come through as object dtype as with the rest of pandas objects.

24.1.18 Quoting and Escape Characters

Quotes (and other escape characters) in embedded fields can be handled in any number of ways. One way is to use backslashes; to properly parse this data, you should pass the `escapechar` option:

```
In [143]: data = 'a,b\n"hello, \\"Bob\\", nice to see you",5'

In [144]: print(data)
a,b
"hello, \"Bob\", nice to see you",5

In [145]: pd.read_csv(StringIO(data), escapechar='\\')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[145]:
                                a  b
0  hello, "Bob", nice to see you  5
```

24.1.19 Files with Fixed Width Columns

While `read_csv` reads delimited data, the *read_fwf()* function works with data files that have known and fixed column widths. The function parameters to `read_fwf` are largely the same as *read_csv* with two extra parameters, and a different usage of the `delimiter` parameter:

- `colspecs`: A list of pairs (tuples) giving the extents of the fixed-width fields of each line as half-open intervals (i.e., [from, to[ ). String value 'infer' can be used to instruct the parser to try detecting the column specifications from the first 100 rows of the data. Default behaviour, if not specified, is to infer.
- `widths`: A list of field widths which can be used instead of 'colspecs' if the intervals are contiguous.
- `delimiter`: Characters to consider as filler characters in the fixed-width file. Can be used to specify the filler character of the fields if it is not spaces (e.g., '~').

Consider a typical fixed-width data file:

```
In [146]: print(open('bar.csv').read())
id8141    360.242940   149.910199   11950.7
id1594    444.953632   166.985655   11788.4
id1849    364.136849   183.628767   11806.2
id1230    413.836124   184.375703   11916.8
id1948    502.953953   173.237159   12468.3
```

In order to parse this file into a DataFrame, we simply need to supply the column specifications to the *read_fwf* function along with the file name:

```
#Column specifications are a list of half-intervals
In [147]: colspecs = [(0, 6), (8, 20), (21, 33), (34, 43)]

In [148]: df = pd.read_fwf('bar.csv', colspecs=colspecs, header=None, index_col=0)

In [149]: df
Out[149]:
                  1           2        3
0
id8141  360.242940  149.910199  11950.7
id1594  444.953632  166.985655  11788.4
id1849  364.136849  183.628767  11806.2
id1230  413.836124  184.375703  11916.8
id1948  502.953953  173.237159  12468.3
```

Note how the parser automatically picks column names X.<column number> when `header=None` argument is specified. Alternatively, you can supply just the column widths for contiguous columns:

```
#Widths are a list of integers
In [150]: widths = [6, 14, 13, 10]

In [151]: df = pd.read_fwf('bar.csv', widths=widths, header=None)

In [152]: df
Out[152]:
        0           1           2        3
0  id8141  360.242940  149.910199  11950.7
1  id1594  444.953632  166.985655  11788.4
2  id1849  364.136849  183.628767  11806.2
3  id1230  413.836124  184.375703  11916.8
4  id1948  502.953953  173.237159  12468.3
```

The parser will take care of extra white spaces around the columns so it's ok to have extra separation between the columns in the file.

By default, `read_fwf` will try to infer the file's `colspecs` by using the first 100 rows of the file. It can do it only in cases when the columns are aligned and correctly separated by the provided `delimiter` (default delimiter is whitespace).

```
In [153]: df = pd.read_fwf('bar.csv', header=None, index_col=0)

In [154]: df
Out[154]:
                 1           2        3
0
id8141  360.242940  149.910199  11950.7
id1594  444.953632  166.985655  11788.4
id1849  364.136849  183.628767  11806.2
id1230  413.836124  184.375703  11916.8
id1948  502.953953  173.237159  12468.3
```

New in version 0.20.0.

`read_fwf` supports the `dtype` parameter for specifying the types of parsed columns to be different from the inferred type.

```
In [155]: pd.read_fwf('bar.csv', header=None, index_col=0).dtypes
Out[155]:
1    float64
2    float64
3    float64
dtype: object

In [156]: pd.read_fwf('bar.csv', header=None, dtype={2: 'object'}).dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[156]:
0     object
1    float64
2     object
3    float64
dtype: object
```

24.1.20 Indexes

24.1.20.1 Files with an "implicit" index column

Consider a file with one less entry in the header than the number of data column:

```
In [157]: print(open('foo.csv').read())
A,B,C
20090101,a,1,2
20090102,b,3,4
20090103,c,4,5
```

In this special case, `read_csv` assumes that the first column is to be used as the index of the DataFrame:

```
In [158]: pd.read_csv('foo.csv')
Out[158]:
          A  B  C
20090101  a  1  2
20090102  b  3  4
20090103  c  4  5
```

Note that the dates weren't automatically parsed. In that case you would need to do as before:

```
In [159]: df = pd.read_csv('foo.csv', parse_dates=True)

In [160]: df.index
Out[160]: DatetimeIndex(['2009-01-01', '2009-01-02', '2009-01-03'], dtype=
↪'datetime64[ns]', freq=None)
```

24.1.20.2 Reading an index with a `MultiIndex`

Suppose you have data indexed by two columns:

```
In [161]: print(open('data/mindex_ex.csv').read())
year,indiv,zit,xit
1977,"A",1.2,.6
1977,"B",1.5,.5
1977,"C",1.7,.8
1978,"A",.2,.06
1978,"B",.7,.2
1978,"C",.8,.3
1978,"D",.9,.5
1978,"E",1.4,.9
1979,"C",.2,.15
1979,"D",.14,.05
1979,"E",.5,.15
1979,"F",1.2,.5
1979,"G",3.4,1.9
1979,"H",5.4,2.7
1979,"I",6.4,1.2
```

The `index_col` argument to `read_csv` and `read_table` can take a list of column numbers to turn multiple columns into a `MultiIndex` for the index of the returned object:

```
In [162]: df = pd.read_csv("data/mindex_ex.csv", index_col=[0,1])
```

```
In [163]: df
Out[163]:
             zit   xit
year indiv
1977 A      1.20  0.60
     B      1.50  0.50
     C      1.70  0.80
1978 A      0.20  0.06
     B      0.70  0.20
     C      0.80  0.30
     D      0.90  0.50
     E      1.40  0.90
1979 C      0.20  0.15
     D      0.14  0.05
     E      0.50  0.15
     F      1.20  0.50
     G      3.40  1.90
     H      5.40  2.70
     I      6.40  1.20

In [164]: df.loc[1978]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
       zit   xit
indiv
A      0.2  0.06
B      0.7  0.20
C      0.8  0.30
D      0.9  0.50
E      1.4  0.90
```

24.1.20.3 Reading columns with a `MultiIndex`

By specifying list of row locations for the `header` argument, you can read in a `MultiIndex` for the columns. Specifying non-consecutive rows will skip the intervening rows.

```
In [165]: from pandas.util.testing import makeCustomDataframe as mkdf

In [166]: df = mkdf(5,3,r_idx_nlevels=2,c_idx_nlevels=4)

In [167]: df.to_csv('mi.csv')

In [168]: print(open('mi.csv').read())
C0,,C_l0_g0,C_l0_g1,C_l0_g2
C1,,C_l1_g0,C_l1_g1,C_l1_g2
C2,,C_l2_g0,C_l2_g1,C_l2_g2
C3,,C_l3_g0,C_l3_g1,C_l3_g2
R0,R1,,,
R_l0_g0,R_l1_g0,R0C0,R0C1,R0C2
R_l0_g1,R_l1_g1,R1C0,R1C1,R1C2
R_l0_g2,R_l1_g2,R2C0,R2C1,R2C2
R_l0_g3,R_l1_g3,R3C0,R3C1,R3C2
R_l0_g4,R_l1_g4,R4C0,R4C1,R4C2


In [169]: pd.read_csv('mi.csv',header=[0,1,2,3],index_col=[0,1])
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
C0                C_l0_g0 C_l0_g1 C_l0_g2
C1                C_l1_g0 C_l1_g1 C_l1_g2
C2                C_l2_g0 C_l2_g1 C_l2_g2
C3                C_l3_g0 C_l3_g1 C_l3_g2
R0       R1
R_l0_g0 R_l1_g0     R0C0    R0C1    R0C2
R_l0_g1 R_l1_g1     R1C0    R1C1    R1C2
R_l0_g2 R_l1_g2     R2C0    R2C1    R2C2
R_l0_g3 R_l1_g3     R3C0    R3C1    R3C2
R_l0_g4 R_l1_g4     R4C0    R4C1    R4C2
```

`read_csv` is also able to interpret a more common format of multi-columns indices.

```
In [170]: print(open('mi2.csv').read())
,a,a,a,b,c,c
,q,r,s,t,u,v
one,1,2,3,4,5,6
two,7,8,9,10,11,12

In [171]: pd.read_csv('mi2.csv',header=[0,1],index_col=0)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[171]:
     a         b   c
     q  r  s   t   u   v
one  1  2  3   4   5   6
two  7  8  9  10  11  12
```

Note: If an `index_col` is not specified (e.g. you don't have an index, or wrote it with `df.to_csv(..., index=False)`, then any `names` on the columns index will be *lost*.

24.1.21 Automatically "sniffing" the delimiter

`read_csv` is capable of inferring delimited (not necessarily comma-separated) files, as pandas uses the `csv.Sniffer` class of the csv module. For this, you have to specify `sep=None`.

```
In [172]: print(open('tmp2.sv').read())
:0:1:2:3
0:0.4691122999071863:-0.2828633443286633:-1.5090585031735124:-1.1356323710171934
1:1.2121120250208506:-0.17321464905330858:0.11920871129693428:-1.0442359662799567
2:-0.8618489633477999:-2.1045692188948086:-0.4949292740687813:1.071803807037338
3:0.7215551622443669:-0.7067711336300845:-1.0395749851146963:0.27185988554282986
4:-0.42497232978883753:0.567020349793672:0.27623201927771873:-1.0874006912859915
5:-0.6736897080883706:0.1136484096888855:-1.4784265524372235:0.5249876671147047
6:0.4047052186802365:0.5770459859204836:-1.7150020161146375:-1.0392684835147725
7:-0.3706468582364464:-1.1578922506419993:-1.344311812731667:0.8448851414248841
8:1.0757697837155533:-0.10904997528022223:1.6435630703622064:-1.4693879595399115
9:0.35702056413309086:-0.6746001037299882:-1.776903716971867:-0.9689138124473498


In [173]: pd.read_csv('tmp2.sv', sep=None, engine='python')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   Unnamed: 0         0         1         2         3
0           0  0.469112 -0.282863 -1.509059 -1.135632
1           1  1.212112 -0.173215  0.119209 -1.044236
```

```
2           2 -0.861849 -2.104569 -0.494929  1.071804
3           3  0.721555 -0.706771 -1.039575  0.271860
4           4 -0.424972  0.567020  0.276232 -1.087401
5           5 -0.673690  0.113648 -1.478427  0.524988
6           6  0.404705  0.577046 -1.715002 -1.039268
7           7 -0.370647 -1.157892 -1.344312  0.844885
8           8  1.075770 -0.109050  1.643563 -1.469388
9           9  0.357021 -0.674600 -1.776904 -0.968914
```

24.1.22 Reading multiple files to create a single DataFrame

It's best to use `concat()` to combine multiple files. See the *cookbook* for an example.

24.1.23 Iterating through files chunk by chunk

Suppose you wish to iterate through a (potentially very large) file lazily rather than reading the entire file into memory, such as the following:

```
In [174]: print(open('tmp.sv').read())
|0|1|2|3
0|0.4691122999071863|-0.2828633443286633|-1.5090585031735124|-1.1356323710171934
1|1.2121120250208506|-0.17321464905330858|0.11920871129693428|-1.0442359662799567
2|-0.8618489633477999|-2.1045692188948086|-0.4949292740687813|1.071803807037338
3|0.7215551622443669|-0.7067711336300845|-1.0395749851146963|0.27185988554282986
4|-0.42497232978883753|0.567020349793672|0.27623201927771873|-1.0874006912859915
5|-0.6736897080883706|0.1136484096888855|-1.4784265524372235|0.5249876671147047
6|0.40470521868023 65|0.5770459859204836|-1.7150020161146375|-1.0392684835147725
7|-0.3706468582364464|-1.1578922506419993|-1.344311812731667|0.8448851414248841
8|1.0757697837155533|-0.10904997528022223|1.6435630703622064|-1.4693879595399115
9|0.35702056413309086|-0.6746001037299882|-1.776903716971867|-0.9689138124473498


In [175]: table = pd.read_table('tmp.sv', sep='|')

In [176]: table
Out[176]:
   Unnamed: 0         0         1         2         3
0           0  0.469112 -0.282863 -1.509059 -1.135632
1           1  1.212112 -0.173215  0.119209 -1.044236
2           2 -0.861849 -2.104569 -0.494929  1.071804
3           3  0.721555 -0.706771 -1.039575  0.271860
4           4 -0.424972  0.567020  0.276232 -1.087401
5           5 -0.673690  0.113648 -1.478427  0.524988
6           6  0.404705  0.577046 -1.715002 -1.039268
7           7 -0.370647 -1.157892 -1.344312  0.844885
8           8  1.075770 -0.109050  1.643563 -1.469388
9           9  0.357021 -0.674600 -1.776904 -0.968914
```

By specifying a `chunksize` to `read_csv` or `read_table`, the return value will be an iterable object of type `TextFileReader`:

```
In [177]: reader = pd.read_table('tmp.sv', sep='|', chunksize=4)

In [178]: reader
Out[178]: <pandas.io.parsers.TextFileReader at 0x120341780>
```

```
In [179]: for chunk in reader:
   .....:     print(chunk)
   .....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\   Unnamed: 0         0  ␣
↪       1         2         3
0           0  0.469112 -0.282863 -1.509059 -1.135632
1           1  1.212112 -0.173215  0.119209 -1.044236
2           2 -0.861849 -2.104569 -0.494929  1.071804
3           3  0.721555 -0.706771 -1.039575  0.271860
   Unnamed: 0         0         1         2         3
4           4 -0.424972  0.567020  0.276232 -1.087401
5           5 -0.673690  0.113648 -1.478427  0.524988
6           6  0.404705  0.577046 -1.715002 -1.039268
7           7 -0.370647 -1.157892 -1.344312  0.844885
   Unnamed: 0         0        1         2         3
8           8  1.075770 -0.10905  1.643563 -1.469388
9           9  0.357021 -0.67460 -1.776904 -0.968914
```

Specifying `iterator=True` will also return the `TextFileReader` object:

```
In [180]: reader = pd.read_table('tmp.sv', sep='|', iterator=True)

In [181]: reader.get_chunk(5)
Out[181]:
   Unnamed: 0         0         1         2         3
0           0  0.469112 -0.282863 -1.509059 -1.135632
1           1  1.212112 -0.173215  0.119209 -1.044236
2           2 -0.861849 -2.104569 -0.494929  1.071804
3           3  0.721555 -0.706771 -1.039575  0.271860
4           4 -0.424972  0.567020  0.276232 -1.087401
```

24.1.24 Specifying the parser engine

Under the hood pandas uses a fast and efficient parser implemented in C as well as a python implementation which is currently more feature-complete. Where possible pandas uses the C parser (specified as `engine='c'`), but may fall back to python if C-unsupported options are specified. Currently, C-unsupported options include:

- `sep` other than a single character (e.g. regex separators)
- `skipfooter`
- `sep=None` with `delim_whitespace=False`

Specifying any of the above options will produce a `ParserWarning` unless the python engine is selected explicitly using `engine='python'`.

24.1.25 Reading remote files

You can pass in a URL to a CSV file:

```
df = pd.read_csv('https://download.bls.gov/pub/time.series/cu/cu.item',
                 sep='\t')
```

S3 URLs are handled as well:

```
df = pd.read_csv('s3://pandas-test/tips.csv')
```

24.1.26 Writing out Data

24.1.26.1 Writing to CSV format

The Series and DataFrame objects have an instance method `to_csv` which allows storing the contents of the object as a comma-separated-values file. The function takes a number of arguments. Only the first is required.

- `path_or_buf`: A string path to the file to write or a StringIO
- `sep` : Field delimiter for the output file (default ",")
- `na_rep`: A string representation of a missing value (default '')
- `float_format`: Format string for floating point numbers
- `cols`: Columns to write (default None)
- `header`: Whether to write out the column names (default True)
- `index`: whether to write row (index) names (default True)
- `index_label`: Column label(s) for index column(s) if desired. If None (default), and *header* and *index* are True, then the index names are used. (A sequence should be given if the DataFrame uses MultiIndex).
- `mode` : Python write mode, default 'w'
- `encoding`: a string representing the encoding to use if the contents are non-ASCII, for python versions prior to 3
- `line_terminator`: Character sequence denoting line end (default '\n')
- `quoting`: Set quoting rules as in csv module (default csv.QUOTE_MINIMAL). Note that if you have set a *float_format* then floats are converted to strings and csv.QUOTE_NONNUMERIC will treat them as non-numeric
- `quotechar`: Character used to quote fields (default '")
- `doublequote`: Control quoting of `quotechar` in fields (default True)
- `escapechar`: Character used to escape `sep` and `quotechar` when appropriate (default None)
- `chunksize`: Number of rows to write at a time
- `tupleize_cols`: If False (default), write as a list of tuples, otherwise write in an expanded line format suitable for `read_csv`
- `date_format`: Format string for datetime objects

24.1.26.2 Writing a formatted string

The DataFrame object has an instance method `to_string` which allows control over the string representation of the object. All arguments are optional:

- `buf` default None, for example a StringIO object
- `columns` default None, which columns to write
- `col_space` default None, minimum width of each column.
- `na_rep` default `NaN`, representation of NA value

- `formatters` default None, a dictionary (by column) of functions each of which takes a single argument and returns a formatted string
- `float_format` default None, a function which takes a single (float) argument and returns a formatted string; to be applied to floats in the DataFrame.
- `sparsify` default True, set to False for a DataFrame with a hierarchical index to print every multiindex key at each row.
- `index_names` default True, will print the names of the indices
- `index` default True, will print the index (ie, row labels)
- `header` default True, will print the column labels
- `justify` default `left`, will print column headers left- or right-justified

The Series object also has a `to_string` method, but with only the `buf`, `na_rep`, `float_format` arguments. There is also a `length` argument which, if set to `True`, will additionally output the length of the Series.

24.2 JSON

Read and write `JSON` format files and strings.

24.2.1 Writing JSON

A `Series` or `DataFrame` can be converted to a valid JSON string. Use `to_json` with optional parameters:

- `path_or_buf` : the pathname or buffer to write the output This can be `None` in which case a JSON string is returned
- `orient` :

  Series :

  - default is `index`
  - allowed values are {`split`, `records`, `index`}

  DataFrame

  - default is `columns`
  - allowed values are {`split`, `records`, `index`, `columns`, `values`}

  The format of the JSON string

`split`	dict like {index -> [index], columns -> [columns], data -> [values]}
`records`	list like [{column -> value}, ... , {column -> value}]
`index`	dict like {index -> {column -> value}}
`columns`	dict like {column -> {index -> value}}
`values`	just the values array

- `date_format` : string, type of date conversion, 'epoch' for timestamp, 'iso' for ISO8601.
- `double_precision` : The number of decimal places to use when encoding floating point values, default 10.
- `force_ascii` : force encoded string to be ASCII, default True.
- `date_unit` : The time unit to encode to, governs timestamp and ISO8601 precision. One of 's', 'ms', 'us' or 'ns' for seconds, milliseconds, microseconds and nanoseconds respectively. Default 'ms'.

- `default_handler` : The handler to call if an object cannot otherwise be converted to a suitable format for JSON. Takes a single argument, which is the object to convert, and returns a serializable object.
- `lines` : If `records` orient, then will write each record per line as json.

Note `NaN`'s, `NaT`'s and `None` will be converted to `null` and `datetime` objects will be converted based on the `date_format` and `date_unit` parameters.

```
In [182]: dfj = pd.DataFrame(randn(5, 2), columns=list('AB'))

In [183]: json = dfj.to_json()

In [184]: json
Out[184]: '{"A":{"0":-1.2945235903,"1":0.2766617129,"2":-0.0139597524,"3":-0.
↪0061535699,"4":0.8957173022},"B":{"0":0.4137381054,"1":-0.472034511,"2":-0.
↪3625429925,"3":-0.923060654,"4":0.8052440254}}'
```

24.2.1.1 Orient Options

There are a number of different options for the format of the resulting JSON file / string. Consider the following DataFrame and Series:

```
In [185]: dfjo = pd.DataFrame(dict(A=range(1, 4), B=range(4, 7), C=range(7, 10)),
   .....:                     columns=list('ABC'), index=list('xyz'))
   .....:

In [186]: dfjo
Out[186]: 
   A  B  C
x  1  4  7
y  2  5  8
z  3  6  9

In [187]: sjo = pd.Series(dict(x=15, y=16, z=17), name='D')

In [188]: sjo
Out[188]: 
x    15
y    16
z    17
Name: D, dtype: int64
```

Column oriented (the default for `DataFrame`) serializes the data as nested JSON objects with column labels acting as the primary index:

```
In [189]: dfjo.to_json(orient="columns")
Out[189]: '{"A":{"x":1,"y":2,"z":3},"B":{"x":4,"y":5,"z":6},"C":{"x":7,"y":8,"z":9}}'

# Not available for Series
```

Index oriented (the default for `Series`) similar to column oriented but the index labels are now primary:

```
In [190]: dfjo.to_json(orient="index")
Out[190]: '{"x":{"A":1,"B":4,"C":7},"y":{"A":2,"B":5,"C":8},"z":{"A":3,"B":6,"C":9}}'

In [191]: sjo.to_json(orient="index")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[191]:␣
↪'{"x":15,"y":16,"z":17}'
```

Record oriented serializes the data to a JSON array of column -> value records, index labels are not included. This is useful for passing DataFrame data to plotting libraries, for example the JavaScript library d3.js:

```
In [192]: dfjo.to_json(orient="records")
Out[192]: '[{"A":1,"B":4,"C":7},{"A":2,"B":5,"C":8},{"A":3,"B":6,"C":9}]'

In [193]: sjo.to_json(orient="records")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[193]:
↪'[15,16,17]'
```

Value oriented is a bare-bones option which serializes to nested JSON arrays of values only, column and index labels are not included:

```
In [194]: dfjo.to_json(orient="values")
Out[194]: '[[1,4,7],[2,5,8],[3,6,9]]'

# Not available for Series
```

Split oriented serializes to a JSON object containing separate entries for values, index and columns. Name is also included for `Series`:

```
In [195]: dfjo.to_json(orient="split")
Out[195]: '{"columns":["A","B","C"],"index":["x","y","z"],"data":[[1,4,7],[2,5,8],[3,
↪6,9]]}'

In [196]: sjo.to_json(orient="split")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[196
↪'{"name":"D","index":["x","y","z"],"data":[15,16,17]}'
```

Note: Any orient option that encodes to a JSON object will not preserve the ordering of index and column labels during round-trip serialization. If you wish to preserve label ordering use the *split* option as it uses ordered containers.

24.2.1.2 Date Handling

Writing in ISO date format

```
In [197]: dfd = pd.DataFrame(randn(5, 2), columns=list('AB'))

In [198]: dfd['date'] = pd.Timestamp('20130101')

In [199]: dfd = dfd.sort_index(1, ascending=False)

In [200]: json = dfd.to_json(date_format='iso')

In [201]: json
Out[201]: '{"date":{"0":"2013-01-01T00:00:00.000Z","1":"2013-01-01T00:00:00.000Z","2":
↪"2013-01-01T00:00:00.000Z","3":"2013-01-01T00:00:00.000Z","4":"2013-01-01T00:00:00.
↪000Z"},"B":{"0":2.5656459463,"1":1.3403088498,"2":-0.2261692849,"3":0.8138502857,"4
↪":-0.8273169356},"A":{"0":-1.2064117817,"1":1.4312559863,"2":-1.1702987971,"3":0.
↪4108345112,"4":0.1320031703}}'
```

Writing in ISO date format, with microseconds

```
In [202]: json = dfd.to_json(date_format='iso', date_unit='us')

In [203]: json
Out[203]: '{"date":{"0":"2013-01-01T00:00:00.000000Z","1":"2013-01-01T00:00:00.000000Z
↪","2":"2013-01-01T00:00:00.000000Z","3":"2013-01-01T00:00:00.000000Z","4":"2013-01-
↪01T00:00:00.000000Z"},"B":{"0":2.5656459463,"1":1.3403088498,"2":-0.2261692849,"3
↪":0.8138502857,"4":-0.8273169356},"A":{"0":-1.2064117817,"1":1.4312559863,"2":-1.
↪1702987971,"3":0.4108345112,"4":0.1320031703}}'
```

Epoch timestamps, in seconds

```
In [204]: json = dfd.to_json(date_format='epoch', date_unit='s')

In [205]: json
Out[205]: '{"date":{"0":1356998400,"1":1356998400,"2":1356998400,"3":1356998400,"4
↪":1356998400},"B":{"0":2.5656459463,"1":1.3403088498,"2":-0.2261692849,"3":0.
↪8138502857,"4":-0.8273169356},"A":{"0":-1.2064117817,"1":1.4312559863,"2":-1.
↪1702987971,"3":0.4108345112,"4":0.1320031703}}'
```

Writing to a file, with a date index and a date column

```
In [206]: dfj2 = dfj.copy()

In [207]: dfj2['date'] = pd.Timestamp('20130101')

In [208]: dfj2['ints'] = list(range(5))

In [209]: dfj2['bools'] = True

In [210]: dfj2.index = pd.date_range('20130101', periods=5)

In [211]: dfj2.to_json('test.json')

In [212]: open('test.json').read()
Out[212]: '{"A":{"1356998400000":-1.2945235903,"1357084800000":0.2766617129,
↪"1357171200000":-0.0139597524,"1357257600000":-0.0061535699,"1357344000000":0.
↪8957173022},"B":{"1356998400000":0.4137381054,"1357084800000":-0.472034511,
↪"1357171200000":-0.3625429925,"1357257600000":-0.923060654,"1357344000000":0.
↪8052440254},"date":{"1356998400000":1356998400000,"1357084800000":1356998400000,
↪"1357171200000":1356998400000,"1357257600000":1356998400000,"1357344000000
↪":1356998400000},"ints":{"1356998400000":0,"1357084800000":1,"1357171200000":2,
↪"1357257600000":3,"1357344000000":4},"bools":{"1356998400000":true,"1357084800000
↪":true,"1357171200000":true,"1357257600000":true,"1357344000000":true}}'
```

24.2.1.3 Fallback Behavior

If the JSON serializer cannot handle the container contents directly it will fallback in the following manner:

- if the dtype is unsupported (e.g. `np.complex`) then the `default_handler`, if provided, will be called for each value, otherwise an exception is raised.
- if an object is unsupported it will attempt the following:
  - check if the object has defined a `toDict` method and call it. A `toDict` method should return a `dict` which will then be JSON serialized.
  - invoke the `default_handler` if one was provided.

- convert the object to a `dict` by traversing its contents. However this will often fail with an `OverflowError` or give unexpected results.

In general the best approach for unsupported objects or dtypes is to provide a `default_handler`. For example:

```
DataFrame([1.0, 2.0, complex(1.0, 2.0)]).to_json()  # raises

RuntimeError: Unhandled numpy dtype 15
```

can be dealt with by specifying a simple `default_handler`:

```
In [213]: pd.DataFrame([1.0, 2.0, complex(1.0, 2.0)]).to_json(default_handler=str)
Out[213]: '{"0":{"0":"(1+0j)","1":"(2+0j)","2":"(1+2j)"}}'
```

24.2.2 Reading JSON

Reading a JSON string to pandas object can take a number of parameters. The parser will try to parse a `DataFrame` if `typ` is not supplied or is `None`. To explicitly force `Series` parsing, pass `typ=series`

- `filepath_or_buffer` : a **VALID** JSON string or file handle / StringIO. The string could be a URL. Valid URL schemes include http, ftp, S3, and file. For file URLs, a host is expected. For instance, a local file could be file ://localhost/path/to/table.json
- `typ` : type of object to recover (series or frame), default 'frame'
- `orient` :

  Series :

  - default is `index`
  - allowed values are {`split`, `records`, `index`}

  DataFrame

  - default is `columns`
  - allowed values are {`split`, `records`, `index`, `columns`, `values`}

  The format of the JSON string

`split`	dict like {index -> [index], columns -> [columns], data -> [values]}
`records`	list like [{column -> value}, ... , {column -> value}]
`index`	dict like {index -> {column -> value}}
`columns`	dict like {column -> {index -> value}}
`values`	just the values array

- `dtype` : if True, infer dtypes, if a dict of column to dtype, then use those, if False, then don't infer dtypes at all, default is True, apply only to the data
- `convert_axes` : boolean, try to convert the axes to the proper dtypes, default is True
- `convert_dates` : a list of columns to parse for dates; If True, then try to parse date-like columns, default is True
- `keep_default_dates` : boolean, default True. If parsing dates, then parse the default date-like columns
- `numpy` : direct decoding to numpy arrays. default is False; Supports numeric data only, although labels may be non-numeric. Also note that the JSON ordering **MUST** be the same for each term if `numpy=True`
- `precise_float` : boolean, default `False`. Set to enable usage of higher precision (strtod) function when decoding string to double values. Default (`False`) is to use fast but less precise builtin functionality

- `date_unit` : string, the timestamp unit to detect if converting dates. Default None. By default the timestamp precision will be detected, if this is not desired then pass one of 's', 'ms', 'us' or 'ns' to force timestamp precision to seconds, milliseconds, microseconds or nanoseconds respectively.
- `lines` : reads file as one json object per line.
- `encoding` : The encoding to use to decode py3 bytes.
- `chunksize` : when used in combination with `lines=True`, return a JsonReader which reads in `chunksize` lines per iteration.

The parser will raise one of `ValueError/TypeError/AssertionError` if the JSON is not parseable.

If a non-default `orient` was used when encoding to JSON be sure to pass the same option here so that decoding produces sensible results, see *Orient Options* for an overview.

24.2.2.1 Data Conversion

The default of `convert_axes=True`, `dtype=True`, and `convert_dates=True` will try to parse the axes, and all of the data into appropriate types, including dates. If you need to override specific dtypes, pass a dict to `dtype`. `convert_axes` should only be set to `False` if you need to preserve string-like numbers (e.g. '1', '2') in an axes.

Note: Large integer values may be converted to dates if `convert_dates=True` and the data and / or column labels appear 'date-like'. The exact threshold depends on the `date_unit` specified. 'date-like' means that the column label meets one of the following criteria:

- it ends with `'_at'`
- it ends with `'_time'`
- it begins with `'timestamp'`
- it is `'modified'`
- it is `'date'`

Warning: When reading JSON data, automatic coercing into dtypes has some quirks:

- an index can be reconstructed in a different order from serialization, that is, the returned order is not guaranteed to be the same as before serialization
- a column that was `float` data will be converted to `integer` if it can be done safely, e.g. a column of `1.`
- bool columns will be converted to `integer` on reconstruction

Thus there are times where you may want to specify specific dtypes via the `dtype` keyword argument.

Reading from a JSON string:

```
In [214]: pd.read_json(json)
Out[214]:
          A         B       date
0 -1.206412  2.565646 2013-01-01
1  1.431256  1.340309 2013-01-01
2 -1.170299 -0.226169 2013-01-01
3  0.410835  0.813850 2013-01-01
4  0.132003 -0.827317 2013-01-01
```

Reading from a file:

```
In [215]: pd.read_json('test.json')
Out[215]:
                   A         B  bools       date  ints
2013-01-01 -1.294524  0.413738   True 2013-01-01     0
2013-01-02  0.276662 -0.472035   True 2013-01-01     1
2013-01-03 -0.013960 -0.362543   True 2013-01-01     2
2013-01-04 -0.006154 -0.923061   True 2013-01-01     3
2013-01-05  0.895717  0.805244   True 2013-01-01     4
```

Don’t convert any data (but still convert axes and dates):

```
In [216]: pd.read_json('test.json', dtype=object).dtypes
Out[216]:
A        object
B        object
bools    object
date     object
ints     object
dtype: object
```

Specify dtypes for conversion:

```
In [217]: pd.read_json('test.json', dtype={'A' : 'float32', 'bools' : 'int8'}).dtypes
Out[217]:
A               float32
B               float64
bools              int8
date     datetime64[ns]
ints              int64
dtype: object
```

Preserve string indices:

```
In [218]: si = pd.DataFrame(np.zeros((4, 4)),
   .....:          columns=list(range(4)),
   .....:          index=[str(i) for i in range(4)])
   .....:

In [219]: si
Out[219]:
     0    1    2    3
0  0.0  0.0  0.0  0.0
1  0.0  0.0  0.0  0.0
2  0.0  0.0  0.0  0.0
3  0.0  0.0  0.0  0.0

In [220]: si.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Index(['0', '1', '2', '3'], dtype='object')

In [221]: si.columns
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Int64Index([0, 1, 2, 3], dtype='int64')

In [222]: json = si.to_json()

In [223]: sij = pd.read_json(json, convert_axes=False)
```

```
In [224]: sij
Out[224]:
   0  1  2  3
0  0  0  0  0
1  0  0  0  0
2  0  0  0  0
3  0  0  0  0

In [225]: sij.index
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[225]:␣
↪Index(['0', '1', '2', '3'], dtype='object')

In [226]: sij.columns
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪Index(['0', '1', '2', '3'], dtype='object')
```

Dates written in nanoseconds need to be read back in nanoseconds:

```
In [227]: json = dfj2.to_json(date_unit='ns')

# Try to parse timestamps as millseconds -> Won't Work
In [228]: dfju = pd.read_json(json, date_unit='ms')

In [229]: dfju
Out[229]:
                            A         B  bools                 date  ints
1356998400000000000 -1.294524  0.413738   True  1356998400000000000     0
1357084800000000000  0.276662 -0.472035   True  1356998400000000000     1
1357171200000000000 -0.013960 -0.362543   True  1356998400000000000     2
1357257600000000000 -0.006154 -0.923061   True  1356998400000000000     3
1357344000000000000  0.895717  0.805244   True  1356998400000000000     4

# Let pandas detect the correct precision
In [230]: dfju = pd.read_json(json)

In [231]: dfju
Out[231]:
                   A         B  bools       date  ints
2013-01-01 -1.294524  0.413738   True 2013-01-01     0
2013-01-02  0.276662 -0.472035   True 2013-01-01     1
2013-01-03 -0.013960 -0.362543   True 2013-01-01     2
2013-01-04 -0.006154 -0.923061   True 2013-01-01     3
2013-01-05  0.895717  0.805244   True 2013-01-01     4

# Or specify that all timestamps are in nanoseconds
In [232]: dfju = pd.read_json(json, date_unit='ns')

In [233]: dfju
Out[233]:
                   A         B  bools       date  ints
2013-01-01 -1.294524  0.413738   True 2013-01-01     0
2013-01-02  0.276662 -0.472035   True 2013-01-01     1
2013-01-03 -0.013960 -0.362543   True 2013-01-01     2
2013-01-04 -0.006154 -0.923061   True 2013-01-01     3
2013-01-05  0.895717  0.805244   True 2013-01-01     4
```

24.2.2.2 The Numpy Parameter

Note: This supports numeric data only. Index and columns labels may be non-numeric, e.g. strings, dates etc.

If `numpy=True` is passed to `read_json` an attempt will be made to sniff an appropriate dtype during deserialization and to subsequently decode directly to numpy arrays, bypassing the need for intermediate Python objects.

This can provide speedups if you are deserialising a large amount of numeric data:

```
In [234]: randfloats = np.random.uniform(-100, 1000, 10000)

In [235]: randfloats.shape = (1000, 10)

In [236]: dffloats = pd.DataFrame(randfloats, columns=list('ABCDEFGHIJ'))

In [237]: jsonfloats = dffloats.to_json()
```

```
In [238]: timeit pd.read_json(jsonfloats)
7.68 ms +- 85.3 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

```
In [239]: timeit pd.read_json(jsonfloats, numpy=True)
5.19 ms +- 329 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

The speedup is less noticeable for smaller datasets:

```
In [240]: jsonfloats = dffloats.head(100).to_json()
```

```
In [241]: timeit pd.read_json(jsonfloats)
4.15 ms +- 24.9 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

```
In [242]: timeit pd.read_json(jsonfloats, numpy=True)
3.37 ms +- 45.5 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

Warning: Direct numpy decoding makes a number of assumptions and may fail or produce unexpected output if these assumptions are not satisfied:

- data is numeric.
- data is uniform. The dtype is sniffed from the first value decoded. A `ValueError` may be raised, or incorrect output may be produced if this condition is not satisfied.
- labels are ordered. Labels are only read from the first container, it is assumed that each subsequent row / column has been encoded in the same order. This should be satisfied if the data was encoded using `to_json` but may not be the case if the JSON is from another source.

24.2.3 Normalization

pandas provides a utility function to take a dict or list of dicts and *normalize* this semi-structured data into a flat table.

```
In [243]: from pandas.io.json import json_normalize

In [244]: data = [{'id': 1, 'name': {'first': 'Coleen', 'last': 'Volk'}},
```

```
   .....:         {'name': {'given': 'Mose', 'family': 'Regner'}},
   .....:         {'id': 2, 'name': 'Faye Raker'}]
   .....:

In [245]: json_normalize(data)
Out[245]:
    id        name name.family name.first name.given name.last
0  1.0         NaN         NaN     Coleen        NaN      Volk
1  NaN         NaN      Regner        NaN       Mose       NaN
2  2.0  Faye Raker         NaN        NaN        NaN       NaN
```

```
In [246]: data = [{'state': 'Florida',
   .....:           'shortname': 'FL',
   .....:           'info': {
   .....:                'governor': 'Rick Scott'
   .....:           },
   .....:           'counties': [{'name': 'Dade', 'population': 12345},
   .....:                        {'name': 'Broward', 'population': 40000},
   .....:                        {'name': 'Palm Beach', 'population': 60000}]},
   .....:          {'state': 'Ohio',
   .....:           'shortname': 'OH',
   .....:           'info': {
   .....:                'governor': 'John Kasich'
   .....:           },
   .....:           'counties': [{'name': 'Summit', 'population': 1234},
   .....:                        {'name': 'Cuyahoga', 'population': 1337}]}]
   .....:

In [247]: json_normalize(data, 'counties', ['state', 'shortname', ['info', 'governor
↪']])
Out[247]:
         name  population    state shortname info.governor
0        Dade       12345  Florida        FL    Rick Scott
1     Broward       40000  Florida        FL    Rick Scott
2  Palm Beach       60000  Florida        FL    Rick Scott
3      Summit        1234     Ohio        OH   John Kasich
4    Cuyahoga        1337     Ohio        OH   John Kasich
```

24.2.4 Line delimited json

New in version 0.19.0.

pandas is able to read and write line-delimited json files that are common in data processing pipelines using Hadoop or Spark.

New in version 0.21.0.

For line-delimited json files, pandas can also return an iterator which reads in `chunksize` lines at a time. This can be useful for large files or to read from a stream.

```
In [248]: jsonl = '''
   .....:     {"a":1,"b":2}
   .....:     {"a":3,"b":4}
   .....: '''
   .....:

In [249]: df = pd.read_json(jsonl, lines=True)
```

```
In [250]: df
Out[250]:
   a  b
0  1  2
1  3  4

In [251]: df.to_json(orient='records', lines=True)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[251]: '{"a":1,"b":2}\n{"a":3,"b":4}'

# reader is an iterator that returns `chunksize` lines each iteration
In [252]: reader = pd.read_json(StringIO(jsonl), lines=True, chunksize=1)

In [253]: reader
Out[253]: <pandas.io.json.json.JsonReader at 0x122daa9b0>

In [254]: for chunk in reader:
   .....:     print(chunk)
   .....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Empty DataFrame
Columns: []
Index: []
   a  b
0  1  2
   a  b
1  3  4
```

24.2.5 Table Schema

New in version 0.20.0.

Table Schema is a spec for describing tabular datasets as a JSON object. The JSON includes information on the field names, types, and other attributes. You can use the orient `table` to build a JSON string with two fields, `schema` and `data`.

```
In [255]: df = pd.DataFrame(
   .....:     {'A': [1, 2, 3],
   .....:      'B': ['a', 'b', 'c'],
   .....:      'C': pd.date_range('2016-01-01', freq='d', periods=3),
   .....:     }, index=pd.Index(range(3), name='idx'))
   .....:

In [256]: df
Out[256]:
     A  B          C
idx
0    1  a 2016-01-01
1    2  b 2016-01-02
2    3  c 2016-01-03

In [257]: df.to_json(orient='table', date_format="iso")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪'{"schema": {"fields":[{"name":"idx","type":"integer"},{"name":"A","type":"integer"}
↪,{"name":"B","type":"string"},{"name":"C","type":"datetime"}],"primaryKey":["idx"],
↪"pandas_version":"0.20.0"}, "data": [{"idx":0,"A":1,"B":"a","C":"2016-01-
↪01T00:00:00.000Z"},{"idx":1,"A":2,"B":"b","C":"2016-01-02T00:00:00.000Z"},{"idx":2,
↪"A":3,"B":"c","C":"2016-01-03T00:00:00.000Z"}]}'
```

The `schema` field contains the `fields` key, which itself contains a list of column name to type pairs, including the `Index` or `MultiIndex` (see below for a list of types). The `schema` field also contains a `primaryKey` field if the (Multi)index is unique.

The second field, `data`, contains the serialized data with the `records` orient. The index is included, and any datetimes are ISO 8601 formatted, as required by the Table Schema spec.

The full list of types supported are described in the Table Schema spec. This table shows the mapping from pandas types:

Pandas type	Table Schema type
int64	integer
float64	number
bool	boolean
datetime64[ns]	datetime
timedelta64[ns]	duration
categorical	any
object	str

A few notes on the generated table schema:

- The `schema` object contains a `pandas_version` field. This contains the version of pandas' dialect of the schema, and will be incremented with each revision.
- All dates are converted to UTC when serializing. Even timezone naïve values, which are treated as UTC with an offset of 0.

```
In [258]: from pandas.io.json import build_table_schema

In [259]: s = pd.Series(pd.date_range('2016', periods=4))

In [260]: build_table_schema(s)
Out[260]:
{'fields': [{'name': 'index', 'type': 'integer'},
  {'name': 'values', 'type': 'datetime'}],
 'pandas_version': '0.20.0',
 'primaryKey': ['index']}
```

- datetimes with a timezone (before serializing), include an additional field `tz` with the time zone name (e.g. `'US/Central'`).

```
In [261]: s_tz = pd.Series(pd.date_range('2016', periods=12,
   .....:                                 tz='US/Central'))
   .....:

In [262]: build_table_schema(s_tz)
Out[262]:
{'fields': [{'name': 'index', 'type': 'integer'},
  {'name': 'values', 'type': 'datetime', 'tz': 'US/Central'}],
 'pandas_version': '0.20.0',
 'primaryKey': ['index']}
```

- Periods are converted to timestamps before serialization, and so have the same behavior of being converted to UTC. In addition, periods will contain and additional field `freq` with the period's frequency, e.g. `'A-DEC'`

```
In [263]: s_per = pd.Series(1, index=pd.period_range('2016', freq='A-DEC',
   .....:                                             periods=4))
```

```
   .....:

In [264]: build_table_schema(s_per)
Out[264]:
{'fields': [{'freq': 'A-DEC', 'name': 'index', 'type': 'datetime'},
  {'name': 'values', 'type': 'integer'}],
 'pandas_version': '0.20.0',
 'primaryKey': ['index']}
```

- Categoricals use the `any` type and an `enum` constraint listing the set of possible values. Additionally, an `ordered` field is included

```
In [265]: s_cat = pd.Series(pd.Categorical(['a', 'b', 'a']))

In [266]: build_table_schema(s_cat)
Out[266]:
{'fields': [{'name': 'index', 'type': 'integer'},
  {'constraints': {'enum': ['a', 'b']},
   'name': 'values',
   'ordered': False,
   'type': 'any'}],
 'pandas_version': '0.20.0',
 'primaryKey': ['index']}
```

- A `primaryKey` field, containing an array of labels, is included *if the index is unique*:

```
In [267]: s_dupe = pd.Series([1, 2], index=[1, 1])

In [268]: build_table_schema(s_dupe)
Out[268]:
{'fields': [{'name': 'index', 'type': 'integer'},
  {'name': 'values', 'type': 'integer'}],
 'pandas_version': '0.20.0'}
```

- The `primaryKey` behavior is the same with MultiIndexes, but in this case the `primaryKey` is an array:

```
In [269]: s_multi = pd.Series(1, index=pd.MultiIndex.from_product([('a', 'b'),
   .....:                                                          (0, 1)]))
   .....:

In [270]: build_table_schema(s_multi)
Out[270]:
{'fields': [{'name': 'level_0', 'type': 'string'},
  {'name': 'level_1', 'type': 'integer'},
  {'name': 'values', 'type': 'integer'}],
 'pandas_version': '0.20.0',
 'primaryKey': FrozenList(['level_0', 'level_1'])}
```

- The default naming roughly follows these rules:
  - For series, the `object.name` is used. If that's none, then the name is `values`
  - For DataFrames, the stringified version of the column name is used
  - For `Index` (not `MultiIndex`), `index.name` is used, with a fallback to `index` if that is None.
  - For `MultiIndex`, `mi.names` is used. If any level has no name, then `level_<i>` is used.

_Table Schema: http://specs.frictionlessdata.io/json-table-schema/

24.3 HTML

24.3.1 Reading HTML Content

Warning: We **highly encourage** you to read the *HTML Table Parsing gotchas* below regarding the issues surrounding the BeautifulSoup4/html5lib/lxml parsers.

The top-level `read_html()` function can accept an HTML string/file/URL and will parse HTML tables into list of pandas DataFrames. Let's look at a few examples.

Note: `read_html` returns a `list` of `DataFrame` objects, even if there is only a single table contained in the HTML content

Read a URL with no options

```
In [271]: url = 'http://www.fdic.gov/bank/individual/failed/banklist.html'

In [272]: dfs = pd.read_html(url)

In [273]: dfs
Out[273]:
[                                            Bank Name                City  \
 0      The Farmers and Merchants State Bank of Argonia             Argonia
 1                                  Fayette County Bank          Saint Elmo
 2    Guaranty Bank, (d/b/a BestBank in Georgia & Mi...           Milwaukee
 3                                        First NBC Bank         New Orleans
 4                                         Proficio Bank  Cottonwood Heights
 5                        Seaway Bank and Trust Company             Chicago
 6                                Harvest Community Bank          Pennsville
 ..                                                   ...                ...
 547                      Hamilton Bank, NA  En Espanol               Miami
 548                                Sinclair National Bank            Gravette
 549                                    Superior Bank, FSB            Hinsdale
 550                                  Malta National Bank               Malta
 551                     First Alliance Bank & Trust Co.          Manchester
 552                   National State Bank of Metropolis          Metropolis
 553                                       Bank of Honolulu            Honolulu

      ST   CERT                Acquiring Institution       Closing Date  \
 0    KS  17719                           Conway Bank   October 13, 2017
 1    IL   1802            United Fidelity Bank, fsb       May 26, 2017
 2    WI  30003  First-Citizens Bank & Trust Company        May 5, 2017
 3    LA  58302                         Whitney Bank     April 28, 2017
 4    UT  35495                    Cache Valley Bank      March 3, 2017
 5    IL  19328                   State Bank of Texas   January 27, 2017
 6    NJ  34951  First-Citizens Bank & Trust Company   January 13, 2017
 ..   ..    ...                                  ...               ...
 547  FL  24382     Israel Discount Bank of New York   January 11, 2002
 548  AR  34248                   Delta Trust & Bank  September 7, 2001
 549  IL  32646                Superior Federal, FSB      July 27, 2001
 550  OH   6629                    North Valley Bank        May 3, 2001
 551  NH  34264  Southern New Hampshire Bank & Trust   February 2, 2001
 552  IL   3815              Banterra Bank of Marion  December 14, 2000
```

```
553  HI  21029                    Bank of the Orient   October 13, 2000

           Updated Date
0      October 20, 2017
1         July 26, 2017
2         July 26, 2017
3         July 26, 2017
4          May 18, 2017
5          May 18, 2017
6          May 18, 2017
..                  ...
547  September 21, 2015
548     October 6, 2017
549     August 19, 2014
550   November 18, 2002
551   February 18, 2003
552      March 17, 2005
553      March 17, 2005

[554 rows x 7 columns]]
```

Note: The data from the above URL changes every Monday so the resulting data above and the data below may be slightly different.

Read in the content of the file from the above URL and pass it to `read_html` as a string

```
In [274]: with open(file_path, 'r') as f:
   .....:     dfs = pd.read_html(f.read())
   .....:

In [275]: dfs
Out[275]:
[                                  Bank Name          City  ST   CERT  \
 0    Banks of Wisconsin d/b/a Bank of Kenosha       Kenosha  WI  35386
 1                       Central Arizona Bank    Scottsdale  AZ  34527
 2                               Sunrise Bank      Valdosta  GA  58185
 3                       Pisgah Community Bank     Asheville  NC  58701
 4                         Douglas County Bank  Douglasville  GA  21649
 5                               Parkway Bank        Lenoir  NC  57158
 6                      Chipola Community Bank      Marianna  FL  58034
 ..                                        ...           ...  ..    ...
 499              Hamilton Bank, NAEn Espanol         Miami  FL  24382
 500                   Sinclair National Bank      Gravette  AR  34248
 501                       Superior Bank, FSB      Hinsdale  IL  32646
 502                       Malta National Bank         Malta  OH   6629
 503           First Alliance Bank & Trust Co.    Manchester  NH  34264
 504         National State Bank of Metropolis    Metropolis  IL   3815
 505                          Bank of Honolulu      Honolulu  HI  21029

                    Acquiring Institution       Closing Date       Updated Date
 0                  North Shore Bank, FSB       May 31, 2013       May 31, 2013
 1                     Western State Bank       May 14, 2013       May 20, 2013
 2                           Synovus Bank       May 10, 2013       May 21, 2013
 3                     Capital Bank, N.A.       May 10, 2013       May 14, 2013
 4                    Hamilton State Bank     April 26, 2013       May 16, 2013
 5       CertusBank, National Association     April 26, 2013       May 17, 2013
```

```
 6          First Federal Bank of Florida     April 19, 2013       May 16, 2013
 ..                                   ...                ...                ...
 499     Israel Discount Bank of New York   January 11, 2002       June 5, 2012
 500                   Delta Trust & Bank  September 7, 2001  February 10, 2004
 501                 Superior Federal, FSB      July 27, 2001       June 5, 2012
 502                     North Valley Bank        May 3, 2001  November 18, 2002
 503  Southern New Hampshire Bank & Trust   February 2, 2001  February 18, 2003
 504              Banterra Bank of Marion  December 14, 2000     March 17, 2005
 505                   Bank of the Orient   October 13, 2000     March 17, 2005

 [506 rows x 7 columns]]
```

You can even pass in an instance of `StringIO` if you so desire

```
In [276]: with open(file_path, 'r') as f:
   .....:     sio = StringIO(f.read())
   .....:

In [277]: dfs = pd.read_html(sio)

In [278]: dfs
Out[278]:
[                                   Bank Name          City  ST   CERT  \
 0    Banks of Wisconsin d/b/a Bank of Kenosha       Kenosha  WI  35386
 1                        Central Arizona Bank    Scottsdale  AZ  34527
 2                                  Sunrise Bank      Valdosta  GA  58185
 3                       Pisgah Community Bank     Asheville  NC  58701
 4                         Douglas County Bank  Douglasville  GA  21649
 5                                Parkway Bank        Lenoir  NC  57158
 6                      Chipola Community Bank      Marianna  FL  58034
 ..                                        ...           ...  ..    ...
 499               Hamilton Bank, NAEn Espanol         Miami  FL  24382
 500                    Sinclair National Bank      Gravette  AR  34248
 501                        Superior Bank, FSB      Hinsdale  IL  32646
 502                       Malta National Bank         Malta  OH   6629
 503           First Alliance Bank & Trust Co.    Manchester  NH  34264
 504         National State Bank of Metropolis    Metropolis  IL   3815
 505                          Bank of Honolulu      Honolulu  HI  21029

                    Acquiring Institution       Closing Date       Updated Date
 0                  North Shore Bank, FSB       May 31, 2013       May 31, 2013
 1                     Western State Bank       May 14, 2013       May 20, 2013
 2                           Synovus Bank       May 10, 2013       May 21, 2013
 3                     Capital Bank, N.A.       May 10, 2013       May 14, 2013
 4                    Hamilton State Bank     April 26, 2013       May 16, 2013
 5       CertusBank, National Association     April 26, 2013       May 17, 2013
 6          First Federal Bank of Florida     April 19, 2013       May 16, 2013
 ..                                   ...                ...                ...
 499     Israel Discount Bank of New York   January 11, 2002       June 5, 2012
 500                   Delta Trust & Bank  September 7, 2001  February 10, 2004
 501                 Superior Federal, FSB      July 27, 2001       June 5, 2012
 502                     North Valley Bank        May 3, 2001  November 18, 2002
 503  Southern New Hampshire Bank & Trust   February 2, 2001  February 18, 2003
 504              Banterra Bank of Marion  December 14, 2000     March 17, 2005
 505                   Bank of the Orient   October 13, 2000     March 17, 2005

 [506 rows x 7 columns]]
```

Note: The following examples are not run by the IPython evaluator due to the fact that having so many network-accessing functions slows down the documentation build. If you spot an error or an example that doesn't run, please do not hesitate to report it over on pandas GitHub issues page.

Read a URL and match a table that contains specific text

```
match = 'Metcalf Bank'
df_list = pd.read_html(url, match=match)
```

Specify a header row (by default `<th>` or `<td>` elements located within a `<thead>` are used to form the column index, if multiple rows are contained within `<thead>` then a multiindex is created); if specified, the header row is taken from the data minus the parsed header elements (`<th>` elements).

```
dfs = pd.read_html(url, header=0)
```

Specify an index column

```
dfs = pd.read_html(url, index_col=0)
```

Specify a number of rows to skip

```
dfs = pd.read_html(url, skiprows=0)
```

Specify a number of rows to skip using a list (`xrange` (Python 2 only) works as well)

```
dfs = pd.read_html(url, skiprows=range(2))
```

Specify an HTML attribute

```
dfs1 = pd.read_html(url, attrs={'id': 'table'})
dfs2 = pd.read_html(url, attrs={'class': 'sortable'})
print(np.array_equal(dfs1[0], dfs2[0]))  # Should be True
```

Specify values that should be converted to NaN

```
dfs = pd.read_html(url, na_values=['No Acquirer'])
```

New in version 0.19.

Specify whether to keep the default set of NaN values

```
dfs = pd.read_html(url, keep_default_na=False)
```

New in version 0.19.

Specify converters for columns. This is useful for numerical text data that has leading zeros. By default columns that are numerical are cast to numeric types and the leading zeros are lost. To avoid this, we can convert these columns to strings.

```
url_mcc = 'https://en.wikipedia.org/wiki/Mobile_country_code'
dfs = pd.read_html(url_mcc, match='Telekom Albania', header=0, converters={'MNC':
str})
```

New in version 0.19.

Use some combination of the above

```
dfs = pd.read_html(url, match='Metcalf Bank', index_col=0)
```

Read in pandas `to_html` output (with some loss of floating point precision)

```
df = pd.DataFrame(randn(2, 2))
s = df.to_html(float_format='{0:.40g}'.format)
dfin = pd.read_html(s, index_col=0)
```

The `lxml` backend will raise an error on a failed parse if that is the only parser you provide (if you only have a single parser you can provide just a string, but it is considered good practice to pass a list with one string if, for example, the function expects a sequence of strings)

```
dfs = pd.read_html(url, 'Metcalf Bank', index_col=0, flavor=['lxml'])
```

or

```
dfs = pd.read_html(url, 'Metcalf Bank', index_col=0, flavor='lxml')
```

However, if you have bs4 and html5lib installed and pass `None` or `['lxml', 'bs4']` then the parse will most likely succeed. Note that *as soon as a parse succeeds, the function will return*.

```
dfs = pd.read_html(url, 'Metcalf Bank', index_col=0, flavor=['lxml', 'bs4'])
```

24.3.2 Writing to HTML files

`DataFrame` objects have an instance method `to_html` which renders the contents of the `DataFrame` as an HTML table. The function arguments are as in the method `to_string` described above.

Note: Not all of the possible options for `DataFrame.to_html` are shown here for brevity's sake. See `to_html()` for the full set of options.

```
In [279]: df = pd.DataFrame(randn(2, 2))

In [280]: df
Out[280]:
          0         1
0 -0.184744  0.496971
1 -0.856240  1.857977

In [281]: print(df.to_html())  # raw html
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\<table␣
↪border="1" class="dataframe">
  <thead>
    <tr style="text-align: right;">
      <th></th>
      <th>0</th>
      <th>1</th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <th>0</th>
      <td>-0.184744</td>
      <td>0.496971</td>
```

```
    </tr>
    <tr>
      <th>1</th>
      <td>-0.856240</td>
      <td>1.857977</td>
    </tr>
  </tbody>
</table>
```

HTML:

The `columns` argument will limit the columns shown

```
In [282]: print(df.to_html(columns=[0]))
<table border="1" class="dataframe">
  <thead>
    <tr style="text-align: right;">
      <th></th>
      <th>0</th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <th>0</th>
      <td>-0.184744</td>
    </tr>
    <tr>
      <th>1</th>
      <td>-0.856240</td>
    </tr>
  </tbody>
</table>
```

HTML:

`float_format` takes a Python callable to control the precision of floating point values

```
In [283]: print(df.to_html(float_format='{0:.10f}'.format))
<table border="1" class="dataframe">
  <thead>
    <tr style="text-align: right;">
      <th></th>
      <th>0</th>
      <th>1</th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <th>0</th>
      <td>-0.1847438576</td>
      <td>0.4969711327</td>
    </tr>
    <tr>
      <th>1</th>
      <td>-0.8562396763</td>
      <td>1.8579766508</td>
    </tr>
  </tbody>
</table>
```

HTML:

`bold_rows` will make the row labels bold by default, but you can turn that off

```
In [284]: print(df.to_html(bold_rows=False))
<table border="1" class="dataframe">
  <thead>
    <tr style="text-align: right;">
      <th></th>
      <th>0</th>
      <th>1</th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <td>0</td>
      <td>-0.184744</td>
      <td>0.496971</td>
    </tr>
    <tr>
      <td>1</td>
      <td>-0.856240</td>
      <td>1.857977</td>
    </tr>
  </tbody>
</table>
```

The `classes` argument provides the ability to give the resulting HTML table CSS classes. Note that these classes are *appended* to the existing `'dataframe'` class.

```
In [285]: print(df.to_html(classes=['awesome_table_class', 'even_more_awesome_class
↪']))
<table border="1" class="dataframe awesome_table_class even_more_awesome_class">
  <thead>
    <tr style="text-align: right;">
      <th></th>
      <th>0</th>
      <th>1</th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <th>0</th>
      <td>-0.184744</td>
      <td>0.496971</td>
    </tr>
    <tr>
      <th>1</th>
      <td>-0.856240</td>
      <td>1.857977</td>
    </tr>
  </tbody>
</table>
```

Finally, the `escape` argument allows you to control whether the "<", ">" and "&" characters escaped in the resulting HTML (by default it is `True`). So to get the HTML without escaped characters pass `escape=False`

```
In [286]: df = pd.DataFrame({'a': list('&<>'), 'b': randn(3)})
```

Escaped:

```
In [287]: print(df.to_html())
<table border="1" class="dataframe">
  <thead>
    <tr style="text-align: right;">
      <th></th>
      <th>a</th>
      <th>b</th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <th>0</th>
      <td>&amp;amp;</td>
      <td>-0.474063</td>
    </tr>
    <tr>
      <th>1</th>
      <td>&lt;</td>
      <td>-0.230305</td>
    </tr>
    <tr>
      <th>2</th>
      <td>&gt;</td>
      <td>-0.400654</td>
    </tr>
  </tbody>
</table>
```

Not escaped:

```
In [288]: print(df.to_html(escape=False))
<table border="1" class="dataframe">
  <thead>
    <tr style="text-align: right;">
      <th></th>
      <th>a</th>
      <th>b</th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <th>0</th>
      <td>&</td>
      <td>-0.474063</td>
    </tr>
    <tr>
      <th>1</th>
      <td><</td>
      <td>-0.230305</td>
    </tr>
    <tr>
      <th>2</th>
      <td>></td>
      <td>-0.400654</td>
```

```
    </tr>
  </tbody>
</table>
```

Note: Some browsers may not show a difference in the rendering of the previous two HTML tables.

24.3.3 HTML Table Parsing Gotchas

There are some versioning issues surrounding the libraries that are used to parse HTML tables in the top-level pandas io function `read_html`.

Issues with lxml

- Benefits
  - **lxml** is very fast
  - **lxml** requires Cython to install correctly.
- Drawbacks
  - **lxml** does *not* make any guarantees about the results of its parse *unless* it is given **strictly valid markup**.
  - In light of the above, we have chosen to allow you, the user, to use the **lxml** backend, but **this backend will use html5lib** if **lxml** fails to parse
  - It is therefore *highly recommended* that you install both **BeautifulSoup4** and **html5lib**, so that you will still get a valid result (provided everything else is valid) even if **lxml** fails.

Issues with BeautifulSoup4 using lxml as a backend

- The above issues hold here as well since **BeautifulSoup4** is essentially just a wrapper around a parser backend.

Issues with BeautifulSoup4 using html5lib as a backend

- Benefits
  - **html5lib** is far more lenient than **lxml** and consequently deals with *real-life markup* in a much saner way rather than just, e.g., dropping an element without notifying you.
  - **html5lib** *generates valid HTML5 markup from invalid markup automatically*. This is extremely important for parsing HTML tables, since it guarantees a valid document. However, that does NOT mean that it is "correct", since the process of fixing markup does not have a single definition.
  - **html5lib** is pure Python and requires no additional build steps beyond its own installation.
- Drawbacks
  - The biggest drawback to using **html5lib** is that it is slow as molasses. However consider the fact that many tables on the web are not big enough for the parsing algorithm runtime to matter. It is more likely that the bottleneck will be in the process of reading the raw text from the URL over the web, i.e., IO (input-output). For very large tables, this might not be true.

24.4 Excel files

The *`read_excel()`* method can read Excel 2003 (`.xls`) and Excel 2007+ (`.xlsx`) files using the `xlrd` Python module. The *`to_excel()`* instance method is used for saving a `DataFrame` to Excel. Generally the semantics are similar to working with *csv* data. See the *cookbook* for some advanced strategies

24.4.1 Reading Excel Files

In the most basic use-case, `read_excel` takes a path to an Excel file, and the `sheet_name` indicating which sheet to parse.

```
# Returns a DataFrame
read_excel('path_to_file.xls', sheet_name='Sheet1')
```

24.4.1.1 `ExcelFile` class

To facilitate working with multiple sheets from the same file, the `ExcelFile` class can be used to wrap the file and can be be passed into `read_excel` There will be a performance benefit for reading multiple sheets as the file is read into memory only once.

```
xlsx = pd.ExcelFile('path_to_file.xls')
df = pd.read_excel(xlsx, 'Sheet1')
```

The `ExcelFile` class can also be used as a context manager.

```
with pd.ExcelFile('path_to_file.xls') as xls:
    df1 = pd.read_excel(xls, 'Sheet1')
    df2 = pd.read_excel(xls, 'Sheet2')
```

The `sheet_names` property will generate a list of the sheet names in the file.

The primary use-case for an `ExcelFile` is parsing multiple sheets with different parameters

```
data = {}
# For when Sheet1's format differs from Sheet2
with pd.ExcelFile('path_to_file.xls') as xls:
    data['Sheet1'] = pd.read_excel(xls, 'Sheet1', index_col=None, na_values=['NA'])
    data['Sheet2'] = pd.read_excel(xls, 'Sheet2', index_col=1)
```

Note that if the same parsing parameters are used for all sheets, a list of sheet names can simply be passed to `read_excel` with no loss in performance.

```
# using the ExcelFile class
data = {}
with pd.ExcelFile('path_to_file.xls') as xls:
    data['Sheet1'] = read_excel(xls, 'Sheet1', index_col=None, na_values=['NA'])
    data['Sheet2'] = read_excel(xls, 'Sheet2', index_col=None, na_values=['NA'])

# equivalent using the read_excel function
data = read_excel('path_to_file.xls', ['Sheet1', 'Sheet2'], index_col=None, na_
↪values=['NA'])
```

New in version 0.17.

`read_excel` can take an `ExcelFile` object as input

24.4.1.2 Specifying Sheets

Note: The second argument is `sheet_name`, not to be confused with `ExcelFile.sheet_names`

Note: An ExcelFile's attribute `sheet_names` provides access to a list of sheets.

- The arguments `sheet_name` allows specifying the sheet or sheets to read.
- The default value for `sheet_name` is 0, indicating to read the first sheet
- Pass a string to refer to the name of a particular sheet in the workbook.
- Pass an integer to refer to the index of a sheet. Indices follow Python convention, beginning at 0.
- Pass a list of either strings or integers, to return a dictionary of specified sheets.
- Pass a `None` to return a dictionary of all available sheets.

```
# Returns a DataFrame
read_excel('path_to_file.xls', 'Sheet1', index_col=None, na_values=['NA'])
```

Using the sheet index:

```
# Returns a DataFrame
read_excel('path_to_file.xls', 0, index_col=None, na_values=['NA'])
```

Using all default values:

```
# Returns a DataFrame
read_excel('path_to_file.xls')
```

Using None to get all sheets:

```
# Returns a dictionary of DataFrames
read_excel('path_to_file.xls',sheet_name=None)
```

Using a list to get multiple sheets:

```
# Returns the 1st and 4th sheet, as a dictionary of DataFrames.
read_excel('path_to_file.xls',sheet_name=['Sheet1',3])
```

`read_excel` can read more than one sheet, by setting `sheet_name` to either a list of sheet names, a list of sheet positions, or `None` to read all sheets. Sheets can be specified by sheet index or sheet name, using an integer or string, respectively.

24.4.1.3 Reading a `MultiIndex`

New in version 0.17.

`read_excel` can read a `MultiIndex` index, by passing a list of columns to `index_col` and a `MultiIndex` column by passing a list of rows to `header`. If either the `index` or `columns` have serialized level names those will be read in as well by specifying the rows/columns that make up the levels.

For example, to read in a `MultiIndex` index without names:

```
In [289]: df = pd.DataFrame({'a':[1,2,3,4], 'b':[5,6,7,8]},
   .....:                   index=pd.MultiIndex.from_product([['a','b'],['c','d']]))
   .....:

In [290]: df.to_excel('path_to_file.xlsx')

In [291]: df = pd.read_excel('path_to_file.xlsx', index_col=[0,1])
```

```
In [292]: df
Out[292]:
     a  b
a c  1  5
  d  2  6
b c  3  7
  d  4  8
```

If the index has level names, they will parsed as well, using the same parameters.

```
In [293]: df.index = df.index.set_names(['lvl1', 'lvl2'])

In [294]: df.to_excel('path_to_file.xlsx')

In [295]: df = pd.read_excel('path_to_file.xlsx', index_col=[0,1])

In [296]: df
Out[296]:
            a  b
lvl1 lvl2
a    c      1  5
     d      2  6
b    c      3  7
     d      4  8
```

If the source file has both `MultiIndex` index and columns, lists specifying each should be passed to `index_col` and `header`

```
In [297]: df.columns = pd.MultiIndex.from_product([['a'],['b', 'd']], names=['c1', 'c2
↪'])

In [298]: df.to_excel('path_to_file.xlsx')

In [299]: df = pd.read_excel('path_to_file.xlsx',
   .....:                     index_col=[0,1], header=[0,1])
   .....:

In [300]: df
Out[300]:
c1          a
c2          b  d
lvl1 lvl2
a    c      1  5
     d      2  6
b    c      3  7
     d      4  8
```

24.4.1.4 Parsing Specific Columns

It is often the case that users will insert columns to do temporary computations in Excel and you may not want to read in those columns. *read_excel* takes a *usecols* keyword to allow you to specify a subset of columns to parse.

If *usecols* is an integer, then it is assumed to indicate the last column to be parsed.

```
read_excel('path_to_file.xls', 'Sheet1', usecols=2)
```

If *usecols* is a list of integers, then it is assumed to be the file column indices to be parsed.

```
read_excel('path_to_file.xls', 'Sheet1', usecols=[0, 2, 3])
```

24.4.1.5 Parsing Dates

Datetime-like values are normally automatically converted to the appropriate dtype when reading the excel file. But if you have a column of strings that *look* like dates (but are not actually formatted as dates in excel), you can use the *parse_dates* keyword to parse those strings to datetimes:

```
read_excel('path_to_file.xls', 'Sheet1', parse_dates=['date_strings'])
```

24.4.1.6 Cell Converters

It is possible to transform the contents of Excel cells via the *converters* option. For instance, to convert a column to boolean:

```
read_excel('path_to_file.xls', 'Sheet1', converters={'MyBools': bool})
```

This options handles missing values and treats exceptions in the converters as missing data. Transformations are applied cell by cell rather than to the column as a whole, so the array dtype is not guaranteed. For instance, a column of integers with missing values cannot be transformed to an array with integer dtype, because NaN is strictly a float. You can manually mask missing data to recover integer dtype:

```
cfun = lambda x: int(x) if x else -1
read_excel('path_to_file.xls', 'Sheet1', converters={'MyInts': cfun})
```

24.4.1.7 dtype Specifications

New in version 0.20.

As an alternative to converters, the type for an entire column can be specified using the *dtype* keyword, which takes a dictionary mapping column names to types. To interpret data with no type inference, use the type `str` or `object`.

```
read_excel('path_to_file.xls', dtype={'MyInts': 'int64', 'MyText': str})
```

24.4.2 Writing Excel Files

24.4.2.1 Writing Excel Files to Disk

To write a DataFrame object to a sheet of an Excel file, you can use the `to_excel` instance method. The arguments are largely the same as `to_csv` described above, the first argument being the name of the excel file, and the optional second argument the name of the sheet to which the DataFrame should be written. For example:

```
df.to_excel('path_to_file.xlsx', sheet_name='Sheet1')
```

Files with a `.xls` extension will be written using `xlwt` and those with a `.xlsx` extension will be written using `xlsxwriter` (if available) or `openpyxl`.

The DataFrame will be written in a way that tries to mimic the REPL output. The `index_label` will be placed in the second row instead of the first. You can place it in the first row by setting the `merge_cells` option in `to_excel()` to `False`:

```
df.to_excel('path_to_file.xlsx', index_label='label', merge_cells=False)
```

The Panel class also has a `to_excel` instance method, which writes each DataFrame in the Panel to a separate sheet.

In order to write separate DataFrames to separate sheets in a single Excel file, one can pass an `ExcelWriter`.

```
with ExcelWriter('path_to_file.xlsx') as writer:
    df1.to_excel(writer, sheet_name='Sheet1')
    df2.to_excel(writer, sheet_name='Sheet2')
```

Note: Wringing a little more performance out of `read_excel` Internally, Excel stores all numeric data as floats. Because this can produce unexpected behavior when reading in data, pandas defaults to trying to convert integers to floats if it doesn't lose information (`1.0 --> 1`). You can pass `convert_float=False` to disable this behavior, which may give a slight performance improvement.

24.4.2.2 Writing Excel Files to Memory

New in version 0.17.

Pandas supports writing Excel files to buffer-like objects such as `StringIO` or `BytesIO` using `ExcelWriter`.

New in version 0.17.

Added support for Openpyxl >= 2.2

```
# Safe import for either Python 2.x or 3.x
try:
    from io import BytesIO
except ImportError:
    from cStringIO import StringIO as BytesIO

bio = BytesIO()

# By setting the 'engine' in the ExcelWriter constructor.
writer = ExcelWriter(bio, engine='xlsxwriter')
df.to_excel(writer, sheet_name='Sheet1')

# Save the workbook
writer.save()

# Seek to the beginning and read to copy the workbook to a variable in memory
bio.seek(0)
workbook = bio.read()
```

Note: `engine` is optional but recommended. Setting the engine determines the version of workbook produced. Setting `engine='xlrd'` will produce an Excel 2003-format workbook (xls). Using either `'openpyxl'` or `'xlsxwriter'` will produce an Excel 2007-format workbook (xlsx). If omitted, an Excel 2007-formatted workbook is produced.

24.4.3 Excel writer engines

`pandas` chooses an Excel writer via two methods:

1. the `engine` keyword argument
2. the filename extension (via the default specified in config options)

By default, `pandas` uses the XlsxWriter for `.xlsx` and openpyxl for `.xlsm` files and xlwt for `.xls` files. If you have multiple engines installed, you can set the default engine through *setting the config options* `io.excel.xlsx.writer` and `io.excel.xls.writer`. pandas will fall back on openpyxl for `.xlsx` files if Xlsxwriter is not available.

To specify which writer you want to use, you can pass an engine keyword argument to `to_excel` and to `ExcelWriter`. The built-in engines are:

- `openpyxl`: This includes stable support for Openpyxl from 1.6.1. However, it is advised to use version 2.2 and higher, especially when working with styles.
- `xlsxwriter`
- `xlwt`

```
# By setting the 'engine' in the DataFrame and Panel 'to_excel()' methods.
df.to_excel('path_to_file.xlsx', sheet_name='Sheet1', engine='xlsxwriter')

# By setting the 'engine' in the ExcelWriter constructor.
writer = ExcelWriter('path_to_file.xlsx', engine='xlsxwriter')

# Or via pandas configuration.
from pandas import options
options.io.excel.xlsx.writer = 'xlsxwriter'

df.to_excel('path_to_file.xlsx', sheet_name='Sheet1')
```

24.4.4 Style and Formatting

The look and feel of Excel worksheets created from pandas can be modified using the following parameters on the `DataFrame`'s `to_excel` method.

- `float_format` : Format string for floating point numbers (default None)
- `freeze_panes` : A tuple of two integers representing the bottommost row and rightmost column to freeze. Each of these parameters is one-based, so (1, 1) will freeze the first row and first column (default None)

24.5 Clipboard

A handy way to grab data is to use the `read_clipboard` method, which takes the contents of the clipboard buffer and passes them to the `read_table` method. For instance, you can copy the following text to the clipboard (CTRL-C on many operating systems):

```
  A B C
x 1 4 p
y 2 5 q
z 3 6 r
```

And then import the data directly to a DataFrame by calling:

```
clipdf = pd.read_clipboard()
```

```
In [301]: clipdf
Out[301]:
   A  B  C
x  1  4  p
y  2  5  q
z  3  6  r
```

The `to_clipboard` method can be used to write the contents of a DataFrame to the clipboard. Following which you can paste the clipboard contents into other applications (CTRL-V on many operating systems). Here we illustrate writing a DataFrame into clipboard and reading it back.

```
In [302]: df = pd.DataFrame(randn(5,3))

In [303]: df
Out[303]:
          0         1         2
0 -0.288267 -0.084905  0.004772
1  1.382989  0.343635 -1.253994
2 -0.124925  0.212244  0.496654
3  0.525417  1.238640 -1.210543
4 -1.175743 -0.172372 -0.734129

In [304]: df.to_clipboard()

In [305]: pd.read_clipboard()
Out[305]:
          0         1         2
0 -0.288267 -0.084905  0.004772
1  1.382989  0.343635 -1.253994
2 -0.124925  0.212244  0.496654
3  0.525417  1.238640 -1.210543
4 -1.175743 -0.172372 -0.734129
```

We can see that we got the same content back, which we had earlier written to the clipboard.

Note: You may need to install xclip or xsel (with gtk or PyQt4 modules) on Linux to use these methods.

24.6 Pickling

All pandas objects are equipped with `to_pickle` methods which use Python's `cPickle` module to save data structures to disk using the pickle format.

```
In [306]: df
Out[306]:
          0         1         2
0 -0.288267 -0.084905  0.004772
1  1.382989  0.343635 -1.253994
2 -0.124925  0.212244  0.496654
3  0.525417  1.238640 -1.210543
4 -1.175743 -0.172372 -0.734129

In [307]: df.to_pickle('foo.pkl')
```

The `read_pickle` function in the `pandas` namespace can be used to load any pickled pandas object (or any other pickled object) from file:

```
In [308]: pd.read_pickle('foo.pkl')
Out[308]:
          0         1         2
0 -0.288267 -0.084905  0.004772
1  1.382989  0.343635 -1.253994
2 -0.124925  0.212244  0.496654
3  0.525417  1.238640 -1.210543
4 -1.175743 -0.172372 -0.734129
```

Warning: Loading pickled data received from untrusted sources can be unsafe.

See: https://docs.python.org/3.6/library/pickle.html

Warning: Several internal refactorings have been done while still preserving compatibility with pickles created with older versions of pandas. However, for such cases, pickled dataframes, series etc, must be read with `pd.read_pickle`, rather than `pickle.load`.

See here and here for some examples of compatibility-breaking changes. See this question for a detailed explanation.

24.6.1 Compressed pickle files

New in version 0.20.0.

`read_pickle()`, *`DataFrame.to_pickle()`* and *`Series.to_pickle()`* can read and write compressed pickle files. The compression types of `gzip`, `bz2`, `xz` are supported for reading and writing. *zip*‘ file supports read only and must contain only one data file to be read in.

The compression type can be an explicit parameter or be inferred from the file extension. If ‘infer’, then use `gzip`, `bz2`, `zip`, or `xz` if filename ends in `'.gz'`, `'.bz2'`, `'.zip'`, or `'.xz'`, respectively.

```
In [309]: df = pd.DataFrame({
   .....:     'A': np.random.randn(1000),
   .....:     'B': 'foo',
   .....:     'C': pd.date_range('20130101', periods=1000, freq='s')})
   .....:

In [310]: df
Out[310]:
            A    B                   C
0    0.478412  foo 2013-01-01 00:00:00
1   -0.783748  foo 2013-01-01 00:00:01
2    1.403558  foo 2013-01-01 00:00:02
3   -0.539282  foo 2013-01-01 00:00:03
4   -1.651012  foo 2013-01-01 00:00:04
5    0.692072  foo 2013-01-01 00:00:05
6    1.022171  foo 2013-01-01 00:00:06
..        ...  ...                 ...
993 -1.613932  foo 2013-01-01 00:16:33
994  1.088104  foo 2013-01-01 00:16:34
995 -0.632963  foo 2013-01-01 00:16:35
```

```
996 -0.585314  foo 2013-01-01 00:16:36
997 -0.275038  foo 2013-01-01 00:16:37
998 -0.937512  foo 2013-01-01 00:16:38
999  0.632369  foo 2013-01-01 00:16:39

[1000 rows x 3 columns]
```

Using an explicit compression type

```
In [311]: df.to_pickle("data.pkl.compress", compression="gzip")

In [312]: rt = pd.read_pickle("data.pkl.compress", compression="gzip")

In [313]: rt
Out[313]:
            A    B                   C
0    0.478412  foo 2013-01-01 00:00:00
1   -0.783748  foo 2013-01-01 00:00:01
2    1.403558  foo 2013-01-01 00:00:02
3   -0.539282  foo 2013-01-01 00:00:03
4   -1.651012  foo 2013-01-01 00:00:04
5    0.692072  foo 2013-01-01 00:00:05
6    1.022171  foo 2013-01-01 00:00:06
..        ...  ...                 ...
993 -1.613932  foo 2013-01-01 00:16:33
994  1.088104  foo 2013-01-01 00:16:34
995 -0.632963  foo 2013-01-01 00:16:35
996 -0.585314  foo 2013-01-01 00:16:36
997 -0.275038  foo 2013-01-01 00:16:37
998 -0.937512  foo 2013-01-01 00:16:38
999  0.632369  foo 2013-01-01 00:16:39

[1000 rows x 3 columns]
```

Inferring compression type from the extension

```
In [314]: df.to_pickle("data.pkl.xz", compression="infer")

In [315]: rt = pd.read_pickle("data.pkl.xz", compression="infer")

In [316]: rt
Out[316]:
            A    B                   C
0    0.478412  foo 2013-01-01 00:00:00
1   -0.783748  foo 2013-01-01 00:00:01
2    1.403558  foo 2013-01-01 00:00:02
3   -0.539282  foo 2013-01-01 00:00:03
4   -1.651012  foo 2013-01-01 00:00:04
5    0.692072  foo 2013-01-01 00:00:05
6    1.022171  foo 2013-01-01 00:00:06
..        ...  ...                 ...
993 -1.613932  foo 2013-01-01 00:16:33
994  1.088104  foo 2013-01-01 00:16:34
995 -0.632963  foo 2013-01-01 00:16:35
996 -0.585314  foo 2013-01-01 00:16:36
997 -0.275038  foo 2013-01-01 00:16:37
998 -0.937512  foo 2013-01-01 00:16:38
999  0.632369  foo 2013-01-01 00:16:39
```

```
[1000 rows x 3 columns]
```

The default is to 'infer

```
In [317]: df.to_pickle("data.pkl.gz")

In [318]: rt = pd.read_pickle("data.pkl.gz")

In [319]: rt
Out[319]:
            A    B                   C
0    0.478412  foo 2013-01-01 00:00:00
1   -0.783748  foo 2013-01-01 00:00:01
2    1.403558  foo 2013-01-01 00:00:02
3   -0.539282  foo 2013-01-01 00:00:03
4   -1.651012  foo 2013-01-01 00:00:04
5    0.692072  foo 2013-01-01 00:00:05
6    1.022171  foo 2013-01-01 00:00:06
..        ...  ...                 ...
993 -1.613932  foo 2013-01-01 00:16:33
994  1.088104  foo 2013-01-01 00:16:34
995 -0.632963  foo 2013-01-01 00:16:35
996 -0.585314  foo 2013-01-01 00:16:36
997 -0.275038  foo 2013-01-01 00:16:37
998 -0.937512  foo 2013-01-01 00:16:38
999  0.632369  foo 2013-01-01 00:16:39

[1000 rows x 3 columns]

In [320]: df["A"].to_pickle("s1.pkl.bz2")

In [321]: rt = pd.read_pickle("s1.pkl.bz2")

In [322]: rt
Out[322]:
0      0.478412
1     -0.783748
2      1.403558
3     -0.539282
4     -1.651012
5      0.692072
6      1.022171
         ...
993   -1.613932
994    1.088104
995   -0.632963
996   -0.585314
997   -0.275038
998   -0.937512
999    0.632369
Name: A, Length: 1000, dtype: float64
```

24.7 msgpack

pandas supports the `msgpack` format for object serialization. This is a lightweight portable binary format, similar to binary JSON, that is highly space efficient, and provides good performance both on the writing (serialization), and reading (deserialization).

Warning: This is a very new feature of pandas. We intend to provide certain optimizations in the io of the `msgpack` data. Since this is marked as an EXPERIMENTAL LIBRARY, the storage format may not be stable until a future release.

As a result of writing format changes and other issues:

Packed with	Can be unpacked with
pre-0.17 / Python 2	any
pre-0.17 / Python 3	any
0.17 / Python 2	• 0.17 / Python 2 • >=0.18 / any Python
0.17 / Python 3	>=0.18 / any Python
0.18	>= 0.18

Reading (files packed by older versions) is backward-compatibile, except for files packed with 0.17 in Python 2, in which case only they can only be unpacked in Python 2.

```
In [323]: df = pd.DataFrame(np.random.rand(5,2),columns=list('AB'))

In [324]: df.to_msgpack('foo.msg')

In [325]: pd.read_msgpack('foo.msg')
Out[325]:
          A         B
0  0.170801  0.895366
1  0.838238  0.052592
2  0.664140  0.289750
3  0.449593  0.872087
4  0.983618  0.744359

In [326]: s = pd.Series(np.random.rand(5),index=pd.date_range('20130101',periods=5))
```

You can pass a list of objects and you will receive them back on deserialization.

```
In [327]: pd.to_msgpack('foo.msg', df, 'foo', np.array([1,2,3]), s)

In [328]: pd.read_msgpack('foo.msg')
Out[328]:
[          A         B
 0  0.170801  0.895366
 1  0.838238  0.052592
 2  0.664140  0.289750
 3  0.449593  0.872087
 4  0.983618  0.744359, 'foo', array([1, 2, 3]), 2013-01-01    0.548134
 2013-01-02    0.503447
 2013-01-03    0.348438
 2013-01-04    0.707267
 2013-01-05    0.261656
```

```
Freq: D, dtype: float64]
```

You can pass `iterator=True` to iterate over the unpacked results

```
In [329]: for o in pd.read_msgpack('foo.msg',iterator=True):
   .....:     print(o)
   .....:
          A         B
0  0.170801  0.895366
1  0.838238  0.052592
2  0.664140  0.289750
3  0.449593  0.872087
4  0.983618  0.744359
foo
[1 2 3]
2013-01-01    0.548134
2013-01-02    0.503447
2013-01-03    0.348438
2013-01-04    0.707267
2013-01-05    0.261656
Freq: D, dtype: float64
```

You can pass `append=True` to the writer to append to an existing pack

```
In [330]: df.to_msgpack('foo.msg',append=True)

In [331]: pd.read_msgpack('foo.msg')
Out[331]:
[          A         B
 0  0.170801  0.895366
 1  0.838238  0.052592
 2  0.664140  0.289750
 3  0.449593  0.872087
 4  0.983618  0.744359, 'foo', array([1, 2, 3]), 2013-01-01    0.548134
 2013-01-02    0.503447
 2013-01-03    0.348438
 2013-01-04    0.707267
 2013-01-05    0.261656
 Freq: D, dtype: float64,           A         B
 0  0.170801  0.895366
 1  0.838238  0.052592
 2  0.664140  0.289750
 3  0.449593  0.872087
 4  0.983618  0.744359]
```

Unlike other io methods, `to_msgpack` is available on both a per-object basis, `df.to_msgpack()` and using the top-level `pd.to_msgpack(...)` where you can pack arbitrary collections of python lists, dicts, scalars, while intermixing pandas objects.

```
In [332]: pd.to_msgpack('foo2.msg', { 'dict' : [ { 'df' : df }, { 'string' : 'foo' },
↪{ 'scalar' : 1. }, { 's' : s } ] })

In [333]: pd.read_msgpack('foo2.msg')
Out[333]:
{'dict': ({'df':           A         B
   0  0.170801  0.895366
   1  0.838238  0.052592
   2  0.664140  0.289750
```

```
   3  0.449593  0.872087
   4  0.983618  0.744359},
  {'string': 'foo'},
  {'scalar': 1.0},
  {'s': 2013-01-01    0.548134
   2013-01-02    0.503447
   2013-01-03    0.348438
   2013-01-04    0.707267
   2013-01-05    0.261656
   Freq: D, dtype: float64})}
```

24.7.1 Read/Write API

Msgpacks can also be read from and written to strings.

```
In [334]: df.to_msgpack()
Out[334]: b'\x84\xa3typ\xadblock_
↪manager\xa5klass\xa9DataFrame\xa4axes\x92\x86\xa3typ\xa5index\xa5klass\xa5Index\xa4name\xc0\xa5dtyp
↪index\xa5klass\xaaRangeIndex\xa4name\xc0\xa5start\x00\xa4stop\x05\xa4step\x01\xa6blocks\x91\x86\xa4
↪<\xfd\xd2f\xcf\xdc\xc5?0\x15\xebN\xd9\xd2\xea?,\x9c\x16A\xa2@\xe5?\xd8/\xdd\xf4
↪"\xc6\xdc?\x11\x1e\x97\x1b\xcdy\xef?&\x1e<\xee\xd6\xa6\xec?p\xd3;\xb2N\xed\xaa?
↪h\xcb\xb1\xbdB\x8b\xd2?\xaf4\x01r"\xe8\xeb?)G6\xd9\xc9\xd1\xe7?
↪\xa5shape\x92\x02\x05\xa5dtype\xa7float64\xa5klass\xaaFloatBlock\xa8compress\xc0'
```

Furthermore you can concatenate the strings to produce a list of the original objects.

```
In [335]: pd.read_msgpack(df.to_msgpack() + s.to_msgpack())
Out[335]:
[          A         B
 0  0.170801  0.895366
 1  0.838238  0.052592
 2  0.664140  0.289750
 3  0.449593  0.872087
 4  0.983618  0.744359, 2013-01-01    0.548134
 2013-01-02    0.503447
 2013-01-03    0.348438
 2013-01-04    0.707267
 2013-01-05    0.261656
 Freq: D, dtype: float64]
```

24.8 HDF5 (PyTables)

`HDFStore` is a dict-like object which reads and writes pandas using the high performance HDF5 format using the excellent PyTables library. See the *cookbook* for some advanced strategies

> **Warning:** pandas requires `PyTables` >= 3.0.0. There is a indexing bug in `PyTables` < 3.2 which may appear when querying stores using an index. If you see a subset of results being returned, upgrade to `PyTables` >= 3.2. Stores created previously will need to be rewritten using the updated version.

Warning: As of version 0.17.0, `HDFStore` will not drop rows that have all missing values by default. Previously, if all values (except the index) were missing, `HDFStore` would not write those rows to disk.

```
In [336]: store = pd.HDFStore('store.h5')

In [337]: print(store)
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
```

Objects can be written to the file just like adding key-value pairs to a dict:

```
In [338]: np.random.seed(1234)

In [339]: index = pd.date_range('1/1/2000', periods=8)

In [340]: s = pd.Series(randn(5), index=['a', 'b', 'c', 'd', 'e'])

In [341]: df = pd.DataFrame(randn(8, 3), index=index,
   .....:                   columns=['A', 'B', 'C'])
   .....:

In [342]: wp = pd.Panel(randn(2, 5, 4), items=['Item1', 'Item2'],
   .....:               major_axis=pd.date_range('1/1/2000', periods=5),
   .....:               minor_axis=['A', 'B', 'C', 'D'])
   .....:

# store.put('s', s) is an equivalent method
In [343]: store['s'] = s

In [344]: store['df'] = df

In [345]: store['wp'] = wp

# the type of stored data
In [346]: store.root.wp._v_attrs.pandas_type
Out[346]: 'wide'

In [347]: store
\\\\\\\\\\\\\\\\Out[347]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
```

In a current or later Python session, you can retrieve stored objects:

```
# store.get('df') is an equivalent method
In [348]: store['df']
Out[348]:
                   A         B         C
2000-01-01  0.887163  0.859588 -0.636524
2000-01-02  0.015696 -2.242685  1.150036
2000-01-03  0.991946  0.953324 -2.021255
2000-01-04 -0.334077  0.002118  0.405453
2000-01-05  0.289092  1.321158 -1.546906
2000-01-06 -0.202646 -0.655969  0.193421
2000-01-07  0.553439  1.318152 -0.469305
2000-01-08  0.675554 -1.817027 -0.183109
```

```
# dotted (attribute) access provides get as well
In [349]: store.df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C
2000-01-01  0.887163  0.859588 -0.636524
2000-01-02  0.015696 -2.242685  1.150036
2000-01-03  0.991946  0.953324 -2.021255
2000-01-04 -0.334077  0.002118  0.405453
2000-01-05  0.289092  1.321158 -1.546906
2000-01-06 -0.202646 -0.655969  0.193421
2000-01-07  0.553439  1.318152 -0.469305
2000-01-08  0.675554 -1.817027 -0.183109
```

Deletion of the object specified by the key

```
# store.remove('wp') is an equivalent method
In [350]: del store['wp']

In [351]: store
Out[351]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
```

Closing a Store, Context Manager

```
In [352]: store.close()

In [353]: store
Out[353]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

In [354]: store.is_open
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[354]: False

# Working with, and automatically closing the store with the context
# manager
In [355]: with pd.HDFStore('store.h5') as store:
   .....:     store.keys()
   .....:
```

24.8.1 Read/Write API

`HDFStore` supports an top-level API using `read_hdf` for reading and `to_hdf` for writing, similar to how `read_csv` and `to_csv` work.

```
In [356]: df_tl = pd.DataFrame(dict(A=list(range(5)), B=list(range(5))))

In [357]: df_tl.to_hdf('store_tl.h5','table',append=True)

In [358]: pd.read_hdf('store_tl.h5', 'table', where = ['index>2'])
Out[358]:
   A  B
3  3  3
4  4  4
```

As of version 0.17.0, HDFStore will no longer drop rows that are all missing by default. This behavior can be enabled by setting `dropna=True`.

```
In [359]: df_with_missing = pd.DataFrame({'col1':[0, np.nan, 2],
   .....:                                 'col2':[1, np.nan, np.nan]})
   .....:

In [360]: df_with_missing
Out[360]:
   col1  col2
0   0.0   1.0
1   NaN   NaN
2   2.0   NaN

In [361]: df_with_missing.to_hdf('file.h5', 'df_with_missing',
   .....:                        format = 'table', mode='w')
   .....:

In [362]: pd.read_hdf('file.h5', 'df_with_missing')
Out[362]:
   col1  col2
0   0.0   1.0
1   NaN   NaN
2   2.0   NaN

In [363]: df_with_missing.to_hdf('file.h5', 'df_with_missing',
   .....:                        format = 'table', mode='w', dropna=True)
   .....:

In [364]: pd.read_hdf('file.h5', 'df_with_missing')
Out[364]:
   col1  col2
0   0.0   1.0
2   2.0   NaN
```

This is also true for the major axis of a `Panel`:

```
In [365]: matrix = [[[np.nan, np.nan, np.nan],[1,np.nan,np.nan]],
   .....:        [[np.nan, np.nan, np.nan], [np.nan,5,6]],
   .....:        [[np.nan, np.nan, np.nan],[np.nan,3,np.nan]]]
   .....:

In [366]: panel_with_major_axis_all_missing = pd.Panel(matrix,
   .....:         items=['Item1', 'Item2','Item3'],
   .....:         major_axis=[1,2],
   .....:         minor_axis=['A', 'B', 'C'])
   .....:

In [367]: panel_with_major_axis_all_missing
Out[367]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 2 (major_axis) x 3 (minor_axis)
Items axis: Item1 to Item3
Major_axis axis: 1 to 2
Minor_axis axis: A to C

In [368]: panel_with_major_axis_all_missing.to_hdf('file.h5', 'panel',
   .....:                                          dropna = True,
   .....:                                          format='table',
```

```
   .....:                                          mode='w')
   .....:

In [369]: reloaded = pd.read_hdf('file.h5', 'panel')

In [370]: reloaded
Out[370]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 1 (major_axis) x 3 (minor_axis)
Items axis: Item1 to Item3
Major_axis axis: 2 to 2
Minor_axis axis: A to C
```

24.8.2 Fixed Format

The examples above show storing using `put`, which write the HDF5 to `PyTables` in a fixed array format, called the `fixed` format. These types of stores are **not** appendable once written (though you can simply remove them and rewrite). Nor are they **queryable**; they must be retrieved in their entirety. They also do not support dataframes with non-unique column names. The `fixed` format stores offer very fast writing and slightly faster reading than `table` stores. This format is specified by default when using `put` or `to_hdf` or by `format='fixed'` or `format='f'`

Warning: A `fixed` format will raise a `TypeError` if you try to retrieve using a `where` .

```
pd.DataFrame(randn(10,2)).to_hdf('test_fixed.h5','df')

pd.read_hdf('test_fixed.h5','df',where='index>5')
TypeError: cannot pass a where specification when reading a fixed format.
           this store must be selected in its entirety
```

24.8.3 Table Format

`HDFStore` supports another `PyTables` format on disk, the `table` format. Conceptually a `table` is shaped very much like a DataFrame, with rows and columns. A `table` may be appended to in the same or other sessions. In addition, delete & query type operations are supported. This format is specified by `format='table'` or `format='t'` to `append` or `put` or `to_hdf`

This format can be set as an option as well `pd.set_option('io.hdf.default_format','table')` to enable `put/append/to_hdf` to by default store in the `table` format.

```
In [371]: store = pd.HDFStore('store.h5')

In [372]: df1 = df[0:4]

In [373]: df2 = df[4:]

# append data (creates a table automatically)
In [374]: store.append('df', df1)

In [375]: store.append('df', df2)

In [376]: store
Out[376]:
<class 'pandas.io.pytables.HDFStore'>
```

```
File path: store.h5

# select the entire object
In [377]: store.select('df')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[377]:
                   A         B         C
2000-01-01  0.887163  0.859588 -0.636524
2000-01-02  0.015696 -2.242685  1.150036
2000-01-03  0.991946  0.953324 -2.021255
2000-01-04 -0.334077  0.002118  0.405453
2000-01-05  0.289092  1.321158 -1.546906
2000-01-06 -0.202646 -0.655969  0.193421
2000-01-07  0.553439  1.318152 -0.469305
2000-01-08  0.675554 -1.817027 -0.183109

# the type of stored data
In [378]: store.root.df._v_attrs.pandas_type
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪'frame_table'
```

Note: You can also create a `table` by passing `format='table'` or `format='t'` to a `put` operation.

24.8.4 Hierarchical Keys

Keys to a store can be specified as a string. These can be in a hierarchical path-name like format (e.g. `foo/bar/bah`), which will generate a hierarchy of sub-stores (or `Groups` in PyTables parlance). Keys can be specified with out the leading '/' and are ALWAYS absolute (e.g. 'foo' refers to '/foo'). Removal operations can remove everything in the sub-store and BELOW, so be *careful*.

```
In [379]: store.put('foo/bar/bah', df)

In [380]: store.append('food/orange', df)

In [381]: store.append('food/apple',  df)

In [382]: store
Out[382]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

# a list of keys are returned
In [383]: store.keys()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[383]: ['/df',
↪ '/food/apple', '/food/orange', '/foo/bar/bah']

# remove all nodes under this level
In [384]: store.remove('food')

In [385]: store
Out[385]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
```

Warning: Hierarchical keys cannot be retrieved as dotted (attribute) access as described above for items stored under the root node.

```
In [8]: store.foo.bar.bah
AttributeError: 'HDFStore' object has no attribute 'foo'

# you can directly access the actual PyTables node but using the root node
In [9]: store.root.foo.bar.bah
Out[9]:
/foo/bar/bah (Group) ''
  children := ['block0_items' (Array), 'block0_values' (Array), 'axis0' (Array),
↪'axis1' (Array)]
```

Instead, use explicit string based keys

```
In [386]: store['foo/bar/bah']
Out[386]:
                   A         B         C
2000-01-01  0.887163  0.859588 -0.636524
2000-01-02  0.015696 -2.242685  1.150036
2000-01-03  0.991946  0.953324 -2.021255
2000-01-04 -0.334077  0.002118  0.405453
2000-01-05  0.289092  1.321158 -1.546906
2000-01-06 -0.202646 -0.655969  0.193421
2000-01-07  0.553439  1.318152 -0.469305
2000-01-08  0.675554 -1.817027 -0.183109
```

24.8.5 Storing Types

24.8.5.1 Storing Mixed Types in a Table

Storing mixed-dtype data is supported. Strings are stored as a fixed-width using the maximum size of the appended column. Subsequent attempts at appending longer strings will raise a `ValueError`.

Passing `min_itemsize={`values`: size}` as a parameter to append will set a larger minimum for the string columns. Storing `floats, strings, ints, bools, datetime64` are currently supported. For string columns, passing `nan_rep = 'nan'` to append will change the default nan representation on disk (which converts to/from *np.nan*), this defaults to *nan*.

```
In [387]: df_mixed = pd.DataFrame({ 'A' : randn(8),
   .....:                           'B' : randn(8),
   .....:                           'C' : np.array(randn(8),dtype='float32'),
   .....:                           'string' :'string',
   .....:                           'int' : 1,
   .....:                           'bool' : True,
   .....:                           'datetime64' : pd.Timestamp('20010102')},
   .....:                          index=list(range(8)))
   .....:

In [388]: df_mixed.loc[df_mixed.index[3:5], ['A', 'B', 'string', 'datetime64']] = np.
↪nan

In [389]: store.append('df_mixed', df_mixed, min_itemsize = {'values': 50})

In [390]: df_mixed1 = store.select('df_mixed')
```

```
In [391]: df_mixed1
Out[391]:
          A         B         C  bool datetime64  int  string
0  0.704721 -1.152659 -0.430096  True 2001-01-02    1  string
1 -0.785435  0.631979  0.767369  True 2001-01-02    1  string
2  0.462060  0.039513  0.984920  True 2001-01-02    1  string
3       NaN       NaN  0.270836  True        NaT    1     NaN
4       NaN       NaN  1.391986  True        NaT    1     NaN
5 -0.926254  1.321106  0.079842  True 2001-01-02    1  string
6  2.007843  0.152631 -0.399965  True 2001-01-02    1  string
7  0.226963  0.164530 -1.027851  True 2001-01-02    1  string

In [392]: df_mixed1.get_dtype_counts()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
bool              1
datetime64[ns]    1
float32           1
float64           2
int64             1
object            1
dtype: int64

# we have provided a minimum string column size
In [393]: store.root.df_mixed.table
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
/df_mixed/table (Table(8,)) ''
  description := {
  "index": Int64Col(shape=(), dflt=0, pos=0),
  "values_block_0": Float64Col(shape=(2,), dflt=0.0, pos=1),
  "values_block_1": Float32Col(shape=(1,), dflt=0.0, pos=2),
  "values_block_2": Int64Col(shape=(1,), dflt=0, pos=3),
  "values_block_3": Int64Col(shape=(1,), dflt=0, pos=4),
  "values_block_4": BoolCol(shape=(1,), dflt=False, pos=5),
  "values_block_5": StringCol(itemsize=50, shape=(1,), dflt=b'', pos=6)}
  byteorder := 'little'
  chunkshape := (689,)
  autoindex := True
  colindexes := {
    "index": Index(6, medium, shuffle, zlib(1)).is_csi=False}
```

24.8.5.2 Storing Multi-Index DataFrames

Storing multi-index dataframes as tables is very similar to storing/selecting from homogeneous index DataFrames.

```
In [394]: index = pd.MultiIndex(levels=[['foo', 'bar', 'baz', 'qux'],
   .....:                              ['one', 'two', 'three']],
   .....:                      labels=[[0, 0, 0, 1, 1, 2, 2, 3, 3, 3],
   .....:                              [0, 1, 2, 0, 1, 1, 2, 0, 1, 2]],
   .....:                      names=['foo', 'bar'])
   .....:

In [395]: df_mi = pd.DataFrame(np.random.randn(10, 3), index=index,
   .....:                     columns=['A', 'B', 'C'])
   .....:
```

```
In [396]: df_mi
Out[396]:
                  A         B         C
foo bar
foo one   -0.584718  0.816594 -0.081947
    two   -0.344766  0.528288 -1.068989
    three -0.511881  0.291205  0.566534
bar one    0.503592  0.285296  0.484288
    two    1.363482 -0.781105 -0.468018
baz two    1.224574 -1.281108  0.875476
    three -1.710715 -0.450765  0.749164
qux one   -0.203933 -0.182175  0.680656
    two   -1.818499  0.047072  0.394844
    three -0.248432 -0.617707 -0.682884

In [397]: store.append('df_mi',df_mi)

In [398]: store.select('df_mi')
Out[398]:
                  A         B         C
foo bar
foo one   -0.584718  0.816594 -0.081947
    two   -0.344766  0.528288 -1.068989
    three -0.511881  0.291205  0.566534
bar one    0.503592  0.285296  0.484288
    two    1.363482 -0.781105 -0.468018
baz two    1.224574 -1.281108  0.875476
    three -1.710715 -0.450765  0.749164
qux one   -0.203933 -0.182175  0.680656
    two   -1.818499  0.047072  0.394844
    three -0.248432 -0.617707 -0.682884

# the levels are automatically included as data columns
In [399]: store.select('df_mi', 'foo=bar')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                A         B         C
foo bar
bar one  0.503592  0.285296  0.484288
    two  1.363482 -0.781105 -0.468018
```

24.8.6 Querying

24.8.6.1 Querying a Table

Warning: This query capabilities have changed substantially starting in `0.13.0`. Queries from prior version are accepted (with a `DeprecationWarning`) printed if its not string-like.

`select` and `delete` operations have an optional criterion that can be specified to select/delete only a subset of the data. This allows one to have a very large on-disk table and retrieve only a portion of the data.

A query is specified using the `Term` class under the hood, as a boolean expression.

- `index` and `columns` are supported indexers of a DataFrame

- major_axis, minor_axis, and items are supported indexers of the Panel
- if data_columns are specified, these can be used as additional indexers

Valid comparison operators are:

=, ==, !=, >, >=, <, <=

Valid boolean expressions are combined with:

- | : or
- & : and
- (and) : for grouping

These rules are similar to how boolean expressions are used in pandas for indexing.

Note:

- = will be automatically expanded to the comparison operator ==
- ~ is the not operator, but can only be used in very limited circumstances
- If a list/tuple of expressions is passed they will be combined via &

The following are valid expressions:

- 'index>=date'
- "columns=['A', 'D']"
- "columns in ['A', 'D']"
- 'columns=A'
- 'columns==A'
- "~(columns=['A','B'])"
- 'index>df.index[3] & string="bar"'
- '(index>df.index[3] & index<=df.index[6]) | string="bar"'
- "ts>=Timestamp('2012-02-01')"
- "major_axis>=20130101"

The indexers are on the left-hand side of the sub-expression:

columns, major_axis, ts

The right-hand side of the sub-expression (after a comparison operator) can be:

- functions that will be evaluated, e.g. Timestamp('2012-02-01')
- strings, e.g. "bar"
- date-like, e.g. 20130101, or "20130101"
- lists, e.g. "['A','B']"
- variables that are defined in the local names space, e.g. date

Note: Passing a string to a query by interpolating it into the query expression is not recommended. Simply assign the string of interest to a variable and use that variable in an expression. For example, do this

```
string = "HolyMoly'"
store.select('df', 'index == string')
```

instead of this

```
string = "HolyMoly'"
store.select('df',  'index == %s' % string)
```

The latter will **not** work and will raise a `SyntaxError`.Note that there's a single quote followed by a double quote in the `string` variable.

If you *must* interpolate, use the `'%r'` format specifier

```
store.select('df', 'index == %r' % string)
```

which will quote `string`.

Here are some examples:

```
In [400]: dfq = pd.DataFrame(randn(10,4),columns=list('ABCD'),index=pd.date_range(
↪'20130101',periods=10))

In [401]: store.append('dfq',dfq,format='table',data_columns=True)
```

Use boolean expressions, with in-line function evaluation.

```
In [402]: store.select('dfq',"index>pd.Timestamp('20130104') & columns=['A', 'B']")
Out[402]:
                   A         B
2013-01-05  1.210384  0.797435
2013-01-06 -0.850346  1.176812
2013-01-07  0.984188 -0.121728
2013-01-08  0.796595 -0.474021
2013-01-09 -0.804834 -2.123620
2013-01-10  0.334198  0.536784
```

Use and inline column reference

```
In [403]: store.select('dfq',where="A>0 or C>0")
Out[403]:
                   A         B         C         D
2013-01-01  0.436258 -1.703013  0.393711 -0.479324
2013-01-02 -0.299016  0.694103  0.678630  0.239556
2013-01-03  0.151227  0.816127  1.893534  0.639633
2013-01-04 -0.962029 -2.085266  1.930247 -1.735349
2013-01-05  1.210384  0.797435 -0.379811  0.702562
2013-01-07  0.984188 -0.121728  2.365769  0.496143
2013-01-08  0.796595 -0.474021 -0.056696  1.357797
2013-01-10  0.334198  0.536784 -0.743830 -0.320204
```

Works with a Panel as well.

```
In [404]: store.append('wp',wp)

In [405]: store
Out[405]:
<class 'pandas.io.pytables.HDFStore'>
```

```
File path: store.h5

In [406]: store.select('wp', "major_axis>pd.Timestamp('20000102') & minor_axis=['A',
↪'B']")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[406]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to B
```

The `columns` keyword can be supplied to select a list of columns to be returned, this is equivalent to passing a `'columns=list_of_columns_to_filter'`:

```
In [407]: store.select('df', "columns=['A', 'B']")
Out[407]:
                   A         B
2000-01-01  0.887163  0.859588
2000-01-02  0.015696 -2.242685
2000-01-03  0.991946  0.953324
2000-01-04 -0.334077  0.002118
2000-01-05  0.289092  1.321158
2000-01-06 -0.202646 -0.655969
2000-01-07  0.553439  1.318152
2000-01-08  0.675554 -1.817027
```

`start` and `stop` parameters can be specified to limit the total search space. These are in terms of the total number of rows in a table.

```
# this is effectively what the storage of a Panel looks like
In [408]: wp.to_frame()
Out[408]:
                     Item1     Item2
major      minor
2000-01-01 A      1.058969  0.215269
           B     -0.397840  0.841009
           C      0.337438 -1.445810
           D      1.047579 -1.401973
2000-01-02 A      1.045938 -0.100918
           B      0.863717 -0.548242
           C     -0.122092 -0.144620
...                    ...       ...
2000-01-04 B      0.036142  0.307969
           C     -2.074978 -0.208499
           D      0.247792  1.033801
2000-01-05 A     -0.897157 -2.400454
           B     -0.136795  2.030604
           C      0.018289 -1.142631
           D      0.755414  0.211883

[20 rows x 2 columns]

# limiting the search
In [409]: store.select('wp',"major_axis>20000102 & minor_axis=['A','B']",
   .....:              start=0, stop=10)
   .....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
```

```
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 1 (major_axis) x 2 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-03 00:00:00
Minor_axis axis: A to B
```

Note: `select` will raise a `ValueError` if the query expression has an unknown variable reference. Usually this means that you are trying to select on a column that is **not** a data_column.

`select` will raise a `SyntaxError` if the query expression is not valid.

24.8.6.2 Using timedelta64[ns]

You can store and query using the `timedelta64[ns]` type. Terms can be specified in the format: `<float>(<unit>)`, where float may be signed (and fractional), and unit can be `D,s,ms,us,ns` for the timedelta. Here's an example:

```
In [410]: from datetime import timedelta

In [411]: dftd = pd.DataFrame(dict(A = pd.Timestamp('20130101'), B = [ pd.Timestamp(
↪'20130101') + timedelta(days=i,seconds=10) for i in range(10) ]))

In [412]: dftd['C'] = dftd['A']-dftd['B']

In [413]: dftd
Out[413]:
           A                   B                  C
0 2013-01-01 2013-01-01 00:00:10  -1 days +23:59:50
1 2013-01-01 2013-01-02 00:00:10  -2 days +23:59:50
2 2013-01-01 2013-01-03 00:00:10  -3 days +23:59:50
3 2013-01-01 2013-01-04 00:00:10  -4 days +23:59:50
4 2013-01-01 2013-01-05 00:00:10  -5 days +23:59:50
5 2013-01-01 2013-01-06 00:00:10  -6 days +23:59:50
6 2013-01-01 2013-01-07 00:00:10  -7 days +23:59:50
7 2013-01-01 2013-01-08 00:00:10  -8 days +23:59:50
8 2013-01-01 2013-01-09 00:00:10  -9 days +23:59:50
9 2013-01-01 2013-01-10 00:00:10 -10 days +23:59:50

In [414]: store.append('dftd',dftd,data_columns=True)

In [415]: store.select('dftd',"C<'-3.5D'")
Out[415]:
           A                   B                  C
4 2013-01-01 2013-01-05 00:00:10  -5 days +23:59:50
5 2013-01-01 2013-01-06 00:00:10  -6 days +23:59:50
6 2013-01-01 2013-01-07 00:00:10  -7 days +23:59:50
7 2013-01-01 2013-01-08 00:00:10  -8 days +23:59:50
8 2013-01-01 2013-01-09 00:00:10  -9 days +23:59:50
9 2013-01-01 2013-01-10 00:00:10 -10 days +23:59:50
```

24.8.6.3 Indexing

You can create/modify an index for a table with `create_table_index` after data is already in the table (after and `append/put` operation). Creating a table index is **highly** encouraged. This will speed your queries a great deal when you use a `select` with the indexed dimension as the `where`.

Note: Indexes are automagically created on the indexables and any data columns you specify. This behavior can be turned off by passing `index=False` to `append`.

```
# we have automagically already created an index (in the first section)
In [416]: i = store.root.df.table.cols.index.index

In [417]: i.optlevel, i.kind
Out[417]: (6, 'medium')

# change an index by passing new parameters
In [418]: store.create_table_index('df', optlevel=9, kind='full')

In [419]: i = store.root.df.table.cols.index.index

In [420]: i.optlevel, i.kind
Out[420]: (9, 'full')
```

Oftentimes when appending large amounts of data to a store, it is useful to turn off index creation for each append, then recreate at the end.

```
In [421]: df_1 = pd.DataFrame(randn(10,2),columns=list('AB'))

In [422]: df_2 = pd.DataFrame(randn(10,2),columns=list('AB'))

In [423]: st = pd.HDFStore('appends.h5',mode='w')

In [424]: st.append('df', df_1, data_columns=['B'], index=False)

In [425]: st.append('df', df_2, data_columns=['B'], index=False)

In [426]: st.get_storer('df').table
Out[426]:
/df/table (Table(20,)) ''
  description := {
  "index": Int64Col(shape=(), dflt=0, pos=0),
  "values_block_0": Float64Col(shape=(1,), dflt=0.0, pos=1),
  "B": Float64Col(shape=(), dflt=0.0, pos=2)}
  byteorder := 'little'
  chunkshape := (2730,)
```

Then create the index when finished appending.

```
In [427]: st.create_table_index('df', columns=['B'], optlevel=9, kind='full')

In [428]: st.get_storer('df').table
Out[428]:
/df/table (Table(20,)) ''
  description := {
  "index": Int64Col(shape=(), dflt=0, pos=0),
  "values_block_0": Float64Col(shape=(1,), dflt=0.0, pos=1),
```

```
  "B": Float64Col(shape=(), dflt=0.0, pos=2)}
  byteorder := 'little'
  chunkshape := (2730,)
  autoindex := True
  colindexes := {
    "B": Index(9, full, shuffle, zlib(1)).is_csi=True}

In [429]: st.close()
```

See here for how to create a completely-sorted-index (CSI) on an existing store.

24.8.6.4 Query via Data Columns

You can designate (and index) certain columns that you want to be able to perform queries (other than the *indexable* columns, which you can always query). For instance say you want to perform this common operation, on-disk, and return just the frame that matches this query. You can specify `data_columns = True` to force all columns to be data_columns

```
In [430]: df_dc = df.copy()

In [431]: df_dc['string'] = 'foo'

In [432]: df_dc.loc[df_dc.index[4:6], 'string'] = np.nan

In [433]: df_dc.loc[df_dc.index[7:9], 'string'] = 'bar'

In [434]: df_dc['string2'] = 'cool'

In [435]: df_dc.loc[df_dc.index[1:3], ['B','C']] = 1.0

In [436]: df_dc
Out[436]:
                   A         B         C string string2
2000-01-01  0.887163  0.859588 -0.636524    foo    cool
2000-01-02  0.015696  1.000000  1.000000    foo    cool
2000-01-03  0.991946  1.000000  1.000000    foo    cool
2000-01-04 -0.334077  0.002118  0.405453    foo    cool
2000-01-05  0.289092  1.321158 -1.546906    NaN    cool
2000-01-06 -0.202646 -0.655969  0.193421    NaN    cool
2000-01-07  0.553439  1.318152 -0.469305    foo    cool
2000-01-08  0.675554 -1.817027 -0.183109    bar    cool

# on-disk operations
In [437]: store.append('df_dc', df_dc, data_columns = ['B', 'C', 'string', 'string2'])

In [438]: store.select('df_dc', where='B>0')
Out[438]:
                   A         B         C string string2
2000-01-01  0.887163  0.859588 -0.636524    foo    cool
2000-01-02  0.015696  1.000000  1.000000    foo    cool
2000-01-03  0.991946  1.000000  1.000000    foo    cool
2000-01-04 -0.334077  0.002118  0.405453    foo    cool
2000-01-05  0.289092  1.321158 -1.546906    NaN    cool
2000-01-07  0.553439  1.318152 -0.469305    foo    cool

# getting creative
In [439]: store.select('df_dc', 'B > 0 & C > 0 & string == foo')
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C string string2
2000-01-02  0.015696  1.000000  1.000000    foo    cool
2000-01-03  0.991946  1.000000  1.000000    foo    cool
2000-01-04 -0.334077  0.002118  0.405453    foo    cool

# this is in-memory version of this type of selection
In [440]: df_dc[(df_dc.B > 0) & (df_dc.C > 0) & (df_dc.string == 'foo')]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C string string2
2000-01-02  0.015696  1.000000  1.000000    foo    cool
2000-01-03  0.991946  1.000000  1.000000    foo    cool
2000-01-04 -0.334077  0.002118  0.405453    foo    cool

# we have automagically created this index and the B/C/string/string2
# columns are stored separately as ``PyTables`` columns
In [441]: store.root.df_dc.table
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
/df_dc/table (Table(8,)) ''
  description := {
  "index": Int64Col(shape=(), dflt=0, pos=0),
  "values_block_0": Float64Col(shape=(1,), dflt=0.0, pos=1),
  "B": Float64Col(shape=(), dflt=0.0, pos=2),
  "C": Float64Col(shape=(), dflt=0.0, pos=3),
  "string": StringCol(itemsize=3, shape=(), dflt=b'', pos=4),
  "string2": StringCol(itemsize=4, shape=(), dflt=b'', pos=5)}
  byteorder := 'little'
  chunkshape := (1680,)
  autoindex := True
  colindexes := {
    "index": Index(6, medium, shuffle, zlib(1)).is_csi=False,
    "B": Index(6, medium, shuffle, zlib(1)).is_csi=False,
    "C": Index(6, medium, shuffle, zlib(1)).is_csi=False,
    "string": Index(6, medium, shuffle, zlib(1)).is_csi=False,
    "string2": Index(6, medium, shuffle, zlib(1)).is_csi=False}
```

There is some performance degradation by making lots of columns into *data columns*, so it is up to the user to designate these. In addition, you cannot change data columns (nor indexables) after the first append/put operation (Of course you can simply read in the data and create a new table!)

24.8.6.5 Iterator

You can pass `iterator=True` or `chunksize=number_in_a_chunk` to `select` and `select_as_multiple` to return an iterator on the results. The default is 50,000 rows returned in a chunk.

```
In [442]: for df in store.select('df', chunksize=3):
   .....:     print(df)
   .....:
                   A         B         C
2000-01-01  0.887163  0.859588 -0.636524
2000-01-02  0.015696 -2.242685  1.150036
2000-01-03  0.991946  0.953324 -2.021255
                   A         B         C
2000-01-04 -0.334077  0.002118  0.405453
```

```
2000-01-05  0.289092  1.321158 -1.546906
2000-01-06 -0.202646 -0.655969  0.193421
                   A         B         C
2000-01-07  0.553439  1.318152 -0.469305
2000-01-08  0.675554 -1.817027 -0.183109
```

Note: You can also use the iterator with `read_hdf` which will open, then automatically close the store when finished iterating.

```
for df in pd.read_hdf('store.h5','df', chunksize=3):
    print(df)
```

Note, that the chunksize keyword applies to the **source** rows. So if you are doing a query, then the chunksize will subdivide the total rows in the table and the query applied, returning an iterator on potentially unequal sized chunks.

Here is a recipe for generating a query and using it to create equal sized return chunks.

```
In [443]: dfeq = pd.DataFrame({'number': np.arange(1,11)})

In [444]: dfeq
Out[444]:
   number
0       1
1       2
2       3
3       4
4       5
5       6
6       7
7       8
8       9
9      10

In [445]: store.append('dfeq', dfeq, data_columns=['number'])

In [446]: def chunks(l, n):
   .....:     return [l[i:i+n] for i in range(0, len(l), n)]
   .....:

In [447]: evens = [2,4,6,8,10]

In [448]: coordinates = store.select_as_coordinates('dfeq','number=evens')

In [449]: for c in chunks(coordinates, 2):
   .....:     print(store.select('dfeq',where=c))
   .....:
   number
1       2
3       4
   number
5       6
7       8
   number
9      10
```

24.8.6.6 Advanced Queries

Select a Single Column

To retrieve a single indexable or data column, use the method `select_column`. This will, for example, enable you to get the index very quickly. These return a `Series` of the result, indexed by the row number. These do not currently accept the `where` selector.

```
In [450]: store.select_column('df_dc', 'index')
Out[450]:
0   2000-01-01
1   2000-01-02
2   2000-01-03
3   2000-01-04
4   2000-01-05
5   2000-01-06
6   2000-01-07
7   2000-01-08
Name: index, dtype: datetime64[ns]

In [451]: store.select_column('df_dc', 'string')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    foo
1    foo
2    foo
3    foo
4    NaN
5    NaN
6    foo
7    bar
Name: string, dtype: object
```

Selecting coordinates

Sometimes you want to get the coordinates (a.k.a the index locations) of your query. This returns an `Int64Index` of the resulting locations. These coordinates can also be passed to subsequent `where` operations.

```
In [452]: df_coord = pd.DataFrame(np.random.randn(1000,2),index=pd.date_range(
↪'20000101',periods=1000))

In [453]: store.append('df_coord',df_coord)

In [454]: c = store.select_as_coordinates('df_coord','index>20020101')

In [455]: c.summary()
Out[455]: 'Int64Index: 268 entries, 732 to 999'

In [456]: store.select('df_coord',where=c)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[456]:
                   0         1
2002-01-02 -0.178266 -0.064638
2002-01-03 -1.204956 -3.880898
2002-01-04  0.974470  0.415160
2002-01-05  1.751967  0.485011
2002-01-06 -0.170894  0.748870
```

```
2002-01-07  0.629793  0.811053
2002-01-08  2.133776  0.238459
...              ...       ...
2002-09-20 -0.181434  0.612399
2002-09-21 -0.763324 -0.354962
2002-09-22 -0.261776  0.812126
2002-09-23  0.482615 -0.886512
2002-09-24 -0.037757 -0.562953
2002-09-25  0.897706  0.383232
2002-09-26 -1.324806  1.139269

[268 rows x 2 columns]
```

Selecting using a where mask

Sometime your query can involve creating a list of rows to select. Usually this `mask` would be a resulting `index` from an indexing operation. This example selects the months of a datetimeindex which are 5.

```
In [457]: df_mask = pd.DataFrame(np.random.randn(1000,2),index=pd.date_range('20000101
↪',periods=1000))

In [458]: store.append('df_mask',df_mask)

In [459]: c = store.select_column('df_mask','index')

In [460]: where = c[pd.DatetimeIndex(c).month==5].index

In [461]: store.select('df_mask',where=where)
Out[461]:
                   0         1
2000-05-01 -1.006245 -0.616759
2000-05-02  0.218940  0.717838
2000-05-03  0.013333  1.348060
2000-05-04  0.662176 -1.050645
2000-05-05 -1.034870 -0.243242
2000-05-06 -0.753366 -1.454329
2000-05-07 -1.022920 -0.476989
...              ...       ...
2002-05-25 -0.509090 -0.389376
2002-05-26  0.150674  1.164337
2002-05-27 -0.332944  0.115181
2002-05-28 -1.048127 -0.605733
2002-05-29  1.418754 -0.442835
2002-05-30 -0.433200  0.835001
2002-05-31 -1.041278  1.401811

[93 rows x 2 columns]
```

Storer Object

If you want to inspect the stored object, retrieve via `get_storer`. You could use this programmatically to say get the number of rows in an object.

```
In [462]: store.get_storer('df_dc').nrows
Out[462]: 8
```

24.8.6.7 Multiple Table Queries

The methods `append_to_multiple` and `select_as_multiple` can perform appending/selecting from multiple tables at once. The idea is to have one table (call it the selector table) that you index most/all of the columns, and perform your queries. The other table(s) are data tables with an index matching the selector table's index. You can then perform a very fast query on the selector table, yet get lots of data back. This method is similar to having a very wide table, but enables more efficient queries.

The `append_to_multiple` method splits a given single DataFrame into multiple tables according to `d`, a dictionary that maps the table names to a list of 'columns' you want in that table. If *None* is used in place of a list, that table will have the remaining unspecified columns of the given DataFrame. The argument `selector` defines which table is the selector table (which you can make queries from). The argument `dropna` will drop rows from the input DataFrame to ensure tables are synchronized. This means that if a row for one of the tables being written to is entirely `np.NaN`, that row will be dropped from all tables.

If `dropna` is False, **THE USER IS RESPONSIBLE FOR SYNCHRONIZING THE TABLES**. Remember that entirely `np.Nan` rows are not written to the HDFStore, so if you choose to call `dropna=False`, some tables may have more rows than others, and therefore `select_as_multiple` may not work or it may return unexpected results.

```
In [463]: df_mt = pd.DataFrame(randn(8, 6), index=pd.date_range('1/1/2000',␣
↪periods=8),
   .....:                                   columns=['A', 'B', 'C', 'D', 'E', 'F'])
   .....:

In [464]: df_mt['foo'] = 'bar'

In [465]: df_mt.loc[df_mt.index[1], ('A', 'B')] = np.nan

# you can also create the tables individually
In [466]: store.append_to_multiple({'df1_mt': ['A', 'B'], 'df2_mt': None },
   .....:                          df_mt, selector='df1_mt')
   .....:

In [467]: store
Out[467]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

# individual tables were created
In [468]: store.select('df1_mt')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[468]:
                   A         B
2000-01-01  0.714697  0.318215
2000-01-02       NaN       NaN
2000-01-03 -0.086919  0.416905
2000-01-04  0.489131 -0.253340
2000-01-05 -0.382952 -0.397373
2000-01-06  0.538116  0.226388
2000-01-07 -2.073479 -0.115926
2000-01-08 -0.695400  0.402493

In [469]: store.select('df2_mt')
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   C         D         E         F  foo
2000-01-01  0.607460  0.790907  0.852225  0.096696  bar
2000-01-02  0.811031 -0.356817  1.047085  0.664705  bar
2000-01-03 -0.764381 -0.287229 -0.089351 -1.035115  bar
2000-01-04 -1.948100 -0.116556  0.800597 -0.796154  bar
2000-01-05 -0.717627  0.156995 -0.344718 -0.171208  bar
2000-01-06  1.541729  0.205256  1.998065  0.953591  bar
2000-01-07  1.391070  0.303013  1.093347 -0.101000  bar
2000-01-08 -1.507639  0.089575  0.658822 -1.037627  bar

# as a multiple
In [470]: store.select_as_multiple(['df1_mt', 'df2_mt'], where=['A>0', 'B>0'],
   .....:                                  selector = 'df1_mt')
   .....:
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
                   A         B         C         D         E         F  foo
2000-01-01  0.714697  0.318215  0.607460  0.790907  0.852225  0.096696  bar
2000-01-06  0.538116  0.226388  1.541729  0.205256  1.998065  0.953591  bar
```

24.8.7 Delete from a Table

You can delete from a table selectively by specifying a `where`. In deleting rows, it is important to understand the `PyTables` deletes rows by erasing the rows, then **moving** the following data. Thus deleting can potentially be a very expensive operation depending on the orientation of your data. This is especially true in higher dimensional objects (`Panel` and `Panel4D`). To get optimal performance, it's worthwhile to have the dimension you are deleting be the first of the `indexables`.

Data is ordered (on the disk) in terms of the `indexables`. Here's a simple use case. You store panel-type data, with dates in the `major_axis` and ids in the `minor_axis`. The data is then interleaved like this:

- date_1 - id_1 - id_2 - . - id_n
- date_2 - id_1 - . - id_n

It should be clear that a delete operation on the `major_axis` will be fairly quick, as one chunk is removed, then the following data moved. On the other hand a delete operation on the `minor_axis` will be very expensive. In this case it would almost certainly be faster to rewrite the table using a `where` that selects all but the missing data.

```
# returns the number of rows deleted
In [471]: store.remove('wp', 'major_axis>20000102' )
Out[471]: 12

In [472]: store.select('wp')
\\\\\\\\\\\\\Out[472]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 2 (major_axis) x 4 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-02 00:00:00
Minor_axis axis: A to D
```

Warning: Please note that HDF5 **DOES NOT RECLAIM SPACE** in the h5 files automatically. Thus, repeatedly deleting (or removing nodes) and adding again, **WILL TEND TO INCREASE THE FILE SIZE**.

To *repack and clean* the file, use *ptrepack*

24.8.8 Notes & Caveats

24.8.8.1 Compression

`PyTables` allows the stored data to be compressed. This applies to all kinds of stores, not just tables. Two parameters are used to control compression: `complevel` and `complib`.

`complevel` specifies if and how hard data is to be compressed. `complevel=0` and `complevel=None` disables compression and `0<complevel<10` enables compression.

`complib` specifies which compression library to use. If nothing is specified the default library `zlib` is used. A compression library usually optimizes for either good compression rates or speed and the results will depend on the type of data. Which type of compression to choose depends on your specific needs and data. The list of supported compression libraries:

- zlib: The default compression library. A classic in terms of compression, achieves good compression rates but is somewhat slow.
- lzo: Fast compression and decompression.
- bzip2: Good compression rates.
- blosc: Fast compression and decompression.

New in version 0.20.2: Support for alternative blosc compressors:

- blosc:blosclz This is the default compressor for `blosc`
- blosc:lz4: A compact, very popular and fast compressor.
- blosc:lz4hc: A tweaked version of LZ4, produces better compression ratios at the expense of speed.
- blosc:snappy: A popular compressor used in many places.
- blosc:zlib: A classic; somewhat slower than the previous ones, but achieving better compression ratios.
- blosc:zstd: An extremely well balanced codec; it provides the best compression ratios among the others above, and at reasonably fast speed.

If `complib` is defined as something other than the listed libraries a `ValueError` exception is issued.

Note: If the library specified with the `complib` option is missing on your platform, compression defaults to `zlib` without further ado.

Enable compression for all objects within the file:

```
store_compressed = pd.HDFStore('store_compressed.h5', complevel=9, complib=
↪'blosc:blosclz')
```

Or on-the-fly compression (this only applies to tables) in stores where compression is not enabled:

```
store.append('df', df, complib='zlib', complevel=5)
```

24.8.8.2 ptrepack

`PyTables` offers better write performance when tables are compressed after they are written, as opposed to turning on compression at the very beginning. You can use the supplied `PyTables` utility `ptrepack`. In addition, `ptrepack` can change compression levels after the fact.

```
ptrepack --chunkshape=auto --propindexes --complevel=9 --complib=blosc in.h5 out.h5
```

Furthermore `ptrepack in.h5 out.h5` will *repack* the file to allow you to reuse previously deleted space. Alternatively, one can simply remove the file and write again, or use the `copy` method.

24.8.8.3 Caveats

> **Warning:** `HDFStore` is **not-threadsafe for writing**. The underlying `PyTables` only supports concurrent reads (via threading or processes). If you need reading and writing *at the same time*, you need to serialize these operations in a single thread in a single process. You will corrupt your data otherwise. See the (GH2397) for more information.

- If you use locks to manage write access between multiple processes, you may want to use `fsync()` before releasing write locks. For convenience you can use `store.flush(fsync=True)` to do this for you.
- Once a `table` is created its items (Panel) / columns (DataFrame) are fixed; only exactly the same columns can be appended
- Be aware that timezones (e.g., `pytz.timezone('US/Eastern')`) are not necessarily equal across timezone versions. So if data is localized to a specific timezone in the HDFStore using one version of a timezone library and that data is updated with another version, the data will be converted to UTC since these timezones are not considered equal. Either use the same version of timezone library or use `tz_convert` with the updated timezone definition.

> **Warning:** `PyTables` will show a `NaturalNameWarning` if a column name cannot be used as an attribute selector. *Natural* identifiers contain only letters, numbers, and underscores, and may not begin with a number. Other identifiers cannot be used in a `where` clause and are generally a bad idea.

24.8.9 DataTypes

`HDFStore` will map an object dtype to the `PyTables` underlying dtype. This means the following types are known to work:

Type	Represents missing values
floating : `float64, float32, float16`	`np.nan`
integer : `int64, int32, int8, uint64,uint32, uint8`	
boolean	
`datetime64[ns]`	`NaT`
`timedelta64[ns]`	`NaT`
categorical : see the section below	
object : `strings`	`np.nan`

`unicode` columns are not supported, and **WILL FAIL**.

24.8.9.1 Categorical Data

You can write data that contains `category` dtypes to a `HDFStore`. Queries work the same as if it was an object array. However, the `category` dtyped data is stored in a more efficient manner.

```
In [473]: dfcat = pd.DataFrame({ 'A' : pd.Series(list('aabbcdba')).astype('category'),
   .....:                        'B' : np.random.randn(8) })
   .....:

In [474]: dfcat
Out[474]:
   A         B
0  a  0.603273
1  a  0.262554
2  b -0.979586
3  b  2.132387
4  c  0.892485
5  d  1.996474
6  b  0.231425
7  a  0.980070

In [475]: dfcat.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
A    category
B     float64
dtype: object

In [476]: cstore = pd.HDFStore('cats.h5', mode='w')

In [477]: cstore.append('dfcat', dfcat, format='table', data_columns=['A'])

In [478]: result = cstore.select('dfcat', where="A in ['b','c']")

In [479]: result
Out[479]:
   A         B
2  b -0.979586
3  b  2.132387
4  c  0.892485
6  b  0.231425

In [480]: result.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[480]:␣
↪
A    category
B     float64
dtype: object
```

24.8.9.2 String Columns

min_itemsize

The underlying implementation of `HDFStore` uses a fixed column width (itemsize) for string columns. A string column itemsize is calculated as the maximum of the length of data (for that column) that is passed to the `HDFStore`, **in the first append**. Subsequent appends, may introduce a string for a column **larger** than the column can hold, an

Exception will be raised (otherwise you could have a silent truncation of these columns, leading to loss of information). In the future we may relax this and allow a user-specified truncation to occur.

Pass `min_itemsize` on the first table creation to a-priori specify the minimum length of a particular string column. `min_itemsize` can be an integer, or a dict mapping a column name to an integer. You can pass `values` as a key to allow all *indexables* or *data_columns* to have this min_itemsize.

Passing a `min_itemsize` dict will cause all passed columns to be created as *data_columns* automatically.

Note: If you are not passing any `data_columns`, then the `min_itemsize` will be the maximum of the length of any string passed

```
In [481]: dfs = pd.DataFrame(dict(A = 'foo', B = 'bar'),index=list(range(5)))

In [482]: dfs
Out[482]:
     A    B
0  foo  bar
1  foo  bar
2  foo  bar
3  foo  bar
4  foo  bar

# A and B have a size of 30
In [483]: store.append('dfs', dfs, min_itemsize = 30)

In [484]: store.get_storer('dfs').table
Out[484]:
/dfs/table (Table(5,)) ''
  description := {
  "index": Int64Col(shape=(), dflt=0, pos=0),
  "values_block_0": StringCol(itemsize=30, shape=(2,), dflt=b'', pos=1)}
  byteorder := 'little'
  chunkshape := (963,)
  autoindex := True
  colindexes := {
    "index": Index(6, medium, shuffle, zlib(1)).is_csi=False}

# A is created as a data_column with a size of 30
# B is size is calculated
In [485]: store.append('dfs2', dfs, min_itemsize = { 'A' : 30 })

In [486]: store.get_storer('dfs2').table
Out[486]:
/dfs2/table (Table(5,)) ''
  description := {
  "index": Int64Col(shape=(), dflt=0, pos=0),
  "values_block_0": StringCol(itemsize=3, shape=(1,), dflt=b'', pos=1),
  "A": StringCol(itemsize=30, shape=(), dflt=b'', pos=2)}
  byteorder := 'little'
  chunkshape := (1598,)
  autoindex := True
  colindexes := {
    "index": Index(6, medium, shuffle, zlib(1)).is_csi=False,
    "A": Index(6, medium, shuffle, zlib(1)).is_csi=False}
```

nan_rep

String columns will serialize a `np.nan` (a missing value) with the `nan_rep` string representation. This defaults to the string value `nan`. You could inadvertently turn an actual `nan` value into a missing value.

```
In [487]: dfss = pd.DataFrame(dict(A = ['foo','bar','nan']))

In [488]: dfss
Out[488]:
     A
0  foo
1  bar
2  nan

In [489]: store.append('dfss', dfss)

In [490]: store.select('dfss')
Out[490]:
     A
0  foo
1  bar
2  NaN

# here you need to specify a different nan rep
In [491]: store.append('dfss2', dfss, nan_rep='_nan_')

In [492]: store.select('dfss2')
Out[492]:
     A
0  foo
1  bar
2  nan
```

24.8.10 External Compatibility

`HDFStore` writes `table` format objects in specific formats suitable for producing loss-less round trips to pandas objects. For external compatibility, `HDFStore` can read native `PyTables` format tables.

It is possible to write an `HDFStore` object that can easily be imported into `R` using the `rhdf5` library (Package website). Create a table format store like this:

```
In [493]: np.random.seed(1)

In [494]: df_for_r = pd.DataFrame({"first": np.random.rand(100),
   .....:                          "second": np.random.rand(100),
   .....:                          "class": np.random.randint(0, 2, (100,))},
   .....:                          index=range(100))
   .....:

In [495]: df_for_r.head()
Out[495]:
   class     first    second
0      0  0.417022  0.326645
1      0  0.720324  0.527058
2      1  0.000114  0.885942
3      1  0.302333  0.357270
4      1  0.146756  0.908535

In [496]: store_export = pd.HDFStore('export.h5')
```

```
In [497]: store_export.append('df_for_r', df_for_r, data_columns=df_dc.columns)

In [498]: store_export
Out[498]:
<class 'pandas.io.pytables.HDFStore'>
File path: export.h5
```

In R this file can be read into a `data.frame` object using the `rhdf5` library. The following example function reads the corresponding column names and data values from the values and assembles them into a `data.frame`:

```
# Load values and column names for all datasets from corresponding nodes and
# insert them into one data.frame object.

library(rhdf5)

loadhdf5data <- function(h5File) {

listing <- h5ls(h5File)
# Find all data nodes, values are stored in *_values and corresponding column
# titles in *_items
data_nodes <- grep("_values", listing$name)
name_nodes <- grep("_items", listing$name)
data_paths = paste(listing$group[data_nodes], listing$name[data_nodes], sep = "/")
name_paths = paste(listing$group[name_nodes], listing$name[name_nodes], sep = "/")
columns = list()
for (idx in seq(data_paths)) {
  # NOTE: matrices returned by h5read have to be transposed to obtain
  # required Fortran order!
  data <- data.frame(t(h5read(h5File, data_paths[idx])))
  names <- t(h5read(h5File, name_paths[idx]))
  entry <- data.frame(data)
  colnames(entry) <- names
  columns <- append(columns, entry)
}

data <- data.frame(columns)

return(data)
}
```

Now you can import the `DataFrame` into R:

```
> data = loadhdf5data("transfer.hdf5")
> head(data)
         first    second class
1 0.4170220047 0.3266449     0
2 0.7203244934 0.5270581     0
3 0.0001143748 0.8859421     1
4 0.3023325726 0.3572698     1
5 0.1467558908 0.9085352     1
6 0.0923385948 0.6233601     1
```

Note: The R function lists the entire HDF5 file's contents and assembles the `data.frame` object from all matching nodes, so use this only as a starting point if you have stored multiple `DataFrame` objects to a single HDF5 file.

24.8.11 Performance

- `tables` format come with a writing performance penalty as compared to `fixed` stores. The benefit is the ability to append/delete and query (potentially very large amounts of data). Write times are generally longer as compared with regular stores. Query times can be quite fast, especially on an indexed axis.
- You can pass `chunksize=<int>` to `append`, specifying the write chunksize (default is 50000). This will significantly lower your memory usage on writing.
- You can pass `expectedrows=<int>` to the first `append`, to set the TOTAL number of expected rows that `PyTables` will expected. This will optimize read/write performance.
- Duplicate rows can be written to tables, but are filtered out in selection (with the last items being selected; thus a table is unique on major, minor pairs)
- A `PerformanceWarning` will be raised if you are attempting to store types that will be pickled by PyTables (rather than stored as endemic types). See Here for more information and some solutions.

24.9 Feather

New in version 0.20.0.

Feather provides binary columnar serialization for data frames. It is designed to make reading and writing data frames efficient, and to make sharing data across data analysis languages easy.

Feather is designed to faithfully serialize and de-serialize DataFrames, supporting all of the pandas dtypes, including extension dtypes such as categorical and datetime with tz.

Several caveats.

- This is a newer library, and the format, though stable, is not guaranteed to be backward compatible to the earlier versions.
- The format will NOT write an `Index`, or `MultiIndex` for the `DataFrame` and will raise an error if a non-default one is provided. You can simply `.reset_index()` in order to store the index.
- Duplicate column names and non-string columns names are not supported
- Non supported types include `Period` and actual python object types. These will raise a helpful error message on an attempt at serialization.

See the Full Documentation

```
In [499]: df = pd.DataFrame({'a': list('abc'),
   .....:                    'b': list(range(1, 4)),
   .....:                    'c': np.arange(3, 6).astype('u1'),
   .....:                    'd': np.arange(4.0, 7.0, dtype='float64'),
   .....:                    'e': [True, False, True],
   .....:                    'f': pd.Categorical(list('abc')),
   .....:                    'g': pd.date_range('20130101', periods=3),
   .....:                    'h': pd.date_range('20130101', periods=3, tz='US/Eastern
↪'),
   .....:                    'i': pd.date_range('20130101', periods=3, freq='ns')})
   .....:

In [500]: df
Out[500]:
   a  b  c    d      e  f          g                          h          i
0  a  1  3  4.0   True  a 2013-01-01 2013-01-01 00:00:00-05:00 2013-01-01
1  b  2  4  5.0  False  b 2013-01-02 2013-01-02 00:00:00-05:00 2013-01-01
```

```
2  c  3  5  6.0   True  c 2013-01-03 2013-01-03 00:00:00-05:00 2013-01-01

In [501]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a                         object
b                          int64
c                          uint8
d                        float64
e                           bool
f                       category
g                 datetime64[ns]
h    datetime64[ns, US/Eastern]
i                 datetime64[ns]
dtype: object
```

Write to a feather file.

```
In [502]: df.to_feather('example.feather')
```

Read from a feather file.

```
In [503]: result = pd.read_feather('example.feather')

In [504]: result
Out[504]:
   a  b  c    d      e  f          g                         h          i
0  a  1  3  4.0   True  a 2013-01-01 2013-01-01 00:00:00-05:00 2013-01-01
1  b  2  4  5.0  False  b 2013-01-02 2013-01-02 00:00:00-05:00 2013-01-01
2  c  3  5  6.0   True  c 2013-01-03 2013-01-03 00:00:00-05:00 2013-01-01

# we preserve dtypes
In [505]: result.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a                         object
b                          int64
c                          uint8
d                        float64
e                           bool
f                       category
g                 datetime64[ns]
h    datetime64[ns, US/Eastern]
i                 datetime64[ns]
dtype: object
```

24.10 Parquet

New in version 0.21.0.

Apache Parquet provides a partitioned binary columnar serialization for data frames. It is designed to make reading and writing data frames efficient, and to make sharing data across data analysis languages easy. Parquet can use a variety of compression techniques to shrink the file size as much as possible while still maintaining good read performance.

Parquet is designed to faithfully serialize and de-serialize `DataFrame` s, supporting all of the pandas dtypes, including extension dtypes such as datetime with tz.

Several caveats.

- The format will NOT write an `Index`, or `MultiIndex` for the `DataFrame` and will raise an error if a non-default one is provided. You can simply `.reset_index(drop=True)` in order to store the index.
- Duplicate column names and non-string columns names are not supported
- Categorical dtypes can be serialized to parquet, but will de-serialize as `object` dtype.
- Non supported types include `Period` and actual python object types. These will raise a helpful error message on an attempt at serialization.

You can specifiy an `engine` to direct the serialization. This can be one of `pyarrow`, or `fastparquet`, or `auto`. If the engine is NOT specified, then the `pd.options.io.parquet.engine` option is checked; if this is also `auto`, then then `pyarrow` is tried, and falling back to `fastparquet`.

See the documentation for pyarrow and fastparquet

Note: These engines are very similar and should read/write nearly identical parquet format files. These libraries differ by having different underlying dependencies (`fastparquet` by using `numba`, while `pyarrow` uses a c-library).

```
In [506]: df = pd.DataFrame({'a': list('abc'),
   .....:                    'b': list(range(1, 4)),
   .....:                    'c': np.arange(3, 6).astype('u1'),
   .....:                    'd': np.arange(4.0, 7.0, dtype='float64'),
   .....:                    'e': [True, False, True],
   .....:                    'f': pd.date_range('20130101', periods=3),
   .....:                    'g': pd.date_range('20130101', periods=3, tz='US/Eastern
↪')})
   .....:

In [507]: df
Out[507]:
   a  b  c    d      e          f                         g
0  a  1  3  4.0   True 2013-01-01 2013-01-01 00:00:00-05:00
1  b  2  4  5.0  False 2013-01-02 2013-01-02 00:00:00-05:00
2  c  3  5  6.0   True 2013-01-03 2013-01-03 00:00:00-05:00

In [508]: df.dtypes
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
a                        object
b                         int64
c                         uint8
d                       float64
e                          bool
f                datetime64[ns]
g    datetime64[ns, US/Eastern]
dtype: object
```

Write to a parquet file.

```
In [509]: df.to_parquet('example_pa.parquet', engine='pyarrow')

In [510]: df.to_parquet('example_fp.parquet', engine='fastparquet')
```

Read from a parquet file.

```
In [511]: result = pd.read_parquet('example_pa.parquet', engine='pyarrow')

In [512]: result = pd.read_parquet('example_fp.parquet', engine='fastparquet')

In [513]: result.dtypes
Out[513]:
a            object
b             int64
c             uint8
d           float64
e              bool
f    datetime64[ns]
g    datetime64[ns]
dtype: object
```

24.11 SQL Queries

The `pandas.io.sql` module provides a collection of query wrappers to both facilitate data retrieval and to reduce dependency on DB-specific API. Database abstraction is provided by SQLAlchemy if installed. In addition you will need a driver library for your database. Examples of such drivers are psycopg2 for PostgreSQL or pymysql for MySQL. For SQLite this is included in Python's standard library by default. You can find an overview of supported drivers for each SQL dialect in the SQLAlchemy docs.

If SQLAlchemy is not installed, a fallback is only provided for sqlite (and for mysql for backwards compatibility, but this is deprecated and will be removed in a future version). This mode requires a Python database adapter which respect the Python DB-API.

See also some *cookbook examples* for some advanced strategies.

The key functions are:

read_sql_table(table_name, con[, schema, ...])	Read SQL database table into a DataFrame.
read_sql_query(sql, con[, index_col, ...])	Read SQL query into a DataFrame.
read_sql(sql, con[, index_col, ...])	Read SQL query or database table into a DataFrame.
DataFrame.to_sql(name, con[, flavor, ...])	Write records stored in a DataFrame to a SQL database.

24.11.1 pandas.read_sql_table

pandas.**read_sql_table**(*table_name*, *con*, *schema=None*, *index_col=None*, *coerce_float=True*, *parse_dates=None*, *columns=None*, *chunksize=None*)

Read SQL database table into a DataFrame.

Given a table name and a SQLAlchemy connectable, returns a DataFrame. This function does not support DBAPI connections.

Parameters **table_name** : string

Name of SQL table in database.

con : SQLAlchemy connectable (or database string URI)

SQLite DBAPI connection mode not supported.

schema : string, default None

Name of SQL schema in database to query (if database flavor supports this). Uses default schema if None (default).

index_col : string or list of strings, optional, default: None

Column(s) to set as index(MultiIndex).

coerce_float : boolean, default True

Attempts to convert values of non-string, non-numeric objects (like decimal.Decimal) to floating point. Can result in loss of Precision.

parse_dates : list or dict, default: None

- List of column names to parse as dates.
- Dict of `{column_name: format string}` where format string is strftime compatible in case of parsing string times or is one of (D, s, ns, ms, us) in case of parsing integer timestamps.
- Dict of `{column_name: arg dict}`, where the arg dict corresponds to the keyword arguments of `pandas.to_datetime()` Especially useful with databases without native Datetime support, such as SQLite.

columns : list, default: None

List of column names to select from SQL table

chunksize : int, default None

If specified, returns an iterator where *chunksize* is the number of rows to include in each chunk.

Returns DataFrame

See also:

read_sql_query Read SQL query into a DataFrame.

read_sql

Notes

Any datetime values with time zone information will be converted to UTC.

24.11.2 pandas.read_sql_query

`pandas.read_sql_query(sql, con, index_col=None, coerce_float=True, params=None, parse_dates=None, chunksize=None)`

Read SQL query into a DataFrame.

Returns a DataFrame corresponding to the result set of the query string. Optionally provide an *index_col* parameter to use one of the columns as the index, otherwise default integer index will be used.

Parameters **sql** : string SQL query or SQLAlchemy Selectable (select or text object)

SQL query to be executed.

con : SQLAlchemy connectable(engine/connection), database string URI,

or sqlite3 DBAPI2 connection Using SQLAlchemy makes it possible to use any DB supported by that library. If a DBAPI2 object, only sqlite3 is supported.

index_col : string or list of strings, optional, default: None

Column(s) to set as index(MultiIndex).

coerce_float : boolean, default True

Attempts to convert values of non-string, non-numeric objects (like decimal.Decimal) to floating point. Useful for SQL result sets.

params : list, tuple or dict, optional, default: None

List of parameters to pass to execute method. The syntax used to pass parameters is database driver dependent. Check your database driver documentation for which of the five syntax styles, described in PEP 249's paramstyle, is supported. Eg. for psycopg2, uses %(name)s so use params={'name' : 'value'}

parse_dates : list or dict, default: None

- List of column names to parse as dates.
- Dict of `{column_name: format string}` where format string is strftime compatible in case of parsing string times, or is one of (D, s, ns, ms, us) in case of parsing integer timestamps.
- Dict of `{column_name: arg dict}`, where the arg dict corresponds to the keyword arguments of *pandas.to_datetime()* Especially useful with databases without native Datetime support, such as SQLite.

chunksize : int, default None

If specified, return an iterator where *chunksize* is the number of rows to include in each chunk.

Returns DataFrame

See also:

read_sql_table Read SQL database table into a DataFrame.

read_sql

Notes

Any datetime values with time zone information parsed via the *parse_dates* parameter will be converted to UTC.

24.11.3 pandas.read_sql

pandas.**read_sql**(*sql*, *con*, *index_col=None*, *coerce_float=True*, *params=None*, *parse_dates=None*, *columns=None*, *chunksize=None*)

Read SQL query or database table into a DataFrame.

Parameters **sql** : string or SQLAlchemy Selectable (select or text object)

SQL query to be executed.

con : SQLAlchemy connectable(engine/connection) or database string URI

or DBAPI2 connection (fallback mode) Using SQLAlchemy makes it possible to use any DB supported by that library. If a DBAPI2 object, only sqlite3 is supported.

index_col : string or list of strings, optional, default: None

Column(s) to set as index(MultiIndex).

coerce_float : boolean, default True

Attempts to convert values of non-string, non-numeric objects (like decimal.Decimal) to floating point, useful for SQL result sets.

params : list, tuple or dict, optional, default: None

List of parameters to pass to execute method. The syntax used to pass parameters is database driver dependent. Check your database driver documentation for which of the five syntax styles, described in PEP 249's paramstyle, is supported. Eg. for psycopg2, uses %(name)s so use params={'name' : 'value'}

parse_dates : list or dict, default: None

- List of column names to parse as dates.
- Dict of `{column_name: format string}` where format string is strftime compatible in case of parsing string times, or is one of (D, s, ns, ms, us) in case of parsing integer timestamps.
- Dict of `{column_name: arg dict}`, where the arg dict corresponds to the keyword arguments of *`pandas.to_datetime()`* Especially useful with databases without native Datetime support, such as SQLite.

columns : list, default: None

List of column names to select from SQL table (only used when reading a table).

chunksize : int, default None

If specified, return an iterator where *chunksize* is the number of rows to include in each chunk.

Returns DataFrame

See also:

read_sql_table Read SQL database table into a DataFrame.

read_sql_query Read SQL query into a DataFrame.

Notes

This function is a convenience wrapper around `read_sql_table` and `read_sql_query` (and for backward compatibility) and will delegate to the specific function depending on the provided input (database table name or SQL query). The delegated function might have more specific notes about their functionality not listed here.

24.11.4 pandas.DataFrame.to_sql

`DataFrame.`**`to_sql`**(*name*, *con*, *flavor=None*, *schema=None*, *if_exists='fail'*, *index=True*, *index_label=None*, *chunksize=None*, *dtype=None*)

Write records stored in a DataFrame to a SQL database.

Parameters **name** : string

Name of SQL table

con : SQLAlchemy engine or DBAPI2 connection (legacy mode)

Using SQLAlchemy makes it possible to use any DB supported by that library. If a DBAPI2 object, only sqlite3 is supported.

flavor : 'sqlite', default None

Deprecated since version 0.19.0: 'sqlite' is the only supported option if SQLAlchemy is not used.

schema : string, default None

Specify the schema (if database flavor supports this). If None, use default schema.

if_exists : {'fail', 'replace', 'append'}, default 'fail'

- fail: If table exists, do nothing.
- replace: If table exists, drop it, recreate it, and insert data.
- append: If table exists, insert data. Create if does not exist.

index : boolean, default True

Write DataFrame index as a column.

index_label : string or sequence, default None

Column label for index column(s). If None is given (default) and *index* is True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

chunksize : int, default None

If not None, then rows will be written in batches of this size at a time. If None, all rows will be written at once.

dtype : dict of column name to SQL type, default None

Optional specifying the datatype for columns. The SQL type should be a SQLAlchemy type, or a string for sqlite3 fallback connection.

Note: The function *read_sql()* is a convenience wrapper around *read_sql_table()* and *read_sql_query()* (and for backward compatibility) and will delegate to specific function depending on the provided input (database table name or sql query). Table names do not need to be quoted if they have special characters.

In the following example, we use the SQlite SQL database engine. You can use a temporary SQLite database where data are stored in "memory".

To connect with SQLAlchemy you use the `create_engine()` function to create an engine object from database URI. You only need to create the engine once per database you are connecting to. For more information on `create_engine()` and the URI formatting, see the examples below and the SQLAlchemy documentation

```
In [514]: from sqlalchemy import create_engine

# Create your engine.
In [515]: engine = create_engine('sqlite:///:memory:')
```

If you want to manage your own connections you can pass one of those instead:

```
with engine.connect() as conn, conn.begin():
    data = pd.read_sql_table('data', conn)
```

24.11.5 Writing DataFrames

Assuming the following data is in a DataFrame `data`, we can insert it into the database using *`to_sql()`*.

id	Date	Col_1	Col_2	Col_3
26	2012-10-18	X	25.7	True
42	2012-10-19	Y	-12.4	False
63	2012-10-20	Z	5.73	True

```
In [516]: data.to_sql('data', engine)
```

With some databases, writing large DataFrames can result in errors due to packet size limitations being exceeded. This can be avoided by setting the `chunksize` parameter when calling `to_sql`. For example, the following writes `data` to the database in batches of 1000 rows at a time:

```
In [517]: data.to_sql('data_chunked', engine, chunksize=1000)
```

24.11.5.1 SQL data types

`to_sql()` will try to map your data to an appropriate SQL data type based on the dtype of the data. When you have columns of dtype `object`, pandas will try to infer the data type.

You can always override the default type by specifying the desired SQL type of any of the columns by using the `dtype` argument. This argument needs a dictionary mapping column names to SQLAlchemy types (or strings for the sqlite3 fallback mode). For example, specifying to use the sqlalchemy `String` type instead of the default `Text` type for string columns:

```
In [518]: from sqlalchemy.types import String

In [519]: data.to_sql('data_dtype', engine, dtype={'Col_1': String})
```

Note: Due to the limited support for timedelta's in the different database flavors, columns with type `timedelta64` will be written as integer values as nanoseconds to the database and a warning will be raised.

Note: Columns of `category` dtype will be converted to the dense representation as you would get with `np.asarray(categorical)` (e.g. for string categories this gives an array of strings). Because of this, reading the database table back in does **not** generate a categorical.

24.11.6 Reading Tables

`read_sql_table()` will read a database table given the table name and optionally a subset of columns to read.

Note: In order to use *`read_sql_table()`*, you **must** have the SQLAlchemy optional dependency installed.

```
In [520]: pd.read_sql_table('data', engine)
Out[520]:
   index  id       Date Col_1  Col_2  Col_3
0      0  26 2010-10-18     X  27.50   True
```

```
1       1  42 2010-10-19     Y -12.50  False
2       2  63 2010-10-20     Z   5.73   True
```

You can also specify the name of the column as the DataFrame index, and specify a subset of columns to be read.

```
In [521]: pd.read_sql_table('data', engine, index_col='id')
Out[521]: 
    index       Date Col_1  Col_2  Col_3
id                                      
26      0 2010-10-18     X  27.50   True
42      1 2010-10-19     Y -12.50  False
63      2 2010-10-20     Z   5.73   True

In [522]: pd.read_sql_table('data', engine, columns=['Col_1', 'Col_2'])
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
  Col_1  Col_2
0     X  27.50
1     Y -12.50
2     Z   5.73
```

And you can explicitly force columns to be parsed as dates:

```
In [523]: pd.read_sql_table('data', engine, parse_dates=['Date'])
Out[523]: 
   index  id       Date Col_1  Col_2  Col_3
0      0  26 2010-10-18     X  27.50   True
1      1  42 2010-10-19     Y -12.50  False
2      2  63 2010-10-20     Z   5.73   True
```

If needed you can explicitly specify a format string, or a dict of arguments to pass to *`pandas.to_datetime()`*:

```
pd.read_sql_table('data', engine, parse_dates={'Date': '%Y-%m-%d'})
pd.read_sql_table('data', engine, parse_dates={'Date': {'format': '%Y-%m-%d %H:%M:%S'}
↪})
```

You can check if a table exists using `has_table()`

24.11.7 Schema support

Reading from and writing to different schema's is supported through the `schema` keyword in the *`read_sql_table()`* and *`to_sql()`* functions. Note however that this depends on the database flavor (sqlite does not have schema's). For example:

```
df.to_sql('table', engine, schema='other_schema')
pd.read_sql_table('table', engine, schema='other_schema')
```

24.11.8 Querying

You can query using raw SQL in the *`read_sql_query()`* function. In this case you must use the SQL variant appropriate for your database. When using SQLAlchemy, you can also pass SQLAlchemy Expression language constructs, which are database-agnostic.

```
In [524]: pd.read_sql_query('SELECT * FROM data', engine)
Out[524]:
   index  id                       Date Col_1  Col_2  Col_3
0      0  26  2010-10-18 00:00:00.000000     X  27.50      1
1      1  42  2010-10-19 00:00:00.000000     Y -12.50      0
2      2  63  2010-10-20 00:00:00.000000     Z   5.73      1
```

Of course, you can specify a more "complex" query.

```
In [525]: pd.read_sql_query("SELECT id, Col_1, Col_2 FROM data WHERE id = 42;",␣
↪engine)
Out[525]:
   id Col_1  Col_2
0  42     Y  -12.5
```

The *read_sql_query()* function supports a `chunksize` argument. Specifying this will return an iterator through chunks of the query result:

```
In [526]: df = pd.DataFrame(np.random.randn(20, 3), columns=list('abc'))

In [527]: df.to_sql('data_chunks', engine, index=False)
```

```
In [528]: for chunk in pd.read_sql_query("SELECT * FROM data_chunks", engine,␣
↪chunksize=5):
   .....:     print(chunk)
   .....:
          a         b         c
0  0.280665 -0.073113  1.160339
1  0.369493  1.904659  1.111057
2  0.659050 -1.627438  0.602319
3  0.420282  0.810952  1.044442
4 -0.400878  0.824006 -0.562305
          a         b         c
0  1.954878 -1.331952 -1.760689
1 -1.650721 -0.890556 -1.119115
2  1.956079 -0.326499 -1.342676
3  1.114383 -0.586524 -1.236853
4  0.875839  0.623362 -0.434957
          a         b         c
0  1.407540  0.129102  1.616950
1  0.502741  1.558806  0.109403
2 -1.219744  2.449369 -0.545774
3 -0.198838 -0.700399 -0.203394
4  0.242669  0.201830  0.661020
          a         b         c
0  1.792158 -0.120465 -1.233121
1 -1.182318 -0.665755 -1.674196
2  0.825030 -0.498214 -0.310985
3 -0.001891 -1.396620 -0.861316
4  0.674712  0.618539 -0.443172
```

You can also run a plain query without creating a dataframe with `execute()`. This is useful for queries that don't return values, such as INSERT. This is functionally equivalent to calling `execute` on the SQLAlchemy engine or db connection object. Again, you must use the SQL syntax variant appropriate for your database.

```
from pandas.io import sql
sql.execute('SELECT * FROM table_name', engine)
```

```
sql.execute('INSERT INTO table_name VALUES(?, ?, ?)', engine, params=[('id', 1, 12.2,␣
↪True)])
```

24.11.9 Engine connection examples

To connect with SQLAlchemy you use the `create_engine()` function to create an engine object from database URI. You only need to create the engine once per database you are connecting to.

```
from sqlalchemy import create_engine

engine = create_engine('postgresql://scott:tiger@localhost:5432/mydatabase')

engine = create_engine('mysql+mysqldb://scott:tiger@localhost/foo')

engine = create_engine('oracle://scott:tiger@127.0.0.1:1521/sidname')

engine = create_engine('mssql+pyodbc://mydsn')

# sqlite://<nohostname>/<path>
# where <path> is relative:
engine = create_engine('sqlite:///foo.db')

# or absolute, starting with a slash:
engine = create_engine('sqlite:////absolute/path/to/foo.db')
```

For more information see the examples the SQLAlchemy documentation

24.11.10 Advanced SQLAlchemy queries

You can use SQLAlchemy constructs to describe your query.

Use `sqlalchemy.text()` to specify query parameters in a backend-neutral way

```
In [529]: import sqlalchemy as sa

In [530]: pd.read_sql(sa.text('SELECT * FROM data where Col_1=:col1'), engine, params=
↪{'col1': 'X'})
Out[530]:
   index  id                        Date Col_1  Col_2  Col_3
0      0  26  2010-10-18 00:00:00.000000     X   27.5      1
```

If you have an SQLAlchemy description of your database you can express where conditions using SQLAlchemy expressions

```
In [531]: metadata = sa.MetaData()

In [532]: data_table = sa.Table('data', metadata,
   .....:     sa.Column('index', sa.Integer),
   .....:     sa.Column('Date', sa.DateTime),
   .....:     sa.Column('Col_1', sa.String),
   .....:     sa.Column('Col_2', sa.Float),
   .....:     sa.Column('Col_3', sa.Boolean),
   .....: )
   .....:
```

```
In [533]: pd.read_sql(sa.select([data_table]).where(data_table.c.Col_3 == True),␣
↪engine)
Out[533]:
   index       Date Col_1  Col_2  Col_3
0      0 2010-10-18     X  27.50   True
1      2 2010-10-20     Z   5.73   True
```

You can combine SQLAlchemy expressions with parameters passed to *read_sql()* using `sqlalchemy.bindparam()`

```
In [534]: import datetime as dt

In [535]: expr = sa.select([data_table]).where(data_table.c.Date > sa.bindparam('date
↪'))

In [536]: pd.read_sql(expr, engine, params={'date': dt.datetime(2010, 10, 18)})
Out[536]:
   index       Date Col_1  Col_2  Col_3
0      1 2010-10-19     Y -12.50  False
1      2 2010-10-20     Z   5.73   True
```

24.11.11 Sqlite fallback

The use of sqlite is supported without using SQLAlchemy. This mode requires a Python database adapter which respect the Python DB-API.

You can create connections like so:

```
import sqlite3
con = sqlite3.connect(':memory:')
```

And then issue the following queries:

```
data.to_sql('data', cnx)
pd.read_sql_query("SELECT * FROM data", con)
```

24.12 Google BigQuery

> **Warning:** Starting in 0.20.0, pandas has split off Google BigQuery support into the separate package `pandas-gbq`. You can `pip install pandas-gbq` to get it.

The `pandas-gbq` package provides functionality to read/write from Google BigQuery.

pandas integrates with this external package. if `pandas-gbq` is installed, you can use the pandas methods `pd.read_gbq` and `DataFrame.to_gbq`, which will call the respective functions from `pandas-gbq`.

Full documentation can be found here

24.13 Stata Format

24.13.1 Writing to Stata format

The method `to_stata()` will write a DataFrame into a .dta file. The format version of this file is always 115 (Stata 12).

```
In [537]: df = pd.DataFrame(randn(10, 2), columns=list('AB'))

In [538]: df.to_stata('stata.dta')
```

Stata data files have limited data type support; only strings with 244 or fewer characters, `int8`, `int16`, `int32`, `float32` and `float64` can be stored in `.dta` files. Additionally, *Stata* reserves certain values to represent missing data. Exporting a non-missing value that is outside of the permitted range in Stata for a particular data type will retype the variable to the next larger size. For example, `int8` values are restricted to lie between -127 and 100 in Stata, and so variables with values above 100 will trigger a conversion to `int16`. `nan` values in floating points data types are stored as the basic missing data type (`.` in *Stata*).

Note: It is not possible to export missing data values for integer data types.

The *Stata* writer gracefully handles other data types including `int64`, `bool`, `uint8`, `uint16`, `uint32` by casting to the smallest supported type that can represent the data. For example, data with a type of `uint8` will be cast to `int8` if all values are less than 100 (the upper bound for non-missing `int8` data in *Stata*), or, if values are outside of this range, the variable is cast to `int16`.

Warning: Conversion from `int64` to `float64` may result in a loss of precision if `int64` values are larger than 2**53.

Warning: `StataWriter` and `to_stata()` only support fixed width strings containing up to 244 characters, a limitation imposed by the version 115 dta file format. Attempting to write *Stata* dta files with strings longer than 244 characters raises a `ValueError`.

24.13.2 Reading from Stata format

The top-level function `read_stata` will read a dta file and return either a DataFrame or a `StataReader` that can be used to read the file incrementally.

```
In [539]: pd.read_stata('stata.dta')
Out[539]:
   index         A         B
0      0  1.810535 -1.305727
1      1 -0.344987 -0.230840
2      2 -2.793085  1.937529
3      3  0.366332 -1.044589
4      4  2.051173  0.585662
5      5  0.429526 -0.606998
6      6  0.106223 -1.525680
7      7  0.795026 -0.374438
8      8  0.134048  1.202055
9      9  0.284748  0.262467
```

Specifying a `chunksize` yields a `StataReader` instance that can be used to read `chunksize` lines from the file at a time. The `StataReader` object can be used as an iterator.

```
In [540]: reader = pd.read_stata('stata.dta', chunksize=3)

In [541]: for df in reader:
   .....:     print(df.shape)
   .....:
(3, 3)
(3, 3)
(3, 3)
(1, 3)
```

For more fine-grained control, use `iterator=True` and specify `chunksize` with each call to `read()`.

```
In [542]: reader = pd.read_stata('stata.dta', iterator=True)

In [543]: chunk1 = reader.read(5)

In [544]: chunk2 = reader.read(5)
```

Currently the `index` is retrieved as a column.

The parameter `convert_categoricals` indicates whether value labels should be read and used to create a `Categorical` variable from them. Value labels can also be retrieved by the function `value_labels`, which requires `read()` to be called before use.

The parameter `convert_missing` indicates whether missing value representations in Stata should be preserved. If `False` (the default), missing values are represented as `np.nan`. If `True`, missing values are represented using `StataMissingValue` objects, and columns containing missing values will have `object` data type.

Note: *`read_stata()`* and `StataReader` support .dta formats 113-115 (Stata 10-12), 117 (Stata 13), and 118 (Stata 14).

Note: Setting `preserve_dtypes=False` will upcast to the standard pandas data types: `int64` for all integer types and `float64` for floating point data. By default, the Stata data types are preserved when importing.

24.13.2.1 Categorical Data

`Categorical` data can be exported to *Stata* data files as value labeled data. The exported data consists of the underlying category codes as integer data values and the categories as value labels. *Stata* does not have an explicit equivalent to a `Categorical` and information about *whether* the variable is ordered is lost when exporting.

Warning: *Stata* only supports string value labels, and so `str` is called on the categories when exporting data. Exporting `Categorical` variables with non-string categories produces a warning, and can result a loss of information if the `str` representations of the categories are not unique.

Labeled data can similarly be imported from *Stata* data files as `Categorical` variables using the keyword argument `convert_categoricals` (`True` by default). The keyword argument `order_categoricals` (`True` by default) determines whether imported `Categorical` variables are ordered.

Note: When importing categorical data, the values of the variables in the *Stata* data file are not preserved since `Categorical` variables always use integer data types between `-1` and `n-1` where `n` is the number of categories. If the original values in the *Stata* data file are required, these can be imported by setting `convert_categoricals=False`, which will import original data (but not the variable labels). The original values can be matched to the imported categorical data since there is a simple mapping between the original *Stata* data values and the category codes of imported Categorical variables: missing values are assigned code `-1`, and the smallest original value is assigned `0`, the second smallest is assigned `1` and so on until the largest original value is assigned the code `n-1`.

Note: *Stata* supports partially labeled series. These series have value labels for some but not all data values. Importing a partially labeled series will produce a `Categorical` with string categories for the values that are labeled and numeric categories for values with no label.

24.14 SAS Formats

New in version 0.17.0.

The top-level function `read_sas()` can read (but not write) SAS *xport* (.XPT) and *SAS7BDAT* (.sas7bdat) format files were added in *v0.18.0*.

SAS files only contain two value types: ASCII text and floating point values (usually 8 bytes but sometimes truncated). For xport files, there is no automatic type conversion to integers, dates, or categoricals. For SAS7BDAT files, the format codes may allow date variables to be automatically converted to dates. By default the whole file is read and returned as a `DataFrame`.

Specify a `chunksize` or use `iterator=True` to obtain reader objects (`XportReader` or `SAS7BDATReader`) for incrementally reading the file. The reader objects also have attributes that contain additional information about the file and its variables.

Read a SAS7BDAT file:

```
df = pd.read_sas('sas_data.sas7bdat')
```

Obtain an iterator and read an XPORT file 100,000 lines at a time:

```
rdr = pd.read_sas('sas_xport.xpt', chunk=100000)
for chunk in rdr:
    do_something(chunk)
```

The specification for the xport file format is available from the SAS web site.

No official documentation is available for the SAS7BDAT format.

24.15 Other file formats

pandas itself only supports IO with a limited set of file formats that map cleanly to its tabular data model. For reading and writing other file formats into and from pandas, we recommend these packages from the broader community.

24.15.1 netCDF

xarray provides data structures inspired by the pandas DataFrame for working with multi-dimensional datasets, with a focus on the netCDF file format and easy conversion to and from pandas.

24.16 Performance Considerations

This is an informal comparison of various IO methods, using pandas 0.20.3. Timings are machine dependent and small differences should be ignored.

```
In [1]: sz = 1000000
In [2]: df = pd.DataFrame({'A': randn(sz), 'B': [1] * sz})

In [3]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 2 columns):
A    1000000 non-null float64
B    1000000 non-null int64
dtypes: float64(1), int64(1)
memory usage: 15.3 MB
```

Writing

```
In [14]: %timeit test_sql_write(df)
2.37 s ± 36.6 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)

In [15]: %timeit test_hdf_fixed_write(df)
194 ms ± 65.9 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)

In [26]: %timeit test_hdf_fixed_write_compress(df)
119 ms ± 2.15 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)

In [16]: %timeit test_hdf_table_write(df)
623 ms ± 125 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)

In [27]: %timeit test_hdf_table_write_compress(df)
563 ms ± 23.7 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)

In [17]: %timeit test_csv_write(df)
3.13 s ± 49.9 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)

In [30]: %timeit test_feather_write(df)
103 ms ± 5.88 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)

In [31]: %timeit test_pickle_write(df)
109 ms ± 3.72 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)

In [32]: %timeit test_pickle_write_compress(df)
3.33 s ± 55.2 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

Reading

```
In [18]: %timeit test_sql_read()
1.35 s ± 14.7 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

```
In [19]: %timeit test_hdf_fixed_read()
14.3 ms ± 438 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)

In [28]: %timeit test_hdf_fixed_read_compress()
23.5 ms ± 672 µs per loop (mean ± std. dev. of 7 runs, 10 loops each)

In [20]: %timeit test_hdf_table_read()
35.4 ms ± 314 µs per loop (mean ± std. dev. of 7 runs, 10 loops each)

In [29]: %timeit test_hdf_table_read_compress()
42.6 ms ± 2.1 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)

In [22]: %timeit test_csv_read()
516 ms ± 27.1 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)

In [33]: %timeit test_feather_read()
4.06 ms ± 115 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)

In [34]: %timeit test_pickle_read()
6.5 ms ± 172 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)

In [35]: %timeit test_pickle_read_compress()
588 ms ± 3.57 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

Space on disk (in bytes)

```
34816000 Aug 21 18:00 test.sql
24009240 Aug 21 18:00 test_fixed.hdf
 7919610 Aug 21 18:00 test_fixed_compress.hdf
24458892 Aug 21 18:00 test_table.hdf
 8657116 Aug 21 18:00 test_table_compress.hdf
28520770 Aug 21 18:00 test.csv
16000248 Aug 21 18:00 test.feather
16000848 Aug 21 18:00 test.pkl
 7554108 Aug 21 18:00 test.pkl.compress
```

And here's the code

```
import os
import pandas as pd
import sqlite3
from numpy.random import randn
from pandas.io import sql

sz = 1000000
df = pd.DataFrame({'A': randn(sz), 'B': [1] * sz})

def test_sql_write(df):
    if os.path.exists('test.sql'):
        os.remove('test.sql')
    sql_db = sqlite3.connect('test.sql')
    df.to_sql(name='test_table', con=sql_db)
    sql_db.close()

def test_sql_read():
    sql_db = sqlite3.connect('test.sql')
    pd.read_sql_query("select * from test_table", sql_db)
    sql_db.close()
```

```
def test_hdf_fixed_write(df):
    df.to_hdf('test_fixed.hdf','test',mode='w')

def test_hdf_fixed_read():
    pd.read_hdf('test_fixed.hdf','test')

def test_hdf_fixed_write_compress(df):
    df.to_hdf('test_fixed_compress.hdf','test',mode='w',complib='blosc')

def test_hdf_fixed_read_compress():
    pd.read_hdf('test_fixed_compress.hdf','test')

def test_hdf_table_write(df):
    df.to_hdf('test_table.hdf','test',mode='w',format='table')

def test_hdf_table_read():
    pd.read_hdf('test_table.hdf','test')

def test_hdf_table_write_compress(df):
    df.to_hdf('test_table_compress.hdf','test',mode='w',complib='blosc',format='table
↪')

def test_hdf_table_read_compress():
    pd.read_hdf('test_table_compress.hdf','test')

def test_csv_write(df):
    df.to_csv('test.csv',mode='w')

def test_csv_read():
    pd.read_csv('test.csv',index_col=0)

def test_feather_write(df):
    df.to_feather('test.feather')

def test_feather_read():
    pd.read_feather('test.feather')

def test_pickle_write(df):
    df.to_pickle('test.pkl')

def test_pickle_read():
    pd.read_pickle('test.pkl')

def test_pickle_write_compress(df):
    df.to_pickle('test.pkl.compress', compression='xz')

def test_pickle_read_compress():
    pd.read_pickle('test.pkl.compress', compression='xz')
```

CHAPTER

TWENTYFIVE

REMOTE DATA ACCESS

25.1 DataReader

The sub-package `pandas.io.data` was deprecated in v.0.17 and removed in v.0.19. Instead there has been created a separately installable pandas-datareader package. This will allow the data modules to be independently updated on your pandas installation.

For code older than < 0.19 you should replace the imports of the following:

```
from pandas.io import data, wb
```

With:

```
from pandas_datareader import data, wb
```

CHAPTER

TWENTYSIX

ENHANCING PERFORMANCE

26.1 Cython (Writing C extensions for pandas)

For many use cases writing pandas in pure python and numpy is sufficient. In some computationally heavy applications however, it can be possible to achieve sizeable speed-ups by offloading work to cython.

This tutorial assumes you have refactored as much as possible in python, for example trying to remove for loops and making use of numpy vectorization, it's always worth optimising in python first.

This tutorial walks through a "typical" process of cythonizing a slow computation. We use an example from the cython documentation but in the context of pandas. Our final cythonized solution is around 100 times faster than the pure python.

26.1.1 Pure python

We have a DataFrame to which we want to apply a function row-wise.

```
In [1]: df = pd.DataFrame({'a': np.random.randn(1000),
   ...:                    'b': np.random.randn(1000),
   ...:                    'N': np.random.randint(100, 1000, (1000)),
   ...:                    'x': 'x'})
   ...:

In [2]: df
Out[2]:
       N         a         b  x
0    585  0.469112 -0.218470  x
1    841 -0.282863 -0.061645  x
2    251 -1.509059 -0.723780  x
3    972 -1.135632  0.551225  x
4    181  1.212112 -0.497767  x
5    458 -0.173215  0.837519  x
6    159  0.119209  1.103245  x
..   ...       ...       ... ..
993  190  0.131892  0.290162  x
994  931  0.342097  0.215341  x
995  374 -1.512743  0.874737  x
996  246  0.933753  1.120790  x
997  157 -0.308013  0.198768  x
998  977 -0.079915  1.757555  x
999  770 -1.010589 -1.115680  x

[1000 rows x 4 columns]
```

Here's the function in pure python:

```
In [3]: def f(x):
   ...:     return x * (x - 1)
   ...:

In [4]: def integrate_f(a, b, N):
   ...:     s = 0
   ...:     dx = (b - a) / N
   ...:     for i in range(N):
   ...:         s += f(a + i * dx)
   ...:     return s * dx
   ...:
```

We achieve our result by using `apply` (row-wise):

```
In [7]: %timeit df.apply(lambda x: integrate_f(x['a'], x['b'], x['N']), axis=1)
10 loops, best of 3: 174 ms per loop
```

But clearly this isn't fast enough for us. Let's take a look and see where the time is spent during this operation (limited to the most time consuming four calls) using the prun ipython magic function:

```
In [5]: %prun -l 4 df.apply(lambda x: integrate_f(x['a'], x['b'], x['N']), axis=1)
         671001 function calls (665992 primitive calls) in 0.256 seconds

   Ordered by: internal time
   List reduced from 145 to 4 due to restriction <4>

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     1000    0.136    0.000    0.200    0.000 <ipython-input-4-91e33489f136>
↪:1(integrate_f)
   552423    0.064    0.000    0.064    0.000 <ipython-input-3-bc41a25943f6>:1(f)
     3000    0.006    0.000    0.038    0.000 base.py:2534(get_value)
     3000    0.004    0.000    0.044    0.000 series.py:620(__getitem__)
```

By far the majority of time is spend inside either `integrate_f` or `f`, hence we'll concentrate our efforts cythonizing these two functions.

Note: In python 2 replacing the `range` with its generator counterpart (`xrange`) would mean the `range` line would vanish. In python 3 `range` is already a generator.

26.1.2 Plain cython

First we're going to need to import the cython magic function to ipython (for cython versions < 0.21 you can use `%load_ext cythonmagic`):

```
In [6]: %load_ext Cython
```

Now, let's simply copy our functions over to cython as is (the suffix is here to distinguish between function versions):

```
In [7]: %%cython
   ...: def f_plain(x):
   ...:     return x * (x - 1)
   ...: def integrate_f_plain(a, b, N):
   ...:     s = 0
```

```
   ...:     dx = (b - a) / N
   ...:     for i in range(N):
   ...:         s += f_plain(a + i * dx)
   ...:     return s * dx
   ...:
```

Note: If you're having trouble pasting the above into your ipython, you may need to be using bleeding edge ipython for paste to play well with cell magics.

```
In [4]: %timeit df.apply(lambda x: integrate_f_plain(x['a'], x['b'], x['N']), axis=1)
10 loops, best of 3: 85.5 ms per loop
```

Already this has shaved a third off, not too bad for a simple copy and paste.

26.1.3 Adding type

We get another huge improvement simply by providing type information:

```
In [8]: %%cython
   ...: cdef double f_typed(double x) except? -2:
   ...:     return x * (x - 1)
   ...: cpdef double integrate_f_typed(double a, double b, int N):
   ...:     cdef int i
   ...:     cdef double s, dx
   ...:     s = 0
   ...:     dx = (b - a) / N
   ...:     for i in range(N):
   ...:         s += f_typed(a + i * dx)
   ...:     return s * dx
   ...:
```

```
In [4]: %timeit df.apply(lambda x: integrate_f_typed(x['a'], x['b'], x['N']), axis=1)
10 loops, best of 3: 20.3 ms per loop
```

Now, we're talking! It's now over ten times faster than the original python implementation, and we haven't *really* modified the code. Let's have another look at what's eating up time:

```
In [9]: %prun -l 4 df.apply(lambda x: integrate_f_typed(x['a'], x['b'], x['N']),␣
↪axis=1)
         118576 function calls (113567 primitive calls) in 0.053 seconds

   Ordered by: internal time
   List reduced from 142 to 4 due to restriction <4>

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     3000    0.006    0.000    0.035    0.000 base.py:2534(get_value)
     3000    0.004    0.000    0.040    0.000 series.py:620(__getitem__)
     9027    0.003    0.000    0.007    0.000 {built-in method builtins.getattr}
        1    0.003    0.003    0.052    0.052 {pandas._libs.lib.reduce}
```

26.1.4 Using ndarray

It's calling series... a lot! It's creating a Series from each row, and get-ting from both the index and the series (three times for each row). Function calls are expensive in python, so maybe we could minimise these by cythonizing the apply part.

Note: We are now passing ndarrays into the cython function, fortunately cython plays very nicely with numpy.

```
In [10]: %%cython
   ....: cimport numpy as np
   ....: import numpy as np
   ....: cdef double f_typed(double x) except? -2:
   ....:     return x * (x - 1)
   ....: cpdef double integrate_f_typed(double a, double b, int N):
   ....:     cdef int i
   ....:     cdef double s, dx
   ....:     s = 0
   ....:     dx = (b - a) / N
   ....:     for i in range(N):
   ....:         s += f_typed(a + i * dx)
   ....:     return s * dx
   ....: cpdef np.ndarray[double] apply_integrate_f(np.ndarray col_a, np.ndarray col_
↪b, np.ndarray col_N):
   ....:     assert (col_a.dtype == np.float and col_b.dtype == np.float and col_N.
↪dtype == np.int)
   ....:     cdef Py_ssize_t i, n = len(col_N)
   ....:     assert (len(col_a) == len(col_b) == n)
   ....:     cdef np.ndarray[double] res = np.empty(n)
   ....:     for i in range(len(col_a)):
   ....:         res[i] = integrate_f_typed(col_a[i], col_b[i], col_N[i])
   ....:     return res
   ....:
```

The implementation is simple, it creates an array of zeros and loops over the rows, applying our `integrate_f_typed`, and putting this in the zeros array.

Warning: You can **not pass** a `Series` directly as a `ndarray` typed parameter to a cython function. Instead pass the actual `ndarray` using the `.values` attribute of the Series. The reason is that the cython definition is specific to an ndarray and not the passed Series.

So, do not do this:

```
apply_integrate_f(df['a'], df['b'], df['N'])
```

But rather, use `.values` to get the underlying `ndarray`

```
apply_integrate_f(df['a'].values, df['b'].values, df['N'].values)
```

Note: Loops like this would be *extremely* slow in python, but in Cython looping over numpy arrays is *fast*.

```
In [4]: %timeit apply_integrate_f(df['a'].values, df['b'].values, df['N'].values)
1000 loops, best of 3: 1.25 ms per loop
```

We've gotten another big improvement. Let's check again where the time is spent:

```
In [11]: %prun -l 4 apply_integrate_f(df['a'].values, df['b'].values, df['N'].values)
         203 function calls in 0.001 seconds

   Ordered by: internal time
   List reduced from 53 to 4 due to restriction <4>

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
        1    0.001    0.001    0.001    0.001 {built-in method _cython_magic_
↪9df59845e7ff190f442cda6f3d60e56c.apply_integrate_f}
        3    0.000    0.000    0.000    0.000 internals.py:3860(iget)
        1    0.000    0.000    0.001    0.001 {built-in method builtins.exec}
        3    0.000    0.000    0.000    0.000 generic.py:1837(_get_item_cache)
```

As one might expect, the majority of the time is now spent in `apply_integrate_f`, so if we wanted to make anymore efficiencies we must continue to concentrate our efforts here.

26.1.5 More advanced techniques

There is still hope for improvement. Here's an example of using some more advanced cython techniques:

```
In [12]: %%cython
   ....: cimport cython
   ....: cimport numpy as np
   ....: import numpy as np
   ....: cdef double f_typed(double x) except? -2:
   ....:     return x * (x - 1)
   ....: cpdef double integrate_f_typed(double a, double b, int N):
   ....:     cdef int i
   ....:     cdef double s, dx
   ....:     s = 0
   ....:     dx = (b - a) / N
   ....:     for i in range(N):
   ....:         s += f_typed(a + i * dx)
   ....:     return s * dx
   ....: @cython.boundscheck(False)
   ....: @cython.wraparound(False)
   ....: cpdef np.ndarray[double] apply_integrate_f_wrap(np.ndarray[double] col_a, np.
↪ndarray[double] col_b, np.ndarray[int] col_N):
   ....:     cdef int i, n = len(col_N)
   ....:     assert len(col_a) == len(col_b) == n
   ....:     cdef np.ndarray[double] res = np.empty(n)
   ....:     for i in range(n):
   ....:         res[i] = integrate_f_typed(col_a[i], col_b[i], col_N[i])
   ....:     return res
   ....:
```

```
In [4]: %timeit apply_integrate_f_wrap(df['a'].values, df['b'].values, df['N'].values)
1000 loops, best of 3: 987 us per loop
```

Even faster, with the caveat that a bug in our cython code (an off-by-one error, for example) might cause a segfault because memory access isn't checked.

26.2 Using numba

A recent alternative to statically compiling cython code, is to use a *dynamic jit-compiler*, `numba`.

Numba gives you the power to speed up your applications with high performance functions written directly in Python. With a few annotations, array-oriented and math-heavy Python code can be just-in-time compiled to native machine instructions, similar in performance to C, C++ and Fortran, without having to switch languages or Python interpreters.

Numba works by generating optimized machine code using the LLVM compiler infrastructure at import time, runtime, or statically (using the included pycc tool). Numba supports compilation of Python to run on either CPU or GPU hardware, and is designed to integrate with the Python scientific software stack.

Note: You will need to install `numba`. This is easy with `conda`, by using: `conda install numba`, see *installing using miniconda*.

Note: As of `numba` version 0.20, pandas objects cannot be passed directly to numba-compiled functions. Instead, one must pass the `numpy` array underlying the `pandas` object to the numba-compiled function as demonstrated below.

26.2.1 Jit

Using `numba` to just-in-time compile your code. We simply take the plain python code from above and annotate with the `@jit` decorator.

```
import numba

@numba.jit
def f_plain(x):
   return x * (x - 1)

@numba.jit
def integrate_f_numba(a, b, N):
   s = 0
   dx = (b - a) / N
   for i in range(N):
       s += f_plain(a + i * dx)
   return s * dx

@numba.jit
def apply_integrate_f_numba(col_a, col_b, col_N):
   n = len(col_N)
   result = np.empty(n, dtype='float64')
   assert len(col_a) == len(col_b) == n
   for i in range(n):
      result[i] = integrate_f_numba(col_a[i], col_b[i], col_N[i])
   return result

def compute_numba(df):
   result = apply_integrate_f_numba(df['a'].values, df['b'].values, df['N'].values)
   return pd.Series(result, index=df.index, name='result')
```

Note that we directly pass `numpy` arrays to the numba function. `compute_numba` is just a wrapper that provides a nicer interface by passing/returning pandas objects.

```
In [4]: %timeit compute_numba(df)
1000 loops, best of 3: 798 us per loop
```

26.2.2 Vectorize

numba can also be used to write vectorized functions that do not require the user to explicitly loop over the observations of a vector; a vectorized function will be applied to each row automatically. Consider the following toy example of doubling each observation:

```
import numba

def double_every_value_nonumba(x):
    return x*2

@numba.vectorize
def double_every_value_withnumba(x):
    return x*2


# Custom function without numba
In [5]: %timeit df['col1_doubled'] = df.a.apply(double_every_value_nonumba)
1000 loops, best of 3: 797 us per loop

# Standard implementation (faster than a custom function)
In [6]: %timeit df['col1_doubled'] = df.a*2
1000 loops, best of 3: 233 us per loop

# Custom function with numba
In [7]: %timeit df['col1_doubled'] = double_every_value_withnumba(df.a.values)
1000 loops, best of 3: 145 us per loop
```

26.2.3 Caveats

Note: numba will execute on any function, but can only accelerate certain classes of functions.

numba is best at accelerating functions that apply numerical functions to numpy arrays. When passed a function that only uses operations it knows how to accelerate, it will execute in nopython mode.

If numba is passed a function that includes something it doesn't know how to work with – a category that currently includes sets, lists, dictionaries, or string functions – it will revert to object mode. In object mode, numba will execute but your code will not speed up significantly. If you would prefer that numba throw an error if it cannot compile a function in a way that speeds up your code, pass numba the argument nopython=True (e.g. @numba.jit(nopython=True)). For more on troubleshooting numba modes, see the numba troubleshooting page.

Read more in the numba docs.

26.3 Expression Evaluation via eval()

The top-level function *pandas.eval()* implements expression evaluation of *Series* and *DataFrame* objects.

Note: To benefit from using `eval()` you need to install `numexpr`. See the *recommended dependencies section* for more details.

The point of using `eval()` for expression evaluation rather than plain Python is two-fold: 1) large `DataFrame` objects are evaluated more efficiently and 2) large arithmetic and boolean expressions are evaluated all at once by the underlying engine (by default `numexpr` is used for evaluation).

Note: You should not use `eval()` for simple expressions or for expressions involving small DataFrames. In fact, `eval()` is many orders of magnitude slower for smaller expressions/objects than plain ol' Python. A good rule of thumb is to only use `eval()` when you have a `DataFrame` with more than 10,000 rows.

`eval()` supports all arithmetic expressions supported by the engine in addition to some extensions available only in pandas.

Note: The larger the frame and the larger the expression the more speedup you will see from using `eval()`.

26.3.1 Supported Syntax

These operations are supported by `pandas.eval()`:

- Arithmetic operations except for the left shift (<<) and right shift (>>) operators, e.g., `df + 2 * pi / s ** 4 % 42 - the_golden_ratio`
- Comparison operations, including chained comparisons, e.g., `2 < df < df2`
- Boolean operations, e.g., `df < df2 and df3 < df4 or not df_bool`
- `list` and `tuple` literals, e.g., `[1, 2]` or `(1, 2)`
- Attribute access, e.g., `df.a`
- Subscript expressions, e.g., `df[0]`
- Simple variable evaluation, e.g., `pd.eval('df')` (this is not very useful)
- Math functions, *sin*, *cos*, *exp*, *log*, *expm1*, *log1p*, *sqrt*, *sinh*, *cosh*, *tanh*, *arcsin*, *arccos*, *arctan*, *arccosh*, *arcsinh*, *arctanh*, *abs* and *arctan2*.

This Python syntax is **not** allowed:

- Expressions
  - Function calls other than math functions.
  - `is`/`is not` operations
  - `if` expressions
  - `lambda` expressions
  - `list`/`set`/`dict` comprehensions
  - Literal `dict` and `set` expressions
  - `yield` expressions
  - Generator expressions
  - Boolean expressions consisting of only scalar values

- Statements
  - Neither simple nor compound statements are allowed. This includes things like `for`, `while`, and `if`.

26.3.2 `eval()` Examples

`pandas.eval()` works well with expressions containing large arrays.

First let's create a few decent-sized arrays to play with:

```
In [13]: nrows, ncols = 20000, 100

In [14]: df1, df2, df3, df4 = [pd.DataFrame(np.random.randn(nrows, ncols)) for _ in␣
↪range(4)]
```

Now let's compare adding them together using plain ol' Python versus *`eval()`*:

```
In [15]: %timeit df1 + df2 + df3 + df4
11.9 ms +- 379 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

```
In [16]: %timeit pd.eval('df1 + df2 + df3 + df4')
8.29 ms +- 156 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

Now let's do the same thing but with comparisons:

```
In [17]: %timeit (df1 > 0) & (df2 > 0) & (df3 > 0) & (df4 > 0)
25.9 ms +- 654 us per loop (mean +- std. dev. of 7 runs, 10 loops each)
```

```
In [18]: %timeit pd.eval('(df1 > 0) & (df2 > 0) & (df3 > 0) & (df4 > 0)')
10.6 ms +- 336 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

`eval()` also works with unaligned pandas objects:

```
In [19]: s = pd.Series(np.random.randn(50))

In [20]: %timeit df1 + df2 + df3 + df4 + s
22.1 ms +- 583 us per loop (mean +- std. dev. of 7 runs, 10 loops each)
```

```
In [21]: %timeit pd.eval('df1 + df2 + df3 + df4 + s')
9.49 ms +- 411 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

Note: Operations such as

```
1 and 2  # would parse to 1 & 2, but should evaluate to 2
3 or 4  # would parse to 3 | 4, but should evaluate to 3
~1  # this is okay, but slower when using eval
```

should be performed in Python. An exception will be raised if you try to perform any boolean/bitwise operations with scalar operands that are not of type `bool` or `np.bool_`. Again, you should perform these kinds of operations in plain Python.

26.3.3 The `DataFrame.eval` method

In addition to the top level *pandas.eval()* function you can also evaluate an expression in the "context" of a *DataFrame*.

```
In [22]: df = pd.DataFrame(np.random.randn(5, 2), columns=['a', 'b'])

In [23]: df.eval('a + b')
Out[23]:
0   -0.246747
1    0.867786
2   -1.626063
3   -1.134978
4   -1.027798
dtype: float64
```

Any expression that is a valid *pandas.eval()* expression is also a valid *DataFrame.eval()* expression, with the added benefit that you don't have to prefix the name of the *DataFrame* to the column(s) you're interested in evaluating.

In addition, you can perform assignment of columns within an expression. This allows for *formulaic evaluation*. The assignment target can be a new column name or an existing column name, and it must be a valid Python identifier.

New in version 0.18.0.

The `inplace` keyword determines whether this assignment will performed on the original `DataFrame` or return a copy with the new column.

> **Warning:** For backwards compatability, `inplace` defaults to `True` if not specified. This will change in a future version of pandas - if your code depends on an inplace assignment you should update to explicitly set `inplace=True`

```
In [24]: df = pd.DataFrame(dict(a=range(5), b=range(5, 10)))

In [25]: df.eval('c = a + b', inplace=True)

In [26]: df.eval('d = a + b + c', inplace=True)

In [27]: df.eval('a = 1', inplace=True)

In [28]: df
Out[28]:
   a  b   c   d
0  1  5   5  10
1  1  6   7  14
2  1  7   9  18
3  1  8  11  22
4  1  9  13  26
```

When `inplace` is set to `False`, a copy of the `DataFrame` with the new or modified columns is returned and the original frame is unchanged.

```
In [29]: df
Out[29]:
   a  b   c   d
0  1  5   5  10
1  1  6   7  14
```

```
2  1  7   9  18
3  1  8  11  22
4  1  9  13  26

In [30]: df.eval('e = a - c', inplace=False)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  b   c   d   e
0  1  5   5  10  -4
1  1  6   7  14  -6
2  1  7   9  18  -8
3  1  8  11  22 -10
4  1  9  13  26 -12

In [31]: df
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   a  b   c   d
0  1  5   5  10
1  1  6   7  14
2  1  7   9  18
3  1  8  11  22
4  1  9  13  26
```

New in version 0.18.0.

As a convenience, multiple assignments can be performed by using a multi-line string.

```
In [32]: df.eval("""
   ....: c = a + b
   ....: d = a + b + c
   ....: a = 1""", inplace=False)
   ....:
Out[32]:
   a  b   c   d
0  1  5   6  12
1  1  6   7  14
2  1  7   8  16
3  1  8   9  18
4  1  9  10  20
```

The equivalent in standard Python would be

```
In [33]: df = pd.DataFrame(dict(a=range(5), b=range(5, 10)))

In [34]: df['c'] = df.a + df.b

In [35]: df['d'] = df.a + df.b + df.c

In [36]: df['a'] = 1

In [37]: df
Out[37]:
   a  b   c   d
0  1  5   5  10
1  1  6   7  14
2  1  7   9  18
3  1  8  11  22
```

```
4  1  9  13  26
```

New in version 0.18.0.

The `query` method gained the `inplace` keyword which determines whether the query modifies the original frame.

```
In [38]: df = pd.DataFrame(dict(a=range(5), b=range(5, 10)))

In [39]: df.query('a > 2')
Out[39]: 
   a  b
3  3  8
4  4  9

In [40]: df.query('a > 2', inplace=True)

In [41]: df
Out[41]: 
   a  b
3  3  8
4  4  9
```

Warning: Unlike with `eval`, the default value for `inplace` for `query` is `False`. This is consistent with prior versions of pandas.

26.3.4 Local Variables

You must *explicitly reference* any local variable that you want to use in an expression by placing the `@` character in front of the name. For example,

```
In [42]: df = pd.DataFrame(np.random.randn(5, 2), columns=list('ab'))

In [43]: newcol = np.random.randn(len(df))

In [44]: df.eval('b + @newcol')
Out[44]: 
0   -0.173926
1    2.493083
2   -0.881831
3   -0.691045
4    1.334703
dtype: float64

In [45]: df.query('b < @newcol')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[45
↪
          a         b
0  0.863987 -0.115998
2 -2.621419 -1.297879
```

If you don't prefix the local variable with `@`, pandas will raise an exception telling you the variable is undefined.

When using *`DataFrame.eval()`* and *`DataFrame.query()`*, this allows you to have a local variable and a *`DataFrame`* column with the same name in an expression.

```
In [46]: a = np.random.randn()

In [47]: df.query('@a < a')
Out[47]: 
          a         b
0  0.863987 -0.115998

In [48]: df.loc[a < df.a]  # same as the previous expression
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[48]: 
          a         b
0  0.863987 -0.115998
```

With *`pandas.eval()`* you cannot use the `@` prefix *at all*, because it isn't defined in that context. `pandas` will let you know this if you try to use `@` in a top-level call to *`pandas.eval()`*. For example,

```
In [49]: a, b = 1, 2

In [50]: pd.eval('@a + b')
Traceback (most recent call last):

  File "/Users/taugspurger/Envs/pandas-dev/lib/python3.6/site-packages/IPython/core/
↪interactiveshell.py", line 2862, in run_code
    exec(code_obj, self.user_global_ns, self.user_ns)

  File "<ipython-input-50-d778d4ee0271>", line 1, in <module>
    pd.eval('@a + b')

  File "/Users/taugspurger/Envs/pandas-dev/lib/python3.6/site-packages/pandas/pandas/
↪core/computation/eval.py", line 282, in eval
    _check_for_locals(expr, level, parser)

  File "/Users/taugspurger/Envs/pandas-dev/lib/python3.6/site-packages/pandas/pandas/
↪core/computation/eval.py", line 149, in _check_for_locals
    raise SyntaxError(msg)

  File "<string>", line unknown
SyntaxError: The '@' prefix is not allowed in top-level eval calls,
please refer to your variables by name without the '@' prefix
```

In this case, you should simply refer to the variables like you would in standard Python.

```
In [51]: pd.eval('a + b')
Out[51]: 3
```

26.3.5 `pandas.eval()` Parsers

There are two different parsers and two different engines you can use as the backend.

The default `'pandas'` parser allows a more intuitive syntax for expressing query-like operations (comparisons, conjunctions and disjunctions). In particular, the precedence of the `&` and `|` operators is made equal to the precedence of the corresponding boolean operations `and` and `or`.

For example, the above conjunction can be written without parentheses. Alternatively, you can use the `'python'` parser to enforce strict Python semantics.

```
In [52]: expr = '(df1 > 0) & (df2 > 0) & (df3 > 0) & (df4 > 0)'
```

```
In [53]: x = pd.eval(expr, parser='python')

In [54]: expr_no_parens = 'df1 > 0 & df2 > 0 & df3 > 0 & df4 > 0'

In [55]: y = pd.eval(expr_no_parens, parser='pandas')

In [56]: np.all(x == y)
Out[56]: True
```

The same expression can be "anded" together with the word `and` as well:

```
In [57]: expr = '(df1 > 0) & (df2 > 0) & (df3 > 0) & (df4 > 0)'

In [58]: x = pd.eval(expr, parser='python')

In [59]: expr_with_ands = 'df1 > 0 and df2 > 0 and df3 > 0 and df4 > 0'

In [60]: y = pd.eval(expr_with_ands, parser='pandas')

In [61]: np.all(x == y)
Out[61]: True
```

The `and` and `or` operators here have the same precedence that they would in vanilla Python.

26.3.6 `pandas.eval()` Backends

There's also the option to make *`eval()`* operate identical to plain ol' Python.

Note: Using the `'python'` engine is generally *not* useful, except for testing other evaluation engines against it. You will achieve **no** performance benefits using *`eval()`* with `engine='python'` and in fact may incur a performance hit.

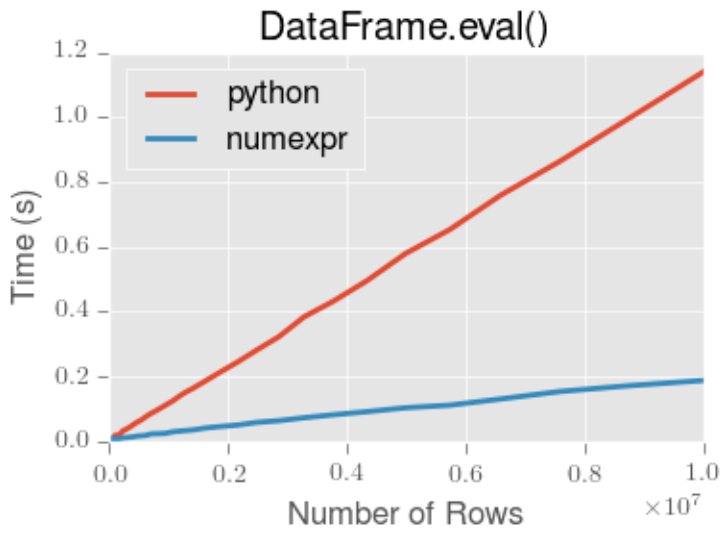
You can see this by using *`pandas.eval()`* with the `'python'` engine. It is a bit slower (not by much) than evaluating the same expression in Python

```
In [62]: %timeit df1 + df2 + df3 + df4
12.4 ms +- 827 us per loop (mean +- std. dev. of 7 runs, 10 loops each)
```

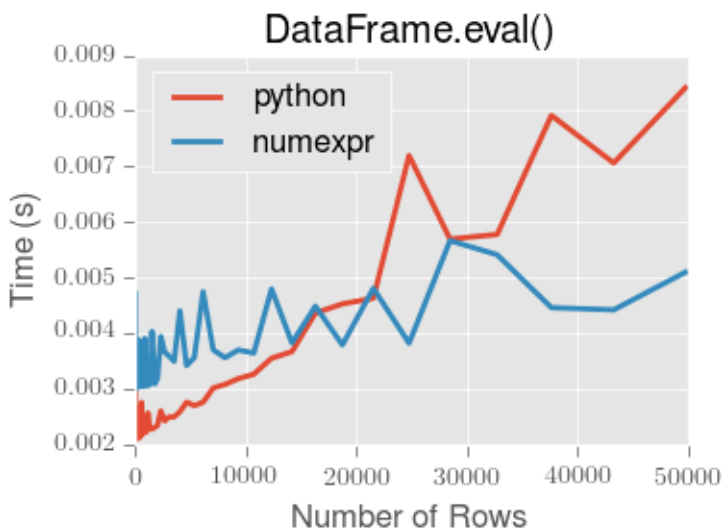
```
In [63]: %timeit pd.eval('df1 + df2 + df3 + df4', engine='python')
13.5 ms +- 1.17 ms per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

26.3.7 `pandas.eval()` Performance

`eval()` is intended to speed up certain kinds of operations. In particular, those operations involving complex expressions with large *`DataFrame`*/*`Series`* objects should see a significant performance benefit. Here is a plot showing the running time of *`pandas.eval()`* as function of the size of the frame involved in the computation. The two lines are two different engines.



Note: Operations with smallish objects (around 15k-20k rows) are faster using plain Python:



This plot was created using a `DataFrame` with 3 columns each containing floating point values generated using `numpy.random.randn()`.

26.3.8 Technical Minutia Regarding Expression Evaluation

Expressions that would result in an object dtype or involve datetime operations (because of `NaT`) must be evaluated in Python space. The main reason for this behavior is to maintain backwards compatibility with versions of numpy < 1.7. In those versions of `numpy` a call to `ndarray.astype(str)` will truncate any strings that are more than 60 characters in length. Second, we can't pass `object` arrays to `numexpr` thus string comparisons must be evaluated in Python space.

The upshot is that this *only* applies to object-dtype'd expressions. So, if you have an expression–for example

```
In [64]: df = pd.DataFrame({'strings': np.repeat(list('cba'), 3),
   ....:                    'nums': np.repeat(range(3), 3)})
   ....:

In [65]: df
Out[65]:
   nums strings
0     0       c
1     0       c
2     0       c
3     1       b
4     1       b
5     1       b
6     2       a
7     2       a
8     2       a

In [66]: df.query('strings == "a" and nums == 1')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
Empty DataFrame
Columns: [nums, strings]
Index: []
```

the numeric part of the comparison (`nums == 1`) will be evaluated by `numexpr`.

In general, `DataFrame.query()`/`pandas.eval()` will evaluate the subexpressions that *can* be evaluated by `numexpr` and those that must be evaluated in Python space transparently to the user. This is done by inferring the result type of an expression from its arguments and operators.

CHAPTER

TWENTYSEVEN

SPARSE DATA STRUCTURES

Note: The `SparsePanel` class has been removed in 0.19.0

We have implemented "sparse" versions of Series and DataFrame. These are not sparse in the typical "mostly 0". Rather, you can view these objects as being "compressed" where any data matching a specific value (`NaN` / missing value, though any value can be chosen) is omitted. A special `SparseIndex` object tracks where data has been "sparsified". This will make much more sense in an example. All of the standard pandas data structures have a `to_sparse` method:

```
In [1]: ts = pd.Series(randn(10))

In [2]: ts[2:-2] = np.nan

In [3]: sts = ts.to_sparse()

In [4]: sts
Out[4]:
0    0.469112
1   -0.282863
2         NaN
3         NaN
4         NaN
5         NaN
6         NaN
7         NaN
8   -0.861849
9   -2.104569
dtype: float64
BlockIndex
Block locations: array([0, 8], dtype=int32)
Block lengths: array([2, 2], dtype=int32)
```

The `to_sparse` method takes a `kind` argument (for the sparse index, see below) and a `fill_value`. So if we had a mostly zero Series, we could convert it to sparse with `fill_value=0`:

```
In [5]: ts.fillna(0).to_sparse(fill_value=0)
Out[5]:
0    0.469112
1   -0.282863
2    0.000000
3    0.000000
4    0.000000
5    0.000000
```

```
6    0.000000
7    0.000000
8   -0.861849
9   -2.104569
dtype: float64
BlockIndex
Block locations: array([0, 8], dtype=int32)
Block lengths: array([2, 2], dtype=int32)
```

The sparse objects exist for memory efficiency reasons. Suppose you had a large, mostly NA DataFrame:

```
In [6]: df = pd.DataFrame(randn(10000, 4))

In [7]: df.iloc[:9998] = np.nan

In [8]: sdf = df.to_sparse()

In [9]: sdf
Out[9]:
             0         1         2         3
0          NaN       NaN       NaN       NaN
1          NaN       NaN       NaN       NaN
2          NaN       NaN       NaN       NaN
3          NaN       NaN       NaN       NaN
4          NaN       NaN       NaN       NaN
5          NaN       NaN       NaN       NaN
6          NaN       NaN       NaN       NaN
...        ...       ...       ...       ...
9993       NaN       NaN       NaN       NaN
9994       NaN       NaN       NaN       NaN
9995       NaN       NaN       NaN       NaN
9996       NaN       NaN       NaN       NaN
9997       NaN       NaN       NaN       NaN
9998  0.509184 -0.774928 -1.369894 -0.382141
9999  0.280249 -1.648493  1.490865 -0.890819

[10000 rows x 4 columns]

In [10]: sdf.density
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪0.0002
```

As you can see, the density (% of values that have not been "compressed") is extremely low. This sparse object takes up much less memory on disk (pickled) and in the Python interpreter. Functionally, their behavior should be nearly identical to their dense counterparts.

Any sparse object can be converted back to the standard dense form by calling `to_dense`:

```
In [11]: sts.to_dense()
Out[11]:
0    0.469112
1   -0.282863
2         NaN
3         NaN
4         NaN
5         NaN
6         NaN
7         NaN
```

```
8   -0.861849
9   -2.104569
dtype: float64
```

27.1 SparseArray

`SparseArray` is the base layer for all of the sparse indexed data structures. It is a 1-dimensional ndarray-like object storing only values distinct from the `fill_value`:

```
In [12]: arr = np.random.randn(10)

In [13]: arr[2:5] = np.nan; arr[7:8] = np.nan

In [14]: sparr = pd.SparseArray(arr)

In [15]: sparr
Out[15]:
[-1.9556635297215477, -1.6588664275960427, nan, nan, nan, 1.1589328886422277, 0.
↪14529711373305043, nan, 0.6060271905134522, 1.3342113401317768]
Fill: nan
IntIndex
Indices: array([0, 1, 5, 6, 8, 9], dtype=int32)
```

Like the indexed objects (SparseSeries, SparseDataFrame), a `SparseArray` can be converted back to a regular ndarray by calling `to_dense`:

```
In [16]: sparr.to_dense()
Out[16]:
array([-1.9557, -1.6589,     nan,     nan,     nan,  1.1589,  0.1453,
           nan,  0.606 ,  1.3342])
```

27.2 SparseList

The `SparseList` class has been deprecated and will be removed in a future version. See the docs of a previous version for documentation on `SparseList`.

27.3 SparseIndex objects

Two kinds of `SparseIndex` are implemented, `block` and `integer`. We recommend using `block` as it's more memory efficient. The `integer` format keeps an arrays of all of the locations where the data are not equal to the fill value. The `block` format tracks only the locations and sizes of blocks of data.

27.4 Sparse Dtypes

Sparse data should have the same dtype as its dense representation. Currently, `float64`, `int64` and `bool` dtypes are supported. Depending on the original dtype, `fill_value` default changes:

- `float64`: `np.nan`

- `int64`: `0`
- `bool`: `False`

```
In [17]: s = pd.Series([1, np.nan, np.nan])

In [18]: s
Out[18]: 
0    1.0
1    NaN
2    NaN
dtype: float64

In [19]: s.to_sparse()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[19]: 
0    1.0
1    NaN
2    NaN
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)

In [20]: s = pd.Series([1, 0, 0])

In [21]: s
Out[21]: 
0    1
1    0
2    0
dtype: int64

In [22]: s.to_sparse()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[22]: 
0    1
1    0
2    0
dtype: int64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)

In [23]: s = pd.Series([True, False, True])

In [24]: s
Out[24]: 
0     True
1    False
2     True
dtype: bool

In [25]: s.to_sparse()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[25]: 
0     True
1    False
2     True
dtype: bool
BlockIndex
Block locations: array([0, 2], dtype=int32)
```

```
Block lengths: array([1, 1], dtype=int32)
```

You can change the dtype using `.astype()`, the result is also sparse. Note that `.astype()` also affects to the `fill_value` to keep its dense representation.

```
In [26]: s = pd.Series([1, 0, 0, 0, 0])

In [27]: s
Out[27]: 
0    1
1    0
2    0
3    0
4    0
dtype: int64

In [28]: ss = s.to_sparse()

In [29]: ss
Out[29]: 
0    1
1    0
2    0
3    0
4    0
dtype: int64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)

In [30]: ss.astype(np.float64)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1.0
1    0.0
2    0.0
3    0.0
4    0.0
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)
```

It raises if any value cannot be coerced to specified dtype.

```
In [1]: ss = pd.Series([1, np.nan, np.nan]).to_sparse()
0    1.0
1    NaN
2    NaN
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)

In [2]: ss.astype(np.int64)
ValueError: unable to coerce current fill_value nan to int64 dtype
```

27.5 Sparse Calculation

You can apply NumPy *ufuncs* to `SparseArray` and get a `SparseArray` as a result.

```
In [31]: arr = pd.SparseArray([1., np.nan, np.nan, -2., np.nan])

In [32]: np.abs(arr)
Out[32]:
[1.0, nan, nan, 2.0, nan]
Fill: nan
IntIndex
Indices: array([0, 3], dtype=int32)
```

The *ufunc* is also applied to `fill_value`. This is needed to get the correct dense result.

```
In [33]: arr = pd.SparseArray([1., -1, -1, -2., -1], fill_value=-1)

In [34]: np.abs(arr)
Out[34]:
[1.0, 1.0, 1.0, 2.0, 1.0]
Fill: 1
IntIndex
Indices: array([0, 3], dtype=int32)

In [35]: np.abs(arr).to_dense()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[35]:␣
↪array([1., 1., 1., 2., 1.])
```

27.6 Interaction with scipy.sparse

27.6.1 SparseDataFrame

New in version 0.20.0.

Pandas supports creating sparse dataframes directly from `scipy.sparse` matrices.

```
In [36]: from scipy.sparse import csr_matrix

In [37]: arr = np.random.random(size=(1000, 5))

In [38]: arr[arr < .9] = 0

In [39]: sp_arr = csr_matrix(arr)

In [40]: sp_arr
Out[40]:
<1000x5 sparse matrix of type '<class 'numpy.float64'>'
        with 517 stored elements in Compressed Sparse Row format>

In [41]: sdf = pd.SparseDataFrame(sp_arr)

In [42]: sdf
Out[42]:
            0    1         2         3    4
0     0.956380 NaN       NaN         NaN  NaN
```

```
1         NaN NaN      NaN       NaN NaN
2         NaN NaN      NaN       NaN NaN
3         NaN NaN      NaN       NaN NaN
4    0.999552 NaN      NaN  0.956153 NaN
5         NaN NaN      NaN       NaN NaN
6    0.913638 NaN      NaN       NaN NaN
..        ...  ..      ...       ...  ..
993       NaN NaN      NaN       NaN NaN
994       NaN NaN      NaN       NaN NaN
995       NaN NaN      NaN  0.998834 NaN
996       NaN NaN      NaN       NaN NaN
997       NaN NaN      NaN       NaN NaN
998       NaN NaN  0.95659       NaN NaN
999       NaN NaN      NaN       NaN NaN

[1000 rows x 5 columns]
```

All sparse formats are supported, but matrices that are not in `COOrdinate` format will be converted, copying data as needed. To convert a `SparseDataFrame` back to sparse SciPy matrix in COO format, you can use the *`SparseDataFrame.to_coo()`* method:

```
In [43]: sdf.to_coo()
Out[43]:
<1000x5 sparse matrix of type '<class 'numpy.float64'>'
        with 517 stored elements in COOrdinate format>
```

27.6.2 SparseSeries

A *`SparseSeries.to_coo()`* method is implemented for transforming a `SparseSeries` indexed by a `MultiIndex` to a `scipy.sparse.coo_matrix`.

The method requires a `MultiIndex` with two or more levels.

```
In [44]: s = pd.Series([3.0, np.nan, 1.0, 3.0, np.nan, np.nan])

In [45]: s.index = pd.MultiIndex.from_tuples([(1, 2, 'a', 0),
   ....:                                      (1, 2, 'a', 1),
   ....:                                      (1, 1, 'b', 0),
   ....:                                      (1, 1, 'b', 1),
   ....:                                      (2, 1, 'b', 0),
   ....:                                      (2, 1, 'b', 1)],
   ....:                                     names=['A', 'B', 'C', 'D'])
   ....:

In [46]: s
Out[46]:
A  B  C  D
1  2  a  0    3.0
         1    NaN
   1  b  0    1.0
         1    3.0
2  1  b  0    NaN
         1    NaN
dtype: float64

# SparseSeries
```

```
In [47]: ss = s.to_sparse()

In [48]: ss
Out[48]:
A  B  C  D
1  2  a  0     3.0
         1     NaN
   1  b  0     1.0
         1     3.0
2  1  b  0     NaN
         1     NaN
dtype: float64
BlockIndex
Block locations: array([0, 2], dtype=int32)
Block lengths: array([1, 2], dtype=int32)
```

In the example below, we transform the `SparseSeries` to a sparse representation of a 2-d array by specifying that the first and second `MultiIndex` levels define labels for the rows and the third and fourth levels define labels for the columns. We also specify that the column and row labels should be sorted in the final sparse representation.

```
In [49]: A, rows, columns = ss.to_coo(row_levels=['A', 'B'],
   ....:                              column_levels=['C', 'D'],
   ....:                              sort_labels=True)
   ....:

In [50]: A
Out[50]:
<3x4 sparse matrix of type '<class 'numpy.float64'>'
        with 3 stored elements in COOrdinate format>

In [51]: A.todense()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
matrix([[0., 0., 1., 3.],
        [3., 0., 0., 0.],
        [0., 0., 0., 0.]])

In [52]: rows
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[(1, 1), (1, 2), (2, 1)]

In [53]: columns
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[('a', 0), ('a', 1), ('b', 0), ('b', 1)]
```

Specifying different row and column labels (and not sorting them) yields a different sparse matrix:

```
In [54]: A, rows, columns = ss.to_coo(row_levels=['A', 'B', 'C'],
   ....:                              column_levels=['D'],
   ....:                              sort_labels=False)
   ....:

In [55]: A
Out[55]:
<3x2 sparse matrix of type '<class 'numpy.float64'>'
        with 3 stored elements in COOrdinate format>

In [56]: A.todense()
```

```
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
matrix([[3., 0.],
        [1., 3.],
        [0., 0.]])

In [57]: rows
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[(1, 2, 'a'), (1, 1, 'b'), (2, 1, 'b')]

In [58]: columns
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪[0, 1]
```

A convenience method *`SparseSeries.from_coo()`* is implemented for creating a `SparseSeries` from a `scipy.sparse.coo_matrix`.

```
In [59]: from scipy import sparse

In [60]: A = sparse.coo_matrix(([3.0, 1.0, 2.0], ([1, 0, 0], [0, 2, 3])),
   ....:                       shape=(3, 4))
   ....:

In [61]: A
Out[61]:
<3x4 sparse matrix of type '<class 'numpy.float64'>'
        with 3 stored elements in COOrdinate format>

In [62]: A.todense()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
matrix([[0., 0., 1., 2.],
        [3., 0., 0., 0.],
        [0., 0., 0., 0.]])
```

The default behaviour (with `dense_index=False`) simply returns a `SparseSeries` containing only the non-null entries.

```
In [63]: ss = pd.SparseSeries.from_coo(A)

In [64]: ss
Out[64]:
0  2    1.0
   3    2.0
1  0    3.0
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([3], dtype=int32)
```

Specifying `dense_index=True` will result in an index that is the Cartesian product of the row and columns coordinates of the matrix. Note that this will consume a significant amount of memory (relative to `dense_index=False`) if the sparse matrix is large (and sparse) enough.

```
In [65]: ss_dense = pd.SparseSeries.from_coo(A, dense_index=True)

In [66]: ss_dense
Out[66]:
```

```
0  0    NaN
   1    NaN
   2    1.0
   3    2.0
1  0    3.0
   1    NaN
   2    NaN
   3    NaN
2  0    NaN
   1    NaN
   2    NaN
   3    NaN
dtype: float64
BlockIndex
Block locations: array([2], dtype=int32)
Block lengths: array([3], dtype=int32)
```

CHAPTER

TWENTYEIGHT

FREQUENTLY ASKED QUESTIONS (FAQ)

28.1 DataFrame memory usage

The memory usage of a dataframe (including the index) is shown when accessing the `info` method of a dataframe. A configuration option, `display.memory_usage` (see *Options and Settings*), specifies if the dataframe's memory usage will be displayed when invoking the `df.info()` method.

For example, the memory usage of the dataframe below is shown when calling `df.info()`:

```
In [1]: dtypes = ['int64', 'float64', 'datetime64[ns]', 'timedelta64[ns]',
   ...:           'complex128', 'object', 'bool']
   ...:

In [2]: n = 5000

In [3]: data = dict([ (t, np.random.randint(100, size=n).astype(t))
   ...:                 for t in dtypes])
   ...:

In [4]: df = pd.DataFrame(data)

In [5]: df['categorical'] = df['object'].astype('category')

In [6]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 8 columns):
bool               5000 non-null bool
complex128         5000 non-null complex128
datetime64[ns]     5000 non-null datetime64[ns]
float64            5000 non-null float64
int64              5000 non-null int64
object             5000 non-null object
timedelta64[ns]    5000 non-null timedelta64[ns]
categorical        5000 non-null category
dtypes: bool(1), category(1), complex128(1), datetime64[ns](1), float64(1), int64(1),␣
↪object(1), timedelta64[ns](1)
memory usage: 289.1+ KB
```

The + symbol indicates that the true memory usage could be higher, because pandas does not count the memory used by values in columns with `dtype=object`.

New in version 0.17.1.

Passing `memory_usage='deep'` will enable a more accurate memory usage report, that accounts for the full usage of the contained objects. This is optional as it can be expensive to do this deeper introspection.

```
In [7]: df.info(memory_usage='deep')
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 8 columns):
bool                5000 non-null bool
complex128          5000 non-null complex128
datetime64[ns]      5000 non-null datetime64[ns]
float64             5000 non-null float64
int64               5000 non-null int64
object              5000 non-null object
timedelta64[ns]     5000 non-null timedelta64[ns]
categorical         5000 non-null category
dtypes: bool(1), category(1), complex128(1), datetime64[ns](1), float64(1), int64(1),␣
↪object(1), timedelta64[ns](1)
memory usage: 425.6 KB
```

By default the display option is set to `True` but can be explicitly overridden by passing the `memory_usage` argument when invoking `df.info()`.

The memory usage of each column can be found by calling the `memory_usage` method. This returns a Series with an index represented by column names and memory usage of each column shown in bytes. For the dataframe above, the memory usage of each column and the total memory usage of the dataframe can be found with the memory_usage method:

```
In [8]: df.memory_usage()
Out[8]:
Index                  80
bool                 5000
complex128          80000
datetime64[ns]      40000
float64             40000
int64               40000
object              40000
timedelta64[ns]     40000
categorical         10920
dtype: int64

# total memory usage of dataframe
In [9]: df.memory_usage().sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪296000
```

By default the memory usage of the dataframe's index is shown in the returned Series, the memory usage of the index can be suppressed by passing the `index=False` argument:

```
In [10]: df.memory_usage(index=False)
Out[10]:
bool                 5000
complex128          80000
datetime64[ns]      40000
float64             40000
int64               40000
object              40000
timedelta64[ns]     40000
categorical         10920
```

```
dtype: int64
```

The memory usage displayed by the `info` method utilizes the `memory_usage` method to determine the memory usage of a dataframe while also formatting the output in human-readable units (base-2 representation; i.e., 1KB = 1024 bytes).

See also *Categorical Memory Usage*.

28.2 Using If/Truth Statements with pandas

pandas follows the numpy convention of raising an error when you try to convert something to a `bool`. This happens in a `if` or when using the boolean operations, `and`, `or`, or `not`. It is not clear what the result of

```
>>> if pd.Series([False, True, False]):
     ...
```

should be. Should it be `True` because it's not zero-length? `False` because there are `False` values? It is unclear, so instead, pandas raises a `ValueError`:

```
>>> if pd.Series([False, True, False]):
    print("I was true")
Traceback
    ...
ValueError: The truth value of an array is ambiguous. Use a.empty, a.any() or a.all().
```

If you see that, you need to explicitly choose what you want to do with it (e.g., use *any()*, *all()* or *empty*). or, you might want to compare if the pandas object is `None`

```
>>> if pd.Series([False, True, False]) is not None:
       print("I was not None")
>>> I was not None
```

or return if `any` value is `True`.

```
>>> if pd.Series([False, True, False]).any():
       print("I am any")
>>> I am any
```

To evaluate single-element pandas objects in a boolean context, use the method `.bool()`:

```
In [11]: pd.Series([True]).bool()
Out[11]: True

In [12]: pd.Series([False]).bool()
\\\\\\\\\\\\\Out[12]: False

In [13]: pd.DataFrame([[True]]).bool()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[13]: True

In [14]: pd.DataFrame([[False]]).bool()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[14]: False
```

28.2.1 Bitwise boolean

Bitwise boolean operators like == and != return a boolean `Series`, which is almost always what you want anyways.

```
>>> s = pd.Series(range(5))
>>> s == 4
0    False
1    False
2    False
3    False
4     True
dtype: bool
```

See *boolean comparisons* for more examples.

28.2.2 Using the `in` operator

Using the Python `in` operator on a Series tests for membership in the index, not membership among the values.

If this behavior is surprising, keep in mind that using `in` on a Python dictionary tests keys, not values, and Series are dict-like. To test for membership in the values, use the method *`isin()`*:

For DataFrames, likewise, `in` applies to the column axis, testing for membership in the list of column names.

28.3 `NaN`, Integer `NA` values and `NA` type promotions

28.3.1 Choice of `NA` representation

For lack of `NA` (missing) support from the ground up in NumPy and Python in general, we were given the difficult choice between either

- A *masked array* solution: an array of data and an array of boolean values indicating whether a value is there or is missing
- Using a special sentinel value, bit pattern, or set of sentinel values to denote `NA` across the dtypes

For many reasons we chose the latter. After years of production use it has proven, at least in my opinion, to be the best decision given the state of affairs in NumPy and Python in general. The special value `NaN` (Not-A-Number) is used everywhere as the `NA` value, and there are API functions `isna` and `notna` which can be used across the dtypes to detect NA values.

However, it comes with it a couple of trade-offs which I most certainly have not ignored.

28.3.2 Support for integer `NA`

In the absence of high performance `NA` support being built into NumPy from the ground up, the primary casualty is the ability to represent NAs in integer arrays. For example:

```
In [15]: s = pd.Series([1, 2, 3, 4, 5], index=list('abcde'))

In [16]: s
Out[16]:
a    1
b    2
c    3
```

```
d    4
e    5
dtype: int64

In [17]: s.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[17]: dtype('int64')

In [18]: s2 = s.reindex(['a', 'b', 'c', 'f', 'u'])

In [19]: s2
Out[19]:
a    1.0
b    2.0
c    3.0
f    NaN
u    NaN
dtype: float64

In [20]: s2.dtype
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[20]: dtype(
↪'float64')
```

This trade-off is made largely for memory and performance reasons, and also so that the resulting Series continues to be "numeric". One possibility is to use `dtype=object` arrays instead.

28.3.3 `NA` type promotions

When introducing NAs into an existing Series or DataFrame via `reindex` or some other means, boolean and integer types will be promoted to a different dtype in order to store the NAs. These are summarized by this table:

Typeclass	Promotion dtype for storing NAs
`floating`	no change
`object`	no change
`integer`	cast to `float64`
`boolean`	cast to `object`

While this may seem like a heavy trade-off, I have found very few cases where this is an issue in practice i.e. storing values greater than 2**53. Some explanation for the motivation is in the next section.

28.3.4 Why not make NumPy like R?

Many people have suggested that NumPy should simply emulate the `NA` support present in the more domain-specific statistical programming language R. Part of the reason is the NumPy type hierarchy:

Typeclass	Dtypes
`numpy.floating`	`float16, float32, float64, float128`
`numpy.integer`	`int8, int16, int32, int64`
`numpy.unsignedinteger`	`uint8, uint16, uint32, uint64`
`numpy.object_`	`object_`
`numpy.bool_`	`bool_`
`numpy.character`	`string_, unicode_`

The R language, by contrast, only has a handful of built-in data types: `integer`, `numeric` (floating-point), `character`, and `boolean`. `NA` types are implemented by reserving special bit patterns for each type to be used

as the missing value. While doing this with the full NumPy type hierarchy would be possible, it would be a more substantial trade-off (especially for the 8- and 16-bit data types) and implementation undertaking.

An alternate approach is that of using masked arrays. A masked array is an array of data with an associated boolean *mask* denoting whether each value should be considered `NA` or not. I am personally not in love with this approach as I feel that overall it places a fairly heavy burden on the user and the library implementer. Additionally, it exacts a fairly high performance cost when working with numerical data compared with the simple approach of using `NaN`. Thus, I have chosen the Pythonic "practicality beats purity" approach and traded integer `NA` capability for a much simpler approach of using a special value in float and object arrays to denote `NA`, and promoting integer arrays to floating when NAs must be introduced.

28.4 Differences with NumPy

For Series and DataFrame objects, `var` normalizes by `N-1` to produce unbiased estimates of the sample variance, while NumPy's `var` normalizes by N, which measures the variance of the sample. Note that `cov` normalizes by `N-1` in both pandas and NumPy.

28.5 Thread-safety

As of pandas 0.11, pandas is not 100% thread safe. The known issues relate to the `DataFrame.copy` method. If you are doing a lot of copying of DataFrame objects shared among threads, we recommend holding locks inside the threads where the data copying occurs.

See this link for more information.

28.6 Byte-Ordering Issues

Occasionally you may have to deal with data that were created on a machine with a different byte order than the one on which you are running Python. A common symptom of this issue is an error like

```
Traceback
    ...
ValueError: Big-endian buffer not supported on little-endian compiler
```

To deal with this issue you should convert the underlying NumPy array to the native system byte order *before* passing it to Series/DataFrame/Panel constructors using something similar to the following:

```
In [21]: x = np.array(list(range(10)), '>i4') # big endian

In [22]: newx = x.byteswap().newbyteorder() # force native byteorder

In [23]: s = pd.Series(newx)
```

See the NumPy documentation on byte order for more details.

CHAPTER

TWENTYNINE

RPY2 / R INTERFACE

> **Warning:** Up to pandas 0.19, a `pandas.rpy` module existed with functionality to convert between pandas and `rpy2` objects. This functionality now lives in the rpy2 project itself. See the updating section of the previous documentation for a guide to port your code from the removed `pandas.rpy` to `rpy2` functions.

rpy2 is an interface to R running embedded in a Python process, and also includes functionality to deal with pandas DataFrames. Converting data frames back and forth between rpy2 and pandas should be largely automated (no need to convert explicitly, it will be done on the fly in most rpy2 functions). To convert explicitly, the functions are `pandas2ri.py2ri()` and `pandas2ri.ri2py()`.

See also the documentation of the rpy2 project: https://rpy2.readthedocs.io.

In the remainder of this page, a few examples of explicit conversion is given. The pandas conversion of rpy2 needs first to be activated:

```
In [1]: from rpy2.robjects import r, pandas2ri

In [2]: pandas2ri.activate()
```

29.1 Transferring R data sets into Python

Once the pandas conversion is activated (`pandas2ri.activate()`), many conversions of R to pandas objects will be done automatically. For example, to obtain the 'iris' dataset as a pandas DataFrame:

```
In [3]: r.data('iris')
Out[3]:
R object with classes: ('character',) mapped to:
<StrVector - Python:0x132e375c8 / R:0x7ff8b921f338>
['iris']

In [4]: r['iris'].head()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
   Sepal.Length  Sepal.Width  Petal.Length  Petal.Width Species
1           5.1          3.5           1.4          0.2  setosa
2           4.9          3.0           1.4          0.2  setosa
3           4.7          3.2           1.3          0.2  setosa
4           4.6          3.1           1.5          0.2  setosa
5           5.0          3.6           1.4          0.2  setosa
```

If the pandas conversion was not activated, the above could also be accomplished by explicitly converting it with the `pandas2ri.ri2py` function (`pandas2ri.ri2py(r['iris'])`).

29.2 Converting DataFrames into R objects

The `pandas2ri.py2ri` function support the reverse operation to convert DataFrames into the equivalent R object (that is, **data.frame**):

```
In [5]: df = pd.DataFrame({'A': [1, 2, 3], 'B': [4, 5, 6], 'C':[7,8,9]},
   ...:                   index=["one", "two", "three"])
   ...:

In [6]: r_dataframe = pandas2ri.py2ri(df)

In [7]: print(type(r_dataframe))
<class 'rpy2.robjects.vectors.DataFrame'>

In [8]: print(r_dataframe)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\      A B C
one   1 4 7
two   2 5 8
three 3 6 9
```

The DataFrame's index is stored as the `rownames` attribute of the data.frame instance.

CHAPTER

THIRTY

PANDAS ECOSYSTEM

Increasingly, packages are being built on top of pandas to address specific needs in data preparation, analysis and visualization. This is encouraging because it means pandas is not only helping users to handle their data tasks but also that it provides a better starting point for developers to build powerful and more focused data tools. The creation of libraries that complement pandas' functionality also allows pandas development to remain focused around it's original requirements.

This is an in-exhaustive list of projects that build on pandas in order to provide tools in the PyData space.

We'd like to make it easier for users to find these project, if you know of other substantial projects that you feel should be on this list, please let us know.

30.1 Statistics and Machine Learning

30.1.1 Statsmodels

Statsmodels is the prominent python "statistics and econometrics library" and it has a long-standing special relationship with pandas. Statsmodels provides powerful statistics, econometrics, analysis and modeling functionality that is out of pandas' scope. Statsmodels leverages pandas objects as the underlying data container for computation.

30.1.2 sklearn-pandas

Use pandas DataFrames in your scikit-learn ML pipeline.

30.2 Visualization

30.2.1 Bokeh

Bokeh is a Python interactive visualization library for large datasets that natively uses the latest web technologies. Its goal is to provide elegant, concise construction of novel graphics in the style of Protovis/D3, while delivering high-performance interactivity over large data to thin clients.

30.2.2 yhat/ggplot

Hadley Wickham's ggplot2 is a foundational exploratory visualization package for the R language. Based on "The Grammar of Graphics" it provides a powerful, declarative and extremely general way to generate bespoke plots of any kind of data. It's really quite incredible. Various implementations to other languages are available, but a faithful

implementation for python users has long been missing. Although still young (as of Jan-2014), the yhat/ggplot project has been progressing quickly in that direction.

30.2.3 Seaborn

Although pandas has quite a bit of "just plot it" functionality built-in, visualization and in particular statistical graphics is a vast field with a long tradition and lots of ground to cover. The Seaborn project builds on top of pandas and matplotlib to provide easy plotting of data which extends to more advanced types of plots then those offered by pandas.

30.2.4 Vincent

The Vincent project leverages Vega (that in turn, leverages d3) to create plots. Although functional, as of Summer 2016 the Vincent project has not been updated in over two years and is unlikely to receive further updates.

30.2.5 IPython Vega

Like Vincent, the IPython Vega project leverages Vega to create plots, but primarily targets the IPython Notebook environment.

30.2.6 Plotly

Plotly's Python API enables interactive figures and web shareability. Maps, 2D, 3D, and live-streaming graphs are rendered with WebGL and D3.js. The library supports plotting directly from a pandas DataFrame and cloud-based collaboration. Users of matplotlib, ggplot for Python, and Seaborn can convert figures into interactive web-based plots. Plots can be drawn in IPython Notebooks , edited with R or MATLAB, modified in a GUI, or embedded in apps and dashboards. Plotly is free for unlimited sharing, and has cloud, offline, or on-premise accounts for private use.

30.2.7 QtPandas

Spun off from the main pandas library, the qtpandas library enables DataFrame visualization and manipulation in PyQt4 and PySide applications.

30.3 IDE

30.3.1 IPython

IPython is an interactive command shell and distributed computing environment. IPython Notebook is a web application for creating IPython notebooks. An IPython notebook is a JSON document containing an ordered list of input/output cells which can contain code, text, mathematics, plots and rich media. IPython notebooks can be converted to a number of open standard output formats (HTML, HTML presentation slides, LaTeX, PDF, ReStructuredText, Markdown, Python) through 'Download As' in the web interface and `ipython nbconvert` in a shell.

Pandas DataFrames implement `_repr_html_` methods which are utilized by IPython Notebook for displaying (abbreviated) HTML tables. (Note: HTML tables may or may not be compatible with non-HTML IPython output formats.)

30.3.2 quantopian/qgrid

qgrid is "an interactive grid for sorting and filtering DataFrames in IPython Notebook" built with SlickGrid.

30.3.3 Spyder

Spyder is a cross-platform Qt-based open-source Python IDE with editing, testing, debugging, and introspection features. Spyder can now introspect and display Pandas DataFrames and show both "column wise min/max and global min/max coloring."

30.4 API

30.4.1 pandas-datareader

`pandas-datareader` is a remote data access library for pandas. `pandas.io` from pandas < 0.17.0 is now refactored/split-off to and importable from `pandas_datareader` (PyPI:`pandas-datareader`). Many/most of the supported APIs have at least a documentation paragraph in the pandas-datareader docs:

The following data feeds are available:

- Yahoo! Finance
- Google Finance
- FRED
- Fama/French
- World Bank
- OECD
- Eurostat
- EDGAR Index

30.4.2 quandl/Python

Quandl API for Python wraps the Quandl REST API to return Pandas DataFrames with timeseries indexes.

30.4.3 pydatastream

PyDatastream is a Python interface to the Thomson Dataworks Enterprise (DWE/Datastream) SOAP API to return indexed Pandas DataFrames or Panels with financial data. This package requires valid credentials for this API (non free).

30.4.4 pandaSDMX

pandaSDMX is a library to retrieve and acquire statistical data and metadata disseminated in SDMX 2.1, an ISO-standard widely used by institutions such as statistics offices, central banks, and international organisations. pandaSDMX can expose datasets and related structural metadata including dataflows, code-lists, and datastructure definitions as pandas Series or multi-indexed DataFrames.

30.4.5 fredapi

fredapi is a Python interface to the Federal Reserve Economic Data (FRED) provided by the Federal Reserve Bank of St. Louis. It works with both the FRED database and ALFRED database that contains point-in-time data (i.e. historic data revisions). fredapi provides a wrapper in python to the FRED HTTP API, and also provides several convenient methods for parsing and analyzing point-in-time data from ALFRED. fredapi makes use of pandas and returns data in a Series or DataFrame. This module requires a FRED API key that you can obtain for free on the FRED website.

30.5 Domain Specific

30.5.1 Geopandas

Geopandas extends pandas data objects to include geographic information which support geometric operations. If your work entails maps and geographical coordinates, and you love pandas, you should take a close look at Geopandas.

30.5.2 xarray

xarray brings the labeled data power of pandas to the physical sciences by providing N-dimensional variants of the core pandas data structures. It aims to provide a pandas-like and pandas-compatible toolkit for analytics on multi-dimensional arrays, rather than the tabular data for which pandas excels.

30.6 Out-of-core

30.6.1 Dask

Dask is a flexible parallel computing library for analytics. Dask allow a familiar `DataFrame` interface to out-of-core, parallel and distributed computing.

30.6.2 Blaze

Blaze provides a standard API for doing computations with various in-memory and on-disk backends: NumPy, Pandas, SQLAlchemy, MongoDB, PyTables, PySpark.

30.6.3 Odo

Odo provides a uniform API for moving data between different formats. It uses pandas own `read_csv` for CSV IO and leverages many existing packages such as PyTables, h5py, and pymongo to move data between non pandas formats. Its graph based approach is also extensible by end users for custom formats that may be too specific for the core of odo.

30.7 Data validation

30.7.1 Engarde

Engarde is a lightweight library used to explicitly state your assumptions abour your datasets and check that they're *actually* true.

CHAPTER

THIRTYONE

COMPARISON WITH R / R LIBRARIES

Since `pandas` aims to provide a lot of the data manipulation and analysis functionality that people use R for, this page was started to provide a more detailed look at the R language and its many third party libraries as they relate to `pandas`. In comparisons with R and CRAN libraries, we care about the following things:

- **Functionality / flexibility**: what can/cannot be done with each tool
- **Performance**: how fast are operations. Hard numbers/benchmarks are preferable
- **Ease-of-use**: Is one tool easier/harder to use (you may have to be the judge of this, given side-by-side code comparisons)

This page is also here to offer a bit of a translation guide for users of these R packages.

For transfer of `DataFrame` objects from `pandas` to R, one option is to use HDF5 files, see *External Compatibility* for an example.

31.1 Quick Reference

We'll start off with a quick reference guide pairing some common R operations using dplyr with pandas equivalents.

31.1.1 Querying, Filtering, Sampling

R	pandas
`dim(df)`	`df.shape`
`head(df)`	`df.head()`
`slice(df, 1:10)`	`df.iloc[:9]`
`filter(df, col1 == 1, col2 == 1)`	`df.query('col1 == 1 & col2 == 1')`
`df[df$col1 == 1 & df$col2 == 1,]`	`df[(df.col1 == 1) & (df.col2 == 1)]`
`select(df, col1, col2)`	`df[['col1', 'col2']]`
`select(df, col1:col3)`	`df.loc[:, 'col1':'col3']`
`select(df, -(col1:col3))`	`df.drop(cols_to_drop, axis=1)` but see[1]
`distinct(select(df, col1))`	`df[['col1']].drop_duplicates()`
`distinct(select(df, col1, col2))`	`df[['col1', 'col2']].drop_duplicates()`
`sample_n(df, 10)`	`df.sample(n=10)`
`sample_frac(df, 0.01)`	`df.sample(frac=0.01)`

[1] R's shorthand for a subrange of columns (`select(df, col1:col3)`) can be approached cleanly in pandas, if you have the list of columns, for example `df[cols[1:3]]` or `df.drop(cols[1:3])`, but doing this by column name is a bit messy.

31.1.2 Sorting

R	pandas
`arrange(df, col1, col2)`	`df.sort_values(['col1', 'col2'])`
`arrange(df, desc(col1))`	`df.sort_values('col1', ascending=False)`

31.1.3 Transforming

R	pandas
`select(df, col_one = col1)`	`df.rename(columns={'col1': 'col_one'})['col_one']`
`rename(df, col_one = col1)`	`df.rename(columns={'col1': 'col_one'})`
`mutate(df, c=a-b)`	`df.assign(c=df.a-df.b)`

31.1.4 Grouping and Summarizing

R	pandas
`summary(df)`	`df.describe()`
`gdf <- group_by(df, col1)`	`gdf = df.groupby('col1')`
`summarise(gdf, avg=mean(col1, na.rm=TRUE))`	`df.groupby('col1').agg({'col1': 'mean'})`
`summarise(gdf, total=sum(col1))`	`df.groupby('col1').sum()`

31.2 Base R

31.2.1 Slicing with R's `c`

R makes it easy to access `data.frame` columns by name

```
df <- data.frame(a=rnorm(5), b=rnorm(5), c=rnorm(5), d=rnorm(5), e=rnorm(5))
df[, c("a", "c", "e")]
```

or by integer location

```
df <- data.frame(matrix(rnorm(1000), ncol=100))
df[, c(1:10, 25:30, 40, 50:100)]
```

Selecting multiple columns by name in `pandas` is straightforward

```
In [1]: df = pd.DataFrame(np.random.randn(10, 3), columns=list('abc'))

In [2]: df[['a', 'c']]
Out[2]:
          a         c
0 -1.039575 -0.424972
1  0.567020 -1.087401
2 -0.673690 -1.478427
3  0.524988  0.577046
4 -1.715002 -0.370647
5 -1.157892  0.844885
```

```
6  1.075770  1.643563
7 -1.469388 -0.674600
8 -1.776904 -1.294524
9  0.413738 -0.472035

In [3]: df.loc[:, ['a', 'c']]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
          a         c
0 -1.039575 -0.424972
1  0.567020 -1.087401
2 -0.673690 -1.478427
3  0.524988  0.577046
4 -1.715002 -0.370647
5 -1.157892  0.844885
6  1.075770  1.643563
7 -1.469388 -0.674600
8 -1.776904 -1.294524
9  0.413738 -0.472035
```

Selecting multiple noncontiguous columns by integer location can be achieved with a combination of the `iloc` indexer attribute and `numpy.r_`.

```
In [4]: named = list('abcdefg')

In [5]: n = 30

In [6]: columns = named + np.arange(len(named), n).tolist()

In [7]: df = pd.DataFrame(np.random.randn(n, n), columns=columns)

In [8]: df.iloc[:, np.r_[:10, 24:30]]
Out[8]:
           a         b         c         d         e         f         g  \
0  -0.013960 -0.362543 -0.006154 -0.923061  0.895717  0.805244 -1.206412
1   0.545952 -1.219217 -1.226825  0.769804 -1.281247 -0.727707 -0.121306
2   2.396780  0.014871  3.357427 -0.317441 -1.236269  0.896171 -0.487602
3  -0.988387  0.094055  1.262731  1.289997  0.082423 -0.055758  0.536580
4  -1.340896  1.846883 -1.328865  1.682706 -1.717693  0.888782  0.228440
5   0.464000  0.227371 -0.496922  0.306389 -2.290613 -1.134623 -1.561819
6  -0.507516 -0.230096  0.394500 -1.934370 -1.652499  1.488753 -0.896484
..       ...       ...       ...       ...       ...       ...       ...
23 -0.083272 -0.273955 -0.772369 -1.242807 -0.386336 -0.182486  0.164816
24  2.071413 -1.364763  1.122066  0.066847  1.751987  0.419071 -1.118283
25  0.036609  0.359986  1.211905  0.850427  1.554957 -0.888463 -1.508808
26 -1.179240  0.238923  1.756671 -0.747571  0.543625 -0.159609 -0.051458
27  0.025645  0.932436 -1.694531 -0.182236 -1.072710  0.466764 -0.072673
28  0.439086  0.812684 -0.128932 -0.142506 -1.137207  0.462001 -0.159466
29 -0.909806 -0.312006  0.383630 -0.631606  1.321415 -0.004799 -2.008210

           7         8         9        24        25        26        27  \
0   2.565646  1.431256  1.340309  0.875906 -2.211372  0.974466 -2.006747
1  -0.097883  0.695775  0.341734 -1.743161 -0.826591 -0.345352  1.314232
2  -0.082240 -2.182937  0.380396  1.266143  0.299368 -0.863838  0.408204
3  -0.489682  0.369374 -0.034571  0.221471 -0.744471  0.758527  1.729689
4   0.901805  1.171216  0.520260  0.650776 -1.461665 -1.137707 -0.891060
5  -0.260838  0.281957  1.523962 -0.008434  1.952541 -1.056652  0.533946
6   0.576897  1.146000  1.487349  2.015523 -1.833722  1.771740 -0.670027
```

```
..        ...       ...       ...       ...       ...       ...       ...
23  0.065624  0.307665 -1.898358  1.389045 -0.873585 -0.699862  0.812477
24  1.010694  0.877138 -0.611561 -1.040389 -0.796211  0.241596  0.385922
25 -0.617855  0.536164  2.175585  1.872601 -2.513465 -0.139184  0.810491
26  0.937882  0.617547  0.287918 -1.584814  0.307941  1.809049  0.296237
27 -0.026233 -0.051744  0.001402  0.150664 -3.060395  0.040268  0.066091
28 -1.788308  0.753604  0.918071  0.922729  0.869610  0.364726 -0.226101
29 -0.481634 -2.056211 -2.106095  0.039227  0.211283  1.440190 -0.989193

          28        29
0  -0.410001 -0.078638
1   0.690579  0.995761
2  -1.048089 -0.025747
3  -0.964980 -0.845696
4  -0.693921  1.613616
5  -1.226970  0.040403
6   0.049307 -0.521493
..       ...       ...
23 -0.469503  1.142702
24 -0.486078  0.433042
25  0.571599 -0.000676
26 -0.143550  0.289401
27 -0.192862  1.979055
28 -0.657647 -0.952699
29  0.313335 -0.399709

[30 rows x 16 columns]
```

31.2.2 aggregate

In R you may want to split data into subsets and compute the mean for each. Using a data.frame called `df` and splitting it into groups `by1` and `by2`:

```
df <- data.frame(
  v1 = c(1,3,5,7,8,3,5,NA,4,5,7,9),
  v2 = c(11,33,55,77,88,33,55,NA,44,55,77,99),
  by1 = c("red", "blue", 1, 2, NA, "big", 1, 2, "red", 1, NA, 12),
  by2 = c("wet", "dry", 99, 95, NA, "damp", 95, 99, "red", 99, NA, NA))
aggregate(x=df[, c("v1", "v2")], by=list(mydf2$by1, mydf2$by2), FUN = mean)
```

The *groupby()* method is similar to base R `aggregate` function.

```
In [9]: df = pd.DataFrame({
   ...:   'v1': [1,3,5,7,8,3,5,np.nan,4,5,7,9],
   ...:   'v2': [11,33,55,77,88,33,55,np.nan,44,55,77,99],
   ...:   'by1': ["red", "blue", 1, 2, np.nan, "big", 1, 2, "red", 1, np.nan, 12],
   ...:   'by2': ["wet", "dry", 99, 95, np.nan, "damp", 95, 99, "red", 99, np.nan,
   ...:           np.nan]
   ...: })
   ...:

In [10]: g = df.groupby(['by1','by2'])

In [11]: g[['v1','v2']].mean()
Out[11]:
            v1    v2
```

```
by1  by2
1    95    5.0  55.0
     99    5.0  55.0
2    95    7.0  77.0
     99    NaN   NaN
big  damp  3.0  33.0
blue dry   3.0  33.0
red  red   4.0  44.0
     wet   1.0  11.0
```

For more details and examples see *the groupby documentation*.

31.2.3 match / %in%

A common way to select data in R is using `%in%` which is defined using the function `match`. The operator `%in%` is used to return a logical vector indicating if there is a match or not:

```
s <- 0:4
s %in% c(2,4)
```

The *isin()* method is similar to R `%in%` operator:

```
In [12]: s = pd.Series(np.arange(5),dtype=np.float32)

In [13]: s.isin([2, 4])
Out[13]:
0    False
1    False
2     True
3    False
4     True
dtype: bool
```

The `match` function returns a vector of the positions of matches of its first argument in its second:

```
s <- 0:4
match(s, c(2,4))
```

For more details and examples see *the reshaping documentation*.

31.2.4 tapply

`tapply` is similar to `aggregate`, but data can be in a ragged array, since the subclass sizes are possibly irregular. Using a data.frame called `baseball`, and retrieving information based on the array `team`:

```
baseball <-
  data.frame(team = gl(5, 5,
             labels = paste("Team", LETTERS[1:5])),
             player = sample(letters, 25),
             batting.average = runif(25, .200, .400))

tapply(baseball$batting.average, baseball.example$team,
       max)
```

In `pandas` we may use *pivot_table()* method to handle this:

```
In [14]: import random

In [15]: import string

In [16]: baseball = pd.DataFrame({
   ....:     'team': ["team %d" % (x+1) for x in range(5)]*5,
   ....:     'player': random.sample(list(string.ascii_lowercase),25),
   ....:     'batting avg': np.random.uniform(.200, .400, 25)
   ....:     })
   ....: 

In [17]: baseball.pivot_table(values='batting avg', columns='team', aggfunc=np.max)
Out[17]: 
team           team 1   team 2    team 3    team 4    team 5
batting avg  0.394457  0.39573  0.343015  0.388863  0.377379
```

For more details and examples see *the reshaping documentation*.

31.2.5 `subset`

The *`query()`* method is similar to the base R `subset` function. In R you might want to get the rows of a `data.frame` where one column's values are less than another column's values:

```
df <- data.frame(a=rnorm(10), b=rnorm(10))
subset(df, a <= b)
df[df$a <= df$b,]  # note the comma
```

In `pandas`, there are a few ways to perform subsetting. You can use *`query()`* or pass an expression as if it were an index/slice as well as standard boolean indexing:

```
In [18]: df = pd.DataFrame({'a': np.random.randn(10), 'b': np.random.randn(10)})

In [19]: df.query('a <= b')
Out[19]: 
          a         b
0 -1.003455 -0.990738
1  0.083515  0.548796
3 -0.524392  0.904400
4 -0.837804  0.746374
8 -0.507219  0.245479

In [20]: df[df.a <= df.b]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          a         b
0 -1.003455 -0.990738
1  0.083515  0.548796
3 -0.524392  0.904400
4 -0.837804  0.746374
8 -0.507219  0.245479

In [21]: df.loc[df.a <= df.b]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
          a         b
0 -1.003455 -0.990738
```

```
1  0.083515  0.548796
3 -0.524392  0.904400
4 -0.837804  0.746374
8 -0.507219  0.245479
```

For more details and examples see *the query documentation*.

31.2.6 `with`

An expression using a data.frame called `df` in R with the columns `a` and `b` would be evaluated using `with` like so:

```
df <- data.frame(a=rnorm(10), b=rnorm(10))
with(df, a + b)
df$a + df$b  # same as the previous expression
```

In `pandas` the equivalent expression, using the `eval()` method, would be:

```
In [22]: df = pd.DataFrame({'a': np.random.randn(10), 'b': np.random.randn(10)})

In [23]: df.eval('a + b')
Out[23]:
0   -0.920205
1   -0.860236
2    1.154370
3    0.188140
4   -1.163718
5    0.001397
6   -0.825694
7   -1.138198
8   -1.708034
9    1.148616
dtype: float64

In [24]: df.a + df.b  # same as the previous expression
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   -0.920205
1   -0.860236
2    1.154370
3    0.188140
4   -1.163718
5    0.001397
6   -0.825694
7   -1.138198
8   -1.708034
9    1.148616
dtype: float64
```

In certain cases `eval()` will be much faster than evaluation in pure Python. For more details and examples see *the eval documentation*.

31.3 plyr

`plyr` is an R library for the split-apply-combine strategy for data analysis. The functions revolve around three data

structures in R, `a` for `arrays`, `l` for `lists`, and `d` for `data.frame`. The table below shows how these data structures could be mapped in Python.

R	Python
array	list
lists	dictionary or list of objects
data.frame	dataframe

31.3.1 ddply

An expression using a data.frame called `df` in R where you want to summarize `x` by `month`:

```
require(plyr)
df <- data.frame(
  x = runif(120, 1, 168),
  y = runif(120, 7, 334),
  z = runif(120, 1.7, 20.7),
  month = rep(c(5,6,7,8),30),
  week = sample(1:4, 120, TRUE)
)

ddply(df, .(month, week), summarize,
      mean = round(mean(x), 2),
      sd = round(sd(x), 2))
```

In `pandas` the equivalent expression, using the *`groupby()`* method, would be:

```
In [25]: df = pd.DataFrame({
   ....:     'x': np.random.uniform(1., 168., 120),
   ....:     'y': np.random.uniform(7., 334., 120),
   ....:     'z': np.random.uniform(1.7, 20.7, 120),
   ....:     'month': [5,6,7,8]*30,
   ....:     'week': np.random.randint(1,4, 120)
   ....: })
   ....:

In [26]: grouped = df.groupby(['month','week'])

In [27]: grouped['x'].agg([np.mean, np.std])
Out[27]:
                  mean        std
month week
5     1      71.840596  52.886392
      2      71.904794  55.786805
      3      89.845632  49.892367
6     1      97.730877  52.442172
      2      93.369836  47.178389
      3      96.592088  58.773744
7     1      59.255715  43.442336
      2      69.634012  28.607369
      3      84.510992  59.761096
8     1     104.787666  31.745437
      2      69.717872  53.747188
      3      79.892221  52.950459
```

For more details and examples see *the groupby documentation*.

31.4 reshape / reshape2

31.4.1 melt.array

An expression using a 3 dimensional array called a in R where you want to melt it into a data.frame:

```
a <- array(c(1:23, NA), c(2,3,4))
data.frame(melt(a))
```

In Python, since a is a list, you can simply use list comprehension.

```
In [28]: a = np.array(list(range(1,24))+[np.NAN]).reshape(2,3,4)

In [29]: pd.DataFrame([tuple(list(x)+[val]) for x, val in np.ndenumerate(a)])
Out[29]:
    0  1  2     3
0   0  0  0   1.0
1   0  0  1   2.0
2   0  0  2   3.0
3   0  0  3   4.0
4   0  1  0   5.0
5   0  1  1   6.0
6   0  1  2   7.0
..  .. .. ..   ...
17  1  1  1  18.0
18  1  1  2  19.0
19  1  1  3  20.0
20  1  2  0  21.0
21  1  2  1  22.0
22  1  2  2  23.0
23  1  2  3   NaN

[24 rows x 4 columns]
```

31.4.2 melt.list

An expression using a list called a in R where you want to melt it into a data.frame:

```
a <- as.list(c(1:4, NA))
data.frame(melt(a))
```

In Python, this list would be a list of tuples, so `DataFrame()` method would convert it to a dataframe as required.

```
In [30]: a = list(enumerate(list(range(1,5))+[np.NAN]))

In [31]: pd.DataFrame(a)
Out[31]:
   0    1
0  0  1.0
1  1  2.0
2  2  3.0
3  3  4.0
4  4  NaN
```

For more details and examples see *the Into to Data Structures documentation*.

31.4.3 `melt.data.frame`

An expression using a data.frame called `cheese` in R where you want to reshape the data.frame:

```
cheese <- data.frame(
  first = c('John', 'Mary'),
  last = c('Doe', 'Bo'),
  height = c(5.5, 6.0),
  weight = c(130, 150)
)
melt(cheese, id=c("first", "last"))
```

In Python, the *`melt()`* method is the R equivalent:

```
In [32]: cheese = pd.DataFrame({'first' : ['John', 'Mary'],
   ....:                        'last' : ['Doe', 'Bo'],
   ....:                        'height' : [5.5, 6.0],
   ....:                        'weight' : [130, 150]})
   ....:

In [33]: pd.melt(cheese, id_vars=['first', 'last'])
Out[33]:
  first last variable  value
0  John  Doe   height    5.5
1  Mary   Bo   height    6.0
2  John  Doe   weight  130.0
3  Mary   Bo   weight  150.0

In [34]: cheese.set_index(['first', 'last']).stack() # alternative way
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 ↪
first  last
John   Doe   height      5.5
             weight    130.0
Mary   Bo    height      6.0
             weight    150.0
dtype: float64
```

For more details and examples see *the reshaping documentation*.

31.4.4 `cast`

In R `acast` is an expression using a data.frame called `df` in R to cast into a higher dimensional array:

```
df <- data.frame(
  x = runif(12, 1, 168),
  y = runif(12, 7, 334),
  z = runif(12, 1.7, 20.7),
  month = rep(c(5,6,7),4),
  week = rep(c(1,2), 6)
)

mdf <- melt(df, id=c("month", "week"))
acast(mdf, week ~ month ~ variable, mean)
```

In Python the best way is to make use of *`pivot_table()`*:

```
In [35]: df = pd.DataFrame({
   ....:     'x': np.random.uniform(1., 168., 12),
   ....:     'y': np.random.uniform(7., 334., 12),
   ....:     'z': np.random.uniform(1.7, 20.7, 12),
   ....:     'month': [5,6,7]*4,
   ....:     'week': [1,2]*6
   ....: })
   ....:

In [36]: mdf = pd.melt(df, id_vars=['month', 'week'])

In [37]: pd.pivot_table(mdf, values='value', index=['variable','week'],
   ....:                  columns=['month'], aggfunc=np.mean)
   ....:
Out[37]:
month                   5           6           7
variable week
x        1     114.001700  132.227290   65.808204
         2     124.669553  147.495706   82.882820
y        1     225.636630  301.864228   91.706834
         2      57.692665  215.851669  218.004383
z        1      17.793871    7.124644   17.679823
         2      15.068355   13.873974    9.394966
```

Similarly for `dcast` which uses a data.frame called `df` in R to aggregate information based on `Animal` and `FeedType`:

```
df <- data.frame(
  Animal = c('Animal1', 'Animal2', 'Animal3', 'Animal2', 'Animal1',
             'Animal2', 'Animal3'),
  FeedType = c('A', 'B', 'A', 'A', 'B', 'B', 'A'),
  Amount = c(10, 7, 4, 2, 5, 6, 2)
)

dcast(df, Animal ~ FeedType, sum, fill=NaN)
# Alternative method using base R
with(df, tapply(Amount, list(Animal, FeedType), sum))
```

Python can approach this in two different ways. Firstly, similar to above using *`pivot_table()`*:

```
In [38]: df = pd.DataFrame({
   ....:     'Animal': ['Animal1', 'Animal2', 'Animal3', 'Animal2', 'Animal1',
   ....:                'Animal2', 'Animal3'],
   ....:     'FeedType': ['A', 'B', 'A', 'A', 'B', 'B', 'A'],
   ....:     'Amount': [10, 7, 4, 2, 5, 6, 2],
   ....: })
   ....:

In [39]: df.pivot_table(values='Amount', index='Animal', columns='FeedType', aggfunc=
↪'sum')
Out[39]:
FeedType     A     B
Animal
Animal1   10.0   5.0
Animal2    2.0  13.0
Animal3    6.0   NaN
```

The second approach is to use the *`groupby()`* method:

```
In [40]: df.groupby(['Animal','FeedType'])['Amount'].sum()
Out[40]:
Animal   FeedType
Animal1  A           10
         B            5
Animal2  A            2
         B           13
Animal3  A            6
Name: Amount, dtype: int64
```

For more details and examples see *the reshaping documentation* or *the groupby documentation*.

31.4.5 `factor`

pandas has a data type for categorical data.

```
cut(c(1,2,3,4,5,6), 3)
factor(c(1,2,3,2,2,3))
```

In pandas this is accomplished with `pd.cut` and `astype("category")`:

```
In [41]: pd.cut(pd.Series([1,2,3,4,5,6]), 3)
Out[41]:
0    (0.995, 2.667]
1    (0.995, 2.667]
2    (2.667, 4.333]
3    (2.667, 4.333]
4      (4.333, 6.0]
5      (4.333, 6.0]
dtype: category
Categories (3, interval[float64]): [(0.995, 2.667] < (2.667, 4.333] < (4.333, 6.0]]

In [42]: pd.Series([1,2,3,2,2,3]).astype("category")
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0    1
1    2
2    3
3    2
4    2
5    3
dtype: category
Categories (3, int64): [1, 2, 3]
```

For more details and examples see *categorical introduction* and the *API documentation*. There is also a documentation regarding the *differences to R's factor*.

CHAPTER

THIRTYTWO

COMPARISON WITH SQL

Since many potential pandas users have some familiarity with SQL, this page is meant to provide some examples of how various SQL operations would be performed using pandas.

If you're new to pandas, you might want to first read through *10 Minutes to pandas* to familiarize yourself with the library.

As is customary, we import pandas and numpy as follows:

```
In [1]: import pandas as pd

In [2]: import numpy as np
```

Most of the examples will utilize the `tips` dataset found within pandas tests. We'll read the data into a DataFrame called *tips* and assume we have a database table of the same name and structure.

```
In [3]: url = 'https://raw.github.com/pandas-dev/pandas/master/pandas/tests/data/tips.
↪csv'

In [4]: tips = pd.read_csv(url)

In [5]: tips.head()
Out[5]:
   total_bill   tip     sex smoker  day    time  size
0       16.99  1.01  Female     No  Sun  Dinner     2
1       10.34  1.66    Male     No  Sun  Dinner     3
2       21.01  3.50    Male     No  Sun  Dinner     3
3       23.68  3.31    Male     No  Sun  Dinner     2
4       24.59  3.61  Female     No  Sun  Dinner     4
```

32.1 SELECT

In SQL, selection is done using a comma-separated list of columns you'd like to select (or a `*` to select all columns):

```
SELECT total_bill, tip, smoker, time
FROM tips
LIMIT 5;
```

With pandas, column selection is done by passing a list of column names to your DataFrame:

```
In [6]: tips[['total_bill', 'tip', 'smoker', 'time']].head(5)
Out[6]:
   total_bill   tip smoker    time
```

```
0       16.99  1.01     No  Dinner
1       10.34  1.66     No  Dinner
2       21.01  3.50     No  Dinner
3       23.68  3.31     No  Dinner
4       24.59  3.61     No  Dinner
```

Calling the DataFrame without the list of column names would display all columns (akin to SQL's `*`).

32.2 WHERE

Filtering in SQL is done via a WHERE clause.

```
SELECT *
FROM tips
WHERE time = 'Dinner'
LIMIT 5;
```

DataFrames can be filtered in multiple ways; the most intuitive of which is using boolean indexing.

```
In [7]: tips[tips['time'] == 'Dinner'].head(5)
Out[7]:
   total_bill   tip     sex smoker  day    time  size
0       16.99  1.01  Female     No  Sun  Dinner     2
1       10.34  1.66    Male     No  Sun  Dinner     3
2       21.01  3.50    Male     No  Sun  Dinner     3
3       23.68  3.31    Male     No  Sun  Dinner     2
4       24.59  3.61  Female     No  Sun  Dinner     4
```

The above statement is simply passing a `Series` of True/False objects to the DataFrame, returning all rows with True.

```
In [8]: is_dinner = tips['time'] == 'Dinner'

In [9]: is_dinner.value_counts()
Out[9]:
True     176
False     68
Name: time, dtype: int64

In [10]: tips[is_dinner].head(5)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[10]:
   total_bill   tip     sex smoker  day    time  size
0       16.99  1.01  Female     No  Sun  Dinner     2
1       10.34  1.66    Male     No  Sun  Dinner     3
2       21.01  3.50    Male     No  Sun  Dinner     3
3       23.68  3.31    Male     No  Sun  Dinner     2
4       24.59  3.61  Female     No  Sun  Dinner     4
```

Just like SQL's OR and AND, multiple conditions can be passed to a DataFrame using | (OR) and & (AND).

```
-- tips of more than $5.00 at Dinner meals
SELECT *
FROM tips
WHERE time = 'Dinner' AND tip > 5.00;
```

```
# tips of more than $5.00 at Dinner meals
In [11]: tips[(tips['time'] == 'Dinner') & (tips['tip'] > 5.00)]
Out[11]:
     total_bill    tip     sex smoker  day    time  size
23        39.42   7.58    Male     No  Sat  Dinner     4
44        30.40   5.60    Male     No  Sun  Dinner     4
47        32.40   6.00    Male     No  Sun  Dinner     4
52        34.81   5.20  Female     No  Sun  Dinner     4
59        48.27   6.73    Male     No  Sat  Dinner     4
116       29.93   5.07    Male     No  Sun  Dinner     4
155       29.85   5.14  Female     No  Sun  Dinner     5
170       50.81  10.00    Male    Yes  Sat  Dinner     3
172        7.25   5.15    Male    Yes  Sun  Dinner     2
181       23.33   5.65    Male    Yes  Sun  Dinner     2
183       23.17   6.50    Male    Yes  Sun  Dinner     4
211       25.89   5.16    Male    Yes  Sat  Dinner     4
212       48.33   9.00    Male     No  Sat  Dinner     4
214       28.17   6.50  Female    Yes  Sat  Dinner     3
239       29.03   5.92    Male     No  Sat  Dinner     3
```

```
-- tips by parties of at least 5 diners OR bill total was more than $45
SELECT *
FROM tips
WHERE size >= 5 OR total_bill > 45;
```

```
# tips by parties of at least 5 diners OR bill total was more than $45
In [12]: tips[(tips['size'] >= 5) | (tips['total_bill'] > 45)]
Out[12]:
     total_bill    tip     sex smoker   day    time  size
59        48.27   6.73    Male     No   Sat  Dinner     4
125       29.80   4.20  Female     No  Thur   Lunch     6
141       34.30   6.70    Male     No  Thur   Lunch     6
142       41.19   5.00    Male     No  Thur   Lunch     5
143       27.05   5.00  Female     No  Thur   Lunch     6
155       29.85   5.14  Female     No   Sun  Dinner     5
156       48.17   5.00    Male     No   Sun  Dinner     6
170       50.81  10.00    Male    Yes   Sat  Dinner     3
182       45.35   3.50    Male    Yes   Sun  Dinner     3
185       20.69   5.00    Male     No   Sun  Dinner     5
187       30.46   2.00    Male    Yes   Sun  Dinner     5
212       48.33   9.00    Male     No   Sat  Dinner     4
216       28.15   3.00    Male    Yes   Sat  Dinner     5
```

NULL checking is done using the `notna()` and `isna()` methods.

```
In [13]: frame = pd.DataFrame({'col1': ['A', 'B', np.NaN, 'C', 'D'],
   ....:                       'col2': ['F', np.NaN, 'G', 'H', 'I']})
   ....:

In [14]: frame
Out[14]:
  col1 col2
0    A    F
1    B  NaN
2  NaN    G
3    C    H
4    D    I
```

Assume we have a table of the same structure as our DataFrame above. We can see only the records where `col2` IS NULL with the following query:

```
SELECT *
FROM frame
WHERE col2 IS NULL;
```

```
In [15]: frame[frame['col2'].isna()]
Out[15]:
  col1 col2
1    B  NaN
```

Getting items where `col1` IS NOT NULL can be done with *`notna()`*.

```
SELECT *
FROM frame
WHERE col1 IS NOT NULL;
```

```
In [16]: frame[frame['col1'].notna()]
Out[16]:
  col1 col2
0    A    F
1    B  NaN
3    C    H
4    D    I
```

32.3 GROUP BY

In pandas, SQL's GROUP BY operations are performed using the similarly named *`groupby()`* method. *`groupby()`* typically refers to a process where we'd like to split a dataset into groups, apply some function (typically aggregation) , and then combine the groups together.

A common SQL operation would be getting the count of records in each group throughout a dataset. For instance, a query getting us the number of tips left by sex:

```
SELECT sex, count(*)
FROM tips
GROUP BY sex;
/*
Female     87
Male      157
*/
```

The pandas equivalent would be:

```
In [17]: tips.groupby('sex').size()
Out[17]:
sex
Female     87
Male      157
dtype: int64
```

Notice that in the pandas code we used *`size()`* and not *`count()`*. This is because *`count()`* applies the function to each column, returning the number of `not null` records within each.

```
In [18]: tips.groupby('sex').count()
Out[18]:
        total_bill  tip  smoker  day  time  size
sex
Female          87   87      87   87    87    87
Male           157  157     157  157   157   157
```

Alternatively, we could have applied the `count()` method to an individual column:

```
In [19]: tips.groupby('sex')['total_bill'].count()
Out[19]:
sex
Female     87
Male      157
Name: total_bill, dtype: int64
```

Multiple functions can also be applied at once. For instance, say we'd like to see how tip amount differs by day of the week - `agg()` allows you to pass a dictionary to your grouped DataFrame, indicating which functions to apply to specific columns.

```
SELECT day, AVG(tip), COUNT(*)
FROM tips
GROUP BY day;
/*
Fri   2.734737   19
Sat   2.993103   87
Sun   3.255132   76
Thur  2.771452   62
*/
```

```
In [20]: tips.groupby('day').agg({'tip': np.mean, 'day': np.size})
Out[20]:
           tip  day
day
Fri   2.734737   19
Sat   2.993103   87
Sun   3.255132   76
Thur  2.771452   62
```

Grouping by more than one column is done by passing a list of columns to the `groupby()` method.

```
SELECT smoker, day, COUNT(*), AVG(tip)
FROM tips
GROUP BY smoker, day;
/*
smoker day
No     Fri      4  2.812500
       Sat     45  3.102889
       Sun     57  3.167895
       Thur    45  2.673778
Yes    Fri     15  2.714000
       Sat     42  2.875476
       Sun     19  3.516842
       Thur    17  3.030000
*/
```

```
In [21]: tips.groupby(['smoker', 'day']).agg({'tip': [np.size, np.mean]})
Out[21]:
              tip
             size      mean
smoker day
No     Fri    4.0  2.812500
       Sat   45.0  3.102889
       Sun   57.0  3.167895
       Thur  45.0  2.673778
Yes    Fri   15.0  2.714000
       Sat   42.0  2.875476
       Sun   19.0  3.516842
       Thur  17.0  3.030000
```

32.4 JOIN

JOINs can be performed with *join()* or *merge()*. By default, *join()* will join the DataFrames on their indices. Each method has parameters allowing you to specify the type of join to perform (LEFT, RIGHT, INNER, FULL) or the columns to join on (column names or indices).

```
In [22]: df1 = pd.DataFrame({'key': ['A', 'B', 'C', 'D'],
   ....:                     'value': np.random.randn(4)})
   ....:

In [23]: df2 = pd.DataFrame({'key': ['B', 'D', 'D', 'E'],
   ....:                     'value': np.random.randn(4)})
   ....:
```

Assume we have two database tables of the same name and structure as our DataFrames.

Now let's go over the various types of JOINs.

32.4.1 INNER JOIN

```
SELECT *
FROM df1
INNER JOIN df2
  ON df1.key = df2.key;
```

```
# merge performs an INNER JOIN by default
In [24]: pd.merge(df1, df2, on='key')
Out[24]:
  key   value_x   value_y
0   B -0.318214  0.543581
1   D  2.169960 -0.426067
2   D  2.169960  1.138079
```

merge() also offers parameters for cases when you'd like to join one DataFrame's column with another DataFrame's index.

```
In [25]: indexed_df2 = df2.set_index('key')

In [26]: pd.merge(df1, indexed_df2, left_on='key', right_index=True)
```

```
Out[26]:
  key   value_x   value_y
1   B -0.318214  0.543581
3   D  2.169960 -0.426067
3   D  2.169960  1.138079
```

32.4.2 LEFT OUTER JOIN

```
-- show all records from df1
SELECT *
FROM df1
LEFT OUTER JOIN df2
  ON df1.key = df2.key;
```

```
# show all records from df1
In [27]: pd.merge(df1, df2, on='key', how='left')
Out[27]:
  key   value_x   value_y
0   A  0.116174       NaN
1   B -0.318214  0.543581
2   C  0.285261       NaN
3   D  2.169960 -0.426067
4   D  2.169960  1.138079
```

32.4.3 RIGHT JOIN

```
-- show all records from df2
SELECT *
FROM df1
RIGHT OUTER JOIN df2
  ON df1.key = df2.key;
```

```
# show all records from df2
In [28]: pd.merge(df1, df2, on='key', how='right')
Out[28]:
  key   value_x   value_y
0   B -0.318214  0.543581
1   D  2.169960 -0.426067
2   D  2.169960  1.138079
3   E       NaN  0.086073
```

32.4.4 FULL JOIN

pandas also allows for FULL JOINs, which display both sides of the dataset, whether or not the joined columns find a match. As of writing, FULL JOINs are not supported in all RDBMS (MySQL).

```
-- show all records from both tables
SELECT *
FROM df1
FULL OUTER JOIN df2
  ON df1.key = df2.key;
```

```
# show all records from both frames
In [29]: pd.merge(df1, df2, on='key', how='outer')
Out[29]:
  key   value_x   value_y
0   A  0.116174       NaN
1   B -0.318214  0.543581
2   C  0.285261       NaN
3   D  2.169960 -0.426067
4   D  2.169960  1.138079
5   E       NaN  0.086073
```

32.5 UNION

UNION ALL can be performed using *concat()*.

```
In [30]: df1 = pd.DataFrame({'city': ['Chicago', 'San Francisco', 'New York City'],
   ....:                     'rank': range(1, 4)})
   ....:

In [31]: df2 = pd.DataFrame({'city': ['Chicago', 'Boston', 'Los Angeles'],
   ....:                     'rank': [1, 4, 5]})
   ....:
```

```
SELECT city, rank
FROM df1
UNION ALL
SELECT city, rank
FROM df2;
/*
         city  rank
      Chicago     1
San Francisco     2
New York City     3
      Chicago     1
       Boston     4
  Los Angeles     5
*/
```

```
In [32]: pd.concat([df1, df2])
Out[32]:
            city  rank
0        Chicago     1
1  San Francisco     2
2  New York City     3
0        Chicago     1
1         Boston     4
2    Los Angeles     5
```

SQL's UNION is similar to UNION ALL, however UNION will remove duplicate rows.

```
SELECT city, rank
FROM df1
UNION
SELECT city, rank
FROM df2;
```

```
-- notice that there is only one Chicago record this time
/*
         city  rank
      Chicago     1
San Francisco     2
New York City     3
       Boston     4
  Los Angeles     5
*/
```

In pandas, you can use `concat()` in conjunction with `drop_duplicates()`.

```
In [33]: pd.concat([df1, df2]).drop_duplicates()
Out[33]:
            city  rank
0        Chicago     1
1  San Francisco     2
2  New York City     3
1         Boston     4
2    Los Angeles     5
```

32.6 Pandas equivalents for some SQL analytic and aggregate functions

32.6.1 Top N rows with offset

```
-- MySQL
SELECT * FROM tips
ORDER BY tip DESC
LIMIT 10 OFFSET 5;
```

```
In [34]: tips.nlargest(10+5, columns='tip').tail(10)
Out[34]:
     total_bill   tip     sex smoker   day    time  size
183       23.17  6.50    Male    Yes   Sun  Dinner     4
214       28.17  6.50  Female    Yes   Sat  Dinner     3
47        32.40  6.00    Male     No   Sun  Dinner     4
239       29.03  5.92    Male     No   Sat  Dinner     3
88        24.71  5.85    Male     No  Thur   Lunch     2
181       23.33  5.65    Male    Yes   Sun  Dinner     2
44        30.40  5.60    Male     No   Sun  Dinner     4
52        34.81  5.20  Female     No   Sun  Dinner     4
85        34.83  5.17  Female     No  Thur   Lunch     4
211       25.89  5.16    Male    Yes   Sat  Dinner     4
```

32.6.2 Top N rows per group

```
-- Oracle's ROW_NUMBER() analytic function
SELECT * FROM (
  SELECT
    t.*,
```

```
    ROW_NUMBER() OVER(PARTITION BY day ORDER BY total_bill DESC) AS rn
  FROM tips t
)
WHERE rn < 3
ORDER BY day, rn;
```

```
In [35]: (tips.assign(rn=tips.sort_values(['total_bill'], ascending=False)
   ....:                      .groupby(['day'])
   ....:                      .cumcount() + 1)
   ....:      .query('rn < 3')
   ....:      .sort_values(['day','rn'])
   ....: )
   ....:
Out[35]:
     total_bill    tip     sex smoker   day    time  size  rn
95        40.17   4.73    Male    Yes   Fri  Dinner     4   1
90        28.97   3.00    Male    Yes   Fri  Dinner     2   2
170       50.81  10.00    Male    Yes   Sat  Dinner     3   1
212       48.33   9.00    Male     No   Sat  Dinner     4   2
156       48.17   5.00    Male     No   Sun  Dinner     6   1
182       45.35   3.50    Male    Yes   Sun  Dinner     3   2
197       43.11   5.00  Female    Yes  Thur   Lunch     4   1
142       41.19   5.00    Male     No  Thur   Lunch     5   2
```

the same using *rank(method='first')* function

```
In [36]: (tips.assign(rnk=tips.groupby(['day'])['total_bill']
   ....:                       .rank(method='first', ascending=False))
   ....:      .query('rnk < 3')
   ....:      .sort_values(['day','rnk'])
   ....: )
   ....:
Out[36]:
     total_bill    tip     sex smoker   day    time  size  rnk
95        40.17   4.73    Male    Yes   Fri  Dinner     4  1.0
90        28.97   3.00    Male    Yes   Fri  Dinner     2  2.0
170       50.81  10.00    Male    Yes   Sat  Dinner     3  1.0
212       48.33   9.00    Male     No   Sat  Dinner     4  2.0
156       48.17   5.00    Male     No   Sun  Dinner     6  1.0
182       45.35   3.50    Male    Yes   Sun  Dinner     3  2.0
197       43.11   5.00  Female    Yes  Thur   Lunch     4  1.0
142       41.19   5.00    Male     No  Thur   Lunch     5  2.0
```

```
-- Oracle's RANK() analytic function
SELECT * FROM (
  SELECT
    t.*,
    RANK() OVER(PARTITION BY sex ORDER BY tip) AS rnk
  FROM tips t
  WHERE tip < 2
)
WHERE rnk < 3
ORDER BY sex, rnk;
```

Let's find tips with (rank < 3) per gender group for (tips < 2). Notice that when using `rank(method='min')` function *rnk_min* remains the same for the same *tip* (as Oracle's RANK() function)

```
In [37]: (tips[tips['tip'] < 2]
   ....:      .assign(rnk_min=tips.groupby(['sex'])['tip']
   ....:                           .rank(method='min'))
   ....:      .query('rnk_min < 3')
   ....:      .sort_values(['sex','rnk_min'])
   ....: )
   ....:
Out[37]:
     total_bill   tip     sex smoker  day    time  size  rnk_min
67         3.07  1.00  Female    Yes  Sat  Dinner     1      1.0
92         5.75  1.00  Female    Yes  Fri  Dinner     2      1.0
111        7.25  1.00  Female     No  Sat  Dinner     1      1.0
236       12.60  1.00    Male    Yes  Sat  Dinner     2      1.0
237       32.83  1.17    Male    Yes  Sat  Dinner     2      2.0
```

32.7 UPDATE

```
UPDATE tips
SET tip = tip*2
WHERE tip < 2;
```

```
In [38]: tips.loc[tips['tip'] < 2, 'tip'] *= 2
```

32.8 DELETE

```
DELETE FROM tips
WHERE tip > 9;
```

In pandas we select the rows that should remain, instead of deleting them

```
In [39]: tips = tips.loc[tips['tip'] <= 9]
```

CHAPTER

THIRTYTHREE

COMPARISON WITH SAS

For potential users coming from SAS this page is meant to demonstrate how different SAS operations would be performed in pandas.

If you're new to pandas, you might want to first read through *10 Minutes to pandas* to familiarize yourself with the library.

As is customary, we import pandas and numpy as follows:

```
In [1]: import pandas as pd

In [2]: import numpy as np
```

Note: Throughout this tutorial, the pandas `DataFrame` will be displayed by calling `df.head()`, which displays the first N (default 5) rows of the `DataFrame`. This is often used in interactive work (e.g. Jupyter notebook or terminal) - the equivalent in SAS would be:

```
proc print data=df(obs=5);
run;
```

33.1 Data Structures

33.1.1 General Terminology Translation

pandas	SAS
`DataFrame`	data set
column	variable
row	observation
groupby	BY-group
`NaN`	.

33.1.2 `DataFrame` / `Series`

A `DataFrame` in pandas is analogous to a SAS data set - a two-dimensional data source with labeled columns that can be of different types. As will be shown in this document, almost any operation that can be applied to a data set using SAS's `DATA` step, can also be accomplished in pandas.

A `Series` is the data structure that represents one column of a `DataFrame`. SAS doesn't have a separate data structure for a single column, but in general, working with a `Series` is analogous to referencing a column in the `DATA` step.

33.1.3 Index

Every `DataFrame` and `Series` has an `Index` - which are labels on the *rows* of the data. SAS does not have an exactly analogous concept. A data set's row are essentially unlabeled, other than an implicit integer index that can be accessed during the `DATA` step (`_N_`).

In pandas, if no index is specified, an integer index is also used by default (first row = 0, second row = 1, and so on). While using a labeled `Index` or `MultiIndex` can enable sophisticated analyses and is ultimately an important part of pandas to understand, for this comparison we will essentially ignore the `Index` and just treat the `DataFrame` as a collection of columns. Please see the *indexing documentation* for much more on how to use an `Index` effectively.

33.2 Data Input / Output

33.2.1 Constructing a DataFrame from Values

A SAS data set can be built from specified values by placing the data after a `datalines` statement and specifying the column names.

```
data df;
    input x y;
    datalines;
    1 2
    3 4
    5 6
    ;
run;
```

A pandas `DataFrame` can be constructed in many different ways, but for a small number of values, it is often convenient to specify it as a python dictionary, where the keys are the column names and the values are the data.

```
In [3]: df = pd.DataFrame({
   ...:            'x': [1, 3, 5],
   ...:            'y': [2, 4, 6]})
   ...:

In [4]: df
Out[4]:
   x  y
0  1  2
1  3  4
2  5  6
```

33.2.2 Reading External Data

Like SAS, pandas provides utilities for reading in data from many formats. The `tips` dataset, found within the pandas tests (csv) will be used in many of the following examples.

SAS provides `PROC IMPORT` to read csv data into a data set.

```
proc import datafile='tips.csv' dbms=csv out=tips replace;
    getnames=yes;
run;
```

The pandas method is *read_csv()*, which works similarly.

```
In [5]: url = 'https://raw.github.com/pandas-dev/pandas/master/pandas/tests/data/tips.
↪csv'

In [6]: tips = pd.read_csv(url)

In [7]: tips.head()
Out[7]:
   total_bill   tip     sex smoker  day    time  size
0       16.99  1.01  Female     No  Sun  Dinner     2
1       10.34  1.66    Male     No  Sun  Dinner     3
2       21.01  3.50    Male     No  Sun  Dinner     3
3       23.68  3.31    Male     No  Sun  Dinner     2
4       24.59  3.61  Female     No  Sun  Dinner     4
```

Like `PROC IMPORT`, `read_csv` can take a number of parameters to specify how the data should be parsed. For example, if the data was instead tab delimited, and did not have column names, the pandas command would be:

```
tips = pd.read_csv('tips.csv', sep='\t', header=None)

# alternatively, read_table is an alias to read_csv with tab delimiter
tips = pd.read_table('tips.csv', header=None)
```

In addition to text/csv, pandas supports a variety of other data formats such as Excel, HDF5, and SQL databases. These are all read via a `pd.read_*` function. See the *IO documentation* for more details.

33.2.3 Exporting Data

The inverse of `PROC IMPORT` in SAS is `PROC EXPORT`

```
proc export data=tips outfile='tips2.csv' dbms=csv;
run;
```

Similarly in pandas, the opposite of `read_csv` is *to_csv()*, and other data formats follow a similar api.

```
tips.to_csv('tips2.csv')
```

33.3 Data Operations

33.3.1 Operations on Columns

In the `DATA` step, arbitrary math expressions can be used on new or existing columns.

```
data tips;
    set tips;
    total_bill = total_bill - 2;
    new_bill = total_bill / 2;
run;
```

pandas provides similar vectorized operations by specifying the individual `Series` in the `DataFrame`. New columns can be assigned in the same way.

```
In [8]: tips['total_bill'] = tips['total_bill'] - 2

In [9]: tips['new_bill'] = tips['total_bill'] / 2.0

In [10]: tips.head()
Out[10]:
   total_bill   tip     sex smoker  day    time  size  new_bill
0       14.99  1.01  Female     No  Sun  Dinner     2     7.495
1        8.34  1.66    Male     No  Sun  Dinner     3     4.170
2       19.01  3.50    Male     No  Sun  Dinner     3     9.505
3       21.68  3.31    Male     No  Sun  Dinner     2    10.840
4       22.59  3.61  Female     No  Sun  Dinner     4    11.295
```

33.3.2 Filtering

Filtering in SAS is done with an `if` or `where` statement, on one or more columns.

```
data tips;
    set tips;
    if total_bill > 10;
run;

data tips;
    set tips;
    where total_bill > 10;
    /* equivalent in this case - where happens before the
       DATA step begins and can also be used in PROC statements */
run;
```

DataFrames can be filtered in multiple ways; the most intuitive of which is using *boolean indexing*

```
In [11]: tips[tips['total_bill'] > 10].head()
Out[11]:
   total_bill   tip     sex smoker  day    time  size
0       14.99  1.01  Female     No  Sun  Dinner     2
2       19.01  3.50    Male     No  Sun  Dinner     3
3       21.68  3.31    Male     No  Sun  Dinner     2
4       22.59  3.61  Female     No  Sun  Dinner     4
5       23.29  4.71    Male     No  Sun  Dinner     4
```

33.3.3 If/Then Logic

In SAS, if/then logic can be used to create new columns.

```
data tips;
    set tips;
    format bucket $4.;

    if total_bill < 10 then bucket = 'low';
    else bucket = 'high';
run;
```

The same operation in pandas can be accomplished using the `where` method from `numpy`.

```
In [12]: tips['bucket'] = np.where(tips['total_bill'] < 10, 'low', 'high')

In [13]: tips.head()
Out[13]:
   total_bill   tip     sex smoker  day    time  size bucket
0       14.99  1.01  Female     No  Sun  Dinner     2   high
1        8.34  1.66    Male     No  Sun  Dinner     3    low
2       19.01  3.50    Male     No  Sun  Dinner     3   high
3       21.68  3.31    Male     No  Sun  Dinner     2   high
4       22.59  3.61  Female     No  Sun  Dinner     4   high
```

33.3.4 Date Functionality

SAS provides a variety of functions to do operations on date/datetime columns.

```
data tips;
    set tips;
    format date1 date2 date1_plusmonth mmddyy10.;
    date1 = mdy(1, 15, 2013);
    date2 = mdy(2, 15, 2015);
    date1_year = year(date1);
    date2_month = month(date2);
    * shift date to beginning of next interval;
    date1_next = intnx('MONTH', date1, 1);
    * count intervals between dates;
    months_between = intck('MONTH', date1, date2);
run;
```

The equivalent pandas operations are shown below. In addition to these functions pandas supports other Time Series features not available in Base SAS (such as resampling and and custom offsets) - see the *timeseries documentation* for more details.

```
In [14]: tips['date1'] = pd.Timestamp('2013-01-15')

In [15]: tips['date2'] = pd.Timestamp('2015-02-15')

In [16]: tips['date1_year'] = tips['date1'].dt.year

In [17]: tips['date2_month'] = tips['date2'].dt.month

In [18]: tips['date1_next'] = tips['date1'] + pd.offsets.MonthBegin()

In [19]: tips['months_between'] = (tips['date2'].dt.to_period('M') -
   ....:                           tips['date1'].dt.to_period('M'))
   ....:

In [20]: tips[['date1','date2','date1_year','date2_month',
   ....:       'date1_next','months_between']].head()
   ....:
Out[20]:
       date1      date2  date1_year  date2_month date1_next months_between
0 2013-01-15 2015-02-15        2013            2 2013-02-01             25
1 2013-01-15 2015-02-15        2013            2 2013-02-01             25
2 2013-01-15 2015-02-15        2013            2 2013-02-01             25
```

```
3 2013-01-15 2015-02-15        2013            2 2013-02-01             25
4 2013-01-15 2015-02-15        2013            2 2013-02-01             25
```

33.3.5 Selection of Columns

SAS provides keywords in the `DATA` step to select, drop, and rename columns.

```
data tips;
    set tips;
    keep sex total_bill tip;
run;

data tips;
    set tips;
    drop sex;
run;

data tips;
    set tips;
    rename total_bill=total_bill_2;
run;
```

The same operations are expressed in pandas below.

```
# keep
In [21]: tips[['sex', 'total_bill', 'tip']].head()
Out[21]: 
      sex  total_bill   tip
0  Female       14.99  1.01
1    Male        8.34  1.66
2    Male       19.01  3.50
3    Male       21.68  3.31
4  Female       22.59  3.61

# drop
In [22]: tips.drop('sex', axis=1).head()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   total_bill   tip smoker  day    time  size
0       14.99  1.01     No  Sun  Dinner     2
1        8.34  1.66     No  Sun  Dinner     3
2       19.01  3.50     No  Sun  Dinner     3
3       21.68  3.31     No  Sun  Dinner     2
4       22.59  3.61     No  Sun  Dinner     4

# rename
In [23]: tips.rename(columns={'total_bill':'total_bill_2'}).head()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
   total_bill_2   tip     sex smoker  day    time  size
0         14.99  1.01  Female     No  Sun  Dinner     2
1          8.34  1.66    Male     No  Sun  Dinner     3
2         19.01  3.50    Male     No  Sun  Dinner     3
3         21.68  3.31    Male     No  Sun  Dinner     2
4         22.59  3.61  Female     No  Sun  Dinner     4
```

33.3.6 Sorting by Values

Sorting in SAS is accomplished via `PROC SORT`

```
proc sort data=tips;
    by sex total_bill;
run;
```

pandas objects have a *`sort_values()`* method, which takes a list of columns to sort by.

```
In [24]: tips = tips.sort_values(['sex', 'total_bill'])

In [25]: tips.head()
Out[25]:
     total_bill   tip     sex smoker   day    time  size
67         1.07  1.00  Female    Yes   Sat  Dinner     1
92         3.75  1.00  Female    Yes   Fri  Dinner     2
111        5.25  1.00  Female     No   Sat  Dinner     1
145        6.35  1.50  Female     No  Thur   Lunch     2
135        6.51  1.25  Female     No  Thur   Lunch     2
```

33.4 String Processing

33.4.1 Length

SAS determines the length of a character string with the LENGTHN and LENGTHC functions. `LENGTHN` excludes trailing blanks and `LENGTHC` includes trailing blanks.

```
data _null_;
set tips;
put(LENGTHN(time));
put(LENGTHC(time));
run;
```

Python determines the length of a character string with the `len` function. `len` includes trailing blanks. Use `len` and `rstrip` to exclude trailing blanks.

```
In [26]: tips['time'].str.len().head()
Out[26]:
67     6
92     6
111    6
145    5
135    5
Name: time, dtype: int64

In [27]: tips['time'].str.rstrip().str.len().head()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[27]:␣
↪
67     6
92     6
111    6
145    5
135    5
Name: time, dtype: int64
```

33.4.2 Find

SAS determines the position of a character in a string with the FINDW function. `FINDW` takes the string defined by the first argument and searches for the first position of the substring you supply as the second argument.

```
data _null_;
set tips;
put(FINDW(sex,'ale'));
run;
```

Python determines the position of a character in a string with the `find` function. `find` searches for the first position of the substring. If the substring is found, the function returns its position. Keep in mind that Python indexes are zero-based and the function will return -1 if it fails to find the substring.

```
In [28]: tips['sex'].str.find("ale").head()
Out[28]:
67     3
92     3
111    3
145    3
135    3
Name: sex, dtype: int64
```

33.4.3 Substring

SAS extracts a substring from a string based on its position with the SUBSTR function.

```
data _null_;
set tips;
put(substr(sex,1,1));
run;
```

With pandas you can use `[]` notation to extract a substring from a string by position locations. Keep in mind that Python indexes are zero-based.

```
In [29]: tips['sex'].str[0:1].head()
Out[29]:
67     F
92     F
111    F
145    F
135    F
Name: sex, dtype: object
```

33.4.4 Scan

The SAS SCAN function returns the nth word from a string. The first argument is the string you want to parse and the second argument specifies which word you want to extract.

```
data firstlast;
input String $60.;
First_Name = scan(string, 1);
Last_Name = scan(string, -1);
datalines2;
```

```
John Smith;
Jane Cook;
;;;
run;
```

Python extracts a substring from a string based on its text by using regular expressions. There are much more powerful approaches, but this just shows a simple approach.

```
In [30]: firstlast = pd.DataFrame({'String': ['John Smith', 'Jane Cook']})

In [31]: firstlast['First_Name'] = firstlast['String'].str.split(" ", expand=True)[0]

In [32]: firstlast['Last_Name'] = firstlast['String'].str.rsplit(" ", expand=True)[0]

In [33]: firstlast
Out[33]:
       String First_Name Last_Name
0  John Smith       John      John
1   Jane Cook       Jane      Jane
```

33.4.5 Upcase, Lowcase, and Propcase

The SAS UPCASE LOWCASE and PROPCASE functions change the case of the argument.

```
data firstlast;
input String $60.;
string_up = UPCASE(string);
string_low = LOWCASE(string);
string_prop = PROPCASE(string);
datalines2;
John Smith;
Jane Cook;
;;;
run;
```

The equivalent Python functions are `upper`, `lower`, and `title`.

```
In [34]: firstlast = pd.DataFrame({'String': ['John Smith', 'Jane Cook']})

In [35]: firstlast['string_up'] = firstlast['String'].str.upper()

In [36]: firstlast['string_low'] = firstlast['String'].str.lower()

In [37]: firstlast['string_prop'] = firstlast['String'].str.title()

In [38]: firstlast
Out[38]:
       String   string_up  string_low string_prop
0  John Smith  JOHN SMITH  john smith  John Smith
1   Jane Cook   JANE COOK   jane cook   Jane Cook
```

33.5 Merging

The following tables will be used in the merge examples

```
In [39]: df1 = pd.DataFrame({'key': ['A', 'B', 'C', 'D'],
   ....:                     'value': np.random.randn(4)})
   ....:

In [40]: df1
Out[40]:
  key     value
0   A -0.857326
1   B  1.075416
2   C  0.371727
3   D  1.065735

In [41]: df2 = pd.DataFrame({'key': ['B', 'D', 'D', 'E'],
   ....:                      'value': np.random.randn(4)})
   ....:

In [42]: df2
Out[42]:
  key     value
0   B -0.227314
1   D  2.102726
2   D -0.092796
3   E  0.094694
```

In SAS, data must be explicitly sorted before merging. Different types of joins are accomplished using the `in=` dummy variables to track whether a match was found in one or both input frames.

```
proc sort data=df1;
    by key;
run;

proc sort data=df2;
    by key;
run;

data left_join inner_join right_join outer_join;
    merge df1(in=a) df2(in=b);

    if a and b then output inner_join;
    if a then output left_join;
    if b then output right_join;
    if a or b then output outer_join;
run;
```

pandas DataFrames have a *`merge()`* method, which provides similar functionality. Note that the data does not have to be sorted ahead of time, and different join types are accomplished via the `how` keyword.

```
In [43]: inner_join = df1.merge(df2, on=['key'], how='inner')

In [44]: inner_join
Out[44]:
  key   value_x   value_y
0   B  1.075416 -0.227314
1   D  1.065735  2.102726
2   D  1.065735 -0.092796

In [45]: left_join = df1.merge(df2, on=['key'], how='left')
```

```
In [46]: left_join
Out[46]:
  key   value_x   value_y
0   A -0.857326       NaN
1   B  1.075416 -0.227314
2   C  0.371727       NaN
3   D  1.065735  2.102726
4   D  1.065735 -0.092796

In [47]: right_join = df1.merge(df2, on=['key'], how='right')

In [48]: right_join
Out[48]:
  key   value_x   value_y
0   B  1.075416 -0.227314
1   D  1.065735  2.102726
2   D  1.065735 -0.092796
3   E       NaN  0.094694

In [49]: outer_join = df1.merge(df2, on=['key'], how='outer')

In [50]: outer_join
Out[50]:
  key   value_x   value_y
0   A -0.857326       NaN
1   B  1.075416 -0.227314
2   C  0.371727       NaN
3   D  1.065735  2.102726
4   D  1.065735 -0.092796
5   E       NaN  0.094694
```

33.6 Missing Data

Like SAS, pandas has a representation for missing data - which is the special float value `NaN` (not a number). Many of the semantics are the same, for example missing data propagates through numeric operations, and is ignored by default for aggregations.

```
In [51]: outer_join
Out[51]:
  key   value_x   value_y
0   A -0.857326       NaN
1   B  1.075416 -0.227314
2   C  0.371727       NaN
3   D  1.065735  2.102726
4   D  1.065735 -0.092796
5   E       NaN  0.094694

In [52]: outer_join['value_x'] + outer_join['value_y']
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0         NaN
1    0.848102
2         NaN
3    3.168461
4    0.972939
```

```
5         NaN
dtype: float64

In [53]: outer_join['value_x'].sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪2.7212865354426201
```

One difference is that missing data cannot be compared to its sentinel value. For example, in SAS you could do this to filter missing values.

```
data outer_join_nulls;
    set outer_join;
    if value_x = .;
run;

data outer_join_no_nulls;
    set outer_join;
    if value_x ^= .;
run;
```

Which doesn't work in in pandas. Instead, the `pd.isna` or `pd.notna` functions should be used for comparisons.

```
In [54]: outer_join[pd.isna(outer_join['value_x'])]
Out[54]:
  key  value_x   value_y
5   E      NaN  0.094694

In [55]: outer_join[pd.notna(outer_join['value_x'])]
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[55]:
  key   value_x   value_y
0   A -0.857326       NaN
1   B  1.075416 -0.227314
2   C  0.371727       NaN
3   D  1.065735  2.102726
4   D  1.065735 -0.092796
```

pandas also provides a variety of methods to work with missing data - some of which would be challenging to express in SAS. For example, there are methods to drop all rows with any missing values, replacing missing values with a specified value, like the mean, or forward filling from previous rows. See the *missing data documentation* for more.

```
In [56]: outer_join.dropna()
Out[56]:
  key   value_x   value_y
1   B  1.075416 -0.227314
3   D  1.065735  2.102726
4   D  1.065735 -0.092796

In [57]: outer_join.fillna(method='ffill')
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
  key   value_x   value_y
0   A -0.857326       NaN
1   B  1.075416 -0.227314
2   C  0.371727 -0.227314
3   D  1.065735  2.102726
4   D  1.065735 -0.092796
5   E  1.065735  0.094694
```

```
In [58]: outer_join['value_x'].fillna(outer_join['value_x'].mean())
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪
0   -0.857326
1    1.075416
2    0.371727
3    1.065735
4    1.065735
5    0.544257
Name: value_x, dtype: float64
```

33.7 GroupBy

33.7.1 Aggregation

SAS's PROC SUMMARY can be used to group by one or more key variables and compute aggregations on numeric columns.

```
proc summary data=tips nway;
    class sex smoker;
    var total_bill tip;
    output out=tips_summed sum=;
run;
```

pandas provides a flexible `groupby` mechanism that allows similar aggregations. See the *groupby documentation* for more details and examples.

```
In [59]: tips_summed = tips.groupby(['sex', 'smoker'])['total_bill', 'tip'].sum()

In [60]: tips_summed.head()
Out[60]:
               total_bill     tip
sex    smoker
Female No          869.68  149.77
       Yes         527.27   96.74
Male   No         1725.75  302.00
       Yes        1217.07  183.07
```

33.7.2 Transformation

In SAS, if the group aggregations need to be used with the original frame, it must be merged back together. For example, to subtract the mean for each observation by smoker group.

```
proc summary data=tips missing nway;
    class smoker;
    var total_bill;
    output out=smoker_means mean(total_bill)=group_bill;
run;

proc sort data=tips;
    by smoker;
run;
```

```
data tips;
    merge tips(in=a) smoker_means(in=b);
    by smoker;
    adj_total_bill = total_bill - group_bill;
    if a and b;
run;
```

pandas `groubpy` provides a `transform` mechanism that allows these type of operations to be succinctly expressed in one operation.

```
In [61]: gb = tips.groupby('smoker')['total_bill']

In [62]: tips['adj_total_bill'] = tips['total_bill'] - gb.transform('mean')

In [63]: tips.head()
Out[63]:
     total_bill   tip     sex smoker   day    time  size  adj_total_bill
67         1.07  1.00  Female    Yes   Sat  Dinner     1      -17.686344
92         3.75  1.00  Female    Yes   Fri  Dinner     2      -15.006344
111        5.25  1.00  Female     No   Sat  Dinner     1      -11.938278
145        6.35  1.50  Female     No  Thur   Lunch     2      -10.838278
135        6.51  1.25  Female     No  Thur   Lunch     2      -10.678278
```

33.7.3 By Group Processing

In addition to aggregation, pandas `groupby` can be used to replicate most other by group processing from SAS. For example, this `DATA` step reads the data by sex/smoker group and filters to the first entry for each.

```
proc sort data=tips;
   by sex smoker;
run;

data tips_first;
    set tips;
    by sex smoker;
    if FIRST.sex or FIRST.smoker then output;
run;
```

In pandas this would be written as:

```
In [64]: tips.groupby(['sex','smoker']).first()
Out[64]:
               total_bill   tip   day    time  size  adj_total_bill
sex    smoker
Female No            5.25  1.00   Sat  Dinner     1      -11.938278
       Yes           1.07  1.00   Sat  Dinner     1      -17.686344
Male   No            5.51  2.00  Thur   Lunch     2      -11.678278
       Yes           5.25  5.15   Sun  Dinner     2      -13.506344
```

33.8 Other Considerations

33.8.1 Disk vs Memory

pandas operates exclusively in memory, where a SAS data set exists on disk. This means that the size of data able to be loaded in pandas is limited by your machine's memory, but also that the operations on that data may be faster.

If out of core processing is needed, one possibility is the dask.dataframe library (currently in development) which provides a subset of pandas functionality for an on-disk `DataFrame`

33.8.2 Data Interop

pandas provides a *`read_sas()`* method that can read SAS data saved in the XPORT or SAS7BDAT binary format.

```
libname xportout xport 'transport-file.xpt';
data xportout.tips;
    set tips(rename=(total_bill=tbill));
    * xport variable names limited to 6 characters;
run;
```

```
df = pd.read_sas('transport-file.xpt')
df = pd.read_sas('binary-file.sas7bdat')
```

You can also specify the file format directly. By default, pandas will try to infer the file format based on its extension.

```
df = pd.read_sas('transport-file.xpt', format='xport')
df = pd.read_sas('binary-file.sas7bdat', format='sas7bdat')
```

XPORT is a relatively limited format and the parsing of it is not as optimized as some of the other pandas readers. An alternative way to interop data between SAS and pandas is to serialize to csv.

```
# version 0.17, 10M rows

In [8]: %time df = pd.read_sas('big.xpt')
Wall time: 14.6 s

In [9]: %time df = pd.read_csv('big.csv')
Wall time: 4.86 s
```

CHAPTER

THIRTYFOUR

API REFERENCE

This page gives an overview of all public pandas objects, functions and methods. In general, all classes and functions exposed in the top-level `pandas.*` namespace are regarded as public.

Further some of the subpackages are public, including `pandas.errors`, `pandas.plotting`, and `pandas.testing`. Certain functions in the the `pandas.io` and `pandas.tseries` submodules are public as well (those mentioned in the documentation). Further, the `pandas.api.types` subpackage holds some public functions related to data types in pandas.

Warning: The `pandas.core`, `pandas.compat`, and `pandas.util` top-level modules are considered to be PRIVATE. Stability of functionality in those modules in not guaranteed.

34.1 Input/Output

34.1.1 Pickling

read_pickle(path[, compression])	Load pickled pandas object (or any other pickled object) from the specified

34.1.1.1 pandas.read_pickle

`pandas.`**`read_pickle`**(*path*, *compression='infer'*)

Load pickled pandas object (or any other pickled object) from the specified file path

Warning: Loading pickled data received from untrusted sources can be unsafe. See: http://docs.python.org/2.7/library/pickle.html

Parameters **path** : string

File path

compression : {'infer', 'gzip', 'bz2', 'xz', 'zip', None}, default 'infer'

For on-the-fly decompression of on-disk data. If 'infer', then use gzip, bz2, xz or zip if path ends in '.gz', '.bz2', '.xz', or '.zip' respectively, and no decompression otherwise. Set to None for no decompression.

New in version 0.20.0.

Returns **unpickled** : type of object stored in file

34.1.2 Flat File

`read_table`(filepath_or_buffer[, sep, ...])	Read general delimited file into DataFrame
`read_csv`(filepath_or_buffer[, sep, ...])	Read CSV (comma-separated) file into DataFrame
`read_fwf`(filepath_or_buffer[, colspecs, widths])	Read a table of fixed-width formatted lines into DataFrame
`read_msgpack`(path_or_buf[, encoding, iterator])	Load msgpack pandas object from the specified

34.1.2.1 pandas.read_table

`pandas.read_table`(*filepath_or_buffer, sep='\t', delimiter=None, header='infer', names=None, index_col=None, usecols=None, squeeze=False, prefix=None, mangle_dupe_cols=True, dtype=None, engine=None, converters=None, true_values=None, false_values=None, skipinitialspace=False, skiprows=None, nrows=None, na_values=None, keep_default_na=True, na_filter=True, verbose=False, skip_blank_lines=True, parse_dates=False, infer_datetime_format=False, keep_date_col=False, date_parser=None, dayfirst=False, iterator=False, chunksize=None, compression='infer', thousands=None, decimal=b'.', lineterminator=None, quotechar='"', quoting=0, escapechar=None, comment=None, encoding=None, dialect=None, tupleize_cols=None, error_bad_lines=True, warn_bad_lines=True, skipfooter=0, skip_footer=0, doublequote=True, delim_whitespace=False, as_recarray=None, compact_ints=None, use_unsigned=None, low_memory=True, buffer_lines=None, memory_map=False, float_precision=None*)

Read general delimited file into DataFrame

Also supports optionally iterating or breaking of the file into chunks.

Additional help can be found in the online docs for IO Tools.

Parameters **filepath_or_buffer** : str, pathlib.Path, py._path.local.LocalPath or any object with a read() method (such as a file handle or StringIO)

The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be file ://localhost/path/to/table.csv

sep : str, default t (tab-stop)

Delimiter to use. If sep is None, the C engine cannot automatically detect the separator, but the Python parsing engine can, meaning the latter will be used and automatically detect the separator by Python's builtin sniffer tool, `csv.Sniffer`. In addition, separators longer than 1 character and different from `'\s+'` will be interpreted as regular expressions and will also force the use of the Python parsing engine. Note that regex delimiters are prone to ignoring quoted data. Regex example: `'\r\t'`

delimiter : str, default `None`

Alternative argument name for sep.

delim_whitespace : boolean, default False

Specifies whether or not whitespace (e.g. `' '` or `' '`) will be used as the sep. Equivalent to setting `sep='\s+'`. If this option is set to True, nothing should be passed in for the `delimiter` parameter.

New in version 0.18.1: support for the Python parser.

header : int or list of ints, default 'infer'

Row number(s) to use as the column names, and the start of the data. Default behavior is as if set to 0 if no `names` passed, otherwise `None`. Explicitly pass `header=0` to be able to replace existing names. The header can be a list of integers that specify row locations for a multi-index on the columns e.g. [0,1,3]. Intervening rows that are not specified will be skipped (e.g. 2 in this example is skipped). Note that this parameter ignores commented lines and empty lines if `skip_blank_lines=True`, so header=0 denotes the first line of data rather than the first line of the file.

names : array-like, default None

List of column names to use. If file contains no header row, then you should explicitly pass header=None. Duplicates in this list will cause a `UserWarning` to be issued.

index_col : int or sequence or False, default None

Column to use as the row labels of the DataFrame. If a sequence is given, a MultiIndex is used. If you have a malformed file with delimiters at the end of each line, you might consider index_col=False to force pandas to _not_ use the first column as the index (row names)

usecols : array-like or callable, default None

Return a subset of the columns. If array-like, all elements must either be positional (i.e. integer indices into the document columns) or strings that correspond to column names provided either by the user in *names* or inferred from the document header row(s). For example, a valid array-like *usecols* parameter would be [0, 1, 2] or ['foo', 'bar', 'baz'].

If callable, the callable function will be evaluated against the column names, returning names where the callable function evaluates to True. An example of a valid callable argument would be `lambda x: x.upper() in ['AAA', 'BBB', 'DDD']`. Using this parameter results in much faster parsing time and lower memory usage.

as_recarray : boolean, default False

Deprecated since version 0.19.0: Please call *pd.read_csv(...).to_records()* instead.

Return a NumPy recarray instead of a DataFrame after parsing the data. If set to True, this option takes precedence over the *squeeze* parameter. In addition, as row indices are not available in such a format, the *index_col* parameter will be ignored.

squeeze : boolean, default False

If the parsed data only contains one column then return a Series

prefix : str, default None

Prefix to add to column numbers when no header, e.g. 'X' for X0, X1, ...

mangle_dupe_cols : boolean, default True

Duplicate columns will be specified as 'X.0'...'X.N', rather than 'X'...'X'. Passing in False will cause data to be overwritten if there are duplicate names in the columns.

dtype : Type name or dict of column -> type, default None

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32} Use *str* or *object* to preserve and not interpret dtype. If converters are specified, they will be applied INSTEAD of dtype conversion.

engine : {'c', 'python'}, optional

Parser engine to use. The C engine is faster while the python engine is currently more feature-complete.

converters : dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels

true_values : list, default None

Values to consider as True

false_values : list, default None

Values to consider as False

skipinitialspace : boolean, default False

Skip spaces after delimiter.

skiprows : list-like or integer or callable, default None

Line numbers to skip (0-indexed) or number of lines to skip (int) at the start of the file.

If callable, the callable function will be evaluated against the row indices, returning True if the row should be skipped and False otherwise. An example of a valid callable argument would be `lambda x: x in [0, 2]`.

skipfooter : int, default 0

Number of lines at bottom of file to skip (Unsupported with engine='c')

skip_footer : int, default 0

Deprecated since version 0.19.0: Use the *skipfooter* parameter instead, as they are identical

nrows : int, default None

Number of rows of file to read. Useful for reading pieces of large files

na_values : scalar, str, list-like, or dict, default None

Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. By default the following values are interpreted as NaN: '', '#N/A', '#N/A N/A', '#NA', '-1.#IND', '-1.#QNAN', '-NaN', '-nan', '1.#IND', '1.#QNAN', 'N/A', 'NA', 'NULL', 'NaN', 'n/a', 'nan', 'null'.

keep_default_na : bool, default True

If na_values are specified and keep_default_na is False the default NaN values are overridden, otherwise they're appended to.

na_filter : boolean, default True

Detect missing value markers (empty strings and the value of na_values). In data without any NAs, passing na_filter=False can improve the performance of reading a large file

verbose : boolean, default False

Indicate number of NA values placed in non-numeric columns

skip_blank_lines : boolean, default True

If True, skip over blank lines rather than interpreting as NaN values

parse_dates : boolean or list of ints or names or list of lists or dict, default False

- boolean. If True -> try parsing the index.

- list of ints or names. e.g. If [1, 2, 3] -> try parsing columns 1, 2, 3 each as a separate date column.
- list of lists. e.g. If [[1, 3]] -> combine columns 1 and 3 and parse as a single date column.
- dict, e.g. {'foo' : [1, 3]} -> parse columns 1, 3 as date and call result 'foo'

If a column or index contains an unparseable date, the entire column or index will be returned unaltered as an object data type. For non-standard datetime parsing, use `pd.to_datetime` after `pd.read_csv`

Note: A fast-path exists for iso8601-formatted dates.

infer_datetime_format : boolean, default False

If True and *parse_dates* is enabled, pandas will attempt to infer the format of the datetime strings in the columns, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by 5-10x.

keep_date_col : boolean, default False

If True and *parse_dates* specifies combining multiple columns then keep the original columns.

date_parser : function, default None

Function to use for converting a sequence of string columns to an array of datetime instances. The default uses `dateutil.parser.parser` to do the conversion. Pandas will try to call *date_parser* in three different ways, advancing to the next if an exception occurs: 1) Pass one or more arrays (as defined by *parse_dates*) as arguments; 2) concatenate (row-wise) the string values from the columns defined by *parse_dates* into a single array and pass that; and 3) call *date_parser* once for each row using one or more strings (corresponding to the columns defined by *parse_dates*) as arguments.

dayfirst : boolean, default False

DD/MM format dates, international and European format

iterator : boolean, default False

Return TextFileReader object for iteration or getting chunks with `get_chunk()`.

chunksize : int, default None

Return TextFileReader object for iteration. See the IO Tools docs for more information on `iterator` and `chunksize`.

compression : {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default 'infer'

For on-the-fly decompression of on-disk data. If 'infer' and *filepath_or_buffer* is path-like, then detect compression from the following extensions: '.gz', '.bz2', '.zip', or '.xz' (otherwise no decompression). If using 'zip', the ZIP file must contain only one data file to be read in. Set to None for no decompression.

New in version 0.18.1: support for 'zip' and 'xz' compression.

thousands : str, default None

Thousands separator

decimal : str, default '.'

Character to recognize as decimal point (e.g. use ',' for European data).

float_precision : string, default None

Specifies which converter the C engine should use for floating-point values. The options are *None* for the ordinary converter, *high* for the high-precision converter, and *round_trip* for the round-trip converter.

lineterminator : str (length 1), default None

Character to break file into lines. Only valid with C parser.

quotechar : str (length 1), optional

The character used to denote the start and end of a quoted item. Quoted items can include the delimiter and it will be ignored.

quoting : int or csv.QUOTE_* instance, default 0

Control field quoting behavior per `csv.QUOTE_*` constants. Use one of QUOTE_MINIMAL (0), QUOTE_ALL (1), QUOTE_NONNUMERIC (2) or QUOTE_NONE (3).

doublequote : boolean, default `True`

When quotechar is specified and quoting is not `QUOTE_NONE`, indicate whether or not to interpret two consecutive quotechar elements INSIDE a field as a single `quotechar` element.

escapechar : str (length 1), default None

One-character string used to escape delimiter when quoting is QUOTE_NONE.

comment : str, default None

Indicates remainder of line should not be parsed. If found at the beginning of a line, the line will be ignored altogether. This parameter must be a single character. Like empty lines (as long as `skip_blank_lines=True`), fully commented lines are ignored by the parameter *header* but not by *skiprows*. For example, if comment='#', parsing '#emptyna,b,cn1,2,3' with *header=0* will result in 'a,b,c' being treated as the header.

encoding : str, default None

Encoding to use for UTF when reading/writing (ex. 'utf-8'). List of Python standard encodings

dialect : str or csv.Dialect instance, default None

If provided, this parameter will override values (default or not) for the following parameters: *delimiter*, *doublequote*, *escapechar*, *skipinitialspace*, *quotechar*, and *quoting*. If it is necessary to override values, a ParserWarning will be issued. See csv.Dialect documentation for more details.

tupleize_cols : boolean, default False

Deprecated since version 0.21.0: This argument will be removed and will always convert to MultiIndex

Leave a list of tuples on columns as is (default is to convert to a MultiIndex on the columns)

error_bad_lines : boolean, default True

Lines with too many fields (e.g. a csv line with too many commas) will by default cause an exception to be raised, and no DataFrame will be returned. If False, then these "bad lines" will dropped from the DataFrame that is returned.

warn_bad_lines : boolean, default True

If error_bad_lines is False, and warn_bad_lines is True, a warning for each "bad line" will be output.

low_memory : boolean, default True

Internally process the file in chunks, resulting in lower memory use while parsing, but possibly mixed type inference. To ensure no mixed types either set False, or specify the type with the *dtype* parameter. Note that the entire file is read into a single DataFrame regardless, use the *chunksize* or *iterator* parameter to return the data in chunks. (Only valid with C parser)

buffer_lines : int, default None

Deprecated since version 0.19.0: This argument is not respected by the parser

compact_ints : boolean, default False

Deprecated since version 0.19.0: Argument moved to `pd.to_numeric`

If compact_ints is True, then for any column that is of integer dtype, the parser will attempt to cast it as the smallest integer dtype possible, either signed or unsigned depending on the specification from the *use_unsigned* parameter.

use_unsigned : boolean, default False

Deprecated since version 0.19.0: Argument moved to `pd.to_numeric`

If integer columns are being compacted (i.e. *compact_ints=True*), specify whether the column should be compacted to the smallest signed or unsigned integer dtype.

memory_map : boolean, default False

If a filepath is provided for *filepath_or_buffer*, map the file object directly onto memory and access the data directly from there. Using this option can improve performance because there is no longer any I/O overhead.

Returns result : DataFrame or TextParser

34.1.2.2 pandas.read_csv

`pandas.`**`read_csv`**(*filepath_or_buffer*, *sep=', '*, *delimiter=None*, *header='infer'*, *names=None*, *index_col=None*, *usecols=None*, *squeeze=False*, *prefix=None*, *mangle_dupe_cols=True*, *dtype=None*, *engine=None*, *converters=None*, *true_values=None*, *false_values=None*, *skipinitialspace=False*, *skiprows=None*, *nrows=None*, *na_values=None*, *keep_default_na=True*, *na_filter=True*, *verbose=False*, *skip_blank_lines=True*, *parse_dates=False*, *infer_datetime_format=False*, *keep_date_col=False*, *date_parser=None*, *dayfirst=False*, *iterator=False*, *chunksize=None*, *compression='infer'*, *thousands=None*, *decimal=b'.'*, *lineterminator=None*, *quotechar='"'*, *quoting=0*, *escapechar=None*, *comment=None*, *encoding=None*, *dialect=None*, *tupleize_cols=None*, *error_bad_lines=True*, *warn_bad_lines=True*, *skipfooter=0*, *skip_footer=0*, *doublequote=True*, *delim_whitespace=False*, *as_recarray=None*, *compact_ints=None*, *use_unsigned=None*, *low_memory=True*, *buffer_lines=None*, *memory_map=False*, *float_precision=None*)

Read CSV (comma-separated) file into DataFrame

Also supports optionally iterating or breaking of the file into chunks.

Additional help can be found in the online docs for IO Tools.

Parameters filepath_or_buffer : str, pathlib.Path, py._path.local.LocalPath or any object with a read() method (such as a file handle or StringIO)

The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be file ://localhost/path/to/table.csv

sep : str, default ‘,’

Delimiter to use. If sep is None, the C engine cannot automatically detect the separator, but the Python parsing engine can, meaning the latter will be used and automatically detect the separator by Python’s builtin sniffer tool, `csv.Sniffer`. In addition, separators longer than 1 character and different from `'\s+'` will be interpreted as regular expressions and will also force the use of the Python parsing engine. Note that regex delimiters are prone to ignoring quoted data. Regex example: `'\r\t'`

delimiter : str, default `None`

Alternative argument name for sep.

delim_whitespace : boolean, default False

Specifies whether or not whitespace (e.g. `' '` or `' '`) will be used as the sep. Equivalent to setting `sep='\s+'`. If this option is set to True, nothing should be passed in for the `delimiter` parameter.

New in version 0.18.1: support for the Python parser.

header : int or list of ints, default ‘infer’

Row number(s) to use as the column names, and the start of the data. Default behavior is as if set to 0 if no `names` passed, otherwise `None`. Explicitly pass `header=0` to be able to replace existing names. The header can be a list of integers that specify row locations for a multi-index on the columns e.g. [0,1,3]. Intervening rows that are not specified will be skipped (e.g. 2 in this example is skipped). Note that this parameter ignores commented lines and empty lines if `skip_blank_lines=True`, so header=0 denotes the first line of data rather than the first line of the file.

names : array-like, default None

List of column names to use. If file contains no header row, then you should explicitly pass header=None. Duplicates in this list will cause a `UserWarning` to be issued.

index_col : int or sequence or False, default None

Column to use as the row labels of the DataFrame. If a sequence is given, a MultiIndex is used. If you have a malformed file with delimiters at the end of each line, you might consider index_col=False to force pandas to _not_ use the first column as the index (row names)

usecols : array-like or callable, default None

Return a subset of the columns. If array-like, all elements must either be positional (i.e. integer indices into the document columns) or strings that correspond to column names provided either by the user in *names* or inferred from the document header row(s). For example, a valid array-like *usecols* parameter would be [0, 1, 2] or [’foo’, ‘bar’, ‘baz’].

If callable, the callable function will be evaluated against the column names, returning names where the callable function evaluates to True. An example of a valid callable argument would be `lambda x: x.upper() in ['AAA', 'BBB', 'DDD']`. Using this parameter results in much faster parsing time and lower memory usage.

as_recarray : boolean, default False

Deprecated since version 0.19.0: Please call *pd.read_csv(...).to_records()* instead.

Return a NumPy recarray instead of a DataFrame after parsing the data. If set to True, this option takes precedence over the *squeeze* parameter. In addition, as row indices are not available in such a format, the *index_col* parameter will be ignored.

squeeze : boolean, default False

If the parsed data only contains one column then return a Series

prefix : str, default None

Prefix to add to column numbers when no header, e.g. 'X' for X0, X1, ...

mangle_dupe_cols : boolean, default True

Duplicate columns will be specified as 'X.0'...'X.N', rather than 'X'...'X'. Passing in False will cause data to be overwritten if there are duplicate names in the columns.

dtype : Type name or dict of column -> type, default None

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32} Use *str* or *object* to preserve and not interpret dtype. If converters are specified, they will be applied INSTEAD of dtype conversion.

engine : {'c', 'python'}, optional

Parser engine to use. The C engine is faster while the python engine is currently more feature-complete.

converters : dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels

true_values : list, default None

Values to consider as True

false_values : list, default None

Values to consider as False

skipinitialspace : boolean, default False

Skip spaces after delimiter.

skiprows : list-like or integer or callable, default None

Line numbers to skip (0-indexed) or number of lines to skip (int) at the start of the file.

If callable, the callable function will be evaluated against the row indices, returning True if the row should be skipped and False otherwise. An example of a valid callable argument would be `lambda x: x in [0, 2]`.

skipfooter : int, default 0

Number of lines at bottom of file to skip (Unsupported with engine='c')

skip_footer : int, default 0

Deprecated since version 0.19.0: Use the *skipfooter* parameter instead, as they are identical

nrows : int, default None

Number of rows of file to read. Useful for reading pieces of large files

na_values : scalar, str, list-like, or dict, default None

Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. By default the following values are interpreted as NaN: '', '#N/A', '#N/A N/A', '#NA', '-1.#IND', '-1.#QNAN', '-NaN', '-nan', '1.#IND', '1.#QNAN', 'N/A', 'NA', 'NULL', 'NaN', 'n/a', 'nan', 'null'.

keep_default_na : bool, default True

If na_values are specified and keep_default_na is False the default NaN values are overridden, otherwise they're appended to.

na_filter : boolean, default True

Detect missing value markers (empty strings and the value of na_values). In data without any NAs, passing na_filter=False can improve the performance of reading a large file

verbose : boolean, default False

Indicate number of NA values placed in non-numeric columns

skip_blank_lines : boolean, default True

If True, skip over blank lines rather than interpreting as NaN values

parse_dates : boolean or list of ints or names or list of lists or dict, default False

- boolean. If True -> try parsing the index.
- list of ints or names. e.g. If [1, 2, 3] -> try parsing columns 1, 2, 3 each as a separate date column.
- list of lists. e.g. If [[1, 3]] -> combine columns 1 and 3 and parse as a single date column.
- dict, e.g. {'foo' : [1, 3]} -> parse columns 1, 3 as date and call result 'foo'

If a column or index contains an unparseable date, the entire column or index will be returned unaltered as an object data type. For non-standard datetime parsing, use `pd.to_datetime` after `pd.read_csv`

Note: A fast-path exists for iso8601-formatted dates.

infer_datetime_format : boolean, default False

If True and *parse_dates* is enabled, pandas will attempt to infer the format of the datetime strings in the columns, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by 5-10x.

keep_date_col : boolean, default False

If True and *parse_dates* specifies combining multiple columns then keep the original columns.

date_parser : function, default None

Function to use for converting a sequence of string columns to an array of datetime instances. The default uses `dateutil.parser.parser` to do the conversion. Pandas will try to call *date_parser* in three different ways, advancing to the next if an exception occurs: 1) Pass one or more arrays (as defined by *parse_dates*) as arguments; 2) concatenate (row-wise) the string values from the columns defined by *parse_dates* into a single array and pass that; and 3) call *date_parser* once for each row using one or more strings (corresponding to the columns defined by *parse_dates*) as arguments.

dayfirst : boolean, default False

DD/MM format dates, international and European format

iterator : boolean, default False

Return TextFileReader object for iteration or getting chunks with `get_chunk()`.

chunksize : int, default None

Return TextFileReader object for iteration. See the IO Tools docs for more information on `iterator` and `chunksize`.

compression : {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default 'infer'

For on-the-fly decompression of on-disk data. If 'infer' and *filepath_or_buffer* is path-like, then detect compression from the following extensions: '.gz', '.bz2', '.zip', or '.xz' (otherwise no decompression). If using 'zip', the ZIP file must contain only one data file to be read in. Set to None for no decompression.

New in version 0.18.1: support for 'zip' and 'xz' compression.

thousands : str, default None

Thousands separator

decimal : str, default '.'

Character to recognize as decimal point (e.g. use ',' for European data).

float_precision : string, default None

Specifies which converter the C engine should use for floating-point values. The options are *None* for the ordinary converter, *high* for the high-precision converter, and *round_trip* for the round-trip converter.

lineterminator : str (length 1), default None

Character to break file into lines. Only valid with C parser.

quotechar : str (length 1), optional

The character used to denote the start and end of a quoted item. Quoted items can include the delimiter and it will be ignored.

quoting : int or csv.QUOTE_* instance, default 0

Control field quoting behavior per `csv.QUOTE_*` constants. Use one of QUOTE_MINIMAL (0), QUOTE_ALL (1), QUOTE_NONNUMERIC (2) or QUOTE_NONE (3).

doublequote : boolean, default `True`

When quotechar is specified and quoting is not `QUOTE_NONE`, indicate whether or not to interpret two consecutive quotechar elements INSIDE a field as a single `quotechar` element.

escapechar : str (length 1), default None

One-character string used to escape delimiter when quoting is QUOTE_NONE.

comment : str, default None

Indicates remainder of line should not be parsed. If found at the beginning of a line, the line will be ignored altogether. This parameter must be a single character. Like empty lines (as long as `skip_blank_lines=True`), fully commented lines are ignored by the parameter *header* but not by *skiprows*. For example, if comment='#', parsing '#emptyna,b,cn1,2,3' with *header=0* will result in 'a,b,c' being treated as the header.

encoding : str, default None

Encoding to use for UTF when reading/writing (ex. 'utf-8'). List of Python standard encodings

dialect : str or csv.Dialect instance, default None

If provided, this parameter will override values (default or not) for the following parameters: *delimiter*, *doublequote*, *escapechar*, *skipinitialspace*, *quotechar*, and *quoting*. If it is necessary to override values, a ParserWarning will be issued. See csv.Dialect documentation for more details.

tupleize_cols : boolean, default False

Deprecated since version 0.21.0: This argument will be removed and will always convert to MultiIndex

Leave a list of tuples on columns as is (default is to convert to a MultiIndex on the columns)

error_bad_lines : boolean, default True

Lines with too many fields (e.g. a csv line with too many commas) will by default cause an exception to be raised, and no DataFrame will be returned. If False, then these "bad lines" will dropped from the DataFrame that is returned.

warn_bad_lines : boolean, default True

If error_bad_lines is False, and warn_bad_lines is True, a warning for each "bad line" will be output.

low_memory : boolean, default True

Internally process the file in chunks, resulting in lower memory use while parsing, but possibly mixed type inference. To ensure no mixed types either set False, or specify the type with the *dtype* parameter. Note that the entire file is read into a single DataFrame regardless, use the *chunksize* or *iterator* parameter to return the data in chunks. (Only valid with C parser)

buffer_lines : int, default None

Deprecated since version 0.19.0: This argument is not respected by the parser

compact_ints : boolean, default False

Deprecated since version 0.19.0: Argument moved to `pd.to_numeric`

If compact_ints is True, then for any column that is of integer dtype, the parser will attempt to cast it as the smallest integer dtype possible, either signed or unsigned depending on the specification from the *use_unsigned* parameter.

use_unsigned : boolean, default False

Deprecated since version 0.19.0: Argument moved to `pd.to_numeric`

If integer columns are being compacted (i.e. *compact_ints=True*), specify whether the column should be compacted to the smallest signed or unsigned integer dtype.

memory_map : boolean, default False

If a filepath is provided for *filepath_or_buffer*, map the file object directly onto memory and access the data directly from there. Using this option can improve performance because there is no longer any I/O overhead.

Returns result : DataFrame or TextParser

34.1.2.3 pandas.read_fwf

`pandas.read_fwf`(*filepath_or_buffer*, *colspecs='infer'*, *widths=None*, ***kwds*)

Read a table of fixed-width formatted lines into DataFrame

Also supports optionally iterating or breaking of the file into chunks.

Additional help can be found in the online docs for IO Tools.

Parameters **filepath_or_buffer** : str, pathlib.Path, py._path.local.LocalPath or any object with a read() method (such as a file handle or StringIO)

The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be file ://localhost/path/to/table.csv

colspecs : list of pairs (int, int) or 'infer'. optional

A list of pairs (tuples) giving the extents of the fixed-width fields of each line as half-open intervals (i.e., [from, to[ ). String value 'infer' can be used to instruct the parser to try detecting the column specifications from the first 100 rows of the data which are not being skipped via skiprows (default='infer').

widths : list of ints. optional

A list of field widths which can be used instead of 'colspecs' if the intervals are contiguous.

delimiter : str, default `' ' + ' '`

Characters to consider as filler characters in the fixed-width file. Can be used to specify the filler character of the fields if it is not spaces (e.g., '~').

delim_whitespace : boolean, default False

Specifies whether or not whitespace (e.g. `'  '` or `' '`) will be used as the sep. Equivalent to setting `sep='\s+'`. If this option is set to True, nothing should be passed in for the `delimiter` parameter.

New in version 0.18.1: support for the Python parser.

header : int or list of ints, default 'infer'

Row number(s) to use as the column names, and the start of the data. Default behavior is as if set to 0 if no `names` passed, otherwise `None`. Explicitly pass `header=0` to be able to replace existing names. The header can be a list of integers that specify row locations for a multi-index on the columns e.g. [0,1,3]. Intervening rows that are not specified will be skipped (e.g. 2 in this example is skipped). Note that this parameter ignores commented lines and empty lines if `skip_blank_lines=True`, so header=0 denotes the first line of data rather than the first line of the file.

names : array-like, default None

List of column names to use. If file contains no header row, then you should explicitly pass header=None. Duplicates in this list will cause a `UserWarning` to be issued.

index_col : int or sequence or False, default None

Column to use as the row labels of the DataFrame. If a sequence is given, a MultiIndex is used. If you have a malformed file with delimiters at the end of each line, you might consider index_col=False to force pandas to _not_ use the first column as the index (row names)

usecols : array-like or callable, default None

Return a subset of the columns. If array-like, all elements must either be positional (i.e. integer indices into the document columns) or strings that correspond to column names provided either by the user in *names* or inferred from the document header row(s). For example, a valid array-like *usecols* parameter would be [0, 1, 2] or ['foo', 'bar', 'baz'].

If callable, the callable function will be evaluated against the column names, returning names where the callable function evaluates to True. An example of a valid callable argument would be `lambda x: x.upper() in ['AAA', 'BBB', 'DDD']`. Using this parameter results in much faster parsing time and lower memory usage.

as_recarray : boolean, default False

Deprecated since version 0.19.0: Please call *pd.read_csv(...).to_records()* instead.

Return a NumPy recarray instead of a DataFrame after parsing the data. If set to True, this option takes precedence over the *squeeze* parameter. In addition, as row indices are not available in such a format, the *index_col* parameter will be ignored.

squeeze : boolean, default False

If the parsed data only contains one column then return a Series

prefix : str, default None

Prefix to add to column numbers when no header, e.g. 'X' for X0, X1, ...

mangle_dupe_cols : boolean, default True

Duplicate columns will be specified as 'X.0'...'X.N', rather than 'X'...'X'. Passing in False will cause data to be overwritten if there are duplicate names in the columns.

dtype : Type name or dict of column -> type, default None

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32} Use *str* or *object* to preserve and not interpret dtype. If converters are specified, they will be applied INSTEAD of dtype conversion.

converters : dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels

true_values : list, default None

Values to consider as True

false_values : list, default None

Values to consider as False

skipinitialspace : boolean, default False

Skip spaces after delimiter.

skiprows : list-like or integer or callable, default None

Line numbers to skip (0-indexed) or number of lines to skip (int) at the start of the file.

If callable, the callable function will be evaluated against the row indices, returning True if the row should be skipped and False otherwise. An example of a valid callable argument would be `lambda x: x in [0, 2]`.

skipfooter : int, default 0

Number of lines at bottom of file to skip (Unsupported with engine='c')

skip_footer : int, default 0

Deprecated since version 0.19.0: Use the *skipfooter* parameter instead, as they are identical

nrows : int, default None

Number of rows of file to read. Useful for reading pieces of large files

na_values : scalar, str, list-like, or dict, default None

Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. By default the following values are interpreted as NaN: '', '#N/A', '#N/A N/A', '#NA', '-1.#IND', '-1.#QNAN', '-NaN', '-nan', '1.#IND', '1.#QNAN', 'N/A', 'NA', 'NULL', 'NaN', 'n/a', 'nan', 'null'.

keep_default_na : bool, default True

If na_values are specified and keep_default_na is False the default NaN values are overridden, otherwise they're appended to.

na_filter : boolean, default True

Detect missing value markers (empty strings and the value of na_values). In data without any NAs, passing na_filter=False can improve the performance of reading a large file

verbose : boolean, default False

Indicate number of NA values placed in non-numeric columns

skip_blank_lines : boolean, default True

If True, skip over blank lines rather than interpreting as NaN values

parse_dates : boolean or list of ints or names or list of lists or dict, default False

- boolean. If True -> try parsing the index.
- list of ints or names. e.g. If [1, 2, 3] -> try parsing columns 1, 2, 3 each as a separate date column.
- list of lists. e.g. If [[1, 3]] -> combine columns 1 and 3 and parse as a single date column.
- dict, e.g. {'foo' : [1, 3]} -> parse columns 1, 3 as date and call result 'foo'

If a column or index contains an unparseable date, the entire column or index will be returned unaltered as an object data type. For non-standard datetime parsing, use `pd.to_datetime` after `pd.read_csv`

Note: A fast-path exists for iso8601-formatted dates.

infer_datetime_format : boolean, default False

If True and *parse_dates* is enabled, pandas will attempt to infer the format of the datetime strings in the columns, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by 5-10x.

keep_date_col : boolean, default False

If True and *parse_dates* specifies combining multiple columns then keep the original columns.

date_parser : function, default None

Function to use for converting a sequence of string columns to an array of datetime instances. The default uses `dateutil.parser.parser` to do the conversion. Pandas

will try to call *date_parser* in three different ways, advancing to the next if an exception occurs: 1) Pass one or more arrays (as defined by *parse_dates*) as arguments; 2) concatenate (row-wise) the string values from the columns defined by *parse_dates* into a single array and pass that; and 3) call *date_parser* once for each row using one or more strings (corresponding to the columns defined by *parse_dates*) as arguments.

dayfirst : boolean, default False

DD/MM format dates, international and European format

iterator : boolean, default False

Return TextFileReader object for iteration or getting chunks with `get_chunk()`.

chunksize : int, default None

Return TextFileReader object for iteration. See the IO Tools docs for more information on `iterator` and `chunksize`.

compression : {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default 'infer'

For on-the-fly decompression of on-disk data. If 'infer' and *filepath_or_buffer* is path-like, then detect compression from the following extensions: '.gz', '.bz2', '.zip', or '.xz' (otherwise no decompression). If using 'zip', the ZIP file must contain only one data file to be read in. Set to None for no decompression.

New in version 0.18.1: support for 'zip' and 'xz' compression.

thousands : str, default None

Thousands separator

decimal : str, default '.'

Character to recognize as decimal point (e.g. use ',' for European data).

float_precision : string, default None

Specifies which converter the C engine should use for floating-point values. The options are *None* for the ordinary converter, *high* for the high-precision converter, and *round_trip* for the round-trip converter.

lineterminator : str (length 1), default None

Character to break file into lines. Only valid with C parser.

quotechar : str (length 1), optional

The character used to denote the start and end of a quoted item. Quoted items can include the delimiter and it will be ignored.

quoting : int or csv.QUOTE_* instance, default 0

Control field quoting behavior per `csv.QUOTE_*` constants. Use one of QUOTE_MINIMAL (0), QUOTE_ALL (1), QUOTE_NONNUMERIC (2) or QUOTE_NONE (3).

doublequote : boolean, default `True`

When quotechar is specified and quoting is not `QUOTE_NONE`, indicate whether or not to interpret two consecutive quotechar elements INSIDE a field as a single `quotechar` element.

escapechar : str (length 1), default None

One-character string used to escape delimiter when quoting is QUOTE_NONE.

comment : str, default None

Indicates remainder of line should not be parsed. If found at the beginning of a line, the line will be ignored altogether. This parameter must be a single character. Like empty lines (as long as `skip_blank_lines=True`), fully commented lines are ignored by the parameter *header* but not by *skiprows*. For example, if comment='#', parsing '#emptyna,b,cn1,2,3' with *header=0* will result in 'a,b,c' being treated as the header.

encoding : str, default None

Encoding to use for UTF when reading/writing (ex. 'utf-8'). List of Python standard encodings

dialect : str or csv.Dialect instance, default None

If provided, this parameter will override values (default or not) for the following parameters: *delimiter*, *doublequote*, *escapechar*, *skipinitialspace*, *quotechar*, and *quoting*. If it is necessary to override values, a ParserWarning will be issued. See csv.Dialect documentation for more details.

tupleize_cols : boolean, default False

Deprecated since version 0.21.0: This argument will be removed and will always convert to MultiIndex

Leave a list of tuples on columns as is (default is to convert to a MultiIndex on the columns)

error_bad_lines : boolean, default True

Lines with too many fields (e.g. a csv line with too many commas) will by default cause an exception to be raised, and no DataFrame will be returned. If False, then these "bad lines" will dropped from the DataFrame that is returned.

warn_bad_lines : boolean, default True

If error_bad_lines is False, and warn_bad_lines is True, a warning for each "bad line" will be output.

low_memory : boolean, default True

Internally process the file in chunks, resulting in lower memory use while parsing, but possibly mixed type inference. To ensure no mixed types either set False, or specify the type with the *dtype* parameter. Note that the entire file is read into a single DataFrame regardless, use the *chunksize* or *iterator* parameter to return the data in chunks. (Only valid with C parser)

buffer_lines : int, default None

Deprecated since version 0.19.0: This argument is not respected by the parser

compact_ints : boolean, default False

Deprecated since version 0.19.0: Argument moved to `pd.to_numeric`

If compact_ints is True, then for any column that is of integer dtype, the parser will attempt to cast it as the smallest integer dtype possible, either signed or unsigned depending on the specification from the *use_unsigned* parameter.

use_unsigned : boolean, default False

Deprecated since version 0.19.0: Argument moved to `pd.to_numeric`

If integer columns are being compacted (i.e. *compact_ints=True*), specify whether the column should be compacted to the smallest signed or unsigned integer dtype.

memory_map : boolean, default False

If a filepath is provided for *filepath_or_buffer*, map the file object directly onto memory and access the data directly from there. Using this option can improve performance because there is no longer any I/O overhead.

Returns result : DataFrame or TextParser

34.1.2.4 pandas.read_msgpack

`pandas.read_msgpack`(*path_or_buf*, *encoding='utf-8'*, *iterator=False*, ***kwargs*)

Load msgpack pandas object from the specified file path

THIS IS AN EXPERIMENTAL LIBRARY and the storage format may not be stable until a future release.

Parameters path_or_buf : string File path, BytesIO like or string

encoding: Encoding for decoding msgpack str type

iterator : boolean, if True, return an iterator to the unpacker

(default is False)

Returns obj : type of object stored in file

34.1.3 Clipboard

`read_clipboard`([sep])	Read text from clipboard and pass to read_table.

34.1.3.1 pandas.read_clipboard

`pandas.read_clipboard`(*sep='\\s+'*, ***kwargs*)

Read text from clipboard and pass to read_table. See read_table for the full argument list

Parameters sep : str, default 's+'.

A string or regex delimiter. The default of 's+' denotes one or more whitespace characters.

Returns parsed : DataFrame

34.1.4 Excel

`read_excel`(io[, sheet_name, header, ...])	Read an Excel table into a pandas DataFrame
`ExcelFile.parse`([sheet_name, header, ...])	Parse specified sheet(s) into a DataFrame

34.1.4.1 pandas.read_excel

`pandas.read_excel`(*io*, *sheet_name=0*, *header=0*, *skiprows=None*, *skip_footer=0*, *index_col=None*, *names=None*, *usecols=None*, *parse_dates=False*, *date_parser=None*, *na_values=None*, *thousands=None*, *convert_float=True*, *converters=None*, *dtype=None*, *true_values=None*, *false_values=None*, *engine=None*, *squeeze=False*, ***kwds*)

Read an Excel table into a pandas DataFrame

Parameters io : string, path object (pathlib.Path or py._path.local.LocalPath),

file-like object, pandas ExcelFile, or xlrd workbook. The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be file://localhost/path/to/workbook.xlsx

sheet_name : string, int, mixed list of strings/ints, or None, default 0

Strings are used for sheet names, Integers are used in zero-indexed sheet positions.

Lists of strings/integers are used to request multiple sheets.

Specify None to get all sheets.

str|int -> DataFrame is returned. list|None -> Dict of DataFrames is returned, with keys representing sheets.

Available Cases

- Defaults to 0 -> 1st sheet as a DataFrame
- 1 -> 2nd sheet as a DataFrame
- "Sheet1" -> 1st sheet as a DataFrame
- [0,1,"Sheet5"] -> 1st, 2nd & 5th sheet as a dictionary of DataFrames
- None -> All sheets as a dictionary of DataFrames

sheetname : string, int, mixed list of strings/ints, or None, default 0

Deprecated since version 0.21.0: Use *sheet_name* instead

header : int, list of ints, default 0

Row (0-indexed) to use for the column labels of the parsed DataFrame. If a list of integers is passed those row positions will be combined into a `MultiIndex`. Use None if there is no header.

skiprows : list-like

Rows to skip at the beginning (0-indexed)

skip_footer : int, default 0

Rows at the end to skip (0-indexed)

index_col : int, list of ints, default None

Column (0-indexed) to use as the row labels of the DataFrame. Pass None if there is no such column. If a list is passed, those columns will be combined into a `MultiIndex`. If a subset of data is selected with `usecols`, index_col is based on the subset.

names : array-like, default None

List of column names to use. If file contains no header row, then you should explicitly pass header=None

converters : dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels, values are functions that take one input argument, the Excel cell content, and return the transformed content.

dtype : Type name or dict of column -> type, default None

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32} Use *object* to preserve data as stored in Excel and not interpret dtype. If converters are specified, they will be applied INSTEAD of dtype conversion.

New in version 0.20.0.

true_values : list, default None

Values to consider as True

New in version 0.19.0.

false_values : list, default None

Values to consider as False

New in version 0.19.0.

parse_cols : int or list, default None

Deprecated since version 0.21.0: Pass in *usecols* instead.

usecols : int or list, default None

- If None then parse all columns,
- If int then indicates last column to be parsed
- If list of ints then indicates list of column numbers to be parsed
- If string then indicates comma separated list of Excel column letters and column ranges (e.g. "A:E" or "A,C,E:F"). Ranges are inclusive of both sides.

squeeze : boolean, default False

If the parsed data only contains one column then return a Series

na_values : scalar, str, list-like, or dict, default None

Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. By default the following values are interpreted as NaN: '', '#N/A', '#N/A N/A', '#NA', '-1.#IND', '-1.#QNAN', '-NaN', '-nan',

'1.#IND', '1.#QNAN', 'N/A', 'NA', 'NULL', 'NaN', 'n/a', 'nan', 'null'.

thousands : str, default None

Thousands separator for parsing string columns to numeric. Note that this parameter is only necessary for columns stored as TEXT in Excel, any numeric columns will automatically be parsed, regardless of display format.

keep_default_na : bool, default True

If na_values are specified and keep_default_na is False the default NaN values are overridden, otherwise they're appended to.

verbose : boolean, default False

Indicate number of NA values placed in non-numeric columns

engine: string, default None

If io is not a buffer or path, this must be set to identify io. Acceptable values are None or xlrd

convert_float : boolean, default True

convert integral floats to int (i.e., 1.0 –> 1). If False, all numeric data will be read in as floats: Excel stores all numbers as floats internally

Returns **parsed** : DataFrame or Dict of DataFrames

DataFrame from the passed in Excel file. See notes in sheet_name argument for more information on when a Dict of Dataframes is returned.

34.1.4.2 pandas.ExcelFile.parse

`ExcelFile.parse`(*sheet_name=0*, *header=0*, *skiprows=None*, *skip_footer=0*, *names=None*, *index_col=None*, *usecols=None*, *parse_dates=False*, *date_parser=None*, *na_values=None*, *thousands=None*, *convert_float=True*, *converters=None*, *true_values=None*, *false_values=None*, *squeeze=False*, ***kwds*)

Parse specified sheet(s) into a DataFrame

Equivalent to read_excel(ExcelFile, ...) See the read_excel docstring for more info on accepted parameters

34.1.5 JSON

read_json([path_or_buf, orient, typ, dtype, ...])	Convert a JSON string to pandas object

34.1.5.1 pandas.read_json

`pandas.read_json`(*path_or_buf=None*, *orient=None*, *typ='frame'*, *dtype=True*, *convert_axes=True*, *convert_dates=True*, *keep_default_dates=True*, *numpy=False*, *precise_float=False*, *date_unit=None*, *encoding=None*, *lines=False*, *chunksize=None*, *compression='infer'*)

Convert a JSON string to pandas object

Parameters **path_or_buf** : a valid JSON string or file-like, default: None

The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be `file://localhost/path/to/table.json`

orient : string,

Indication of expected JSON string format. Compatible JSON strings can be produced by `to_json()` with a corresponding orient value. The set of possible orients is:

- `'split'` : dict like `{index -> [index], columns -> [columns], data -> [values]}`
- `'records'` : list like `[{column -> value}, ... , {column -> value}]`
- `'index'` : dict like `{index -> {column -> value}}`
- `'columns'` : dict like `{column -> {index -> value}}`
- `'values'` : just the values array

The allowed and default values depend on the value of the *typ* parameter.

- when `typ == 'series'`,
  - allowed orients are `{'split','records','index'}`

  - default is `'index'`
  - The Series index must be unique for orient `'index'`.
- when `typ == 'frame'`,
  - allowed orients are `{'split','records','index', 'columns', 'values'}`
  - default is `'columns'`
  - The DataFrame index must be unique for orients `'index'` and `'columns'`.
  - The DataFrame columns must be unique for orients `'index'`, `'columns'`, and `'records'`.

typ : type of object to recover (series or frame), default 'frame'

dtype : boolean or dict, default True

If True, infer dtypes, if a dict of column to dtype, then use those, if False, then don't infer dtypes at all, applies only to the data.

convert_axes : boolean, default True

Try to convert the axes to the proper dtypes.

convert_dates : boolean, default True

List of columns to parse for dates; If True, then try to parse datelike columns default is True; a column label is datelike if

- it ends with `'_at'`,
- it ends with `'_time'`,
- it begins with `'timestamp'`,
- it is `'modified'`, or
- it is `'date'`

keep_default_dates : boolean, default True

If parsing dates, then parse the default datelike columns

numpy : boolean, default False

Direct decoding to numpy arrays. Supports numeric data only, but non-numeric column and index labels are supported. Note also that the JSON ordering MUST be the same for each term if numpy=True.

precise_float : boolean, default False

Set to enable usage of higher precision (strtod) function when decoding string to double values. Default (False) is to use fast but less precise builtin functionality

date_unit : string, default None

The timestamp unit to detect if converting dates. The default behaviour is to try and detect the correct precision, but if this is not desired then pass one of 's', 'ms', 'us' or 'ns' to force parsing only seconds, milliseconds, microseconds or nanoseconds respectively.

lines : boolean, default False

Read the file as a json object per line.

New in version 0.19.0.

encoding : str, default is 'utf-8'

The encoding to use to decode py3 bytes.

New in version 0.19.0.

chunksize: integer, default None

Return JsonReader object for iteration. See the line-delimted json docs for more information on `chunksize`. This can only be passed if *lines=True*. If this is None, the file will be read into memory all at once.

New in version 0.21.0.

compression : {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default 'infer'

For on-the-fly decompression of on-disk data. If 'infer', then use gzip, bz2, zip or xz if path_or_buf is a string ending in '.gz', '.bz2', '.zip', or 'xz', respectively, and no decompression otherwise. If using 'zip', the ZIP file must contain only one data file to be read in. Set to None for no decompression.

New in version 0.21.0.

Returns result : Series or DataFrame, depending on the value of *typ*.

See also:

`DataFrame.to_json`

Examples

```
>>> df = pd.DataFrame([['a', 'b'], ['c', 'd']],
...                   index=['row 1', 'row 2'],
...                   columns=['col 1', 'col 2'])
```

Encoding/decoding a Dataframe using `'split'` formatted JSON:

```
>>> df.to_json(orient='split')
'{"columns":["col 1","col 2"],
  "index":["row 1","row 2"],
  "data":[["a","b"],["c","d"]]}'
>>> pd.read_json(_, orient='split')
      col 1 col 2
row 1     a     b
row 2     c     d
```

Encoding/decoding a Dataframe using `'index'` formatted JSON:

```
>>> df.to_json(orient='index')
'{"row 1":{"col 1":"a","col 2":"b"},"row 2":{"col 1":"c","col 2":"d"}}'
>>> pd.read_json(_, orient='index')
      col 1 col 2
row 1     a     b
row 2     c     d
```

Encoding/decoding a Dataframe using `'records'` formatted JSON. Note that index labels are not preserved with this encoding.

```
>>> df.to_json(orient='records')
'[{"col 1":"a","col 2":"b"},{"col 1":"c","col 2":"d"}]'
>>> pd.read_json(_, orient='records')
  col 1 col 2
0     a     b
1     c     d
```

Encoding with Table Schema

```
>>> df.to_json(orient='table')
'{"schema": {"fields": [{"name": "index", "type": "string"},
                        {"name": "col 1", "type": "string"},
                        {"name": "col 2", "type": "string"}],
                "primaryKey": "index",
                "pandas_version": "0.20.0"},
    "data": [{"index": "row 1", "col 1": "a", "col 2": "b"},
            {"index": "row 2", "col 1": "c", "col 2": "d"}]}'
```

json_normalize(data[, record_path, meta, ...])	"Normalize" semi-structured JSON data into a flat table
build_table_schema(data[, index, ...])	Create a Table schema from `data`.

34.1.5.2 pandas.io.json.json_normalize

`pandas.io.json.`**`json_normalize`**(*data*, *record_path=None*, *meta=None*, *meta_prefix=None*, *record_prefix=None*, *errors='raise'*, *sep='.'*)

"Normalize" semi-structured JSON data into a flat table

Parameters **data** : dict or list of dicts

Unserialized JSON objects

record_path : string or list of strings, default None

Path in each object to list of records. If not passed, data will be assumed to be an array of records

meta : list of paths (string or list of strings), default None

Fields to use as metadata for each record in resulting table

record_prefix : string, default None

If True, prefix records with dotted (?) path, e.g. foo.bar.field if path to records is ['foo', 'bar']

meta_prefix : string, default None

errors : {'raise', 'ignore'}, default 'raise'

- 'ignore' : will ignore KeyError if keys listed in meta are not always present
- 'raise' : will raise KeyError if keys listed in meta are not always present

New in version 0.20.0.

sep : string, default '.'

Nested records will generate names separated by sep, e.g., for sep='.', { 'foo' : { 'bar' : 0 } } -> foo.bar

New in version 0.20.0.

Returns **frame** : DataFrame

Examples

```
>>> from pandas.io.json import json_normalize
>>> data = [{'id': 1, 'name': {'first': 'Coleen', 'last': 'Volk'}},
...         {'name': {'given': 'Mose', 'family': 'Regner'}},
...         {'id': 2, 'name': 'Faye Raker'}]
>>> json_normalize(data)
    id        name name.family name.first name.given name.last
0  1.0         NaN         NaN     Coleen        NaN      Volk
1  NaN         NaN      Regner        NaN       Mose       NaN
2  2.0  Faye Raker         NaN        NaN        NaN       NaN
```

```
>>> data = [{'state': 'Florida',
...          'shortname': 'FL',
...          'info': {
...               'governor': 'Rick Scott'
...          },
...          'counties': [{'name': 'Dade', 'population': 12345},
...                       {'name': 'Broward', 'population': 40000},
...                       {'name': 'Palm Beach', 'population': 60000}]},
...         {'state': 'Ohio',
...          'shortname': 'OH',
...          'info': {
...               'governor': 'John Kasich'
...          },
...          'counties': [{'name': 'Summit', 'population': 1234},
...                       {'name': 'Cuyahoga', 'population': 1337}]}]
>>> result = json_normalize(data, 'counties', ['state', 'shortname',
...                                            ['info', 'governor']])
>>> result
         name  population info.governor    state shortname
0        Dade       12345    Rick Scott  Florida        FL
1     Broward       40000    Rick Scott  Florida        FL
2  Palm Beach       60000    Rick Scott  Florida        FL
3      Summit        1234   John Kasich     Ohio        OH
4    Cuyahoga        1337   John Kasich     Ohio        OH
```

34.1.5.3 pandas.io.json.build_table_schema

`pandas.io.json.`**`build_table_schema`**(*data*, *index=True*, *primary_key=None*, *version=True*)

Create a Table schema from `data`.

Parameters **data** : Series, DataFrame

index : bool, default True

Whether to include `data.index` in the schema.

primary_key : bool or None, default True

column names to designate as the primary key. The default *None* will set *'primaryKey'* to the index level or levels if the index is unique.

version : bool, default True

Whether to include a field *pandas_version* with the version of pandas that generated the schema.

Returns **schema** : dict

Notes

See *_as_json_table_type* for conversion types. Timedeltas as converted to ISO8601 duration format with 9 decimal places after the secnods field for nanosecond precision.

Categoricals are converted to the *any* dtype, and use the *enum* field constraint to list the allowed values. The *ordered* attribute is included in an *ordered* field.

Examples

```
>>> df = pd.DataFrame(
...     {'A': [1, 2, 3],
...      'B': ['a', 'b', 'c'],
...      'C': pd.date_range('2016-01-01', freq='d', periods=3),
...     }, index=pd.Index(range(3), name='idx'))
>>> build_table_schema(df)
{'fields': [{'name': 'idx', 'type': 'integer'},
{'name': 'A', 'type': 'integer'},
{'name': 'B', 'type': 'string'},
{'name': 'C', 'type': 'datetime'}],
'pandas_version': '0.20.0',
'primaryKey': ['idx']}
```

34.1.6 HTML

read_html(io[, match, flavor, header, ...])	Read HTML tables into a `list` of `DataFrame` objects.

34.1.6.1 pandas.read_html

pandas.**read_html**(*io*, *match='.+'*, *flavor=None*, *header=None*, *index_col=None*, *skiprows=None*, *attrs=None*, *parse_dates=False*, *tupleize_cols=None*, *thousands=', '*, *encoding=None*, *decimal='.'*, *converters=None*, *na_values=None*, *keep_default_na=True*)

Read HTML tables into a `list` of `DataFrame` objects.

Parameters **io** : str or file-like

A URL, a file-like object, or a raw string containing HTML. Note that lxml only accepts the http, ftp and file url protocols. If you have a URL that starts with `'https'` you might try removing the `'s'`.

match : str or compiled regular expression, optional

The set of tables containing text matching this regex or string will be returned. Unless the HTML is extremely simple you will probably need to pass a non-empty string here. Defaults to '.+' (match any non-empty string). The default value will return all tables contained on a page. This value is converted to a regular expression so that there is consistent behavior between Beautiful Soup and lxml.

flavor : str or None, container of strings

The parsing engine to use. 'bs4' and 'html5lib' are synonymous with each other, they are both there for backwards compatibility. The default of `None` tries to use `lxml` to parse and if that fails it falls back on `bs4` + `html5lib`.

header : int or list-like or None, optional

The row (or list of rows for a *`MultiIndex`*) to use to make the columns headers.

index_col : int or list-like or None, optional

The column (or list of columns) to use to create the index.

skiprows : int or list-like or slice or None, optional

0-based. Number of rows to skip after parsing the column integer. If a sequence of integers or a slice is given, will skip the rows indexed by that sequence. Note that a single element sequence means 'skip the nth row' whereas an integer means 'skip n rows'.

attrs : dict or None, optional

This is a dictionary of attributes that you can pass to use to identify the table in the HTML. These are not checked for validity before being passed to lxml or Beautiful Soup. However, these attributes must be valid HTML table attributes to work correctly. For example,

```
attrs = {'id': 'table'}
```

is a valid attribute dictionary because the 'id' HTML tag attribute is a valid HTML attribute for *any* HTML tag as per this document.

```
attrs = {'asdf': 'table'}
```

is *not* a valid attribute dictionary because 'asdf' is not a valid HTML attribute even if it is a valid XML attribute. Valid HTML 4.01 table attributes can be found here. A working draft of the HTML 5 spec can be found here. It contains the latest information on table attributes for the modern web.

parse_dates : bool, optional

See *`read_csv()`* for more details.

tupleize_cols : bool, optional

If `False` try to parse multiple header rows into a *`MultiIndex`*, otherwise return raw tuples. Defaults to `False`.

Deprecated since version 0.21.0: This argument will be removed and will always convert to MultiIndex

thousands : str, optional

Separator to use to parse thousands. Defaults to `','`.

encoding : str or None, optional

The encoding used to decode the web page. Defaults to `None`.''None'' preserves the previous encoding behavior, which depends on the underlying parser library (e.g., the parser library will try to use the encoding provided by the document).

decimal : str, default '.'

Character to recognize as decimal point (e.g. use ',' for European data).

New in version 0.19.0.

converters : dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels, values are functions that take one input argument, the cell (not column) content, and return the transformed content.

New in version 0.19.0.

na_values : iterable, default None

Custom NA values

New in version 0.19.0.

keep_default_na : bool, default True

If na_values are specified and keep_default_na is False the default NaN values are overridden, otherwise they're appended to

New in version 0.19.0.

Returns **dfs** : list of DataFrames

See also:

`pandas.read_csv`

Notes

Before using this function you should read the *gotchas about the HTML parsing libraries*.

Expect to do some cleanup after you call this function. For example, you might need to manually assign column names if the column names are converted to NaN when you pass the *header=0* argument. We try to assume as little as possible about the structure of the table and push the idiosyncrasies of the HTML contained in the table to the user.

This function searches for `<table>` elements and only for `<tr>` and `<th>` rows and `<td>` elements within each `<tr>` or `<th>` element in the table. `<td>` stands for "table data".

Similar to `read_csv()` the *header* argument is applied **after** *skiprows* is applied.

This function will *always* return a list of `DataFrame` *or* it will fail, e.g., it will *not* return an empty list.

Examples

See the *read_html documentation in the IO section of the docs* for some examples of reading in HTML tables.

34.1.7 HDFStore: PyTables (HDF5)

`read_hdf`(path_or_buf[, key, mode])	read from the store, close it if we opened it
`HDFStore.put`(key, value[, format, append])	Store object in HDFStore
`HDFStore.append`(key, value[, format, ...])	Append to Table in file.
`HDFStore.get`(key)	Retrieve pandas object stored in file
`HDFStore.select`(key[, where, start, stop, ...])	Retrieve pandas object stored in file, optionally based on where
`HDFStore.info`()	print detailed information on the store

34.1.7.1 pandas.read_hdf

`pandas.read_hdf`(*path_or_buf*, *key=None*, *mode='r'*, ***kwargs*)

read from the store, close it if we opened it

Retrieve pandas object stored in file, optionally based on where criteria

Parameters **path_or_buf** : path (string), buffer or path object (pathlib.Path or

py._path.local.LocalPath) designating the file to open, or an already opened pd.HDFStore object

New in version 0.19.0: support for pathlib, py.path.

key : group identifier in the store. Can be omitted if the HDF file

contains a single pandas object.

mode : string, {'r', 'r+', 'a'}, default 'r'. Mode to use when opening

the file. Ignored if path_or_buf is a pd.HDFStore.

where : list of Term (or convertable) objects, optional

start : optional, integer (defaults to None), row number to start

selection

stop : optional, integer (defaults to None), row number to stop

selection

columns : optional, a list of columns that if not None, will limit the

return columns

iterator : optional, boolean, return an iterator, default False

chunksize : optional, nrows to include in iteration, return an iterator

Returns The selected object

34.1.7.2 pandas.HDFStore.put

`HDFStore.put`(*key*, *value*, *format=None*, *append=False*, ***kwargs*)

Store object in HDFStore

Parameters **key** : object

value : {Series, DataFrame, Panel}

format : 'fixed(f)|table(t)', default is 'fixed'

fixed(f) [Fixed format] Fast writing/reading. Not-appendable, nor searchable

table(t) [Table format] Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data

append : boolean, default False

This will force Table format, append the input data to the existing.

data_columns : list of columns to create as data columns, or True to

use all columns. See here # noqa

encoding : default None, provide an encoding for strings

dropna : boolean, default False, do not write an ALL nan row to

the store settable by the option 'io.hdf.dropna_table'

34.1.7.3 pandas.HDFStore.append

`HDFStore.append(key, value, format=None, append=True, columns=None, dropna=None, **kwargs)`

Append to Table in file. Node must already exist and be Table format.

Parameters **key** : object

value : {Series, DataFrame, Panel, Panel4D}

format: 'table' is the default

table(t) [table format] Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data

append : boolean, default True, append the input data to the

existing

data_columns : list of columns, or True, default None

List of columns to create as indexed data columns for on-disk queries, or True to use all columns. By default only the axes of the object are indexed. See here.

min_itemsize : dict of columns that specify minimum string sizes

nan_rep : string to use as string nan represenation

chunksize : size to chunk the writing

expectedrows : expected TOTAL row size of this table

encoding : default None, provide an encoding for strings

dropna : boolean, default False, do not write an ALL nan row to

the store settable by the option 'io.hdf.dropna_table'

Notes

Does *not* check if data being appended overlaps with existing data in the table, so be careful

34.1.7.4 pandas.HDFStore.get

`HDFStore.get(key)`

Retrieve pandas object stored in file

Parameters **key** : object

Returns **obj** : type of object stored in file

34.1.7.5 pandas.HDFStore.select

`HDFStore.select`(*key*, *where=None*, *start=None*, *stop=None*, *columns=None*, *iterator=False*, *chunksize=None*, *auto_close=False*, ***kwargs*)

Retrieve pandas object stored in file, optionally based on where criteria

Parameters **key** : object

where : list of Term (or convertable) objects, optional

start : integer (defaults to None), row number to start selection

stop : integer (defaults to None), row number to stop selection

columns : a list of columns that if not None, will limit the return columns

iterator : boolean, return an iterator, default False

chunksize : nrows to include in iteration, return an iterator

auto_close : boolean, should automatically close the store when finished, default is False

Returns The selected object

34.1.7.6 pandas.HDFStore.info

`HDFStore.info`()

print detailed information on the store

New in version 0.21.0.

34.1.8 Feather

`read_feather`(path[, nthreads])	Load a feather-format object from the file path

34.1.8.1 pandas.read_feather

`pandas.read_feather`(*path*, *nthreads=1*)

Load a feather-format object from the file path

Parameters **path** : string file path, or file-like object

nthreads : int, default 1

Number of CPU threads to use when reading to pandas.DataFrame

Returns type of object stored in file

34.1.9 Parquet

`read_parquet`(path[, engine])	Load a parquet object from the file path, returning a DataFrame.

34.1.9.1 pandas.read_parquet

pandas.**read_parquet**(*path*, *engine='auto'*, ***kwargs*)

Load a parquet object from the file path, returning a DataFrame.

Parameters **path** : string

File path

engine : {'auto', 'pyarrow', 'fastparquet'}, default 'auto'

Parquet reader library to use. If 'auto', then the option 'io.parquet.engine' is used. If 'auto', then the first library to be installed is used.

kwargs are passed to the engine

Returns DataFrame

34.1.10 SAS

read_sas(filepath_or_buffer[, format, ...])	Read SAS files stored as either XPORT or SAS7BDAT format files.

34.1.10.1 pandas.read_sas

pandas.**read_sas**(*filepath_or_buffer*, *format=None*, *index=None*, *encoding=None*, *chunksize=None*, *iterator=False*)

Read SAS files stored as either XPORT or SAS7BDAT format files.

Parameters **filepath_or_buffer** : string or file-like object

Path to the SAS file.

format : string {'xport', 'sas7bdat'} or None

If None, file format is inferred. If 'xport' or 'sas7bdat', uses the corresponding format.

index : identifier of index column, defaults to None

Identifier of column that should be used as index of the DataFrame.

encoding : string, default is None

Encoding for text data. If None, text data are stored as raw bytes.

chunksize : int

Read file *chunksize* lines at a time, returns iterator.

iterator : bool, defaults to False

If True, returns an iterator for reading the file incrementally.

Returns DataFrame if iterator=False and chunksize=None, else SAS7BDATReader

or XportReader

34.1.11 SQL

read_sql_table(table_name, con[, schema, ...])	Read SQL database table into a DataFrame.

Continued on next page

Table 34.12 – continued from previous page

read_sql_query(sql, con[, index_col, ...])	Read SQL query into a DataFrame.
read_sql(sql, con[, index_col, ...])	Read SQL query or database table into a DataFrame.

34.1.12 Google BigQuery

read_gbq(query[, project_id, index_col, ...])	Load data from Google BigQuery.

34.1.12.1 pandas.read_gbq

pandas.**read_gbq**(*query*, *project_id=None*, *index_col=None*, *col_order=None*, *reauth=False*, *verbose=True*, *private_key=None*, *dialect='legacy'*, ***kwargs*)

Load data from Google BigQuery.

The main method a user calls to execute a Query in Google BigQuery and read results into a pandas DataFrame.

Google BigQuery API Client Library v2 for Python is used. Documentation is available here

Authentication to the Google BigQuery service is via OAuth 2.0.

- If "private_key" is not provided:

  By default "application default credentials" are used.

  If default application credentials are not found or are restrictive, user account credentials are used. In this case, you will be asked to grant permissions for product name 'pandas GBQ'.

- If "private_key" is provided:

  Service account credentials will be used to authenticate.

Parameters **query** : str

SQL-Like Query to return data values

project_id : str

Google BigQuery Account project ID.

index_col : str (optional)

Name of result column to use for index in results DataFrame

col_order : list(str) (optional)

List of BigQuery column names in the desired order for results DataFrame

reauth : boolean (default False)

Force Google BigQuery to reauthenticate the user. This is useful if multiple accounts are used.

verbose : boolean (default True)

Verbose output

private_key : str (optional)

Service account private key in JSON format. Can be file path or string contents. This is useful for remote server authentication (eg. jupyter iPython notebook on remote host)

dialect : {'legacy', 'standard'}, default 'legacy'

'legacy' : Use BigQuery's legacy SQL dialect. 'standard' : Use BigQuery's standard SQL (beta), which is compliant with the SQL 2011 standard. For more information see BigQuery SQL Reference

****kwargs** : Arbitrary keyword arguments

configuration (dict): query config parameters for job processing. For example:

configuration = {'query': {'useQueryCache': False}}

For more information see BigQuery SQL Reference

Returns df: DataFrame

DataFrame representing results of query

34.1.13 STATA

`read_stata`(filepath_or_buffer[, ...])	Read Stata file into DataFrame

34.1.13.1 pandas.read_stata

pandas.**read_stata**(*filepath_or_buffer*, *convert_dates=True*, *convert_categoricals=True*, *encoding=None*, *index_col=None*, *convert_missing=False*, *preserve_dtypes=True*, *columns=None*, *order_categoricals=True*, *chunksize=None*, *iterator=False*)

Read Stata file into DataFrame

Parameters **filepath_or_buffer** : string or file-like object

Path to .dta file or object implementing a binary read() functions

convert_dates : boolean, defaults to True

Convert date variables to DataFrame time values

convert_categoricals : boolean, defaults to True

Read value labels and convert columns to Categorical/Factor variables

encoding : string, None or encoding

Encoding used to parse the files. None defaults to latin-1.

index_col : string, optional, default: None

Column to set as index

convert_missing : boolean, defaults to False

Flag indicating whether to convert missing values to their Stata representations. If False, missing values are replaced with nan. If True, columns containing missing values are returned with object data types and missing values are represented by StataMissingValue objects.

preserve_dtypes : boolean, defaults to True

Preserve Stata datatypes. If False, numeric data are upcast to pandas default types for foreign data (float64 or int64)

columns : list or None

Columns to retain. Columns will be returned in the given order. None returns all columns

order_categoricals : boolean, defaults to True

Flag indicating whether converted categorical data are ordered.

chunksize : int, default None

Return StataReader object for iterations, returns chunks with given number of lines

iterator : boolean, default False

Return StataReader object

Returns DataFrame or StataReader

Examples

Read a Stata dta file:

```
>>> df = pandas.read_stata('filename.dta')
```

Read a Stata dta file in 10,000 line chunks:

```
>>> itr = pandas.read_stata('filename.dta', chunksize=10000)
>>> for chunk in itr:
>>>     do_something(chunk)
```

StataReader.data(**kwargs)	Reads observations from Stata file, converting them into a dataframe
StataReader.data_label()	Returns data label of Stata file
StataReader.value_labels()	Returns a dict, associating each variable name a dict, associating
StataReader.variable_labels()	Returns variable labels as a dict, associating each variable name
StataWriter.write_file()	

34.1.13.2 pandas.io.stata.StataReader.data

`StataReader.`**`data`**`(`***kwargs*`)`

Reads observations from Stata file, converting them into a dataframe

Deprecated since version This: is a legacy method. Use *read* in new code.

Parameters **convert_dates** : boolean, defaults to True

Convert date variables to DataFrame time values

convert_categoricals : boolean, defaults to True

Read value labels and convert columns to Categorical/Factor variables

index_col : string, optional, default: None

Column to set as index

convert_missing : boolean, defaults to False

Flag indicating whether to convert missing values to their Stata representations. If False, missing values are replaced with nan. If True, columns containing missing values are re-

turned with object data types and missing values are represented by StataMissingValue objects.

preserve_dtypes : boolean, defaults to True

Preserve Stata datatypes. If False, numeric data are upcast to pandas default types for foreign data (float64 or int64)

columns : list or None

Columns to retain. Columns will be returned in the given order. None returns all columns

order_categoricals : boolean, defaults to True

Flag indicating whether converted categorical data are ordered.

Returns DataFrame

34.1.13.3 pandas.io.stata.StataReader.data_label

`StataReader.data_label()`

Returns data label of Stata file

34.1.13.4 pandas.io.stata.StataReader.value_labels

`StataReader.value_labels()`

Returns a dict, associating each variable name a dict, associating each value its corresponding label

34.1.13.5 pandas.io.stata.StataReader.variable_labels

`StataReader.variable_labels()`

Returns variable labels as a dict, associating each variable name with corresponding label

34.1.13.6 pandas.io.stata.StataWriter.write_file

`StataWriter.write_file()`

34.2 General functions

34.2.1 Data manipulations

melt(frame[, id_vars, value_vars, var_name, ...])	"Unpivots" a DataFrame from wide format to long format, optionally
pivot(index, columns, values)	Produce 'pivot' table based on 3 columns of this DataFrame.
pivot_table(data[, values, index, columns, ...])	Create a spreadsheet-style pivot table as a DataFrame.
crosstab(index, columns[, values, rownames, ...])	Compute a simple cross-tabulation of two (or more) factors.
cut(x, bins[, right, labels, retbins, ...])	Return indices of half-open bins to which each value of x belongs.

Continued on next page

Table 34.16 – continued from previous page

qcut(x, q[, labels, retbins, precision, ...])	Quantile-based discretization function.
merge(left, right[, how, on, left_on, ...])	Merge DataFrame objects by performing a database-style join operation by columns or indexes.
merge_ordered(left, right[, on, left_on, ...])	Perform merge with optional filling/interpolation designed for ordered data like time series data.
merge_asof(left, right[, on, left_on, ...])	Perform an asof merge.
concat(objs[, axis, join, join_axes, ...])	Concatenate pandas objects along a particular axis with optional set logic along the other axes.
get_dummies(data[, prefix, prefix_sep, ...])	Convert categorical variable into dummy/indicator variables
factorize(values[, sort, order, ...])	Encode input values as an enumerated type or categorical variable
unique(values)	Hash table-based unique.
wide_to_long(df, stubnames, i, j[, sep, suffix])	Wide panel to long format.

34.2.1.1 pandas.melt

pandas.**melt**(*frame*, *id_vars=None*, *value_vars=None*, *var_name=None*, *value_name='value'*, *col_level=None*)

"Unpivots" a DataFrame from wide format to long format, optionally leaving identifier variables set.

This function is useful to massage a DataFrame into a format where one or more columns are identifier variables (*id_vars*), while all other columns, considered measured variables (*value_vars*), are "unpivoted" to the row axis, leaving just two non-identifier columns, 'variable' and 'value'.

Parameters **frame** : DataFrame

id_vars : tuple, list, or ndarray, optional

Column(s) to use as identifier variables.

value_vars : tuple, list, or ndarray, optional

Column(s) to unpivot. If not specified, uses all columns that are not set as *id_vars*.

var_name : scalar

Name to use for the 'variable' column. If None it uses `frame.columns.name` or 'variable'.

value_name : scalar, default 'value'

Name to use for the 'value' column.

col_level : int or string, optional

If columns are a MultiIndex then use this level to melt.

See also:

DataFrame.melt, *pivot_table*, *DataFrame.pivot*

Examples

```
>>> import pandas as pd
>>> df = pd.DataFrame({'A': {0: 'a', 1: 'b', 2: 'c'},
...                    'B': {0: 1, 1: 3, 2: 5},
...                    'C': {0: 2, 1: 4, 2: 6}})
```

```
>>> df
   A  B  C
0  a  1  2
1  b  3  4
2  c  5  6
```

```
>>> pd.melt(df, id_vars=['A'], value_vars=['B'])
   A variable  value
0  a        B      1
1  b        B      3
2  c        B      5
```

```
>>> pd.melt(df, id_vars=['A'], value_vars=['B', 'C'])
   A variable  value
0  a        B      1
1  b        B      3
2  c        B      5
3  a        C      2
4  b        C      4
5  c        C      6
```

The names of 'variable' and 'value' columns can be customized:

```
>>> pd.melt(df, id_vars=['A'], value_vars=['B'],
...         var_name='myVarname', value_name='myValname')
   A myVarname  myValname
0  a         B          1
1  b         B          3
2  c         B          5
```

If you have multi-index columns:

```
>>> df.columns = [list('ABC'), list('DEF')]
>>> df
   A  B  C
   D  E  F
0  a  1  2
1  b  3  4
2  c  5  6
```

```
>>> pd.melt(df, col_level=0, id_vars=['A'], value_vars=['B'])
   A variable  value
0  a        B      1
1  b        B      3
2  c        B      5
```

```
>>> pd.melt(df, id_vars=[('A', 'D')], value_vars=[('B', 'E')])
  (A, D) variable_0 variable_1  value
0      a          B          E      1
1      b          B          E      3
2      c          B          E      5
```

34.2.1.2 pandas.pivot

`pandas.pivot(index, columns, values)`

Produce 'pivot' table based on 3 columns of this DataFrame. Uses unique values from index / columns and fills with values.

Parameters **index** : ndarray

Labels to use to make new frame's index

columns : ndarray

Labels to use to make new frame's columns

values : ndarray

Values to use for populating new frame's values

Returns DataFrame

See also:

DataFrame.pivot_table generalization of pivot that can handle duplicate values for one index/column pair

Notes

Obviously, all 3 of the input arguments must have the same length

34.2.1.3 pandas.pivot_table

`pandas.pivot_table(data, values=None, index=None, columns=None, aggfunc='mean', fill_value=None, margins=False, dropna=True, margins_name='All')`

Create a spreadsheet-style pivot table as a DataFrame. The levels in the pivot table will be stored in MultiIndex objects (hierarchical indexes) on the index and columns of the result DataFrame

Parameters **data** : DataFrame

values : column to aggregate, optional

index : column, Grouper, array, or list of the previous

If an array is passed, it must be the same length as the data. The list can contain any of the other types (except list). Keys to group by on the pivot table index. If an array is passed, it is being used as the same manner as column values.

columns : column, Grouper, array, or list of the previous

If an array is passed, it must be the same length as the data. The list can contain any of the other types (except list). Keys to group by on the pivot table column. If an array is passed, it is being used as the same manner as column values.

aggfunc : function or list of functions, default numpy.mean

If list of functions passed, the resulting pivot table will have hierarchical columns whose top level are the function names (inferred from the function objects themselves)

fill_value : scalar, default None

Value to replace missing values with

margins : boolean, default False

Add all row / columns (e.g. for subtotal / grand totals)

dropna : boolean, default True

Do not include columns whose entries are all NaN

margins_name : string, default 'All'

Name of the row / column that will contain the totals when margins is True.

Returns table : DataFrame

See also:

DataFrame.pivot pivot without aggregation that can handle non-numeric data

Examples

```
>>> df = pd.DataFrame({"A": ["foo", "foo", "foo", "foo", "foo",
...                          "bar", "bar", "bar", "bar"],
...                    "B": ["one", "one", "one", "two", "two",
...                          "one", "one", "two", "two"],
...                    "C": ["small", "large", "large", "small",
...                          "small", "large", "small", "small",
...                          "large"],
...                    "D": [1, 2, 2, 3, 3, 4, 5, 6, 7]})
>>> df
     A    B      C  D
0  foo  one  small  1
1  foo  one  large  2
2  foo  one  large  2
3  foo  two  small  3
4  foo  two  small  3
5  bar  one  large  4
6  bar  one  small  5
7  bar  two  small  6
8  bar  two  large  7
```

```
>>> table = pivot_table(df, values='D', index=['A', 'B'],
...                     columns=['C'], aggfunc=np.sum)
>>> table
...
C        large  small
A   B
bar one    4.0    5.0
    two    7.0    6.0
foo one    4.0    1.0
    two    NaN    6.0
```

34.2.1.4 pandas.crosstab

pandas.**crosstab**(*index*, *columns*, *values=None*, *rownames=None*, *colnames=None*, *aggfunc=None*, *margins=False*, *margins_name='All'*, *dropna=True*, *normalize=False*)

Compute a simple cross-tabulation of two (or more) factors. By default computes a frequency table of the factors unless an array of values and an aggregation function are passed

Parameters index : array-like, Series, or list of arrays/Series

Values to group by in the rows

columns : array-like, Series, or list of arrays/Series

Values to group by in the columns

values : array-like, optional

Array of values to aggregate according to the factors. Requires *aggfunc* be specified.

aggfunc : function, optional

If specified, requires *values* be specified as well

rownames : sequence, default None

If passed, must match number of row arrays passed

colnames : sequence, default None

If passed, must match number of column arrays passed

margins : boolean, default False

Add row/column margins (subtotals)

margins_name : string, default 'All'

Name of the row / column that will contain the totals when margins is True.

New in version 0.21.0.

dropna : boolean, default True

Do not include columns whose entries are all NaN

normalize : boolean, {'all', 'index', 'columns'}, or {0,1}, default False

Normalize by dividing all values by the sum of values.

- If passed 'all' or *True*, will normalize over all values.
- If passed 'index' will normalize over each row.
- If passed 'columns' will normalize over each column.
- If margins is *True*, will also normalize margin values.

New in version 0.18.1.

Returns **crosstab** : DataFrame

Notes

Any Series passed will have their name attributes used unless row or column names for the cross-tabulation are specified.

Any input passed containing Categorical data will have **all** of its categories included in the cross-tabulation, even if the actual data does not contain any instances of a particular category.

In the event that there aren't overlapping indexes an empty DataFrame will be returned.

Examples

```
>>> a = np.array(["foo", "foo", "foo", "foo", "bar", "bar",
...               "bar", "bar", "foo", "foo", "foo"], dtype=object)
>>> b = np.array(["one", "one", "one", "two", "one", "one",
...               "one", "two", "two", "two", "one"], dtype=object)
>>> c = np.array(["dull", "dull", "shiny", "dull", "dull", "shiny",
...               "shiny", "dull", "shiny", "shiny", "shiny"],
...               dtype=object)
```

```
>>> pd.crosstab(a, [b, c], rownames=['a'], colnames=['b', 'c'])
...
b   one        two
c   dull shiny dull shiny
a
bar    1     2    1     0
foo    2     2    1     2
```

```
>>> foo = pd.Categorical(['a', 'b'], categories=['a', 'b', 'c'])
>>> bar = pd.Categorical(['d', 'e'], categories=['d', 'e', 'f'])
>>> crosstab(foo, bar)  # 'c' and 'f' are not represented in the data,
...                     # but they still will be counted in the output
...
col_0  d  e  f
row_0
a      1  0  0
b      0  1  0
c      0  0  0
```

34.2.1.5 pandas.cut

`pandas.cut`(*x*, *bins*, *right=True*, *labels=None*, *retbins=False*, *precision=3*, *include_lowest=False*)

Return indices of half-open bins to which each value of *x* belongs.

Parameters **x** : array-like

Input array to be binned. It has to be 1-dimensional.

bins : int, sequence of scalars, or IntervalIndex

If *bins* is an int, it defines the number of equal-width bins in the range of *x*. However, in this case, the range of *x* is extended by .1% on each side to include the min or max values of *x*. If *bins* is a sequence it defines the bin edges allowing for non-uniform bin width. No extension of the range of *x* is done in this case.

right : bool, optional

Indicates whether the bins include the rightmost edge or not. If right == True (the default), then the bins [1,2,3,4] indicate (1,2], (2,3], (3,4].

labels : array or boolean, default None

Used as labels for the resulting bins. Must be of the same length as the resulting bins. If False, return only integer indicators of the bins.

retbins : bool, optional

Whether to return the bins or not. Can be useful if bins is given as a scalar.

precision : int, optional

The precision at which to store and display the bins labels

include_lowest : bool, optional

Whether the first interval should be left-inclusive or not.

Returns **out** : Categorical or Series or array of integers if labels is False

The return type (Categorical or Series) depends on the input: a Series of type category if input is a Series else Categorical. Bins are represented as categories when categorical data is returned.

bins : ndarray of floats

Returned only if *retbins* is True.

Notes

The *cut* function can be useful for going from a continuous variable to a categorical variable. For example, *cut* could convert ages to groups of age ranges.

Any NA values will be NA in the result. Out of bounds values will be NA in the resulting Categorical object

Examples

```
>>> pd.cut(np.array([.2, 1.4, 2.5, 6.2, 9.7, 2.1]), 3, retbins=True)
...
([(0.19, 3.367], (0.19, 3.367], (0.19, 3.367], (3.367, 6.533], ...
Categories (3, interval[float64]): [(0.19, 3.367] < (3.367, 6.533] ...
```

```
>>> pd.cut(np.array([.2, 1.4, 2.5, 6.2, 9.7, 2.1]),
...        3, labels=["good", "medium", "bad"])
...
[good, good, good, medium, bad, good]
Categories (3, object): [good < medium < bad]
```

```
>>> pd.cut(np.ones(5), 4, labels=False)
array([1, 1, 1, 1, 1])
```

34.2.1.6 pandas.qcut

`pandas.qcut`(*x*, *q*, *labels=None*, *retbins=False*, *precision=3*, *duplicates='raise'*)

Quantile-based discretization function. Discretize variable into equal-sized buckets based on rank or based on sample quantiles. For example 1000 values for 10 quantiles would produce a Categorical object indicating quantile membership for each data point.

Parameters **x** : ndarray or Series

q : integer or array of quantiles

Number of quantiles. 10 for deciles, 4 for quartiles, etc. Alternately array of quantiles, e.g. [0, .25, .5, .75, 1.] for quartiles

labels : array or boolean, default None

Used as labels for the resulting bins. Must be of the same length as the resulting bins. If False, return only integer indicators of the bins.

retbins : bool, optional

Whether to return the (bins, labels) or not. Can be useful if bins is given as a scalar.

precision : int, optional

The precision at which to store and display the bins labels

duplicates : {default 'raise', 'drop'}, optional

If bin edges are not unique, raise ValueError or drop non-uniques.

New in version 0.20.0.

Returns **out** : Categorical or Series or array of integers if labels is False

The return type (Categorical or Series) depends on the input: a Series of type category if input is a Series else Categorical. Bins are represented as categories when categorical data is returned.

bins : ndarray of floats

Returned only if *retbins* is True.

Notes

Out of bounds values will be NA in the resulting Categorical object

Examples

```
>>> pd.qcut(range(5), 4)
...
[(-0.001, 1.0], (-0.001, 1.0], (1.0, 2.0], (2.0, 3.0], (3.0, 4.0]]
Categories (4, interval[float64]): [(-0.001, 1.0] < (1.0, 2.0] ...
```

```
>>> pd.qcut(range(5), 3, labels=["good", "medium", "bad"])
...
[good, good, medium, bad, bad]
Categories (3, object): [good < medium < bad]
```

```
>>> pd.qcut(range(5), 4, labels=False)
array([0, 0, 1, 2, 3])
```

34.2.1.7 pandas.merge

pandas.**merge**(*left*, *right*, *how='inner'*, *on=None*, *left_on=None*, *right_on=None*, *left_index=False*, *right_index=False*, *sort=False*, *suffixes=('_x', '_y')*, *copy=True*, *indicator=False*, *validate=None*)

Merge DataFrame objects by performing a database-style join operation by columns or indexes.

If joining columns on columns, the DataFrame indexes *will be ignored*. Otherwise if joining indexes on indexes or indexes on a column or columns, the index will be passed on.

Parameters **left** : DataFrame

right : DataFrame

how : {'left', 'right', 'outer', 'inner'}, default 'inner'

- left: use only keys from left frame, similar to a SQL left outer join; preserve key order
- right: use only keys from right frame, similar to a SQL right outer join; preserve key order
- outer: use union of keys from both frames, similar to a SQL full outer join; sort keys lexicographically
- inner: use intersection of keys from both frames, similar to a SQL inner join; preserve the order of the left keys

on : label or list

Field names to join on. Must be found in both DataFrames. If on is None and not merging on indexes, then it merges on the intersection of the columns by default.

left_on : label or list, or array-like

Field names to join on in left DataFrame. Can be a vector or list of vectors of the length of the DataFrame to use a particular vector as the join key instead of columns

right_on : label or list, or array-like

Field names to join on in right DataFrame or vector/list of vectors per left_on docs

left_index : boolean, default False

Use the index from the left DataFrame as the join key(s). If it is a MultiIndex, the number of keys in the other DataFrame (either the index or a number of columns) must match the number of levels

right_index : boolean, default False

Use the index from the right DataFrame as the join key. Same caveats as left_index

sort : boolean, default False

Sort the join keys lexicographically in the result DataFrame. If False, the order of the join keys depends on the join type (how keyword)

suffixes : 2-length sequence (tuple, list, ...)

Suffix to apply to overlapping column names in the left and right side, respectively

copy : boolean, default True

If False, do not copy data unnecessarily

indicator : boolean or string, default False

If True, adds a column to output DataFrame called "_merge" with information on the source of each row. If string, column with information on source of each row will be added to output DataFrame, and column will be named value of string. Information column is Categorical-type and takes on a value of "left_only" for observations whose merge key only appears in 'left' DataFrame, "right_only" for observations whose merge key only appears in 'right' DataFrame, and "both" if the observation's merge key is found in both.

New in version 0.17.0.

validate : string, default None

If specified, checks if merge is of specified type.

- "one_to_one" or "1:1": check if merge keys are unique in both left and right datasets.
- "one_to_many" or "1:m": check if merge keys are unique in left dataset.
- "many_to_one" or "m:1": check if merge keys are unique in right dataset.
- "many_to_many" or "m:m": allowed, but does not result in checks.

New in version 0.21.0.

Returns **merged** : DataFrame

The output type will the be same as 'left', if it is a subclass of DataFrame.

See also:

merge_ordered, *merge_asof*

Examples

```
>>> A              >>> B
    lkey value         rkey value
0   foo  1         0   foo  5
1   bar  2         1   bar  6
2   baz  3         2   qux  7
3   foo  4         3   bar  8
```

```
>>> A.merge(B, left_on='lkey', right_on='rkey', how='outer')
   lkey  value_x  rkey  value_y
0  foo   1        foo   5
1  foo   4        foo   5
2  bar   2        bar   6
3  bar   2        bar   8
4  baz   3        NaN   NaN
5  NaN   NaN      qux   7
```

34.2.1.8 pandas.merge_ordered

pandas.**merge_ordered**(*left*, *right*, *on=None*, *left_on=None*, *right_on=None*, *left_by=None*, *right_by=None*, *fill_method=None*, *suffixes=('_x', '_y')*, *how='outer'*)

Perform merge with optional filling/interpolation designed for ordered data like time series data. Optionally perform group-wise merge (see examples)

Parameters **left** : DataFrame

right : DataFrame

on : label or list

Field names to join on. Must be found in both DataFrames.

left_on : label or list, or array-like

Field names to join on in left DataFrame. Can be a vector or list of vectors of the length of the DataFrame to use a particular vector as the join key instead of columns

right_on : label or list, or array-like

Field names to join on in right DataFrame or vector/list of vectors per left_on docs

left_by : column name or list of column names

Group left DataFrame by group columns and merge piece by piece with right DataFrame

right_by : column name or list of column names

Group right DataFrame by group columns and merge piece by piece with left DataFrame

fill_method : {'ffill', None}, default None

Interpolation method for data

suffixes : 2-length sequence (tuple, list, ...)

Suffix to apply to overlapping column names in the left and right side, respectively

how : {'left', 'right', 'outer', 'inner'}, default 'outer'

- left: use only keys from left frame (SQL: left outer join)
- right: use only keys from right frame (SQL: right outer join)
- outer: use union of keys from both frames (SQL: full outer join)
- inner: use intersection of keys from both frames (SQL: inner join)

New in version 0.19.0.

Returns **merged** : DataFrame

The output type will the be same as 'left', if it is a subclass of DataFrame.

See also:

merge, *merge_asof*

Examples

```
>>> A                      >>> B
      key  lvalue group         key  rvalue
0   a       1     a        0     b       1
1   c       2     a        1     c       2
2   e       3     a        2     d       3
3   a       1     b
4   c       2     b
5   e       3     b
```

```
>>> ordered_merge(A, B, fill_method='ffill', left_by='group')
   key  lvalue group  rvalue
0    a       1     a     NaN
1    b       1     a       1
2    c       2     a       2
3    d       2     a       3
4    e       3     a       3
5    f       3     a       4
6    a       1     b     NaN
7    b       1     b       1
8    c       2     b       2
9    d       2     b       3
10   e       3     b       3
11   f       3     b       4
```

34.2.1.9 pandas.merge_asof

`pandas.merge_asof`(*left*, *right*, *on=None*, *left_on=None*, *right_on=None*, *left_index=False*, *right_index=False*, *by=None*, *left_by=None*, *right_by=None*, *suffixes=('_x', '_y')*, *tolerance=None*, *allow_exact_matches=True*, *direction='backward'*)

Perform an asof merge. This is similar to a left-join except that we match on nearest key rather than equal keys.

Both DataFrames must be sorted by the key.

For each row in the left DataFrame:

- A "backward" search selects the last row in the right DataFrame whose 'on' key is less than or equal to the left's key.
- A "forward" search selects the first row in the right DataFrame whose 'on' key is greater than or equal to the left's key.
- A "nearest" search selects the row in the right DataFrame whose 'on' key is closest in absolute distance to the left's key.

The default is "backward" and is compatible in versions below 0.20.0. The direction parameter was added in version 0.20.0 and introduces "forward" and "nearest".

Optionally match on equivalent keys with 'by' before searching with 'on'.

New in version 0.19.0.

Parameters **left** : DataFrame

right : DataFrame

on : label

Field name to join on. Must be found in both DataFrames. The data MUST be ordered. Furthermore this must be a numeric column, such as datetimelike, integer, or float. On or left_on/right_on must be given.

left_on : label

Field name to join on in left DataFrame.

right_on : label

Field name to join on in right DataFrame.

left_index : boolean

Use the index of the left DataFrame as the join key.

New in version 0.19.2.

right_index : boolean

Use the index of the right DataFrame as the join key.

New in version 0.19.2.

by : column name or list of column names

Match on these columns before performing merge operation.

left_by : column name

Field names to match on in the left DataFrame.

New in version 0.19.2.

right_by : column name

Field names to match on in the right DataFrame.

New in version 0.19.2.

suffixes : 2-length sequence (tuple, list, ...)

Suffix to apply to overlapping column names in the left and right side, respectively.

tolerance : integer or Timedelta, optional, default None

Select asof tolerance within this range; must be compatible with the merge index.

allow_exact_matches : boolean, default True

- If True, allow matching with the same 'on' value (i.e. less-than-or-equal-to / greater-than-or-equal-to)
- If False, don't match the same 'on' value (i.e., stricly less-than / strictly greater-than)

direction : 'backward' (default), 'forward', or 'nearest'

Whether to search for prior, subsequent, or closest matches.

New in version 0.20.0.

Returns merged : DataFrame

See also:

merge, *merge_ordered*

Examples

```
>>> left = pd.DataFrame({'a': [1, 5, 10], 'left_val': ['a', 'b', 'c']})
>>> left
    a left_val
0   1        a
1   5        b
2  10        c
```

```
>>> right = pd.DataFrame({'a': [1, 2, 3, 6, 7],
...                       'right_val': [1, 2, 3, 6, 7]})
>>> right
   a  right_val
0  1          1
1  2          2
2  3          3
3  6          6
4  7          7
```

```
>>> pd.merge_asof(left, right, on='a')
    a left_val  right_val
0   1        a          1
1   5        b          3
2  10        c          7
```

```
>>> pd.merge_asof(left, right, on='a', allow_exact_matches=False)
    a left_val  right_val
0   1        a        NaN
1   5        b        3.0
2  10        c        7.0
```

```
>>> pd.merge_asof(left, right, on='a', direction='forward')
    a left_val  right_val
0   1        a        1.0
1   5        b        6.0
2  10        c        NaN
```

```
>>> pd.merge_asof(left, right, on='a', direction='nearest')
    a left_val  right_val
0   1        a          1
1   5        b          6
2  10        c          7
```

We can use indexed DataFrames as well.

```
>>> left = pd.DataFrame({'left_val': ['a', 'b', 'c']}, index=[1, 5, 10])
>>> left
   left_val
1         a
5         b
10        c
```

```
>>> right = pd.DataFrame({'right_val': [1, 2, 3, 6, 7]},
...                      index=[1, 2, 3, 6, 7])
>>> right
   right_val
1          1
2          2
3          3
6          6
7          7
```

```
>>> pd.merge_asof(left, right, left_index=True, right_index=True)
   left_val  right_val
1         a          1
5         b          3
10        c          7
```

Here is a real-world times-series example

```
>>> quotes
                     time ticker     bid     ask
0 2016-05-25 13:30:00.023   GOOG  720.50  720.93
1 2016-05-25 13:30:00.023   MSFT   51.95   51.96
2 2016-05-25 13:30:00.030   MSFT   51.97   51.98
3 2016-05-25 13:30:00.041   MSFT   51.99   52.00
4 2016-05-25 13:30:00.048   GOOG  720.50  720.93
5 2016-05-25 13:30:00.049   AAPL   97.99   98.01
6 2016-05-25 13:30:00.072   GOOG  720.50  720.88
7 2016-05-25 13:30:00.075   MSFT   52.01   52.03
```

```
>>> trades
                     time ticker   price  quantity
0 2016-05-25 13:30:00.023   MSFT   51.95        75
1 2016-05-25 13:30:00.038   MSFT   51.95       155
2 2016-05-25 13:30:00.048   GOOG  720.77       100
3 2016-05-25 13:30:00.048   GOOG  720.92       100
```

```
4 2016-05-25 13:30:00.048   AAPL   98.00       100
```

By default we are taking the asof of the quotes

```
>>> pd.merge_asof(trades, quotes,
...                       on='time',
...                       by='ticker')
                     time ticker   price  quantity     bid     ask
0 2016-05-25 13:30:00.023   MSFT   51.95        75   51.95   51.96
1 2016-05-25 13:30:00.038   MSFT   51.95       155   51.97   51.98
2 2016-05-25 13:30:00.048   GOOG  720.77       100  720.50  720.93
3 2016-05-25 13:30:00.048   GOOG  720.92       100  720.50  720.93
4 2016-05-25 13:30:00.048   AAPL   98.00       100     NaN     NaN
```

We only asof within 2ms between the quote time and the trade time

```
>>> pd.merge_asof(trades, quotes,
...                       on='time',
...                       by='ticker',
...                       tolerance=pd.Timedelta('2ms'))
                     time ticker   price  quantity     bid     ask
0 2016-05-25 13:30:00.023   MSFT   51.95        75   51.95   51.96
1 2016-05-25 13:30:00.038   MSFT   51.95       155     NaN     NaN
2 2016-05-25 13:30:00.048   GOOG  720.77       100  720.50  720.93
3 2016-05-25 13:30:00.048   GOOG  720.92       100  720.50  720.93
4 2016-05-25 13:30:00.048   AAPL   98.00       100     NaN     NaN
```

We only asof within 10ms between the quote time and the trade time and we exclude exact matches on time. However *prior* data will propagate forward

```
>>> pd.merge_asof(trades, quotes,
...                       on='time',
...                       by='ticker',
...                       tolerance=pd.Timedelta('10ms'),
...                       allow_exact_matches=False)
                     time ticker   price  quantity     bid     ask
0 2016-05-25 13:30:00.023   MSFT   51.95        75     NaN     NaN
1 2016-05-25 13:30:00.038   MSFT   51.95       155   51.97   51.98
2 2016-05-25 13:30:00.048   GOOG  720.77       100  720.50  720.93
3 2016-05-25 13:30:00.048   GOOG  720.92       100  720.50  720.93
4 2016-05-25 13:30:00.048   AAPL   98.00       100     NaN     NaN
```

34.2.1.10 pandas.concat

`pandas.concat`(*objs*, *axis=0*, *join='outer'*, *join_axes=None*, *ignore_index=False*, *keys=None*, *levels=None*, *names=None*, *verify_integrity=False*, *copy=True*)

Concatenate pandas objects along a particular axis with optional set logic along the other axes.

Can also add a layer of hierarchical indexing on the concatenation axis, which may be useful if the labels are the same (or overlapping) on the passed axis number.

Parameters **objs** : a sequence or mapping of Series, DataFrame, or Panel objects

If a dict is passed, the sorted keys will be used as the *keys* argument, unless it is passed, in which case the values will be selected (see below). Any None objects will be dropped silently unless they are all None in which case a ValueError will be raised

axis : {0/'index', 1/'columns'}, default 0

The axis to concatenate along

join : {'inner', 'outer'}, default 'outer'

How to handle indexes on other axis(es)

join_axes : list of Index objects

Specific indexes to use for the other n - 1 axes instead of performing inner/outer set logic

ignore_index : boolean, default False

If True, do not use the index values along the concatenation axis. The resulting axis will be labeled 0, ..., n - 1. This is useful if you are concatenating objects where the concatenation axis does not have meaningful indexing information. Note the index values on the other axes are still respected in the join.

keys : sequence, default None

If multiple levels passed, should contain tuples. Construct hierarchical index using the passed keys as the outermost level

levels : list of sequences, default None

Specific levels (unique values) to use for constructing a MultiIndex. Otherwise they will be inferred from the keys

names : list, default None

Names for the levels in the resulting hierarchical index

verify_integrity : boolean, default False

Check whether the new concatenated axis contains duplicates. This can be very expensive relative to the actual data concatenation

copy : boolean, default True

If False, do not copy data unnecessarily

Returns **concatenated** : object, type of objs

When concatenating all `Series` along the index (axis=0), a `Series` is returned. When `objs` contains at least one `DataFrame`, a `DataFrame` is returned. When concatenating along the columns (axis=1), a `DataFrame` is returned.

See also:

`Series.append`, *`DataFrame.append`*, *`DataFrame.join`*, *`DataFrame.merge`*

Notes

The keys, levels, and names arguments are all optional.

A walkthrough of how this method fits in with other tools for combining pandas objects can be found here.

Examples

Combine two `Series`.

```
>>> s1 = pd.Series(['a', 'b'])
>>> s2 = pd.Series(['c', 'd'])
>>> pd.concat([s1, s2])
0    a
1    b
0    c
1    d
dtype: object
```

Clear the existing index and reset it in the result by setting the `ignore_index` option to `True`.

```
>>> pd.concat([s1, s2], ignore_index=True)
0    a
1    b
2    c
3    d
dtype: object
```

Add a hierarchical index at the outermost level of the data with the `keys` option.

```
>>> pd.concat([s1, s2], keys=['s1', 's2',])
s1  0    a
    1    b
s2  0    c
    1    d
dtype: object
```

Label the index keys you create with the `names` option.

```
>>> pd.concat([s1, s2], keys=['s1', 's2'],
...           names=['Series name', 'Row ID'])
Series name  Row ID
s1           0         a
             1         b
s2           0         c
             1         d
dtype: object
```

Combine two `DataFrame` objects with identical columns.

```
>>> df1 = pd.DataFrame([['a', 1], ['b', 2]],
...                    columns=['letter', 'number'])
>>> df1
  letter  number
0      a       1
1      b       2
>>> df2 = pd.DataFrame([['c', 3], ['d', 4]],
...                    columns=['letter', 'number'])
>>> df2
  letter  number
0      c       3
1      d       4
>>> pd.concat([df1, df2])
  letter  number
0      a       1
1      b       2
0      c       3
1      d       4
```

Combine `DataFrame` objects with overlapping columns and return everything. Columns outside the intersection will be filled with `NaN` values.

```
>>> df3 = pd.DataFrame([['c', 3, 'cat'], ['d', 4, 'dog']],
...                    columns=['letter', 'number', 'animal'])
>>> df3
  letter  number animal
0      c       3    cat
1      d       4    dog
>>> pd.concat([df1, df3])
  animal letter  number
0    NaN      a       1
1    NaN      b       2
0    cat      c       3
1    dog      d       4
```

Combine `DataFrame` objects with overlapping columns and return only those that are shared by passing `inner` to the `join` keyword argument.

```
>>> pd.concat([df1, df3], join="inner")
  letter  number
0      a       1
1      b       2
0      c       3
1      d       4
```

Combine `DataFrame` objects horizontally along the x axis by passing in `axis=1`.

```
>>> df4 = pd.DataFrame([['bird', 'polly'], ['monkey', 'george']],
...                    columns=['animal', 'name'])
>>> pd.concat([df1, df4], axis=1)
  letter  number  animal    name
0      a       1    bird   polly
1      b       2  monkey  george
```

Prevent the result from including duplicate index values with the `verify_integrity` option.

```
>>> df5 = pd.DataFrame([1], index=['a'])
>>> df5
   0
a  1
>>> df6 = pd.DataFrame([2], index=['a'])
>>> df6
   0
a  2
>>> pd.concat([df5, df6], verify_integrity=True)
Traceback (most recent call last):
    ...
ValueError: Indexes have overlapping values: ['a']
```

34.2.1.11 pandas.get_dummies

`pandas.get_dummies`(*data*, *prefix=None*, *prefix_sep='_'*, *dummy_na=False*, *columns=None*, *sparse=False*, *drop_first=False*)

Convert categorical variable into dummy/indicator variables

Parameters **data** : array-like, Series, or DataFrame

prefix : string, list of strings, or dict of strings, default None

String to append DataFrame column names Pass a list with length equal to the number of columns when calling get_dummies on a DataFrame. Alternatively, *prefix* can be a dictionary mapping column names to prefixes.

prefix_sep : string, default '_'

If appending prefix, separator/delimiter to use. Or pass a list or dictionary as with *prefix*.

dummy_na : bool, default False

Add a column to indicate NaNs, if False NaNs are ignored.

columns : list-like, default None

Column names in the DataFrame to be encoded. If *columns* is None then all the columns with *object* or *category* dtype will be converted.

sparse : bool, default False

Whether the dummy columns should be sparse or not. Returns SparseDataFrame if *data* is a Series or if all columns are included. Otherwise returns a DataFrame with some SparseBlocks.

drop_first : bool, default False

Whether to get k-1 dummies out of k categorical levels by removing the first level.

New in version 0.18.0.

Returns

——-

dummies : DataFrame or SparseDataFrame

See also:

Series.str.get_dummies

Examples

```
>>> import pandas as pd
>>> s = pd.Series(list('abca'))
```

```
>>> pd.get_dummies(s)
   a  b  c
0  1  0  0
1  0  1  0
2  0  0  1
3  1  0  0
```

```
>>> s1 = ['a', 'b', np.nan]
```

```
>>> pd.get_dummies(s1)
   a  b
0  1  0
1  0  1
2  0  0
```

```
>>> pd.get_dummies(s1, dummy_na=True)
   a  b  NaN
0  1  0    0
1  0  1    0
2  0  0    1
```

```
>>> df = pd.DataFrame({'A': ['a', 'b', 'a'], 'B': ['b', 'a', 'c'],
...                    'C': [1, 2, 3]})
```

```
>>> pd.get_dummies(df, prefix=['col1', 'col2'])
   C  col1_a  col1_b  col2_a  col2_b  col2_c
0  1       1       0       0       1       0
1  2       0       1       1       0       0
2  3       1       0       0       0       1
```

```
>>> pd.get_dummies(pd.Series(list('abcaa')))
   a  b  c
0  1  0  0
1  0  1  0
2  0  0  1
3  1  0  0
4  1  0  0
```

```
>>> pd.get_dummies(pd.Series(list('abcaa')), drop_first=True)
   b  c
0  0  0
1  1  0
2  0  1
3  0  0
4  0  0
```

34.2.1.12 pandas.factorize

`pandas.factorize`(*values*, *sort=False*, *order=None*, *na_sentinel=-1*, *size_hint=None*)

Encode input values as an enumerated type or categorical variable

Parameters **values** : ndarray (1-d)

Sequence

sort : boolean, default False

Sort by values

na_sentinel : int, default -1

Value to mark "not found"

size_hint : hint to the hashtable sizer

Returns **labels** : the indexer to the original array

uniques : ndarray (1-d) or Index

the unique values. Index is returned when passed values is Index or Series

note: an array of Periods will ignore sort as it returns an always sorted

PeriodIndex

34.2.1.13 pandas.unique

pandas.**unique**(*values*)

Hash table-based unique. Uniques are returned in order of appearance. This does NOT sort.

Significantly faster than numpy.unique. Includes NA values.

Parameters **values** : 1d array-like

Returns unique values.

- If the input is an Index, the return is an Index
- If the input is a Categorical dtype, the return is a Categorical
- If the input is a Series/ndarray, the return will be an ndarray

See also:

pandas.Index.unique, *pandas.Series.unique*

Examples

```
>>> pd.unique(pd.Series([2, 1, 3, 3]))
array([2, 1, 3])
```

```
>>> pd.unique(pd.Series([2] + [1] * 5))
array([2, 1])
```

```
>>> pd.unique(Series([pd.Timestamp('20160101'),
...                   pd.Timestamp('20160101')]))
array(['2016-01-01T00:00:00.000000000'], dtype='datetime64[ns]')
```

```
>>> pd.unique(pd.Series([pd.Timestamp('20160101', tz='US/Eastern'),
...                      pd.Timestamp('20160101', tz='US/Eastern')]))
array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')],
      dtype=object)
```

```
>>> pd.unique(pd.Index([pd.Timestamp('20160101', tz='US/Eastern'),
...                     pd.Timestamp('20160101', tz='US/Eastern')]))
DatetimeIndex(['2016-01-01 00:00:00-05:00'],
...           dtype='datetime64[ns, US/Eastern]', freq=None)
```

```
>>> pd.unique(list('baabc'))
array(['b', 'a', 'c'], dtype=object)
```

An unordered Categorical will return categories in the order of appearance.

```
>>> pd.unique(Series(pd.Categorical(list('baabc'))))
[b, a, c]
Categories (3, object): [b, a, c]
```

```
>>> pd.unique(Series(pd.Categorical(list('baabc'),
...                                 categories=list('abc'))))
[b, a, c]
Categories (3, object): [b, a, c]
```

An ordered Categorical preserves the category ordering.

```
>>> pd.unique(Series(pd.Categorical(list('baabc'),
...                                 categories=list('abc'),
...                                 ordered=True)))
[b, a, c]
Categories (3, object): [a < b < c]
```

An array of tuples

```
>>> pd.unique([('a', 'b'), ('b', 'a'), ('a', 'c'), ('b', 'a')])
array([('a', 'b'), ('b', 'a'), ('a', 'c')], dtype=object)
```

34.2.1.14 pandas.wide_to_long

`pandas.wide_to_long`(*df*, *stubnames*, *i*, *j*, *sep='‘*, *suffix='\\d+'*)

Wide panel to long format. Less flexible but more user-friendly than melt.

With stubnames ['A', 'B'], this function expects to find one or more group of columns with format Asuffix1, Asuffix2,..., Bsuffix1, Bsuffix2,... You specify what you want to call this suffix in the resulting long format with *j* (for example *j='year'*)

Each row of these wide variables are assumed to be uniquely identified by *i* (can be a single column name or a list of column names)

All remaining variables in the data frame are left intact.

Parameters **df** : DataFrame

The wide-format DataFrame

stubnames : str or list-like

The stub name(s). The wide format variables are assumed to start with the stub names.

i : str or list-like

Column(s) to use as id variable(s)

j : str

The name of the subobservation variable. What you wish to name your suffix in the long format.

sep : str, default “”

A character indicating the separation of the variable names in the wide format, to be stripped from the names in the long format. For example, if your column names are A-suffix1, A-suffix2, you can strip the hypen by specifying *sep='-‘*

New in version 0.20.0.

suffix : str, default '\d+'

A regular expression capturing the wanted suffixes. '\d+' captures numeric suffixes. Suffixes with no numbers could be specified with the negated character class '\D+'. You can also further disambiguate suffixes, for example, if your wide variables are of the form Aone, Btwo,.., and you have an unrelated column Arating, you can ignore the last one by specifying *suffix='(!?one|two)'*

New in version 0.20.0.

Returns DataFrame

A DataFrame that contains each stub name as a variable, with new index (i, j)

Notes

All extra variables are left untouched. This simply uses *pandas.melt* under the hood, but is hard-coded to "do the right thing" in a typicaly case.

Examples

```
>>> import pandas as pd
>>> import numpy as np
>>> np.random.seed(123)
>>> df = pd.DataFrame({"A1970" : {0 : "a", 1 : "b", 2 : "c"},
...                    "A1980" : {0 : "d", 1 : "e", 2 : "f"},
...                    "B1970" : {0 : 2.5, 1 : 1.2, 2 : .7},
...                    "B1980" : {0 : 3.2, 1 : 1.3, 2 : .1},
...                    "X"     : dict(zip(range(3), np.random.randn(3)))
...                   })
>>> df["id"] = df.index
>>> df
  A1970 A1980  B1970  B1980         X  id
0     a     d    2.5    3.2 -1.085631   0
1     b     e    1.2    1.3  0.997345   1
2     c     f    0.7    0.1  0.282978   2
>>> pd.wide_to_long(df, ["A", "B"], i="id", j="year")
...
               X  A    B
id year
0  1970 -1.085631  a  2.5
1  1970  0.997345  b  1.2
2  1970  0.282978  c  0.7
0  1980 -1.085631  d  3.2
1  1980  0.997345  e  1.3
2  1980  0.282978  f  0.1
```

With multuple id columns

```
>>> df = pd.DataFrame({
...     'famid': [1, 1, 1, 2, 2, 2, 3, 3, 3],
...     'birth': [1, 2, 3, 1, 2, 3, 1, 2, 3],
...     'ht1': [2.8, 2.9, 2.2, 2, 1.8, 1.9, 2.2, 2.3, 2.1],
...     'ht2': [3.4, 3.8, 2.9, 3.2, 2.8, 2.4, 3.3, 3.4, 2.9]
... })
>>> df
   birth  famid  ht1  ht2
0      1      1  2.8  3.4
1      2      1  2.9  3.8
2      3      1  2.2  2.9
3      1      2  2.0  3.2
4      2      2  1.8  2.8
5      3      2  1.9  2.4
6      1      3  2.2  3.3
7      2      3  2.3  3.4
8      3      3  2.1  2.9
>>> l = pd.wide_to_long(df, stubnames='ht', i=['famid', 'birth'], j='age')
```

```
>>> l
...
                   ht
famid birth age
1     1     1    2.8
            2    3.4
      2     1    2.9
            2    3.8
      3     1    2.2
            2    2.9
2     1     1    2.0
            2    3.2
      2     1    1.8
            2    2.8
      3     1    1.9
            2    2.4
3     1     1    2.2
            2    3.3
      2     1    2.3
            2    3.4
      3     1    2.1
            2    2.9
```

Going from long back to wide just takes some creative use of *unstack*

```
>>> w = l.reset_index().set_index(['famid', 'birth', 'age']).unstack()
>>> w.columns = pd.Index(w.columns).str.join('')
>>> w.reset_index()
   famid  birth  ht1  ht2
0      1      1  2.8  3.4
1      1      2  2.9  3.8
2      1      3  2.2  2.9
3      2      1  2.0  3.2
4      2      2  1.8  2.8
5      2      3  1.9  2.4
6      3      1  2.2  3.3
7      3      2  2.3  3.4
8      3      3  2.1  2.9
```

Less wieldy column names are also handled

```
>>> np.random.seed(0)
>>> df = pd.DataFrame({'A(quarterly)-2010': np.random.rand(3),
...                    'A(quarterly)-2011': np.random.rand(3),
...                    'B(quarterly)-2010': np.random.rand(3),
...                    'B(quarterly)-2011': np.random.rand(3),
...                    'X' : np.random.randint(3, size=3)})
>>> df['id'] = df.index
>>> df
   A(quarterly)-2010  A(quarterly)-2011  B(quarterly)-2010  ...
0           0.548814           0.544883           0.437587  ...
1           0.715189           0.423655           0.891773  ...
2           0.602763           0.645894           0.963663  ...
   X  id
0  0   0
1  1   1
2  1   2
```

```
>>> pd.wide_to_long(df, ['A(quarterly)', 'B(quarterly)'], i='id',
...                 j='year', sep='-')
...
         X  A(quarterly)  B(quarterly)
id year
0  2010  0      0.548814     0.437587
1  2010  1      0.715189     0.891773
2  2010  1      0.602763     0.963663
0  2011  0      0.544883     0.383442
1  2011  1      0.423655     0.791725
2  2011  1      0.645894     0.528895
```

If we have many columns, we could also use a regex to find our stubnames and pass that list on to wide_to_long

```
>>> stubnames = sorted(
...     set([match[0] for match in df.columns.str.findall(
...         r'[A-B]\(.*\)').values if match != [] ])
... )
>>> list(stubnames)
['A(quarterly)', 'B(quarterly)']
```

34.2.2 Top-level missing data

isna(obj)	Detect missing values (NaN in numeric arrays, None/NaN in object arrays)
isnull(obj)	Detect missing values (NaN in numeric arrays, None/NaN in object arrays)
notna(obj)	Replacement for numpy.isfinite / -numpy.isnan which is suitable for use on object arrays.
notnull(obj)	Replacement for numpy.isfinite / -numpy.isnan which is suitable for use on object arrays.

34.2.2.1 pandas.isna

pandas.**isna**(*obj*)

Detect missing values (NaN in numeric arrays, None/NaN in object arrays)

Parameters **arr** : ndarray or object value

Object to check for null-ness

Returns **isna** : array-like of bool or bool

Array or bool indicating whether an object is null or if an array is given which of the element is null.

See also:

pandas.notna boolean inverse of pandas.isna

pandas.isnull alias of isna

34.2.2.2 pandas.isnull

`pandas.isnull(obj)`

Detect missing values (NaN in numeric arrays, None/NaN in object arrays)

Parameters **arr** : ndarray or object value

Object to check for null-ness

Returns **isna** : array-like of bool or bool

Array or bool indicating whether an object is null or if an array is given which of the element is null.

See also:

pandas.notna boolean inverse of pandas.isna

pandas.isnull alias of isna

34.2.2.3 pandas.notna

`pandas.notna(obj)`

Replacement for numpy.isfinite / -numpy.isnan which is suitable for use on object arrays.

Parameters **arr** : ndarray or object value

Object to check for *not*-null-ness

Returns **notisna** : array-like of bool or bool

Array or bool indicating whether an object is *not* null or if an array is given which of the element is *not* null.

See also:

pandas.isna boolean inverse of pandas.notna

pandas.notnull alias of notna

34.2.2.4 pandas.notnull

`pandas.notnull(obj)`

Replacement for numpy.isfinite / -numpy.isnan which is suitable for use on object arrays.

Parameters **arr** : ndarray or object value

Object to check for *not*-null-ness

Returns **notisna** : array-like of bool or bool

Array or bool indicating whether an object is *not* null or if an array is given which of the element is *not* null.

See also:

pandas.isna boolean inverse of pandas.notna

pandas.notnull alias of notna

34.2.3 Top-level conversions

to_numeric(arg[, errors, downcast])	Convert argument to a numeric type.

34.2.3.1 pandas.to_numeric

pandas.**to_numeric**(*arg*, *errors='raise'*, *downcast=None*)

Convert argument to a numeric type.

Parameters **arg** : list, tuple, 1-d array, or Series

errors : {'ignore', 'raise', 'coerce'}, default 'raise'

- If 'raise', then invalid parsing will raise an exception
- If 'coerce', then invalid parsing will be set as NaN
- If 'ignore', then invalid parsing will return the input

downcast : {'integer', 'signed', 'unsigned', 'float'} , default None

If not None, and if the data has been successfully cast to a numerical dtype (or if the data was numeric to begin with), downcast that resulting data to the smallest numerical dtype possible according to the following rules:

- 'integer' or 'signed': smallest signed int dtype (min.: np.int8)
- 'unsigned': smallest unsigned int dtype (min.: np.uint8)
- 'float': smallest float dtype (min.: np.float32)

As this behaviour is separate from the core conversion to numeric values, any errors raised during the downcasting will be surfaced regardless of the value of the 'errors' input.

In addition, downcasting will only occur if the size of the resulting data's dtype is strictly larger than the dtype it is to be cast to, so if none of the dtypes checked satisfy that specification, no downcasting will be performed on the data.

New in version 0.19.0.

Returns **ret** : numeric if parsing succeeded.

Return type depends on input. Series if Series, otherwise ndarray

See also:

pandas.DataFrame.astype Cast argument to a specified dtype.

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

numpy.ndarray.astype Cast a numpy array to a specified type.

Examples

Take separate series and convert to numeric, coercing when told to

```
>>> import pandas as pd
>>> s = pd.Series(['1.0', '2', -3])
>>> pd.to_numeric(s)
0    1.0
1    2.0
2   -3.0
dtype: float64
>>> pd.to_numeric(s, downcast='float')
0    1.0
1    2.0
2   -3.0
dtype: float32
>>> pd.to_numeric(s, downcast='signed')
0    1
1    2
2   -3
dtype: int8
>>> s = pd.Series(['apple', '1.0', '2', -3])
>>> pd.to_numeric(s, errors='ignore')
0    apple
1      1.0
2        2
3       -3
dtype: object
>>> pd.to_numeric(s, errors='coerce')
0    NaN
1    1.0
2    2.0
3   -3.0
dtype: float64
```

34.2.4 Top-level dealing with datetimelike

to_datetime(arg[, errors, dayfirst, ...])	Convert argument to datetime.
to_timedelta(arg[, unit, box, errors])	Convert argument to timedelta
date_range([start, end, periods, freq, tz, ...])	Return a fixed frequency DatetimeIndex, with day (calendar) as the default
bdate_range([start, end, periods, freq, tz, ...])	Return a fixed frequency DatetimeIndex, with business day as the default
period_range([start, end, periods, freq, name])	Return a fixed frequency PeriodIndex, with day (calendar) as the default
timedelta_range([start, end, periods, freq, ...])	Return a fixed frequency TimedeltaIndex, with day as the default
infer_freq(index[, warn])	Infer the most likely frequency given the input index.

34.2.4.1 pandas.to_datetime

pandas.**to_datetime**(*arg*, *errors='raise'*, *dayfirst=False*, *yearfirst=False*, *utc=None*, *box=True*, *format=None*, *exact=True*, *unit=None*, *infer_datetime_format=False*, *origin='unix'*)

Convert argument to datetime.

Parameters **arg** : integer, float, string, datetime, list, tuple, 1-d array, Series

errors : {'ignore', 'raise', 'coerce'}, default 'raise'

- If 'raise', then invalid parsing will raise an exception
- If 'coerce', then invalid parsing will be set as NaT
- If 'ignore', then invalid parsing will return the input

dayfirst : boolean, default False

Specify a date parse order if *arg* is str or its list-likes. If True, parses dates with the day first, eg 10/11/12 is parsed as 2012-11-10. Warning: dayfirst=True is not strict, but will prefer to parse with day first (this is a known bug, based on dateutil behavior).

yearfirst : boolean, default False

Specify a date parse order if *arg* is str or its list-likes.

- If True parses dates with the year first, eg 10/11/12 is parsed as 2010-11-12.
- If both dayfirst and yearfirst are True, yearfirst is preceded (same as dateutil).

Warning: yearfirst=True is not strict, but will prefer to parse with year first (this is a known bug, based on dateutil beahavior).

utc : boolean, default None

Return UTC DatetimeIndex if True (converting any tz-aware datetime.datetime objects as well).

box : boolean, default True

- If True returns a DatetimeIndex
- If False returns ndarray of values.

format : string, default None

strftime to parse time, eg "%d/%m/%Y", note that "%f" will parse all the way up to nanoseconds.

exact : boolean, True by default

- If True, require an exact format match.
- If False, allow the format to match anywhere in the target string.

unit : string, default 'ns'

unit of the arg (D,s,ms,us,ns) denote the unit, which is an integer or float number. This will be based off the origin. Example, with unit='ms' and origin='unix' (the default), this would calculate the number of milliseconds to the unix epoch start.

infer_datetime_format : boolean, default False

If True and no *format* is given, attempt to infer the format of the datetime strings, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by ~5-10x.

origin : scalar, default is 'unix'

Define the reference date. The numeric values would be parsed as number of units (defined by *unit*) since this reference date.

- If 'unix' (or POSIX) time; origin is set to 1970-01-01.
- If 'julian', unit must be 'D', and origin is set to beginning of Julian Calendar. Julian day number 0 is assigned to the day starting at noon on January 1, 4713 BC.

- If Timestamp convertible, origin is set to Timestamp identified by origin.

Returns **ret** : datetime if parsing succeeded.

Return type depends on input:

- list-like: DatetimeIndex
- Series: Series of datetime64 dtype
- scalar: Timestamp

In case when it is not possible to return designated types (e.g. when any element of input is before Timestamp.min or after Timestamp.max) return will have datetime.datetime type (or correspoding array/Series).

See also:

pandas.DataFrame.astype Cast argument to a specified dtype.

pandas.to_timedelta Convert argument to timedelta.

Examples

Assembling a datetime from multiple columns of a DataFrame. The keys can be common abbreviations like ['year', 'month', 'day', 'minute', 'second', 'ms', 'us', 'ns']) or plurals of the same

```
>>> df = pd.DataFrame({'year': [2015, 2016],
                       'month': [2, 3],
                       'day': [4, 5]})
>>> pd.to_datetime(df)
0   2015-02-04
1   2016-03-05
dtype: datetime64[ns]
```

If a date does not meet the timestamp limitations, passing errors='ignore' will return the original input instead of raising any exception.

Passing errors='coerce' will force an out-of-bounds date to NaT, in addition to forcing non-dates (or non-parseable dates) to NaT.

```
>>> pd.to_datetime('13000101', format='%Y%m%d', errors='ignore')
datetime.datetime(1300, 1, 1, 0, 0)
>>> pd.to_datetime('13000101', format='%Y%m%d', errors='coerce')
NaT
```

Passing infer_datetime_format=True can often-times speedup a parsing if its not an ISO8601 format exactly, but in a regular format.

```
>>> s = pd.Series(['3/11/2000', '3/12/2000', '3/13/2000']*1000)
```

```
>>> s.head()
0    3/11/2000
1    3/12/2000
2    3/13/2000
3    3/11/2000
4    3/12/2000
dtype: object
```

```
>>> %timeit pd.to_datetime(s,infer_datetime_format=True)
100 loops, best of 3: 10.4 ms per loop
```

```
>>> %timeit pd.to_datetime(s,infer_datetime_format=False)
1 loop, best of 3: 471 ms per loop
```

Using a unix epoch time

```
>>> pd.to_datetime(1490195805, unit='s')
Timestamp('2017-03-22 15:16:45')
>>> pd.to_datetime(1490195805433502912, unit='ns')
Timestamp('2017-03-22 15:16:45.433502912')
```

Warning: For float arg, precision rounding might happen. To prevent unexpected behavior use a fixed-width exact type.

Using a non-unix epoch origin

```
>>> pd.to_datetime([1, 2, 3], unit='D',
                   origin=pd.Timestamp('1960-01-01'))
0    1960-01-02
1    1960-01-03
2    1960-01-04
```

34.2.4.2 pandas.to_timedelta

`pandas.to_timedelta`(*arg*, *unit='ns'*, *box=True*, *errors='raise'*)

Convert argument to timedelta

Parameters **arg** : string, timedelta, list, tuple, 1-d array, or Series

unit : unit of the arg (D,h,m,s,ms,us,ns) denote the unit, which is an integer/float number

box : boolean, default True

- If True returns a Timedelta/TimedeltaIndex of the results
- if False returns a np.timedelta64 or ndarray of values of dtype timedelta64[ns]

errors : {'ignore', 'raise', 'coerce'}, default 'raise'

- If 'raise', then invalid parsing will raise an exception
- If 'coerce', then invalid parsing will be set as NaT
- If 'ignore', then invalid parsing will return the input

Returns **ret** : timedelta64/arrays of timedelta64 if parsing succeeded

See also:

pandas.DataFrame.astype Cast argument to a specified dtype.

pandas.to_datetime Convert argument to datetime.

Examples

Parsing a single string to a Timedelta:

```
>>> pd.to_timedelta('1 days 06:05:01.00003')
Timedelta('1 days 06:05:01.000030')
>>> pd.to_timedelta('15.5us')
Timedelta('0 days 00:00:00.000015')
```

Parsing a list or array of strings:

```
>>> pd.to_timedelta(['1 days 06:05:01.00003', '15.5us', 'nan'])
TimedeltaIndex(['1 days 06:05:01.000030', '0 days 00:00:00.000015', NaT],
               dtype='timedelta64[ns]', freq=None)
```

Converting numbers by specifying the *unit* keyword argument:

```
>>> pd.to_timedelta(np.arange(5), unit='s')
TimedeltaIndex(['00:00:00', '00:00:01', '00:00:02',
                '00:00:03', '00:00:04'],
               dtype='timedelta64[ns]', freq=None)
>>> pd.to_timedelta(np.arange(5), unit='d')
TimedeltaIndex(['0 days', '1 days', '2 days', '3 days', '4 days'],
               dtype='timedelta64[ns]', freq=None)
```

34.2.4.3 pandas.date_range

`pandas.date_range`(*start=None*, *end=None*, *periods=None*, *freq='D'*, *tz=None*, *normalize=False*, *name=None*, *closed=None*, ***kwargs*)

Return a fixed frequency DatetimeIndex, with day (calendar) as the default frequency

Parameters **start** : string or datetime-like, default None

Left bound for generating dates

end : string or datetime-like, default None

Right bound for generating dates

periods : integer, default None

Number of periods to generate

freq : string or DateOffset, default 'D' (calendar daily)

Frequency strings can have multiples, e.g. '5H'

tz : string, default None

Time zone name for returning localized DatetimeIndex, for example Asia/Hong_Kong

normalize : bool, default False

Normalize start/end dates to midnight before generating date range

name : string, default None

Name of the resulting DatetimeIndex

closed : string, default None

Make the interval closed with respect to the given frequency to the 'left', 'right', or both sides (None)

Returns **rng** : DatetimeIndex

Notes

Of the three parameters: `start`, `end`, and `periods`, exactly two must be specified.

To learn more about the frequency strings, please see this link.

34.2.4.4 pandas.bdate_range

`pandas.bdate_range`(*start=None*, *end=None*, *periods=None*, *freq='B'*, *tz=None*, *normalize=True*, *name=None*, *weekmask=None*, *holidays=None*, *closed=None*, ***kwargs*)

Return a fixed frequency DatetimeIndex, with business day as the default frequency

Parameters **start** : string or datetime-like, default None

Left bound for generating dates

end : string or datetime-like, default None

Right bound for generating dates

periods : integer, default None

Number of periods to generate

freq : string or DateOffset, default 'B' (business daily)

Frequency strings can have multiples, e.g. '5H'

tz : string or None

Time zone name for returning localized DatetimeIndex, for example Asia/Beijing

normalize : bool, default False

Normalize start/end dates to midnight before generating date range

name : string, default None

Name of the resulting DatetimeIndex

weekmask : string or None, default None

Weekmask of valid business days, passed to `numpy.busdaycalendar`, only used when custom frequency strings are passed. The default value None is equivalent to 'Mon Tue Wed Thu Fri'

New in version 0.21.0.

holidays : list-like or None, default None

Dates to exclude from the set of valid business days, passed to `numpy.busdaycalendar`, only used when custom frequency strings are passed

New in version 0.21.0.

closed : string, default None

Make the interval closed with respect to the given frequency to the 'left', 'right', or both sides (None)

Returns **rng** : DatetimeIndex

Notes

Of the three parameters: `start`, `end`, and `periods`, exactly two must be specified.

To learn more about the frequency strings, please see this link.

34.2.4.5 pandas.period_range

`pandas.period_range`(*start=None*, *end=None*, *periods=None*, *freq='D'*, *name=None*)

Return a fixed frequency PeriodIndex, with day (calendar) as the default frequency

Parameters **start** : string or period-like, default None

Left bound for generating periods

end : string or period-like, default None

Right bound for generating periods

periods : integer, default None

Number of periods to generate

freq : string or DateOffset, default 'D' (calendar daily)

Frequency alias

name : string, default None

Name of the resulting PeriodIndex

Returns **prng** : PeriodIndex

Notes

Of the three parameters: `start`, `end`, and `periods`, exactly two must be specified.

To learn more about the frequency strings, please see this link.

Examples

```
>>> pd.period_range(start='2017-01-01', end='2018-01-01', freq='M')
PeriodIndex(['2017-01', '2017-02', '2017-03', '2017-04', '2017-05',
             '2017-06', '2017-06', '2017-07', '2017-08', '2017-09',
             '2017-10', '2017-11', '2017-12', '2018-01'],
            dtype='period[M]', freq='M')
```

If `start` or `end` are `Period` objects, they will be used as anchor endpoints for a `PeriodIndex` with frequency matching that of the `period_range` constructor.

```
>>> pd.period_range(start=pd.Period('2017Q1', freq='Q'),
...                 end=pd.Period('2017Q2', freq='Q'), freq='M')
PeriodIndex(['2017-03', '2017-04', '2017-05', '2017-06'],
            dtype='period[M]', freq='M')
```

34.2.4.6 pandas.timedelta_range

pandas.**timedelta_range**(*start=None*, *end=None*, *periods=None*, *freq='D'*, *name=None*, *closed=None*)

Return a fixed frequency TimedeltaIndex, with day as the default frequency

Parameters **start** : string or timedelta-like, default None

Left bound for generating timedeltas

end : string or timedelta-like, default None

Right bound for generating timedeltas

periods : integer, default None

Number of periods to generate

freq : string or DateOffset, default 'D' (calendar daily)

Frequency strings can have multiples, e.g. '5H'

name : string, default None

Name of the resulting TimedeltaIndex

closed : string, default None

Make the interval closed with respect to the given frequency to the 'left', 'right', or both sides (None)

Returns **rng** : TimedeltaIndex

Notes

Of the three parameters: `start`, `end`, and `periods`, exactly two must be specified.

To learn more about the frequency strings, please see this link.

Examples

```
>>> pd.timedelta_range(start='1 day', periods=4)
TimedeltaIndex(['1 days', '2 days', '3 days', '4 days'],
               dtype='timedelta64[ns]', freq='D')
```

The `closed` parameter specifies which endpoint is included. The default behavior is to include both endpoints.

```
>>> pd.timedelta_range(start='1 day', periods=4, closed='right')
TimedeltaIndex(['2 days', '3 days', '4 days'],
               dtype='timedelta64[ns]', freq='D')
```

The `freq` parameter specifies the frequency of the TimedeltaIndex. Only fixed frequencies can be passed, non-fixed frequencies such as 'M' (month end) will raise.

```
>>> pd.timedelta_range(start='1 day', end='2 days', freq='6H')
TimedeltaIndex(['1 days 00:00:00', '1 days 06:00:00', '1 days 12:00:00',
                '1 days 18:00:00', '2 days 00:00:00'],
               dtype='timedelta64[ns]', freq='6H')
```

34.2.4.7 pandas.infer_freq

pandas.**infer_freq**(*index*, *warn=True*)

Infer the most likely frequency given the input index. If the frequency is uncertain, a warning will be printed.

Parameters **index** : DatetimeIndex or TimedeltaIndex

if passed a Series will use the values of the series (NOT THE INDEX)

warn : boolean, default True

Returns **freq** : string or None

None if no discernible frequency TypeError if the index is not datetime-like ValueError if there are less than three values.

34.2.5 Top-level dealing with intervals

interval_range([start, end, periods, freq, ...])	Return a fixed frequency IntervalIndex

34.2.5.1 pandas.interval_range

pandas.**interval_range**(*start=None*, *end=None*, *periods=None*, *freq=None*, *name=None*, *closed='right'*)

Return a fixed frequency IntervalIndex

Parameters **start** : numeric or datetime-like, default None

Left bound for generating intervals

end : numeric or datetime-like, default None

Right bound for generating intervals

periods : integer, default None

Number of periods to generate

freq : numeric, string, or DateOffset, default None

The length of each interval. Must be consistent with the type of start and end, e.g. 2 for numeric, or '5H' for datetime-like. Default is 1 for numeric and 'D' (calendar daily) for datetime-like.

name : string, default None

Name of the resulting IntervalIndex

closed : string, default 'right'

options are: 'left', 'right', 'both', 'neither'

Returns **rng** : IntervalIndex

See also:

IntervalIndex an Index of intervals that are all closed on the same side.

Notes

Of the three parameters: `start`, `end`, and `periods`, exactly two must be specified.

Examples

Numeric `start` and `end` is supported.

```
>>> pd.interval_range(start=0, end=5)
IntervalIndex([(0, 1], (1, 2], (2, 3], (3, 4], (4, 5]]
              closed='right', dtype='interval[int64]')
```

Additionally, datetime-like input is also supported.

```
>>> pd.interval_range(start=pd.Timestamp('2017-01-01'),
                      end=pd.Timestamp('2017-01-04'))
IntervalIndex([(2017-01-01, 2017-01-02], (2017-01-02, 2017-01-03],
               (2017-01-03, 2017-01-04]]
              closed='right', dtype='interval[datetime64[ns]]')
```

The `freq` parameter specifies the frequency between the left and right. endpoints of the individual intervals within the `IntervalIndex`. For numeric `start` and `end`, the frequency must also be numeric.

```
>>> pd.interval_range(start=0, periods=4, freq=1.5)
IntervalIndex([(0.0, 1.5], (1.5, 3.0], (3.0, 4.5], (4.5, 6.0]]
              closed='right', dtype='interval[float64]')
```

Similarly, for datetime-like `start` and `end`, the frequency must be convertible to a DateOffset.

```
>>> pd.interval_range(start=pd.Timestamp('2017-01-01'),
                      periods=3, freq='MS')
IntervalIndex([(2017-01-01, 2017-02-01], (2017-02-01, 2017-03-01],
               (2017-03-01, 2017-04-01]]
              closed='right', dtype='interval[datetime64[ns]]')
```

The `closed` parameter specifies which endpoints of the individual intervals within the `IntervalIndex` are closed.

```
>>> pd.interval_range(end=5, periods=4, closed='both')
IntervalIndex([[1, 2], [2, 3], [3, 4], [4, 5]]
              closed='both', dtype='interval[int64]')
```

34.2.6 Top-level evaluation

eval(expr[, parser, engine, truediv, ...])	Evaluate a Python expression as a string using various backends.

34.2.6.1 pandas.eval

pandas.**eval**(*expr*, *parser='pandas'*, *engine=None*, *truediv=True*, *local_dict=None*, *global_dict=None*, *resolvers=()*, *level=0*, *target=None*, *inplace=False*)

Evaluate a Python expression as a string using various backends.

The following arithmetic operations are supported: `+`, `-`, `*`, `/`, `**`, `%`, `//` (python engine only) along with the following boolean operations: `|` (or), `&` (and), and `~` (not). Additionally, the `'pandas'` parser allows the use of `and`, `or`, and `not` with the same semantics as the corresponding bitwise operators. *`Series`* and *`DataFrame`* objects are supported and behave as they would with plain ol' Python evaluation.

Parameters **expr** : str or unicode

The expression to evaluate. This string cannot contain any Python statements, only Python expressions.

parser : string, default 'pandas', {'pandas', 'python'}

The parser to use to construct the syntax tree from the expression. The default of `'pandas'` parses code slightly different than standard Python. Alternatively, you can parse an expression using the `'python'` parser to retain strict Python semantics. See the *enhancing performance* documentation for more details.

engine : string or None, default 'numexpr', {'python', 'numexpr'}

The engine used to evaluate the expression. Supported engines are

- None : tries to use `numexpr`, falls back to `python`
- **`'numexpr'`: This default engine evaluates pandas objects using** numexpr for large speed ups in complex expressions with large frames.
- **`'python'`: Performs operations as if you had `eval`'d in top** level python. This engine is generally not that useful.

More backends may be available in the future.

truediv : bool, optional

Whether to use true division, like in Python >= 3

local_dict : dict or None, optional

A dictionary of local variables, taken from locals() by default.

global_dict : dict or None, optional

A dictionary of global variables, taken from globals() by default.

resolvers : list of dict-like or None, optional

A list of objects implementing the `__getitem__` special method that you can use to inject an additional collection of namespaces to use for variable lookup. For example, this is used in the *`query()`* method to inject the `index` and `columns` variables that refer to their respective *`DataFrame`* instance attributes.

level : int, optional

The number of prior stack frames to traverse and add to the current scope. Most users will **not** need to change this parameter.

target : object, optional, default None

This is the target object for assignment. It is used when there is variable assignment in the expression. If so, then *target* must support item assignment with string keys, and if a copy is being returned, it must also support *.copy()*.

inplace : bool, default False

If *target* is provided, and the expression mutates *target*, whether to modify *target* in-place. Otherwise, return a copy of *target* with the mutation.

Returns ndarray, numeric scalar, DataFrame, Series

Raises **ValueError**

There are many instances where such an error can be raised:

- *target=None*, but the expression is multiline.
- The expression is multiline, but not all them have item assignment. An example of such an arrangement is this:

  a = b + 1 a + 2

  Here, there are expressions on different lines, making it multiline, but the last line has no variable assigned to the output of *a + 2*.
- *inplace=True*, but the expression is missing item assignment.
- Item assignment is provided, but the *target* does not support string item assignment.
- Item assignment is provided and *inplace=False*, but the *target* does not support the *.copy()* method

See also:

`pandas.DataFrame.query`, `pandas.DataFrame.eval`

Notes

The `dtype` of any objects involved in an arithmetic `%` operation are recursively cast to `float64`.

See the *enhancing performance* documentation for more details.

34.2.7 Testing

`test`([extra_args])	

34.2.7.1 pandas.test

`pandas.`**`test`**(*extra_args=None*)

34.3 Series

34.3.1 Constructor

`Series`([data, index, dtype, name, copy, ...])	One-dimensional ndarray with axis labels (including time series).

34.3.1.1 pandas.Series

class `pandas.`**`Series`**(*data=None*, *index=None*, *dtype=None*, *name=None*, *copy=False*, *fastpath=False*)

One-dimensional ndarray with axis labels (including time series).

Labels need not be unique but must be a hashable type. The object supports both integer- and label-based

indexing and provides a host of methods for performing operations involving the index. Statistical methods from ndarray have been overridden to automatically exclude missing data (currently represented as NaN).

Operations between Series (+, -, /, , *) align values based on their associated index values– they need not be the same length. The result index will be the sorted union of the two indexes.

Parameters **data** : array-like, dict, or scalar value

Contains data stored in Series

index : array-like or Index (1d)

Values must be hashable and have the same length as *data*. Non-unique index values are allowed. Will default to RangeIndex(len(data)) if not provided. If both a dict and index sequence are used, the index will override the keys found in the dict.

dtype : numpy.dtype or None

If None, dtype will be inferred

copy : boolean, default False

Copy input data

Attributes

`T`	return the transpose, which is by definition self
`asobject`	return object Series which contains boxed values
`at`	Fast label-based scalar accessor
`axes`	Return a list of the row axis labels
`base`	return the base object if the memory of the underlying data is
`blocks`	Internal property, property synonym for as_blocks()
`data`	return the data pointer of the underlying data
`dtype`	return the dtype object of the underlying data
`dtypes`	return the dtype object of the underlying data
`empty`	
`flags`	
`ftype`	return if the data is sparse|dense
`ftypes`	return if the data is sparse|dense
`hasnans`	
`iat`	Fast integer location scalar accessor.
`iloc`	Purely integer-location based indexing for selection by position.
`imag`	
`is_copy`	
`is_monotonic`	Return boolean if values in the object are
`is_monotonic_decreasing`	Return boolean if values in the object are
`is_monotonic_increasing`	Return boolean if values in the object are
`is_unique`	Return boolean if values in the object are unique
`itemsize`	return the size of the dtype of the item of the underlying data
`ix`	A primarily label-location based indexer, with integer position fallback.

Continued on next page

Table 34.24 – continued from previous page

loc	Purely label-location based indexer for selection by label.
name	
nbytes	return the number of bytes in the underlying data
ndim	return the number of dimensions of the underlying data,
real	
shape	return a tuple of the shape of the underlying data
size	return the number of elements in the underlying data
strides	return the strides of the underlying data
values	Return Series as ndarray or ndarray-like

pandas.Series.T

`Series.T`

return the transpose, which is by definition self

pandas.Series.asobject

`Series.asobject`

return object Series which contains boxed values

this is an internal non-public method

pandas.Series.at

`Series.at`

Fast label-based scalar accessor

Similarly to `loc`, `at` provides **label** based scalar lookups. You can also set using these indexers.

pandas.Series.axes

`Series.axes`

Return a list of the row axis labels

pandas.Series.base

`Series.base`

return the base object if the memory of the underlying data is shared

pandas.Series.blocks

`Series.blocks`

Internal property, property synonym for as_blocks()

Deprecated since version 0.21.0.

pandas.Series.data

`Series.data`
return the data pointer of the underlying data

pandas.Series.dtype

`Series.dtype`
return the dtype object of the underlying data

pandas.Series.dtypes

`Series.dtypes`
return the dtype object of the underlying data

pandas.Series.empty

`Series.empty`

pandas.Series.flags

`Series.flags`

pandas.Series.ftype

`Series.ftype`
return if the data is sparse|dense

pandas.Series.ftypes

`Series.ftypes`
return if the data is sparse|dense

pandas.Series.hasnans

`Series.hasnans` = None

pandas.Series.iat

`Series.iat`
Fast integer location scalar accessor.

Similarly to `iloc`, `iat` provides **integer** based lookups. You can also set using these indexers.

pandas.Series.iloc

`Series.iloc`

Purely integer-location based indexing for selection by position.

`.iloc[]` is primarily integer position based (from `0` to `length-1` of the axis), but may also be used with a boolean array.

Allowed inputs are:

- An integer, e.g. `5`.
- A list or array of integers, e.g. `[4, 3, 0]`.
- A slice object with ints, e.g. `1:7`.
- A boolean array.
- A `callable` function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

`.iloc` will raise `IndexError` if a requested indexer is out-of-bounds, except *slice* indexers which allow out-of-bounds indexing (this conforms with python/numpy *slice* semantics).

See more at *Selection by Position*

pandas.Series.imag

`Series.imag`

pandas.Series.is_copy

`Series.is_copy` = **None**

pandas.Series.is_monotonic

`Series.is_monotonic`

Return boolean if values in the object are monotonic_increasing

New in version 0.19.0.

Returns **is_monotonic** : boolean

pandas.Series.is_monotonic_decreasing

`Series.is_monotonic_decreasing`

Return boolean if values in the object are monotonic_decreasing

New in version 0.19.0.

Returns **is_monotonic_decreasing** : boolean

pandas.Series.is_monotonic_increasing

`Series.is_monotonic_increasing`

Return boolean if values in the object are monotonic_increasing

New in version 0.19.0.

Returns **is_monotonic** : boolean

pandas.Series.is_unique

`Series.is_unique`

Return boolean if values in the object are unique

Returns **is_unique** : boolean

pandas.Series.itemsize

`Series.itemsize`

return the size of the dtype of the item of the underlying data

pandas.Series.ix

`Series.ix`

A primarily label-location based indexer, with integer position fallback.

`.ix[]` supports mixed integer and label based access. It is primarily label based, but will fall back to integer positional access unless the corresponding axis is of integer type.

`.ix` is the most general indexer and will support any of the inputs in `.loc` and `.iloc`. `.ix` also supports floating point label schemes. `.ix` is exceptionally useful when dealing with mixed positional and label based hierachical indexes.

However, when an axis is integer based, ONLY label based access and not positional access is supported. Thus, in such cases, it's usually better to be explicit and use `.iloc` or `.loc`.

See more at *Advanced Indexing*.

pandas.Series.loc

`Series.loc`

Purely label-location based indexer for selection by label.

`.loc[]` is primarily label based, but may also be used with a boolean array.

Allowed inputs are:

- A single label, e.g. `5` or `'a'`, (note that `5` is interpreted as a *label* of the index, and **never** as an integer position along the index).
- A list or array of labels, e.g. `['a', 'b', 'c']`.
- A slice object with labels, e.g. `'a':'f'` (note that contrary to usual python slices, **both** the start and the stop are included!).
- A boolean array.

- A `callable` function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

`.loc` will raise a `KeyError` when the items are not found.

See more at *Selection by Label*

pandas.Series.name

`Series.name`

pandas.Series.nbytes

`Series.nbytes`

return the number of bytes in the underlying data

pandas.Series.ndim

`Series.ndim`

return the number of dimensions of the underlying data, by definition 1

pandas.Series.real

`Series.real`

pandas.Series.shape

`Series.shape`

return a tuple of the shape of the underlying data

pandas.Series.size

`Series.size`

return the number of elements in the underlying data

pandas.Series.strides

`Series.strides`

return the strides of the underlying data

pandas.Series.values

`Series.values`

Return Series as ndarray or ndarray-like depending on the dtype

Returns **arr** : numpy.ndarray or ndarray-like

Examples

```
>>> pd.Series([1, 2, 3]).values
array([1, 2, 3])
```

```
>>> pd.Series(list('aabc')).values
array(['a', 'a', 'b', 'c'], dtype=object)
```

```
>>> pd.Series(list('aabc')).astype('category').values
[a, a, b, c]
Categories (3, object): [a, b, c]
```

Timezone aware datetime data is converted to UTC:

```
>>> pd.Series(pd.date_range('20130101', periods=3,
...                         tz='US/Eastern')).values
array(['2013-01-01T05:00:00.000000000',
       '2013-01-02T05:00:00.000000000',
       '2013-01-03T05:00:00.000000000'], dtype='datetime64[ns]')
```

Methods

abs()	Return an object with absolute value taken–only applicable to objects that are all numeric.
add(other[, level, fill_value, axis])	Addition of series and other, element-wise (binary operator *add*).
add_prefix(prefix)	Concatenate prefix string with panel items names.
add_suffix(suffix)	Concatenate suffix string with panel items names.
agg(func[, axis])	Aggregate using callable, string, dict, or list of string/callables
aggregate(func[, axis])	Aggregate using callable, string, dict, or list of string/callables
align(other[, join, axis, level, copy, ...])	Align two objects on their axes with the
all([axis, bool_only, skipna, level])	Return whether all elements are True over requested axis
any([axis, bool_only, skipna, level])	Return whether any element is True over requested axis
append(to_append[, ignore_index, ...])	Concatenate two or more Series.
apply(func[, convert_dtype, args])	Invoke function on values of Series.
argmax(*args, **kwargs)	
argmin(*args, **kwargs)	
argsort([axis, kind, order])	Overrides ndarray.argsort.
as_blocks([copy])	Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.
as_matrix([columns])	Convert the frame to its Numpy-array representation.
asfreq(freq[, method, how, normalize, ...])	Convert TimeSeries to specified frequency.
asof(where[, subset])	The last row without any NaN is taken (or the last row without
astype(dtype[, copy, errors])	Cast a pandas object to a specified dtype `dtype`.
at_time(time[, asof])	Select values at particular time of day (e.g.
autocorr([lag])	Lag-N autocorrelation

Continued on next page

Table 34.25 – continued from previous page

`between`(left, right[, inclusive])	Return boolean Series equivalent to left <= series <= right.
`between_time`(start_time, end_time[, ...])	Select values between particular times of the day (e.g., 9:00-9:30 AM).
`bfill`([axis, inplace, limit, downcast])	Synonym for `DataFrame.fillna(method='bfill')`
`bool`()	Return the bool of a single element PandasObject.
`cat`	alias of `CategoricalAccessor`
`clip`([lower, upper, axis, inplace])	Trim values at input threshold(s).
`clip_lower`(threshold[, axis, inplace])	Return copy of the input with values below given value(s) truncated.
`clip_upper`(threshold[, axis, inplace])	Return copy of input with values above given value(s) truncated.
`combine`(other, func[, fill_value])	Perform elementwise binary operation on two Series using given function
`combine_first`(other)	Combine Series values, choosing the calling Series's values first.
`compound`([axis, skipna, level])	Return the compound percentage of the values for the requested axis
`compress`(condition, *args, **kwargs)	Return selected slices of an array along given axis as a Series
`consolidate`([inplace])	DEPRECATED: consolidate will be an internal implementation only.
`convert_objects`([convert_dates, ...])	Deprecated.
`copy`([deep])	Make a copy of this objects data.
`corr`(other[, method, min_periods])	Compute correlation with *other* Series, excluding missing values
`count`([level])	Return number of non-NA/null observations in the Series
`cov`(other[, min_periods])	Compute covariance with Series, excluding missing values
`cummax`([axis, skipna])	Return cumulative max over requested axis.
`cummin`([axis, skipna])	Return cumulative minimum over requested axis.
`cumprod`([axis, skipna])	Return cumulative product over requested axis.
`cumsum`([axis, skipna])	Return cumulative sum over requested axis.
`describe`([percentiles, include, exclude])	Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding `NaN` values.
`diff`([periods])	1st discrete difference of object
`div`(other[, level, fill_value, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
`divide`(other[, level, fill_value, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
`dot`(other)	Matrix multiplication with DataFrame or inner-product with Series
`drop`([labels, axis, index, columns, level, ...])	Return new object with labels in requested axis removed.
`drop_duplicates`([keep, inplace])	Return Series with duplicate values removed
`dropna`([axis, inplace])	Return Series without null values
`dt`	alias of `CombinedDatetimelikeProperties`
`duplicated`([keep])	Return boolean Series denoting duplicate values

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Table 34.25 – continued from previous page

eq(other[, level, fill_value, axis])	Equal to of series and other, element-wise (binary operator *eq*).
equals(other)	Determines if two NDFrame objects contain the same elements.
ewm([com, span, halflife, alpha, ...])	Provides exponential weighted functions
expanding([min_periods, freq, center, axis])	Provides expanding transformations.
factorize([sort, na_sentinel])	Encode the object as an enumerated type or categorical variable
ffill([axis, inplace, limit, downcast])	Synonym for DataFrame.fillna(method='ffill')
fillna([value, method, axis, inplace, ...])	Fill NA/NaN values using the specified method
filter([items, like, regex, axis])	Subset rows or columns of dataframe according to labels in the specified index.
first(offset)	Convenience method for subsetting initial periods of time series data based on a date offset.
first_valid_index()	Return index for first non-NA/null value.
floordiv(other[, level, fill_value, axis])	Integer division of series and other, element-wise (binary operator *floordiv*).
from_array(arr[, index, name, dtype, copy, ...])	
from_csv(path[, sep, parse_dates, header, ...])	Read CSV file (DEPRECATED, please use pandas.read_csv() instead).
ge(other[, level, fill_value, axis])	Greater than or equal to of series and other, element-wise (binary operator *ge*).
get(key[, default])	Get item from object for given key (DataFrame column, Panel slice, etc.).
get_dtype_counts()	Return the counts of dtypes in this object.
get_ftype_counts()	Return the counts of ftypes in this object.
get_value(label[, takeable])	Quickly retrieve single value at passed index label
get_values()	same as values (but handles sparseness conversions); is a view
groupby([by, axis, level, as_index, sort, ...])	Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.
gt(other[, level, fill_value, axis])	Greater than of series and other, element-wise (binary operator *gt*).
head([n])	Return the first n rows.
hist([by, ax, grid, xlabelsize, xrot, ...])	Draw histogram of the input series using matplotlib
idxmax([axis, skipna])	Index *label* of the first occurrence of maximum of values.
idxmin([axis, skipna])	Index *label* of the first occurrence of minimum of values.
infer_objects()	Attempt to infer better dtypes for object columns.
interpolate([method, axis, limit, inplace, ...])	Interpolate values according to different methods.
isin(values)	Return a boolean Series showing whether each element in the Series is exactly contained in the passed sequence of values.
isna()	Return a boolean same-sized object indicating if the values are NA.
isnull()	Return a boolean same-sized object indicating if the values are NA.

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Table 34.25 – continued from previous page

item()	return the first element of the underlying data as a python
items()	Lazily iterate over (index, value) tuples
iteritems()	Lazily iterate over (index, value) tuples
keys()	Alias for index
kurt([axis, skipna, level, numeric_only])	Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0).
kurtosis([axis, skipna, level, numeric_only])	Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0).
last(offset)	Convenience method for subsetting final periods of time series data based on a date offset.
last_valid_index()	Return index for last non-NA/null value.
le(other[, level, fill_value, axis])	Less than or equal to of series and other, element-wise (binary operator *le*).
lt(other[, level, fill_value, axis])	Less than of series and other, element-wise (binary operator *lt*).
mad([axis, skipna, level])	Return the mean absolute deviation of the values for the requested axis
map(arg[, na_action])	Map values of Series using input correspondence (which can be
mask(cond[, other, inplace, axis, level, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.
max([axis, skipna, level, numeric_only])	This method returns the maximum of the values in the object.
mean([axis, skipna, level, numeric_only])	Return the mean of the values for the requested axis
median([axis, skipna, level, numeric_only])	Return the median of the values for the requested axis
memory_usage([index, deep])	Memory usage of the Series
min([axis, skipna, level, numeric_only])	This method returns the minimum of the values in the object.
mod(other[, level, fill_value, axis])	Modulo of series and other, element-wise (binary operator *mod*).
mode()	Return the mode(s) of the dataset.
mul(other[, level, fill_value, axis])	Multiplication of series and other, element-wise (binary operator *mul*).
multiply(other[, level, fill_value, axis])	Multiplication of series and other, element-wise (binary operator *mul*).
ne(other[, level, fill_value, axis])	Not equal to of series and other, element-wise (binary operator *ne*).
nlargest([n, keep])	Return the largest *n* elements.
nonzero()	Return the indices of the elements that are non-zero
notna()	Return a boolean same-sized object indicating if the values are not NA.
notnull()	Return a boolean same-sized object indicating if the values are not NA.
nsmallest([n, keep])	Return the smallest *n* elements.
nunique([dropna])	Return number of unique elements in the object.
pct_change([periods, fill_method, limit, freq])	Percent change over given number of periods.
pipe(func, *args, **kwargs)	Apply func(self, *args, **kwargs)

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Table 34.25 – continued from previous page

plot	alias of SeriesPlotMethods
pop(item)	Return item and drop from frame.
pow(other[, level, fill_value, axis])	Exponential power of series and other, element-wise (binary operator *pow*).
prod([axis, skipna, level, numeric_only])	Return the product of the values for the requested axis
product([axis, skipna, level, numeric_only])	Return the product of the values for the requested axis
ptp([axis, skipna, level, numeric_only])	Returns the difference between the maximum value and the minimum value in the object.
put(*args, **kwargs)	Applies the *put* method to its *values* attribute if it has one.
quantile([q, interpolation])	Return value at the given quantile, a la numpy.percentile.
radd(other[, level, fill_value, axis])	Addition of series and other, element-wise (binary operator *radd*).
rank([axis, method, numeric_only, ...])	Compute numerical data ranks (1 through n) along axis.
ravel([order])	Return the flattened underlying data as an ndarray
rdiv(other[, level, fill_value, axis])	Floating division of series and other, element-wise (binary operator *rtruediv*).
reindex([index])	Conform Series to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
reindex_axis(labels[, axis])	for compatibility with higher dims
reindex_like(other[, method, copy, limit, ...])	Return an object with matching indices to myself.
rename([index])	Alter Series index labels or name
rename_axis(mapper[, axis, copy, inplace])	Alter the name of the index or columns.
reorder_levels(order)	Rearrange index levels using input order.
repeat(repeats, *args, **kwargs)	Repeat elements of an Series.
replace([to_replace, value, inplace, limit, ...])	Replace values given in 'to_replace' with 'value'.
resample(rule[, how, axis, fill_method, ...])	Convenience method for frequency conversion and resampling of time series.
reset_index([level, drop, name, inplace])	Analogous to the pandas.DataFrame.reset_index() function, see docstring there.
reshape(*args, **kwargs)	Deprecated since version 0.19.0.
rfloordiv(other[, level, fill_value, axis])	Integer division of series and other, element-wise (binary operator *rfloordiv*).
rmod(other[, level, fill_value, axis])	Modulo of series and other, element-wise (binary operator *rmod*).
rmul(other[, level, fill_value, axis])	Multiplication of series and other, element-wise (binary operator *rmul*).
rolling(window[, min_periods, freq, center, ...])	Provides rolling window calculations.
round([decimals])	Round each value in a Series to the given number of decimals.
rpow(other[, level, fill_value, axis])	Exponential power of series and other, element-wise (binary operator *rpow*).
rsub(other[, level, fill_value, axis])	Subtraction of series and other, element-wise (binary operator *rsub*).
rtruediv(other[, level, fill_value, axis])	Floating division of series and other, element-wise (binary operator *rtruediv*).
sample([n, frac, replace, weights, ...])	Returns a random sample of items from an axis of object.

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Table 34.25 – continued from previous page

searchsorted(value[, side, sorter])	Find indices where elements should be inserted to maintain order.
select(crit[, axis])	Return data corresponding to axis labels matching criteria
sem([axis, skipna, level, ddof, numeric_only])	Return unbiased standard error of the mean over requested axis.
set_axis(labels[, axis, inplace])	Assign desired index to given axis
set_value(label, value[, takeable])	Quickly set single value at passed label.
shift([periods, freq, axis])	Shift index by desired number of periods with an optional time freq
skew([axis, skipna, level, numeric_only])	Return unbiased skew over requested axis
slice_shift([periods, axis])	Equivalent to *shift* without copying data.
sort_index([axis, level, ascending, ...])	Sort object by labels (along an axis)
sort_values([axis, ascending, inplace, ...])	Sort by the values along either axis
sortlevel([level, ascending, sort_remaining])	DEPRECATED: use `Series.sort_index()`
squeeze([axis])	Squeeze length 1 dimensions.
std([axis, skipna, level, ddof, numeric_only])	Return sample standard deviation over requested axis.
str	alias of `StringMethods`
sub(other[, level, fill_value, axis])	Subtraction of series and other, element-wise (binary operator *sub*).
subtract(other[, level, fill_value, axis])	Subtraction of series and other, element-wise (binary operator *sub*).
sum([axis, skipna, level, numeric_only])	Return the sum of the values for the requested axis
swapaxes(axis1, axis2[, copy])	Interchange axes and swap values axes appropriately
swaplevel([i, j, copy])	Swap levels i and j in a MultiIndex
tail([n])	Return the last n rows.
take(indices[, axis, convert, is_copy])	Return the elements in the given *positional* indices along an axis.
to_clipboard([excel, sep])	Attempt to write text representation of object to the system clipboard This can be pasted into Excel, for example.
to_csv([path, index, sep, na_rep, ...])	Write Series to a comma-separated values (csv) file
to_dense()	Return dense representation of NDFrame (as opposed to sparse)
to_dict([into])	Convert Series to {label -> value} dict or dict-like object.
to_excel(excel_writer[, sheet_name, na_rep, ...])	Write Series to an excel sheet
to_frame([name])	Convert Series to DataFrame
to_hdf(path_or_buf, key, **kwargs)	Write the contained data to an HDF5 file using HDFStore.
to_json([path_or_buf, orient, date_format, ...])	Convert the object to a JSON string.
to_latex([buf, columns, col_space, header, ...])	Render an object to a tabular environment table.
to_msgpack([path_or_buf, encoding])	msgpack (serialize) object to input file path
to_period([freq, copy])	Convert Series from DatetimeIndex to PeriodIndex with desired
to_pickle(path[, compression, protocol])	Pickle (serialize) object to input file path.
to_sparse([kind, fill_value])	Convert Series to SparseSeries
to_sql(name, con[, flavor, schema, ...])	Write records stored in a DataFrame to a SQL database.
to_string([buf, na_rep, float_format, ...])	Render a string representation of the Series

Continued on next page

Table 34.25 – continued from previous page

`to_timestamp`([freq, how, copy])	Cast to datetimeindex of timestamps, at *beginning* of period
`to_xarray`()	Return an xarray object from the pandas object.
`tolist`()	Return a list of the values.
`transform`(func, *args, **kwargs)	Call function producing a like-indexed NDFrame
`transpose`(*args, **kwargs)	return the transpose, which is by definition self
`truediv`(other[, level, fill_value, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
`truncate`([before, after, axis, copy])	Truncates a sorted DataFrame/Series before and/or after some particular index value.
`tshift`([periods, freq, axis])	Shift the time index, using the index's frequency if available.
`tz_convert`(tz[, axis, level, copy])	Convert tz-aware axis to target time zone.
`tz_localize`(tz[, axis, level, copy, ambiguous])	Localize tz-naive TimeSeries to target time zone.
`unique`()	Return unique values in the object.
`unstack`([level, fill_value])	Unstack, a.k.a.
`update`(other)	Modify Series in place using non-NA values from passed Series.
`valid`([inplace])	
`value_counts`([normalize, sort, ascending, ...])	Returns object containing counts of unique values.
`var`([axis, skipna, level, ddof, numeric_only])	Return unbiased variance over requested axis.
`view`([dtype])	
`where`(cond[, other, inplace, axis, level, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.
`xs`(key[, axis, level, drop_level])	Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.

pandas.Series.abs

`Series.abs()`

Return an object with absolute value taken–only applicable to objects that are all numeric.

Returns abs: type of caller

pandas.Series.add

`Series.add(other, level=None, fill_value=None, axis=0)`

Addition of series and other, element-wise (binary operator *add*).

Equivalent to `series + other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.radd

pandas.Series.add_prefix

`Series.add_prefix(prefix)`

Concatenate prefix string with panel items names.

Parameters **prefix** : string

Returns **with_prefix** : type of caller

pandas.Series.add_suffix

`Series.add_suffix(suffix)`

Concatenate suffix string with panel items names.

Parameters **suffix** : string

Returns **with_suffix** : type of caller

pandas.Series.agg

`Series.agg(func, axis=0, *args, **kwargs)`

Aggregate using callable, string, dict, or list of string/callables

New in version 0.20.0.

Parameters **func** : callable, string, dictionary, or list of string/callables

Function to use for aggregating the data. If a function, must either work when passed a Series or when passed to Series.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted Combinations are:

- string function name
- function
- list of functions
- dict of column names -> functions (or list of functions)

Returns **aggregated** : Series

See also:

pandas.Series.apply, *pandas.Series.transform*

Notes

Numpy functions mean/median/prod/sum/std/var are special cased so the default behavior is applying the function along axis=0 (e.g., np.mean(arr_2d, axis=0)) as opposed to mimicking the default Numpy behavior (e.g., np.mean(arr_2d)).

agg is an alias for *aggregate*. Use the alias.

Examples

```
>>> s = Series(np.random.randn(10))
```

```
>>> s.agg('min')
-1.3018049988556679
```

```
>>> s.agg(['min', 'max'])
min   -1.301805
max    1.127688
dtype: float64
```

pandas.Series.aggregate

`Series.aggregate`(*func*, *axis=0*, **args*, ***kwargs*)

Aggregate using callable, string, dict, or list of string/callables

New in version 0.20.0.

Parameters **func** : callable, string, dictionary, or list of string/callables

Function to use for aggregating the data. If a function, must either work when passed a Series or when passed to Series.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted Combinations are:

- string function name
- function
- list of functions
- dict of column names -> functions (or list of functions)

Returns **aggregated** : Series

See also:

pandas.Series.apply, *pandas.Series.transform*

Notes

Numpy functions mean/median/prod/sum/std/var are special cased so the default behavior is applying the function along axis=0 (e.g., np.mean(arr_2d, axis=0)) as opposed to mimicking the default Numpy behavior (e.g., np.mean(arr_2d)).

agg is an alias for *aggregate*. Use the alias.

Examples

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>>> s = Series(np.random.randn(10))
```

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-1.3018049988556679
```

```
>>> s.agg(['min', 'max'])
min   -1.301805
max    1.127688
dtype: float64
```

pandas.Series.align

`Series.align`(*other*, *join='outer'*, *axis=None*, *level=None*, *copy=True*, *fill_value=None*, *method=None*, *limit=None*, *fill_axis=0*, *broadcast_axis=None*)

Align two objects on their axes with the specified join method for each axis Index

Parameters **other** : DataFrame or Series

join : {'outer', 'inner', 'left', 'right'}, default 'outer'

axis : allowed axis of the other object, default None

Align on index (0), columns (1), or both (None)

level : int or level name, default None

Broadcast across a level, matching Index values on the passed MultiIndex level

copy : boolean, default True

Always returns new objects. If copy=False and no reindexing is required then original objects are returned.

fill_value : scalar, default np.NaN

Value to use for missing values. Defaults to NaN, but can be any "compatible" value

method : str, default None

limit : int, default None

fill_axis : {0, 'index'}, default 0

Filling axis, method and limit

broadcast_axis : {0, 'index'}, default None

Broadcast values along this axis, if aligning two objects of different dimensions

New in version 0.17.0.

Returns **(left, right)** : (Series, type of other)

Aligned objects

pandas.Series.all

`Series.all`(*axis=None*, *bool_only=None*, *skipna=None*, *level=None*, ***kwargs*)

Return whether all elements are True over requested axis

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

bool_only : boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

Returns **all** : scalar or Series (if level specified)

pandas.Series.any

`Series.`**`any`**(*axis=None*, *bool_only=None*, *skipna=None*, *level=None*, ***kwargs*)

Return whether any element is True over requested axis

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

bool_only : boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

Returns **any** : scalar or Series (if level specified)

pandas.Series.append

`Series.`**`append`**(*to_append*, *ignore_index=False*, *verify_integrity=False*)

Concatenate two or more Series.

Parameters **to_append** : Series or list/tuple of Series

ignore_index : boolean, default False

If True, do not use the index labels.

verify_integrity : boolean, default False

If True, raise Exception on creating index with duplicates

Returns **appended** : Series

See also:

`pandas.concat` General function to concatenate DataFrame, Series or Panel objects

Notes

Iteratively appending to a Series can be more computationally intensive than a single concatenate. A better solution is to append values to a list and then concatenate the list with the original Series all at once.

Examples

```
>>> s1 = pd.Series([1, 2, 3])
>>> s2 = pd.Series([4, 5, 6])
>>> s3 = pd.Series([4, 5, 6], index=[3,4,5])
>>> s1.append(s2)
0    1
1    2
2    3
0    4
1    5
2    6
dtype: int64
```

```
>>> s1.append(s3)
0    1
1    2
2    3
3    4
4    5
5    6
dtype: int64
```

With *ignore_index* set to True:

```
>>> s1.append(s2, ignore_index=True)
0    1
1    2
2    3
3    4
4    5
5    6
dtype: int64
```

With *verify_integrity* set to True:

```
>>> s1.append(s2, verify_integrity=True)
Traceback (most recent call last):
...
ValueError: Indexes have overlapping values: [0, 1, 2]
```

pandas.Series.apply

`Series.apply`(*func*, *convert_dtype=True*, *args=()*, ***kwds*)

Invoke function on values of Series. Can be ufunc (a NumPy function that applies to the entire Series) or a Python function that only works on single values

Parameters **func** : function

convert_dtype : boolean, default True

Try to find better dtype for elementwise function results. If False, leave as dtype=object

args : tuple

Positional arguments to pass to function in addition to the value

Additional keyword arguments will be passed as keywords to the function

Returns **y** : Series or DataFrame if func returns a Series

See also:

Series.map For element-wise operations

Series.agg only perform aggregating type operations

Series.transform only perform transformating type operations

Examples

Create a series with typical summer temperatures for each city.

```
>>> import pandas as pd
>>> import numpy as np
>>> series = pd.Series([20, 21, 12], index=['London',
... 'New York','Helsinki'])
>>> series
London      20
New York    21
Helsinki    12
dtype: int64
```

Square the values by defining a function and passing it as an argument to `apply()`.

```
>>> def square(x):
...     return x**2
>>> series.apply(square)
London      400
New York    441
Helsinki    144
dtype: int64
```

Square the values by passing an anonymous function as an argument to `apply()`.

```
>>> series.apply(lambda x: x**2)
London      400
New York    441
Helsinki    144
dtype: int64
```

Define a custom function that needs additional positional arguments and pass these additional arguments using the `args` keyword.

```
>>> def subtract_custom_value(x, custom_value):
...     return x-custom_value
```

```
>>> series.apply(subtract_custom_value, args=(5,))
London      15
New York    16
```

```
Helsinki     7
dtype: int64
```

Define a custom function that takes keyword arguments and pass these arguments to `apply`.

```
>>> def add_custom_values(x, **kwargs):
...     for month in kwargs:
...         x+=kwargs[month]
...         return x
```

```
>>> series.apply(add_custom_values, june=30, july=20, august=25)
London      95
New York    96
Helsinki    87
dtype: int64
```

Use a function from the Numpy library.

```
>>> series.apply(np.log)
London      2.995732
New York    3.044522
Helsinki    2.484907
dtype: float64
```

pandas.Series.argmax

`Series.argmax`(**args*, ***kwargs*)

pandas.Series.argmin

`Series.argmin`(**args*, ***kwargs*)

pandas.Series.argsort

`Series.argsort`(*axis=0*, *kind='quicksort'*, *order=None*)

Overrides ndarray.argsort. Argsorts the value, omitting NA/null values, and places the result in the same locations as the non-NA values

Parameters **axis** : int (can only be zero)

kind : {'mergesort', 'quicksort', 'heapsort'}, default 'quicksort'

Choice of sorting algorithm. See np.sort for more information. 'mergesort' is the only stable algorithm

order : ignored

Returns **argsorted** : Series, with -1 indicated where nan values are present

See also:

`numpy.ndarray.argsort`

pandas.Series.as_blocks

`Series.as_blocks(copy=True)`

Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.

Deprecated since version 0.21.0.

NOTE: the dtypes of the blocks WILL BE PRESERVED HERE (unlike in as_matrix)

Parameters **copy** : boolean, default True

Returns **values** : a dict of dtype -> Constructor Types

pandas.Series.as_matrix

`Series.as_matrix(columns=None)`

Convert the frame to its Numpy-array representation.

Parameters **columns: list, optional, default:None**

If None, return all columns, otherwise, returns specified columns.

Returns **values** : ndarray

If the caller is heterogeneous and contains booleans or objects, the result will be of dtype=object. See Notes.

See also:

pandas.DataFrame.values

Notes

Return is NOT a Numpy-matrix, rather, a Numpy-array.

The dtype will be a lower-common-denominator dtype (implicit upcasting); that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen. Use this with care if you are not dealing with the blocks.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. If dtypes are int32 and uint8, dtype will be upcase to int32. By numpy.find_common_type convention, mixing int64 and uint64 will result in a flot64 dtype.

This method is provided for backwards compatibility. Generally, it is recommended to use '.values'.

pandas.Series.asfreq

`Series.asfreq(freq, method=None, how=None, normalize=False, fill_value=None)`

Convert TimeSeries to specified frequency.

Optionally provide filling method to pad/backfill missing values.

Returns the original data conformed to a new index with the specified frequency. `resample` is more appropriate if an operation, such as summarization, is necessary to represent the data at the new frequency.

Parameters **freq** : DateOffset object, or string

method : {'backfill'/'bfill', 'pad'/'ffill'}, default None

Method to use for filling holes in reindexed Series (note this does not fill NaNs that already were present):

- 'pad' / 'ffill': propagate last valid observation forward to next valid
- 'backfill' / 'bfill': use NEXT valid observation to fill

how : {'start', 'end'}, default end

For PeriodIndex only, see PeriodIndex.asfreq

normalize : bool, default False

Whether to reset output index to midnight

fill_value: scalar, optional

Value to use for missing values, applied during upsampling (note this does not fill NaNs that already were present).

New in version 0.20.0.

Returns converted : type of caller

See also:

reindex

Notes

To learn more about the frequency strings, please see this link.

Examples

Start by creating a series with 4 one minute timestamps.

```
>>> index = pd.date_range('1/1/2000', periods=4, freq='T')
>>> series = pd.Series([0.0, None, 2.0, 3.0], index=index)
>>> df = pd.DataFrame({'s':series})
>>> df
                      s
2000-01-01 00:00:00    0.0
2000-01-01 00:01:00    NaN
2000-01-01 00:02:00    2.0
2000-01-01 00:03:00    3.0
```

Upsample the series into 30 second bins.

```
>>> df.asfreq(freq='30S')
                      s
2000-01-01 00:00:00    0.0
2000-01-01 00:00:30    NaN
2000-01-01 00:01:00    NaN
2000-01-01 00:01:30    NaN
2000-01-01 00:02:00    2.0
2000-01-01 00:02:30    NaN
2000-01-01 00:03:00    3.0
```

Upsample again, providing a `fill value`.

```
>>> df.asfreq(freq='30S', fill_value=9.0)
                     s
2000-01-01 00:00:00    0.0
2000-01-01 00:00:30    9.0
2000-01-01 00:01:00    NaN
2000-01-01 00:01:30    9.0
2000-01-01 00:02:00    2.0
2000-01-01 00:02:30    9.0
2000-01-01 00:03:00    3.0
```

Upsample again, providing a `method`.

```
>>> df.asfreq(freq='30S', method='bfill')
                     s
2000-01-01 00:00:00    0.0
2000-01-01 00:00:30    NaN
2000-01-01 00:01:00    NaN
2000-01-01 00:01:30    2.0
2000-01-01 00:02:00    2.0
2000-01-01 00:02:30    3.0
2000-01-01 00:03:00    3.0
```

pandas.Series.asof

`Series.asof(where, subset=None)`

The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)

New in version 0.19.0: For DataFrame

If there is no good value, NaN is returned for a Series a Series of NaN values for a DataFrame

Parameters **where** : date or array of dates

subset : string or list of strings, default None

if not None use these columns for NaN propagation

Returns where is scalar

- value or NaN if input is Series
- Series if input is DataFrame

where is Index: same shape object as input

See also:

merge_asof

Notes

Dates are assumed to be sorted Raises if this is not the case

pandas.Series.astype

`Series.astype`(*dtype*, *copy=True*, *errors='raise'*, ***kwargs*)

Cast a pandas object to a specified dtype `dtype`.

Parameters **dtype** : data type, or dict of column name -> data type

Use a numpy.dtype or Python type to cast entire pandas object to the same type. Alternatively, use {col: dtype, ...}, where col is a column label and dtype is a numpy.dtype or Python type to cast one or more of the DataFrame's columns to column-specific types.

copy : bool, default True.

Return a copy when `copy=True` (be very careful setting `copy=False` as changes to values then may propagate to other pandas objects).

errors : {'raise', 'ignore'}, default 'raise'.

Control raising of exceptions on invalid data for provided dtype.

- `raise` : allow exceptions to be raised
- `ignore` : suppress exceptions. On error return original object

New in version 0.20.0.

raise_on_error : raise on invalid input

Deprecated since version 0.20.0: Use `errors` instead

kwargs : keyword arguments to pass on to the constructor

Returns **casted** : type of caller

See also:

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

pandas.to_numeric Convert argument to a numeric type.

numpy.ndarray.astype Cast a numpy array to a specified type.

Examples

```
>>> ser = pd.Series([1, 2], dtype='int32')
>>> ser
0    1
1    2
dtype: int32
>>> ser.astype('int64')
0    1
1    2
dtype: int64
```

Convert to categorical type:

```
>>> ser.astype('category')
0    1
1    2
```

```
dtype: category
Categories (2, int64): [1, 2]
```

Convert to ordered categorical type with custom ordering:

```
>>> ser.astype('category', ordered=True, categories=[2, 1])
0    1
1    2
dtype: category
Categories (2, int64): [2 < 1]
```

Note that using `copy=False` and changing data on a new pandas object may propagate changes:

```
>>> s1 = pd.Series([1,2])
>>> s2 = s1.astype('int', copy=False)
>>> s2[0] = 10
>>> s1  # note that s1[0] has changed too
0    10
1     2
dtype: int64
```

pandas.Series.at_time

`Series.at_time`(*time*, *asof=False*)

Select values at particular time of day (e.g. 9:30AM).

Parameters **time** : datetime.time or string

Returns **values_at_time** : type of caller

pandas.Series.autocorr

`Series.autocorr`(*lag=1*)

Lag-N autocorrelation

Parameters **lag** : int, default 1

Number of lags to apply before performing autocorrelation.

Returns **autocorr** : float

pandas.Series.between

`Series.between`(*left*, *right*, *inclusive=True*)

Return boolean Series equivalent to left <= series <= right. NA values will be treated as False

Parameters **left** : scalar

Left boundary

right : scalar

Right boundary

Returns **is_between** : Series

pandas.Series.between_time

`Series.between_time(start_time, end_time, include_start=True, include_end=True)`

Select values between particular times of the day (e.g., 9:00-9:30 AM).

Parameters **start_time** : datetime.time or string

end_time : datetime.time or string

include_start : boolean, default True

include_end : boolean, default True

Returns **values_between_time** : type of caller

pandas.Series.bfill

`Series.bfill(axis=None, inplace=False, limit=None, downcast=None)`

Synonym for `DataFrame.fillna(method='bfill')`

pandas.Series.bool

`Series.bool()`

Return the bool of a single element PandasObject.

This must be a boolean scalar value, either True or False. Raise a ValueError if the PandasObject does not have exactly 1 element, or that element is not boolean

pandas.Series.cat

`Series.cat()`

Accessor object for categorical properties of the Series values.

Be aware that assigning to *categories* is a inplace operation, while all methods return new categorical data per default (but can be called with *inplace=True*).

Examples

```
>>> s.cat.categories
>>> s.cat.categories = list('abc')
>>> s.cat.rename_categories(list('cab'))
>>> s.cat.reorder_categories(list('cab'))
>>> s.cat.add_categories(['d','e'])
>>> s.cat.remove_categories(['d'])
>>> s.cat.remove_unused_categories()
>>> s.cat.set_categories(list('abcde'))
>>> s.cat.as_ordered()
>>> s.cat.as_unordered()
```

pandas.Series.clip

`Series.clip`(*lower=None*, *upper=None*, *axis=None*, *inplace=False*, **args*, ***kwargs*)

Trim values at input threshold(s).

Parameters **lower** : float or array_like, default None

upper : float or array_like, default None

axis : int or string axis name, optional

Align object with lower and upper along the given axis.

inplace : boolean, default False

Whether to perform the operation in place on the data New in version 0.21.0.

Returns **clipped** : Series

Examples

```
>>> df
          0         1
0  0.335232 -1.256177
1 -1.367855  0.746646
2  0.027753 -1.176076
3  0.230930 -0.679613
4  1.261967  0.570967
```

```
>>> df.clip(-1.0, 0.5)
          0         1
0  0.335232 -1.000000
1 -1.000000  0.500000
2  0.027753 -1.000000
3  0.230930 -0.679613
4  0.500000  0.500000
```

```
>>> t
0   -0.3
1   -0.2
2   -0.1
3    0.0
4    0.1
dtype: float64
```

```
>>> df.clip(t, t + 1, axis=0)
          0         1
0  0.335232 -0.300000
1 -0.200000  0.746646
2  0.027753 -0.100000
3  0.230930  0.000000
4  1.100000  0.570967
```

pandas.Series.clip_lower

`Series.clip_lower(threshold, axis=None, inplace=False)`

Return copy of the input with values below given value(s) truncated.

Parameters **threshold** : float or array_like

axis : int or string axis name, optional

Align object with threshold along the given axis.

inplace : boolean, default False

Whether to perform the operation in place on the data New in version 0.21.0.

Returns **clipped** : same type as input

See also:

clip

pandas.Series.clip_upper

`Series.clip_upper(threshold, axis=None, inplace=False)`

Return copy of input with values above given value(s) truncated.

Parameters **threshold** : float or array_like

axis : int or string axis name, optional

Align object with threshold along the given axis.

inplace : boolean, default False

Whether to perform the operation in place on the data New in version 0.21.0.

Returns **clipped** : same type as input

See also:

clip

pandas.Series.combine

`Series.combine(other, func, fill_value=nan)`

Perform elementwise binary operation on two Series using given function with optional fill value when an index is missing from one Series or the other

Parameters **other** : Series or scalar value

func : function

fill_value : scalar value

Returns **result** : Series

pandas.Series.combine_first

`Series.combine_first(other)`

Combine Series values, choosing the calling Series's values first. Result index will be the union of the two indexes

Parameters **other** : Series

Returns **y** : Series

pandas.Series.compound

`Series.compound(axis=None, skipna=None, level=None)`

Return the compound percentage of the values for the requested axis

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **compounded** : scalar or Series (if level specified)

pandas.Series.compress

`Series.compress(condition, *args, **kwargs)`

Return selected slices of an array along given axis as a Series

See also:

`numpy.ndarray.compress`

pandas.Series.consolidate

`Series.consolidate(inplace=False)`

DEPRECATED: consolidate will be an internal implementation only.

pandas.Series.convert_objects

`Series.convert_objects(convert_dates=True, convert_numeric=False, convert_timedeltas=True, copy=True)`

Deprecated. Attempt to infer better dtype for object columns

Parameters **convert_dates** : boolean, default True

If True, convert to date where possible. If 'coerce', force conversion, with unconvertible values becoming NaT.

convert_numeric : boolean, default False

If True, attempt to coerce to numbers (including strings), with unconvertible values becoming NaN.

convert_timedeltas : boolean, default True

If True, convert to timedelta where possible. If 'coerce', force conversion, with unconvertible values becoming NaT.

copy : boolean, default True

If True, return a copy even if no copy is necessary (e.g. no conversion was done). Note: This is meant for internal use, and should not be confused with inplace.

Returns **converted** : same as input object

See also:

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

pandas.to_numeric Return a fixed frequency timedelta index, with day as the default.

pandas.Series.copy

`Series.copy(deep=True)`

Make a copy of this objects data.

Parameters **deep** : boolean or string, default True

Make a deep copy, including a copy of the data and the indices. With `deep=False` neither the indices or the data are copied.

Note that when `deep=True` data is copied, actual python objects will not be copied recursively, only the reference to the object. This is in contrast to `copy.deepcopy` in the Standard Library, which recursively copies object data.

Returns **copy** : type of caller

pandas.Series.corr

`Series.corr(other, method='pearson', min_periods=None)`

Compute correlation with *other* Series, excluding missing values

Parameters **other** : Series

method : {'pearson', 'kendall', 'spearman'}

- pearson : standard correlation coefficient
- kendall : Kendall Tau correlation coefficient
- spearman : Spearman rank correlation

min_periods : int, optional

Minimum number of observations needed to have a valid result

Returns **correlation** : float

pandas.Series.count

`Series.count(level=None)`

Return number of non-NA/null observations in the Series

Parameters **level** : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns **nobs** : int or Series (if level specified)

pandas.Series.cov

`Series.cov(other, min_periods=None)`

Compute covariance with Series, excluding missing values

Parameters **other** : Series

min_periods : int, optional

Minimum number of observations needed to have a valid result

Returns **covariance** : float

Normalized by N-1 (unbiased estimator).

pandas.Series.cummax

`Series.cummax(axis=None, skipna=True, *args, **kwargs)`

Return cumulative max over requested axis.

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cummax** : scalar

See also:

`pandas.core.window.Expanding.max` Similar functionality but ignores `NaN` values.

pandas.Series.cummin

`Series.cummin(axis=None, skipna=True, *args, **kwargs)`

Return cumulative minimum over requested axis.

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cummin** : scalar

See also:

`pandas.core.window.Expanding.min` Similar functionality but ignores `NaN` values.

pandas.Series.cumprod

`Series.cumprod(axis=None, skipna=True, *args, **kwargs)`

Return cumulative product over requested axis.

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cumprod** : scalar

See also:

pandas.core.window.Expanding.prod Similar functionality but ignores `NaN` values.

pandas.Series.cumsum

`Series.cumsum(axis=None, skipna=True, *args, **kwargs)`

Return cumulative sum over requested axis.

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cumsum** : scalar

See also:

pandas.core.window.Expanding.sum Similar functionality but ignores `NaN` values.

pandas.Series.describe

`Series.describe(percentiles=None, include=None, exclude=None)`

Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding `NaN` values.

Analyzes both numeric and object series, as well as `DataFrame` column sets of mixed data types. The output will vary depending on what is provided. Refer to the notes below for more detail.

Parameters **percentiles** : list-like of numbers, optional

The percentiles to include in the output. All should fall between 0 and 1. The default is `[.25, .5, .75]`, which returns the 25th, 50th, and 75th percentiles.

include : 'all', list-like of dtypes or None (default), optional

A white list of data types to include in the result. Ignored for `Series`. Here are the options:

- 'all' : All columns of the input will be included in the output.
- A list-like of dtypes : Limits the results to the provided data types. To limit the result to numeric types submit `numpy.number`. To limit it instead to object columns submit the `numpy.object` data type. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To select pandas categorical columns, use `'category'`

- None (default) : The result will include all numeric columns.

exclude : list-like of dtypes or None (default), optional,

A black list of data types to omit from the result. Ignored for `Series`. Here are the options:

- A list-like of dtypes : Excludes the provided data types from the result. To exclude numeric types submit `numpy.number`. To exclude object columns submit the data type `numpy.object`. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To exclude pandas categorical columns, use `'category'`
- None (default) : The result will exclude nothing.

Returns summary: Series/DataFrame of summary statistics

See also:

`DataFrame.count`, *`DataFrame.max`*, *`DataFrame.min`*, *`DataFrame.mean`*, *`DataFrame.std`*, *`DataFrame.select_dtypes`*

Notes

For numeric data, the result's index will include `count`, `mean`, `std`, `min`, `max` as well as lower, `50` and upper percentiles. By default the lower percentile is `25` and the upper percentile is `75`. The `50` percentile is the same as the median.

For object data (e.g. strings or timestamps), the result's index will include `count`, `unique`, `top`, and `freq`. The `top` is the most common value. The `freq` is the most common value's frequency. Timestamps also include the `first` and `last` items.

If multiple object values have the highest count, then the `count` and `top` results will be arbitrarily chosen from among those with the highest count.

For mixed data types provided via a `DataFrame`, the default is to return only an analysis of numeric columns. If the dataframe consists only of object and categorical data without any numeric columns, the default is to return an analysis of both the object and categorical columns. If `include='all'` is provided as an option, the result will include a union of attributes of each type.

The *include* and *exclude* parameters can be used to limit which columns in a `DataFrame` are analyzed for the output. The parameters are ignored when analyzing a `Series`.

Examples

Describing a numeric `Series`.

```
>>> s = pd.Series([1, 2, 3])
>>> s.describe()
count    3.0
mean     2.0
std      1.0
min      1.0
25%      1.5
50%      2.0
75%      2.5
max      3.0
```

Describing a categorical `Series`.

```
>>> s = pd.Series(['a', 'a', 'b', 'c'])
>>> s.describe()
count     4
unique    3
top       a
freq      2
dtype: object
```

Describing a timestamp `Series`.

```
>>> s = pd.Series([
...   np.datetime64("2000-01-01"),
...   np.datetime64("2010-01-01"),
...   np.datetime64("2010-01-01")
... ])
>>> s.describe()
count                       3
unique                      2
top       2010-01-01 00:00:00
freq                        2
first     2000-01-01 00:00:00
last      2010-01-01 00:00:00
dtype: object
```

Describing a `DataFrame`. By default only numeric fields are returned.

```
>>> df = pd.DataFrame({ 'object': ['a', 'b', 'c'],
...                     'numeric': [1, 2, 3],
...                     'categorical': pd.Categorical(['d','e','f'])
...                   })
>>> df.describe()
       numeric
count      3.0
mean       2.0
std        1.0
min        1.0
25%        1.5
50%        2.0
75%        2.5
max        3.0
```

Describing all columns of a `DataFrame` regardless of data type.

```
>>> df.describe(include='all')
        categorical  numeric object
count             3      3.0      3
unique            3      NaN      3
top               f      NaN      c
freq              1      NaN      1
mean            NaN      2.0    NaN
std             NaN      1.0    NaN
min             NaN      1.0    NaN
25%             NaN      1.5    NaN
50%             NaN      2.0    NaN
75%             NaN      2.5    NaN
max             NaN      3.0    NaN
```

Describing a column from a `DataFrame` by accessing it as an attribute.

```
>>> df.numeric.describe()
count    3.0
mean     2.0
std      1.0
min      1.0
25%      1.5
50%      2.0
75%      2.5
max      3.0
Name: numeric, dtype: float64
```

Including only numeric columns in a `DataFrame` description.

```
>>> df.describe(include=[np.number])
       numeric
count      3.0
mean       2.0
std        1.0
min        1.0
25%        1.5
50%        2.0
75%        2.5
max        3.0
```

Including only string columns in a `DataFrame` description.

```
>>> df.describe(include=[np.object])
       object
count       3
unique      3
top         c
freq        1
```

Including only categorical columns from a `DataFrame` description.

```
>>> df.describe(include=['category'])
       categorical
count            3
unique           3
top              f
freq             1
```

Excluding numeric columns from a `DataFrame` description.

```
>>> df.describe(exclude=[np.number])
       categorical object
count            3      3
unique           3      3
top              f      c
freq             1      1
```

Excluding object columns from a `DataFrame` description.

```
>>> df.describe(exclude=[np.object])
        categorical  numeric
count            3      3.0
```

```
unique           3      NaN
top              f      NaN
freq             1      NaN
mean           NaN      2.0
std            NaN      1.0
min            NaN      1.0
25%            NaN      1.5
50%            NaN      2.0
75%            NaN      2.5
max            NaN      3.0
```

pandas.Series.diff

`Series.diff`(*periods=1*)

1st discrete difference of object

Parameters **periods** : int, default 1

Periods to shift for forming difference

Returns **diffed** : Series

pandas.Series.div

`Series.div`(*other*, *level=None*, *fill_value=None*, *axis=0*)

Floating division of series and other, element-wise (binary operator *truediv*).

Equivalent to `series / other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

`Series.rtruediv`

pandas.Series.divide

`Series.divide`(*other*, *level=None*, *fill_value=None*, *axis=0*)

Floating division of series and other, element-wise (binary operator *truediv*).

Equivalent to `series / other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns result : Series

See also:

Series.rtruediv

pandas.Series.dot

`Series.dot(other)`

Matrix multiplication with DataFrame or inner-product with Series objects

Parameters other : Series or DataFrame

Returns dot_product : scalar or Series

pandas.Series.drop

`Series.drop(labels=None, axis=0, index=None, columns=None, level=None, inplace=False, errors='raise')`

Return new object with labels in requested axis removed.

Parameters labels : single label or list-like

Index or column labels to drop.

axis : int or axis name

Whether to drop labels from the index (0 / 'index') or columns (1 / 'columns').

index, columns : single label or list-like

Alternative to specifying *axis* (`labels, axis=1` is equivalent to `columns=labels`).

New in version 0.21.0.

level : int or level name, default None

For MultiIndex

inplace : bool, default False

If True, do operation inplace and return None.

errors : {'ignore', 'raise'}, default 'raise'

If 'ignore', suppress error and existing labels are dropped.

Returns dropped : type of caller

Notes

Specifying both *labels* and *index* or *columns* will raise a ValueError.

Examples

```
>>> df = pd.DataFrame(np.arange(12).reshape(3,4),
                      columns=['A', 'B', 'C', 'D'])
>>> df
   A  B   C   D
0  0  1   2   3
1  4  5   6   7
2  8  9  10  11
```

Drop columns

```
>>> df.drop(['B', 'C'], axis=1)
   A   D
0  0   3
1  4   7
2  8  11
```

```
>>> df.drop(columns=['B', 'C'])
   A   D
0  0   3
1  4   7
2  8  11
```

Drop a row by index

```
>>> df.drop([0, 1])
   A  B   C   D
2  8  9  10  11
```

pandas.Series.drop_duplicates

`Series.drop_duplicates`(*keep='first', inplace=False*)

Return Series with duplicate values removed

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Drop duplicates except for the first occurrence.
- `last` : Drop duplicates except for the last occurrence.
- False : Drop all duplicates.

inplace : boolean, default False

If True, performs operation inplace and returns None.

Returns **deduplicated** : Series

pandas.Series.dropna

`Series.dropna`(*axis=0, inplace=False, **kwargs*)

Return Series without null values

Returns **valid** : Series

inplace : boolean, default False

Do operation in place.

pandas.Series.dt

`Series.dt()`

Accessor object for datetimelike properties of the Series values.

Examples

```
>>> s.dt.hour
>>> s.dt.second
>>> s.dt.quarter
```

Returns a Series indexed like the original Series. Raises TypeError if the Series does not contain datetimelike values.

pandas.Series.duplicated

`Series.duplicated(keep='first')`

Return boolean Series denoting duplicate values

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Mark duplicates as `True` except for the first occurrence.
- `last` : Mark duplicates as `True` except for the last occurrence.
- False : Mark all duplicates as `True`.

Returns **duplicated** : Series

pandas.Series.eq

`Series.eq(other, level=None, fill_value=None, axis=0)`

Equal to of series and other, element-wise (binary operator *eq*).

Equivalent to `series == other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

`Series.None`

pandas.Series.equals

`Series.equals(other)`

Determines if two NDFrame objects contain the same elements. NaNs in the same location are considered equal.

pandas.Series.ewm

`Series.ewm(com=None, span=None, halflife=None, alpha=None, min_periods=0, freq=None, adjust=True, ignore_na=False, axis=0)`

Provides exponential weighted functions

New in version 0.18.0.

Parameters **com** : float, optional

Specify decay in terms of center of mass, $\alpha = 1/(1 + com),\ \text{for}\ com \geq 0$

span : float, optional

Specify decay in terms of span, $\alpha = 2/(span + 1),\ \text{for}\ span \geq 1$

halflife : float, optional

Specify decay in terms of half-life, $\alpha = 1 - exp(log(0.5)/halflife),\ \text{for}\ halflife > 0$

alpha : float, optional

Specify smoothing factor α directly, $0 < \alpha \leq 1$

New in version 0.18.0.

min_periods : int, default 0

Minimum number of observations in window required to have a value (otherwise result is NA).

freq : None or string alias / date offset object, default=None

Deprecated since version 0.18.0: Frequency to conform to before computing statistic

adjust : boolean, default True

Divide by decaying adjustment factor in beginning periods to account for imbalance in relative weightings (viewing EWMA as a moving average)

ignore_na : boolean, default False

Ignore missing values when calculating weights; specify True to reproduce pre-0.15.0 behavior

Returns a Window sub-classed for the particular operation

Notes

Exactly one of center of mass, span, half-life, and alpha must be provided. Allowed values and relationship between the parameters are specified in the parameter descriptions above; see the link at the end of this section for a detailed explanation.

The *freq* keyword is used to conform time series data to a specified frequency by resampling the data. This is done with the default parameters of `resample()` (i.e. using the *mean*).

When adjust is True (default), weighted averages are calculated using weights (1-alpha)**(n-1), (1-alpha)**(n-2), ..., 1-alpha, 1.

When adjust is False, weighted averages are calculated recursively as: weighted_average[0] = arg[0]; weighted_average[i] = (1-alpha)*weighted_average[i-1] + alpha*arg[i].

When ignore_na is False (default), weights are based on absolute positions. For example, the weights of x and y used in calculating the final weighted average of [x, None, y] are (1-alpha)**2 and 1 (if adjust is True), and (1-alpha)**2 and alpha (if adjust is False).

When ignore_na is True (reproducing pre-0.15.0 behavior), weights are based on relative positions. For example, the weights of x and y used in calculating the final weighted average of [x, None, y] are 1-alpha and 1 (if adjust is True), and 1-alpha and alpha (if adjust is False).

More details can be found at http://pandas.pydata.org/pandas-docs/stable/computation.html#exponentially-weighted-windows

Examples

```
>>> df = DataFrame({'B': [0, 1, 2, np.nan, 4]})
     B
0  0.0
1  1.0
2  2.0
3  NaN
4  4.0
```

```
>>> df.ewm(com=0.5).mean()
          B
0  0.000000
1  0.750000
2  1.615385
3  1.615385
4  3.670213
```

pandas.Series.expanding

`Series.expanding(min_periods=1, freq=None, center=False, axis=0)`

Provides expanding transformations.

New in version 0.18.0.

Parameters **min_periods** : int, default None

Minimum number of observations in window required to have a value (otherwise result is NA).

freq : string or DateOffset object, optional (default None)

Deprecated since version 0.18.0: Frequency to conform the data to before computing the statistic. Specified as a frequency string or DateOffset object.

center : boolean, default False

Set the labels at the center of the window.

axis : int or string, default 0

Returns a Window sub-classed for the particular operation

Notes

By default, the result is set to the right edge of the window. This can be changed to the center of the window by setting `center=True`.

The *freq* keyword is used to conform time series data to a specified frequency by resampling the data. This is done with the default parameters of `resample()` (i.e. using the *mean*).

Examples

```
>>> df = DataFrame({'B': [0, 1, 2, np.nan, 4]})
     B
0  0.0
1  1.0
2  2.0
3  NaN
4  4.0
```

```
>>> df.expanding(2).sum()
     B
0  NaN
1  1.0
2  3.0
3  3.0
4  7.0
```

pandas.Series.factorize

`Series.factorize`(*sort=False*, *na_sentinel=-1*)

Encode the object as an enumerated type or categorical variable

Parameters **sort** : boolean, default False

Sort by values

na_sentinel: int, default -1

Value to mark "not found"

Returns **labels** : the indexer to the original array

uniques : the unique Index

pandas.Series.ffill

`Series.ffill`(*axis=None*, *inplace=False*, *limit=None*, *downcast=None*)

Synonym for `DataFrame.fillna(method='ffill')`

pandas.Series.fillna

`Series.fillna`(*value=None*, *method=None*, *axis=None*, *inplace=False*, *limit=None*, *downcast=None*, ***kwargs*)

Fill NA/NaN values using the specified method

Parameters **value** : scalar, dict, Series, or DataFrame

Value to use to fill holes (e.g. 0), alternately a dict/Series/DataFrame of values specifying which value to use for each index (for a Series) or column (for a DataFrame). (values not in the dict/Series/DataFrame will not be filled). This value cannot be a list.

method : {'backfill', 'bfill', 'pad', 'ffill', None}, default None

Method to use for filling holes in reindexed Series pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation to fill gap

axis : {0, 'index'}

inplace : boolean, default False

If True, fill in place. Note: this will modify any other views on this object, (e.g. a no-copy slice for a column in a DataFrame).

limit : int, default None

If method is specified, this is the maximum number of consecutive NaN values to forward/backward fill. In other words, if there is a gap with more than this number of consecutive NaNs, it will only be partially filled. If method is not specified, this is the maximum number of entries along the entire axis where NaNs will be filled. Must be greater than 0 if not None.

downcast : dict, default is None

a dict of item->dtype of what to downcast if possible, or the string 'infer' which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns **filled** : Series

See also:

reindex, *asfreq*

Examples

```
>>> df = pd.DataFrame([[np.nan, 2, np.nan, 0],
...                    [3, 4, np.nan, 1],
...                    [np.nan, np.nan, np.nan, 5],
...                    [np.nan, 3, np.nan, 4]],
...                    columns=list('ABCD'))
>>> df
     A    B   C  D
0  NaN  2.0 NaN  0
1  3.0  4.0 NaN  1
2  NaN  NaN NaN  5
3  NaN  3.0 NaN  4
```

Replace all NaN elements with 0s.

```
>>> df.fillna(0)
    A   B   C   D
0   0.0 2.0 0.0 0
1   3.0 4.0 0.0 1
2   0.0 0.0 0.0 5
3   0.0 3.0 0.0 4
```

We can also propagate non-null values forward or backward.

```
>>> df.fillna(method='ffill')
    A   B   C   D
0   NaN 2.0 NaN 0
1   3.0 4.0 NaN 1
2   3.0 4.0 NaN 5
3   3.0 3.0 NaN 4
```

Replace all NaN elements in column 'A', 'B', 'C', and 'D', with 0, 1, 2, and 3 respectively.

```
>>> values = {'A': 0, 'B': 1, 'C': 2, 'D': 3}
>>> df.fillna(value=values)
    A   B   C   D
0   0.0 2.0 2.0 0
1   3.0 4.0 2.0 1
2   0.0 1.0 2.0 5
3   0.0 3.0 2.0 4
```

Only replace the first NaN element.

```
>>> df.fillna(value=values, limit=1)
    A   B   C   D
0   0.0 2.0 2.0 0
1   3.0 4.0 NaN 1
2   NaN 1.0 NaN 5
3   NaN 3.0 NaN 4
```

pandas.Series.filter

`Series.filter`(*items=None*, *like=None*, *regex=None*, *axis=None*)

Subset rows or columns of dataframe according to labels in the specified index.

Note that this routine does not filter a dataframe on its contents. The filter is applied to the labels of the index.

Parameters **items** : list-like

List of info axis to restrict to (must not all be present)

like : string

Keep info axis where "arg in col == True"

regex : string (regular expression)

Keep info axis with re.search(regex, col) == True

axis : int or string axis name

The axis to filter on. By default this is the info axis, 'index' for Series, 'columns' for DataFrame

Returns same type as input object

See also:

pandas.DataFrame.loc

Notes

The `items`, `like`, and `regex` parameters are enforced to be mutually exclusive.

`axis` defaults to the info axis that is used when indexing with `[]`.

Examples

```
>>> df
one  two  three
mouse     1    2      3
rabbit    4    5      6
```

```
>>> # select columns by name
>>> df.filter(items=['one', 'three'])
one  three
mouse     1      3
rabbit    4      6
```

```
>>> # select columns by regular expression
>>> df.filter(regex='e$', axis=1)
one  three
mouse     1      3
rabbit    4      6
```

```
>>> # select rows containing 'bbi'
>>> df.filter(like='bbi', axis=0)
one  two  three
rabbit    4    5      6
```

pandas.Series.first

`Series.`**`first`**(*offset*)

Convenience method for subsetting initial periods of time series data based on a date offset.

Parameters **offset** : string, DateOffset, dateutil.relativedelta

Returns **subset** : type of caller

Examples

ts.first('10D') -> First 10 days

pandas.Series.first_valid_index

`Series.`**`first_valid_index`**()

Return index for first non-NA/null value.

Returns **scalar** : type of index

Notes

If all elements are non-NA/null, returns None. Also returns None for empty Series.

pandas.Series.floordiv

`Series.floordiv(other, level=None, fill_value=None, axis=0)`

Integer division of series and other, element-wise (binary operator *floordiv*).

Equivalent to `series // other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.rfloordiv

pandas.Series.from_array

classmethod `Series.from_array(arr, index=None, name=None, dtype=None, copy=False, fastpath=False)`

pandas.Series.from_csv

classmethod `Series.from_csv(path, sep=', ', parse_dates=True, header=None, index_col=0, encoding=None, infer_datetime_format=False)`

Read CSV file (DEPRECATED, please use *pandas.read_csv()* instead).

It is preferable to use the more powerful *pandas.read_csv()* for most general purposes, but `from_csv` makes for an easy roundtrip to and from a file (the exact counterpart of `to_csv`), especially with a time Series.

This method only differs from *pandas.read_csv()* in some defaults:

- *index_col* is `0` instead of `None` (take first column as index by default)
- *header* is `None` instead of `0` (the first row is not used as the column names)
- *parse_dates* is `True` instead of `False` (try parsing the index as datetime by default)

With *pandas.read_csv()*, the option `squeeze=True` can be used to return a Series like `from_csv`.

Parameters **path** : string file path or file handle / StringIO

sep : string, default ','

Field delimiter

parse_dates : boolean, default True

Parse dates. Different default from read_table

header : int, default None

Row to use as header (skip prior rows)

index_col : int or sequence, default 0

Column to use for index. If a sequence is given, a MultiIndex is used. Different default from read_table

encoding : string, optional

a string representing the encoding to use if the contents are non-ascii, for python versions prior to 3

infer_datetime_format: boolean, default False

If True and *parse_dates* is True for a column, try to infer the datetime format based on the first datetime string. If the format can be inferred, there often will be a large parsing speed-up.

Returns **y** : Series

See also:

pandas.read_csv

pandas.Series.ge

`Series.ge(other, level=None, fill_value=None, axis=0)`

Greater than or equal to of series and other, element-wise (binary operator *ge*).

Equivalent to `series >= other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

`Series.None`

pandas.Series.get

`Series.get(key, default=None)`

Get item from object for given key (DataFrame column, Panel slice, etc.). Returns default value if not found.

Parameters **key** : object

Returns value : type of items contained in object

pandas.Series.get_dtype_counts

`Series.get_dtype_counts()`

Return the counts of dtypes in this object.

pandas.Series.get_ftype_counts

`Series.get_ftype_counts()`

Return the counts of ftypes in this object.

pandas.Series.get_value

`Series.get_value(label, takeable=False)`

Quickly retrieve single value at passed index label

Deprecated since version 0.21.0.

Please use .at[] or .iat[] accessors.

Parameters index : label

takeable : interpret the index as indexers, default False

Returns value : scalar value

pandas.Series.get_values

`Series.get_values()`

same as values (but handles sparseness conversions); is a view

pandas.Series.groupby

`Series.groupby(by=None, axis=0, level=None, as_index=True, sort=True, group_keys=True, squeeze=False, **kwargs)`

Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.

Parameters by : mapping, function, str, or iterable

Used to determine the groups for the groupby. If `by` is a function, it's called on each value of the object's index. If a dict or Series is passed, the Series or dict VALUES will be used to determine the groups (the Series' values are first aligned; see `.align()` method). If an ndarray is passed, the values are used as-is determine the groups. A str or list of strs may be passed to group by the columns in `self`

axis : int, default 0

level : int, level name, or sequence of such, default None

If the axis is a MultiIndex (hierarchical), group by a particular level or levels

as_index : boolean, default True

For aggregated output, return object with group labels as the index. Only relevant for DataFrame input. as_index=False is effectively "SQL-style" grouped output

sort : boolean, default True

Sort group keys. Get better performance by turning this off. Note this does not influence the order of observations within each group. groupby preserves the order of rows within each group.

group_keys : boolean, default True

When calling apply, add group keys to index to identify pieces

squeeze : boolean, default False

reduce the dimensionality of the return type if possible, otherwise return a consistent type

Returns GroupBy object

Examples

DataFrame results

```
>>> data.groupby(func, axis=0).mean()
>>> data.groupby(['col1', 'col2'])['col3'].mean()
```

DataFrame with hierarchical index

```
>>> data.groupby(['col1', 'col2']).mean()
```

pandas.Series.gt

`Series.gt`(*other*, *level=None*, *fill_value=None*, *axis=0*)

Greater than of series and other, element-wise (binary operator *gt*).

Equivalent to `series > other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

`Series.None`

pandas.Series.head

`Series.head(n=5)`

Return the first n rows.

Parameters **n** : int, default 5

Number of rows to select.

Returns **obj_head** : type of caller

The first n rows of the caller object.

pandas.Series.hist

`Series.hist(by=None, ax=None, grid=True, xlabelsize=None, xrot=None, ylabelsize=None, yrot=None, figsize=None, bins=10, **kwds)`

Draw histogram of the input series using matplotlib

Parameters **by** : object, optional

If passed, then used to form histograms for separate groups

ax : matplotlib axis object

If not passed, uses gca()

grid : boolean, default True

Whether to show axis grid lines

xlabelsize : int, default None

If specified changes the x-axis label size

xrot : float, default None

rotation of x axis labels

ylabelsize : int, default None

If specified changes the y-axis label size

yrot : float, default None

rotation of y axis labels

figsize : tuple, default None

figure size in inches by default

bins: integer, default 10

Number of histogram bins to be used

kwds : keywords

To be passed to the actual plotting function

Notes

See matplotlib documentation online for more on this

pandas.Series.idxmax

`Series.idxmax(axis=None, skipna=True, *args, **kwargs)`

Index *label* of the first occurrence of maximum of values.

Parameters **skipna** : boolean, default True

Exclude NA/null values

Returns **idxmax** : Index of maximum of values

See also:

`DataFrame.idxmax`, `numpy.ndarray.argmax`

Notes

This method is the Series version of `ndarray.argmax`. This method returns the label of the maximum, while `ndarray.argmax` returns the position. To get the position, use `series.values.argmax()`.

pandas.Series.idxmin

`Series.idxmin(axis=None, skipna=True, *args, **kwargs)`

Index *label* of the first occurrence of minimum of values.

Parameters **skipna** : boolean, default True

Exclude NA/null values

Returns **idxmin** : Index of minimum of values

See also:

`DataFrame.idxmin`, `numpy.ndarray.argmin`

Notes

This method is the Series version of `ndarray.argmin`. This method returns the label of the minimum, while `ndarray.argmin` returns the position. To get the position, use `series.values.argmin()`.

pandas.Series.infer_objects

`Series.infer_objects()`

Attempt to infer better dtypes for object columns.

Attempts soft conversion of object-dtyped columns, leaving non-object and unconvertible columns unchanged. The inference rules are the same as during normal Series/DataFrame construction.

New in version 0.21.0.

Returns **converted** : same type as input object

See also:

`pandas.to_datetime` Convert argument to datetime.

`pandas.to_timedelta` Convert argument to timedelta.

pandas.to_numeric Convert argument to numeric typeR

Examples

```
>>> df = pd.DataFrame({"A": ["a", 1, 2, 3]})
>>> df = df.iloc[1:]
>>> df
   A
1  1
2  2
3  3
```

```
>>> df.dtypes
A    object
dtype: object
```

```
>>> df.infer_objects().dtypes
A    int64
dtype: object
```

pandas.Series.interpolate

`Series.interpolate`(*method='linear', axis=0, limit=None, inplace=False, limit_direction='forward', downcast=None, **kwargs*)

Interpolate values according to different methods.

Please note that only `method='linear'` is supported for DataFrames/Series with a MultiIndex.

Parameters method : {'linear', 'time', 'index', 'values', 'nearest', 'zero', 'slinear', 'quadratic', 'cubic', 'barycentric', 'krogh', 'polynomial', 'spline', 'piecewise_polynomial', 'from_derivatives', 'pchip', 'akima'}

- 'linear': ignore the index and treat the values as equally spaced. This is the only method supported on MultiIndexes. default
- 'time': interpolation works on daily and higher resolution data to interpolate given length of interval
- 'index', 'values': use the actual numerical values of the index
- 'nearest', 'zero', 'slinear', 'quadratic', 'cubic', 'barycentric', 'polynomial' is passed to `scipy.interpolate.interp1d`. Both 'polynomial' and 'spline' require that you also specify an *order* (int), e.g. df.interpolate(method='polynomial', order=4). These use the actual numerical values of the index.
- 'krogh', 'piecewise_polynomial', 'spline', 'pchip' and 'akima' are all wrappers around the scipy interpolation methods of similar names. These use the actual numerical values of the index. For more information on their behavior, see the scipy documentation and tutorial documentation
- 'from_derivatives' refers to BPoly.from_derivatives which replaces 'piecewise_polynomial' interpolation method in scipy 0.18

New in version 0.18.1: Added support for the 'akima' method Added interpolate method 'from_derivatives' which replaces 'piecewise_polynomial' in scipy 0.18; backwards-compatible with scipy < 0.18

axis : {0, 1}, default 0

- 0: fill column-by-column
- 1: fill row-by-row

limit : int, default None.

Maximum number of consecutive NaNs to fill. Must be greater than 0.

limit_direction : {'forward', 'backward', 'both'}, default 'forward'

If limit is specified, consecutive NaNs will be filled in this direction.

New in version 0.17.0.

inplace : bool, default False

Update the NDFrame in place if possible.

downcast : optional, 'infer' or None, defaults to None

Downcast dtypes if possible.

kwargs : keyword arguments to pass on to the interpolating function.

Returns Series or DataFrame of same shape interpolated at the NaNs

See also:

reindex, *replace*, *fillna*

Examples

Filling in NaNs

```
>>> s = pd.Series([0, 1, np.nan, 3])
>>> s.interpolate()
0    0
1    1
2    2
3    3
dtype: float64
```

pandas.Series.isin

`Series.isin(values)`

Return a boolean *Series* showing whether each element in the *Series* is exactly contained in the passed sequence of `values`.

Parameters **values** : set or list-like

The sequence of values to test. Passing in a single string will raise a `TypeError`. Instead, turn a single string into a `list` of one element.

New in version 0.18.1.

Support for values as a set

Returns **isin** : Series (bool dtype)

Raises **TypeError**

- If `values` is a string

See also:

pandas.DataFrame.isin

Examples

```
>>> s = pd.Series(list('abc'))
>>> s.isin(['a', 'c', 'e'])
0     True
1    False
2     True
dtype: bool
```

Passing a single string as `s.isin('a')` will raise an error. Use a list of one element instead:

```
>>> s.isin(['a'])
0     True
1    False
2    False
dtype: bool
```

pandas.Series.isna

`Series.isna()`

Return a boolean same-sized object indicating if the values are NA.

See also:

Series.notna boolean inverse of isna

Series.isnull alias of isna

isna top-level isna

pandas.Series.isnull

`Series.isnull()`

Return a boolean same-sized object indicating if the values are NA.

See also:

Series.notna boolean inverse of isna

Series.isnull alias of isna

isna top-level isna

pandas.Series.item

`Series.item()`

return the first element of the underlying data as a python scalar

pandas.Series.items

`Series.items()`

Lazily iterate over (index, value) tuples

pandas.Series.iteritems

`Series.iteritems()`

Lazily iterate over (index, value) tuples

pandas.Series.keys

`Series.keys()`

Alias for index

pandas.Series.kurt

`Series.kurt(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **kurt** : scalar or Series (if level specified)

pandas.Series.kurtosis

`Series.kurtosis(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **kurt** : scalar or Series (if level specified)

pandas.Series.last

`Series.last(offset)`

Convenience method for subsetting final periods of time series data based on a date offset.

Parameters **offset** : string, DateOffset, dateutil.relativedelta

Returns **subset** : type of caller

Examples

ts.last('5M') -> Last 5 months

pandas.Series.last_valid_index

`Series.last_valid_index()`

Return index for last non-NA/null value.

Returns **scalar** : type of index

Notes

If all elements are non-NA/null, returns None. Also returns None for empty Series.

pandas.Series.le

`Series.le(other, level=None, fill_value=None, axis=0)`

Less than or equal to of series and other, element-wise (binary operator *le*).

Equivalent to `series <= other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns result : Series

See also:

`Series.None`

pandas.Series.lt

`Series.lt(other, level=None, fill_value=None, axis=0)`

Less than of series and other, element-wise (binary operator *lt*).

Equivalent to `series < other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters other : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns result : Series

See also:

`Series.None`

pandas.Series.mad

`Series.mad(axis=None, skipna=None, level=None)`

Return the mean absolute deviation of the values for the requested axis

Parameters axis : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns mad : scalar or Series (if level specified)

pandas.Series.map

`Series.map(arg, na_action=None)`

Map values of Series using input correspondence (which can be a dict, Series, or function)

Parameters **arg** : function, dict, or Series

na_action : {None, 'ignore'}

If 'ignore', propagate NA values, without passing them to the mapping function

Returns **y** : Series

same index as caller

See also:

Series.apply For applying more complex functions on a Series

DataFrame.apply Apply a function row-/column-wise

DataFrame.applymap Apply a function elementwise on a whole DataFrame

Notes

When *arg* is a dictionary, values in Series that are not in the dictionary (as keys) are converted to `NaN`. However, if the dictionary is a `dict` subclass that defines `__missing__` (i.e. provides a method for default values), then this default is used rather than `NaN`:

```
>>> from collections import Counter
>>> counter = Counter()
>>> counter['bar'] += 1
>>> y.map(counter)
1    0
2    1
3    0
dtype: int64
```

Examples

Map inputs to outputs (both of type *Series*)

```
>>> x = pd.Series([1,2,3], index=['one', 'two', 'three'])
>>> x
one      1
two      2
three    3
dtype: int64
```

```
>>> y = pd.Series(['foo', 'bar', 'baz'], index=[1,2,3])
>>> y
1    foo
2    bar
3    baz
```

```
>>> x.map(y)
one   foo
two   bar
three baz
```

If *arg* is a dictionary, return a new Series with values converted according to the dictionary's mapping:

```
>>> z = {1: 'A', 2: 'B', 3: 'C'}
```

```
>>> x.map(z)
one   A
two   B
three C
```

Use na_action to control whether NA values are affected by the mapping function.

```
>>> s = pd.Series([1, 2, 3, np.nan])
```

```
>>> s2 = s.map('this is a string {}'.format, na_action=None)
0    this is a string 1.0
1    this is a string 2.0
2    this is a string 3.0
3    this is a string nan
dtype: object
```

```
>>> s3 = s.map('this is a string {}'.format, na_action='ignore')
0    this is a string 1.0
1    this is a string 2.0
2    this is a string 3.0
3                     NaN
dtype: object
```

pandas.Series.mask

`Series.mask(cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)`

Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.

Parameters **cond** : boolean NDFrame, array-like, or callable

Where *cond* is False, keep the original value. Where True, replace with corresponding value from *other*. If *cond* is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as cond.

other : scalar, NDFrame, or callable

Entries where *cond* is True are replaced with corresponding value from *other*. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as other.

inplace : boolean, default False

Whether to perform the operation in place on the data

axis : alignment axis if needed, default None

level : alignment level if needed, default None

errors : str, {'raise', 'ignore'}, default 'raise'

- `raise` : allow exceptions to be raised
- `ignore` : suppress exceptions. On error return original object

Note that currently this parameter won't affect the results and will always coerce to a suitable dtype.

try_cast : boolean, default False

try to cast the result back to the input type (if possible),

raise_on_error : boolean, default True

Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.

Returns **wh** : same type as caller

See also:

`DataFrame.where()`

Notes

The mask method is an application of the if-then idiom. For each element in the calling DataFrame, if `cond` is `False` the element is used; otherwise the corresponding element from the DataFrame `other` is used.

The signature for *`DataFrame.where()`* differs from `numpy.where()`. Roughly `df1.where(m, df2)` is equivalent to `np.where(m, df1, df2)`.

For further details and examples see the `mask` documentation in *indexing*.

Examples

```
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0    NaN
1    1.0
2    2.0
3    3.0
4    4.0
```

```
>>> s.mask(s > 0)
0    0.0
1    NaN
2    NaN
3    NaN
4    NaN
```

```
>>> s.where(s > 1, 10)
0    10.0
1    10.0
2    2.0
3    3.0
4    4.0
```

```
>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
   A  B
0  0 -1
1 -2  3
2 -4 -5
3  6 -7
4 -8  9
>>> df.where(m, -df) == np.where(m, df, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
>>> df.where(m, -df) == df.mask(~m, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
```

pandas.Series.max

`Series.max`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

This method returns the maximum of the values in the object. If you want the *index* of the maximum, use `idxmax`. This is the equivalent of the `numpy.ndarray` method `argmax`.

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **max** : scalar or Series (if level specified)

pandas.Series.mean

`Series.mean`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the mean of the values for the requested axis

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **mean** : scalar or Series (if level specified)

pandas.Series.median

`Series.median`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the median of the values for the requested axis

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **median** : scalar or Series (if level specified)

pandas.Series.memory_usage

`Series.memory_usage`(*index=True*, *deep=False*)

Memory usage of the Series

Parameters **index** : bool

Specifies whether to include memory usage of Series index

deep : bool

Introspect the data deeply, interrogate *object* dtypes for system-level memory consumption

Returns scalar bytes of memory consumed

See also:

`numpy.ndarray.nbytes`

Notes

Memory usage does not include memory consumed by elements that are not components of the array if deep=False

pandas.Series.min

`Series.min(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

This method returns the minimum of the values in the object. If you want the *index* of the minimum, use `idxmin`. This is the equivalent of the `numpy.ndarray` method `argmin`.

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **min** : scalar or Series (if level specified)

pandas.Series.mod

`Series.mod(other, level=None, fill_value=None, axis=0)`

Modulo of series and other, element-wise (binary operator *mod*).

Equivalent to `series % other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

`Series.rmod`

pandas.Series.mode

`Series.mode()`

Return the mode(s) of the dataset.

Always returns Series even if only one value is returned.

Returns **modes** : Series (sorted)

pandas.Series.mul

`Series.mul(other, level=None, fill_value=None, axis=0)`

Multiplication of series and other, element-wise (binary operator *mul*).

Equivalent to `series * other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.rmul

pandas.Series.multiply

`Series.multiply(other, level=None, fill_value=None, axis=0)`

Multiplication of series and other, element-wise (binary operator *mul*).

Equivalent to `series * other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.rmul

pandas.Series.ne

`Series.ne(other, level=None, fill_value=None, axis=0)`

Not equal to of series and other, element-wise (binary operator *ne*).

Equivalent to `series != other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns result : Series

See also:

`Series.None`

pandas.Series.nlargest

`Series.nlargest(n=5, keep='first')`

Return the largest *n* elements.

Parameters n : int

Return this many descending sorted values

keep : {'first', 'last', False}, default 'first'

Where there are duplicate values: - `first` : take the first occurrence. - `last` : take the last occurrence.

Returns top_n : Series

The n largest values in the Series, in sorted order

See also:

`Series.nsmallest`

Notes

Faster than `.sort_values(ascending=False).head(n)` for small *n* relative to the size of the `Series` object.

Examples

```
>>> import pandas as pd
>>> import numpy as np
>>> s = pd.Series(np.random.randn(10**6))
>>> s.nlargest(10)  # only sorts up to the N requested
219921    4.644710
82124     4.608745
421689    4.564644
425277    4.447014
718691    4.414137
43154     4.403520
283187    4.313922
595519    4.273635
503969    4.250236
121637    4.240952
dtype: float64
```

pandas.Series.nonzero

`Series.nonzero()`

Return the indices of the elements that are non-zero

This method is equivalent to calling *numpy.nonzero* on the series data. For compatability with NumPy, the return value is the same (a tuple with an array of indices for each dimension), but it will always be a one-item tuple because series only have one dimension.

See also:

`numpy.nonzero`

Examples

```
>>> s = pd.Series([0, 3, 0, 4])
>>> s.nonzero()
(array([1, 3]),)
>>> s.iloc[s.nonzero()[0]]
1    3
3    4
dtype: int64
```

pandas.Series.notna

`Series.notna()`

Return a boolean same-sized object indicating if the values are not NA.

See also:

Series.isna boolean inverse of notna

Series.notnull alias of notna

notna top-level notna

pandas.Series.notnull

`Series.notnull()`

Return a boolean same-sized object indicating if the values are not NA.

See also:

Series.isna boolean inverse of notna

Series.notnull alias of notna

notna top-level notna

pandas.Series.nsmallest

`Series.nsmallest(n=5, keep='first')`

Return the smallest *n* elements.

Parameters **n** : int

Return this many ascending sorted values

keep : {'first', 'last', False}, default 'first'

Where there are duplicate values: - `first` : take the first occurrence. - `last` : take the last occurrence.

Returns **bottom_n** : Series

The n smallest values in the Series, in sorted order

See also:

`Series.nlargest`

Notes

Faster than `.sort_values().head(n)` for small *n* relative to the size of the `Series` object.

Examples

```
>>> import pandas as pd
>>> import numpy as np
>>> s = pd.Series(np.random.randn(10**6))
>>> s.nsmallest(10)  # only sorts up to the N requested
288532   -4.954580
732345   -4.835960
64803    -4.812550
446457   -4.609998
501225   -4.483945
669476   -4.472935
973615   -4.401699
621279   -4.355126
773916   -4.347355
359919   -4.331927
dtype: float64
```

pandas.Series.nunique

`Series.`**`nunique`**(*dropna=True*)

Return number of unique elements in the object.

Excludes NA values by default.

Parameters **dropna** : boolean, default True

Don't include NaN in the count.

Returns **nunique** : int

pandas.Series.pct_change

`Series.`**`pct_change`**(*periods=1, fill_method='pad', limit=None, freq=None, **kwargs*)

Percent change over given number of periods.

Parameters periods : int, default 1

Periods to shift for forming percent change

fill_method : str, default 'pad'

How to handle NAs before computing percent changes

limit : int, default None

The number of consecutive NAs to fill before stopping

freq : DateOffset, timedelta, or offset alias string, optional

Increment to use from time series API (e.g. 'M' or BDay())

Returns chg : NDFrame

Notes

By default, the percentage change is calculated along the stat axis: 0, or `Index`, for `DataFrame` and 1, or `minor` for `Panel`. You can change this with the `axis` keyword argument.

pandas.Series.pipe

`Series.pipe`(*func*, **args*, ***kwargs*)

Apply func(self, *args, **kwargs)

Parameters func : function

function to apply to the NDFrame. `args`, and `kwargs` are passed into `func`. Alternatively a `(callable, data_keyword)` tuple where `data_keyword` is a string indicating the keyword of `callable` that expects the NDFrame.

args : iterable, optional

positional arguments passed into `func`.

kwargs : mapping, optional

a dictionary of keyword arguments passed into `func`.

Returns object : the return type of `func`.

See also:

pandas.DataFrame.apply, *pandas.DataFrame.applymap*, *pandas.Series.map*

Notes

Use `.pipe` when chaining together functions that expect Series, DataFrames or GroupBy objects. Instead of writing

```
>>> f(g(h(df), arg1=a), arg2=b, arg3=c)
```

You can write

```
>>> (df.pipe(h)
...     .pipe(g, arg1=a)
...     .pipe(f, arg2=b, arg3=c)
... )
```

If you have a function that takes the data as (say) the second argument, pass a tuple indicating which keyword expects the data. For example, suppose `f` takes its data as `arg2`:

```
>>> (df.pipe(h)
...     .pipe(g, arg1=a)
...     .pipe((f, 'arg2'), arg1=a, arg3=c)
...  )
```

pandas.Series.plot

`Series.plot`(*kind='line'*, *ax=None*, *figsize=None*, *use_index=True*, *title=None*, *grid=None*, *legend=False*, *style=None*, *logx=False*, *logy=False*, *loglog=False*, *xticks=None*, *yticks=None*, *xlim=None*, *ylim=None*, *rot=None*, *fontsize=None*, *colormap=None*, *table=False*, *yerr=None*, *xerr=None*, *label=None*, *secondary_y=False*, ***kwds*)

Make plots of Series using matplotlib / pylab.

New in version 0.17.0: Each plot kind has a corresponding method on the `Series.plot` accessor: `s.plot(kind='line')` is equivalent to `s.plot.line()`.

Parameters **data** : Series

kind : str

- 'line' : line plot (default)
- 'bar' : vertical bar plot
- 'barh' : horizontal bar plot
- 'hist' : histogram
- 'box' : boxplot
- 'kde' : Kernel Density Estimation plot
- 'density' : same as 'kde'
- 'area' : area plot
- 'pie' : pie plot

ax : matplotlib axes object

If not passed, uses gca()

figsize : a tuple (width, height) in inches

use_index : boolean, default True

Use index as ticks for x axis

title : string or list

Title to use for the plot. If a string is passed, print the string at the top of the figure. If a list is passed and *subplots* is True, print each item in the list above the corresponding subplot.

grid : boolean, default None (matlab style default)

Axis grid lines

legend : False/True/'reverse'

Place legend on axis subplots

style : list or dict

matplotlib line style per column

logx : boolean, default False

Use log scaling on x axis

logy : boolean, default False

Use log scaling on y axis

loglog : boolean, default False

Use log scaling on both x and y axes

xticks : sequence

Values to use for the xticks

yticks : sequence

Values to use for the yticks

xlim : 2-tuple/list

ylim : 2-tuple/list

rot : int, default None

Rotation for ticks (xticks for vertical, yticks for horizontal plots)

fontsize : int, default None

Font size for xticks and yticks

colormap : str or matplotlib colormap object, default None

Colormap to select colors from. If string, load colormap with that name from matplotlib.

colorbar : boolean, optional

If True, plot colorbar (only relevant for 'scatter' and 'hexbin' plots)

position : float

Specify relative alignments for bar plot layout. From 0 (left/bottom-end) to 1 (right/top-end). Default is 0.5 (center)

table : boolean, Series or DataFrame, default False

If True, draw a table using the data in the DataFrame and the data will be transposed to meet matplotlib's default layout. If a Series or DataFrame is passed, use passed data to draw a table.

yerr : DataFrame, Series, array-like, dict and str

See *Plotting with Error Bars* for detail.

xerr : same types as yerr.

label : label argument to provide to plot

secondary_y : boolean or sequence of ints, default False

If True then y-axis will be on the right

mark_right : boolean, default True

When using a secondary_y axis, automatically mark the column labels with "(right)" in the legend

kwds : keywords

Options to pass to matplotlib plotting method

Returns axes : matplotlib.AxesSubplot or np.array of them

Notes

- See matplotlib documentation online for more on this subject
- If *kind* = 'bar' or 'barh', you can specify relative alignments for bar plot layout by *position* keyword. From 0 (left/bottom-end) to 1 (right/top-end). Default is 0.5 (center)

pandas.Series.pop

`Series.pop(item)`

Return item and drop from frame. Raise KeyError if not found.

Parameters item : str

Column label to be popped

Returns popped : Series

Examples

```
>>> df = pd.DataFrame([('falcon', 'bird',    389.0),
...                    ('parrot', 'bird',     24.0),
...                    ('lion',   'mammal',   80.5),
...                    ('monkey', 'mammal', np.nan)],
...                   columns=('name', 'class', 'max_speed'))
>>> df
     name   class  max_speed
0  falcon    bird      389.0
1  parrot    bird       24.0
2    lion  mammal       80.5
3  monkey  mammal        NaN
```

```
>>> df.pop('class')
0      bird
1      bird
2    mammal
3    mammal
Name: class, dtype: object
```

```
>>> df
     name  max_speed
0  falcon      389.0
1  parrot       24.0
```

```
2    lion       80.5
3  monkey        NaN
```

pandas.Series.pow

`Series.pow`(*other*, *level=None*, *fill_value=None*, *axis=0*)

Exponential power of series and other, element-wise (binary operator *pow*).

Equivalent to `series ** other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.rpow

pandas.Series.prod

`Series.prod`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the product of the values for the requested axis

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **prod** : scalar or Series (if level specified)

pandas.Series.product

`Series.product`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the product of the values for the requested axis

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **prod** : scalar or Series (if level specified)

pandas.Series.ptp

`Series.ptp(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

Returns the difference between the maximum value and the minimum value in the object. This is the equivalent of the `numpy.ndarray` method `ptp`.

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **ptp** : scalar or Series (if level specified)

pandas.Series.put

`Series.put(*args, **kwargs)`

Applies the *put* method to its *values* attribute if it has one.

See also:

`numpy.ndarray.put`

pandas.Series.quantile

`Series.quantile(q=0.5, interpolation='linear')`

Return value at the given quantile, a la numpy.percentile.

Parameters **q** : float or array-like, default 0.5 (50% quantile)

0 <= q <= 1, the quantile(s) to compute

interpolation : {'linear', 'lower', 'higher', 'midpoint', 'nearest'}

New in version 0.18.0.

This optional parameter specifies the interpolation method to use, when the desired quantile lies between two data points *i* and *j*:

- linear: *i + (j - i) * fraction*, where *fraction* is the fractional part of the index surrounded by *i* and *j*.
- lower: *i*.
- higher: *j*.
- nearest: *i* or *j* whichever is nearest.
- midpoint: (*i* + *j*) / 2.

Returns **quantile** : float or Series

if `q` is an array, a Series will be returned where the index is `q` and the values are the quantiles.

Examples

```
>>> s = Series([1, 2, 3, 4])
>>> s.quantile(.5)
2.5
>>> s.quantile([.25, .5, .75])
0.25    1.75
0.50    2.50
0.75    3.25
dtype: float64
```

pandas.Series.radd

`Series.`**`radd`**(*other*, *level=None*, *fill_value=None*, *axis=0*)

Addition of series and other, element-wise (binary operator *radd*).

Equivalent to `other + series`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

`Series.add`

pandas.Series.rank

`Series.rank(axis=0, method='average', numeric_only=None, na_option='keep', ascending=True, pct=False)`

Compute numerical data ranks (1 through n) along axis. Equal values are assigned a rank that is the average of the ranks of those values

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

index to direct ranking

method : {'average', 'min', 'max', 'first', 'dense'}

- average: average rank of group
- min: lowest rank in group
- max: highest rank in group
- first: ranks assigned in order they appear in the array
- dense: like 'min', but rank always increases by 1 between groups

numeric_only : boolean, default None

Include only float, int, boolean data. Valid only for DataFrame or Panel objects

na_option : {'keep', 'top', 'bottom'}

- keep: leave NA values where they are
- top: smallest rank if ascending
- bottom: smallest rank if descending

ascending : boolean, default True

False for ranks by high (1) to low (N)

pct : boolean, default False

Computes percentage rank of data

Returns **ranks** : same type as caller

pandas.Series.ravel

`Series.ravel(order='C')`

Return the flattened underlying data as an ndarray

See also:

`numpy.ndarray.ravel`

pandas.Series.rdiv

`Series.rdiv(other, level=None, fill_value=None, axis=0)`

Floating division of series and other, element-wise (binary operator *rtruediv*).

Equivalent to `other / series`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.truediv

pandas.Series.reindex

`Series.reindex(index=None, **kwargs)`

Conform Series to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index. A new object is produced unless the new index is equivalent to the current one and copy=False

Parameters **index** : array-like, optional (should be specified using keywords)

New labels / index to conform to. Preferably an Index object to avoid duplicating data

method : {None, 'backfill'/'bfill', 'pad'/'ffill', 'nearest'}, optional

method to use for filling holes in reindexed DataFrame. Please note: this is only applicable to DataFrames/Series with a monotonically increasing/decreasing index.

- default: don't fill gaps
- pad / ffill: propagate last valid observation forward to next valid
- backfill / bfill: use next valid observation to fill gap
- nearest: use nearest valid observations to fill gap

copy : boolean, default True

Return a new object, even if the passed indexes are the same

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

fill_value : scalar, default np.NaN

Value to use for missing values. Defaults to NaN, but can be any "compatible" value

limit : int, default None

Maximum number of consecutive elements to forward or backward fill

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array,

Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns reindexed : Series

Examples

`DataFrame.reindex` supports two calling conventions

- `(index=index_labels, columns=column_labels, ...)`
- `(labels, axis={'index', 'columns'}, ...)`

We *highly* recommend using keyword arguments to clarify your intent.

Create a dataframe with some fictional data.

```
>>> index = ['Firefox', 'Chrome', 'Safari', 'IE10', 'Konqueror']
>>> df = pd.DataFrame({
...      'http_status': [200,200,404,404,301],
...      'response_time': [0.04, 0.02, 0.07, 0.08, 1.0]},
...       index=index)
>>> df
           http_status  response_time
Firefox            200           0.04
Chrome             200           0.02
Safari             404           0.07
IE10               404           0.08
Konqueror          301           1.00
```

Create a new index and reindex the dataframe. By default values in the new index that do not have corresponding records in the dataframe are assigned `NaN`.

```
>>> new_index= ['Safari', 'Iceweasel', 'Comodo Dragon', 'IE10',
...              'Chrome']
>>> df.reindex(new_index)
               http_status  response_time
Safari               404.0           0.07
Iceweasel              NaN            NaN
Comodo Dragon          NaN            NaN
IE10                 404.0           0.08
Chrome               200.0           0.02
```

We can fill in the missing values by passing a value to the keyword `fill_value`. Because the index is not monotonically increasing or decreasing, we cannot use arguments to the keyword `method` to fill the `NaN` values.

```
>>> df.reindex(new_index, fill_value=0)
               http_status  response_time
Safari                 404           0.07
Iceweasel                0           0.00
Comodo Dragon            0           0.00
IE10                   404           0.08
Chrome                 200           0.02
```

```
>>> df.reindex(new_index, fill_value='missing')
              http_status response_time
Safari                404          0.07
Iceweasel         missing       missing
Comodo Dragon     missing       missing
IE10                  404          0.08
Chrome                200          0.02
```

We can also reindex the columns.

```
>>> df.reindex(columns=['http_status', 'user_agent'])
           http_status  user_agent
Firefox            200         NaN
Chrome             200         NaN
Safari             404         NaN
IE10               404         NaN
Konqueror          301         NaN
```

Or we can use "axis-style" keyword arguments

```
>>> df.reindex(['http_status', 'user_agent'], axis="columns")
           http_status  user_agent
Firefox            200         NaN
Chrome             200         NaN
Safari             404         NaN
IE10               404         NaN
Konqueror          301         NaN
```

To further illustrate the filling functionality in `reindex`, we will create a dataframe with a monotonically increasing index (for example, a sequence of dates).

```
>>> date_index = pd.date_range('1/1/2010', periods=6, freq='D')
>>> df2 = pd.DataFrame({"prices": [100, 101, np.nan, 100, 89, 88]},
...                    index=date_index)
>>> df2
            prices
2010-01-01     100
2010-01-02     101
2010-01-03     NaN
2010-01-04     100
2010-01-05      89
2010-01-06      88
```

Suppose we decide to expand the dataframe to cover a wider date range.

```
>>> date_index2 = pd.date_range('12/29/2009', periods=10, freq='D')
>>> df2.reindex(date_index2)
            prices
2009-12-29     NaN
2009-12-30     NaN
2009-12-31     NaN
2010-01-01     100
2010-01-02     101
2010-01-03     NaN
2010-01-04     100
2010-01-05      89
2010-01-06      88
2010-01-07     NaN
```

The index entries that did not have a value in the original data frame (for example, '2009-12-29') are by default filled with NaN. If desired, we can fill in the missing values using one of several options.

For example, to backpropagate the last valid value to fill the NaN values, pass bfill as an argument to the method keyword.

```
>>> df2.reindex(date_index2, method='bfill')
            prices
2009-12-29     100
2009-12-30     100
2009-12-31     100
2010-01-01     100
2010-01-02     101
2010-01-03     NaN
2010-01-04     100
2010-01-05      89
2010-01-06      88
2010-01-07     NaN
```

Please note that the NaN value present in the original dataframe (at index value 2010-01-03) will not be filled by any of the value propagation schemes. This is because filling while reindexing does not look at dataframe values, but only compares the original and desired indexes. If you do want to fill in the NaN values present in the original dataframe, use the fillna() method.

See the *user guide* for more.

pandas.Series.reindex_axis

`Series.`**`reindex_axis`**(*labels*, *axis=0*, ***kwargs*)

for compatibility with higher dims

pandas.Series.reindex_like

`Series.`**`reindex_like`**(*other*, *method=None*, *copy=True*, *limit=None*, *tolerance=None*)

Return an object with matching indices to myself.

Parameters **other** : Object

method : string or None

copy : boolean, default True

limit : int, default None

Maximum number of consecutive labels to fill for inexact matches.

tolerance : optional

Maximum distance between labels of the other object and this object for inexact matches. Can be list-like.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **reindexed** : same as input

Notes

Like calling s.reindex(index=other.index, columns=other.columns, method=...)

pandas.Series.rename

`Series.rename(index=None, **kwargs)`

Alter Series index labels or name

Function / dict values must be unique (1-to-1). Labels not contained in a dict / Series will be left as-is. Extra labels listed don't throw an error.

Alternatively, change `Series.name` with a scalar value.

See the *user guide* for more.

Parameters **index** : scalar, hashable sequence, dict-like or function, optional

dict-like or functions are transformations to apply to the index. Scalar or hashable sequence-like will alter the `Series.name` attribute.

copy : boolean, default True

Also copy underlying data

inplace : boolean, default False

Whether to return a new %(klass)s. If True then value of copy is ignored.

level : int or level name, default None

In case of a MultiIndex, only rename labels in the specified level.

Returns **renamed** : Series (new object)

See also:

pandas.Series.rename_axis

Examples

```
>>> s = pd.Series([1, 2, 3])
>>> s
0    1
1    2
2    3
dtype: int64
>>> s.rename("my_name") # scalar, changes Series.name
0    1
1    2
2    3
Name: my_name, dtype: int64
>>> s.rename(lambda x: x ** 2)  # function, changes labels
0    1
1    2
4    3
dtype: int64
>>> s.rename({1: 3, 2: 5})  # mapping, changes labels
0    1
3    2
```

```
5    3
dtype: int64
```

pandas.Series.rename_axis

`Series.rename_axis(mapper, axis=0, copy=True, inplace=False)`

Alter the name of the index or columns.

Parameters **mapper** : scalar, list-like, optional

Value to set the axis name attribute.

axis : int or string, default 0

copy : boolean, default True

Also copy underlying data

inplace : boolean, default False

Returns **renamed** : type of caller or None if inplace=True

See also:

pandas.Series.rename, *pandas.DataFrame.rename*, *pandas.Index.rename*

Notes

Prior to version 0.21.0, `rename_axis` could also be used to change the axis *labels* by passing a mapping or scalar. This behavior is deprecated and will be removed in a future version. Use `rename` instead.

Examples

```
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.rename_axis("foo")
     A  B
foo
0    1  4
1    2  5
2    3  6
```

```
>>> df.rename_axis("bar", axis="columns")
bar  A  B
0    1  4
1    2  5
2    3  6
```

pandas.Series.reorder_levels

`Series.reorder_levels(order)`

Rearrange index levels using input order. May not drop or duplicate levels

Parameters **order** : list of int representing new level order.

(reference level by number or key)

axis : where to reorder levels

Returns type of caller (new object)

pandas.Series.repeat

`Series.repeat(repeats, *args, **kwargs)`

Repeat elements of an Series. Refer to *numpy.ndarray.repeat* for more information about the *repeats* argument.

See also:

`numpy.ndarray.repeat`

pandas.Series.replace

`Series.replace(to_replace=None, value=None, inplace=False, limit=None, regex=False, method='pad', axis=None)`

Replace values given in 'to_replace' with 'value'.

Parameters **to_replace** : str, regex, list, dict, Series, numeric, or None

- str or regex:
  - str: string exactly matching *to_replace* will be replaced with *value*
  - regex: regexs matching *to_replace* will be replaced with *value*
- list of str, regex, or numeric:
  - First, if *to_replace* and *value* are both lists, they **must** be the same length.
  - Second, if `regex=True` then all of the strings in **both** lists will be interpreted as regexs otherwise they will match directly. This doesn't matter much for *value* since there are only a few possible substitution regexes you can use.
  - str and regex rules apply as above.
- dict:
  - Nested dictionaries, e.g., {'a': {'b': nan}}, are read as follows: look in column 'a' for the value 'b' and replace it with nan. You can nest regular expressions as well. Note that column names (the top-level dictionary keys in a nested dictionary) **cannot** be regular expressions.
  - Keys map to column names and values map to substitution values. You can treat this as a special case of passing two lists except that you are specifying the column to search in.
- None:
  - This means that the `regex` argument must be a string, compiled regular expression, or list, dict, ndarray or Series of such elements. If *value* is also `None` then this **must** be a nested dictionary or `Series`.

See the examples section for examples of each of these.

value : scalar, dict, list, str, regex, default None

Value to use to fill holes (e.g. 0), alternately a dict of values specifying which value to use for each column (columns not in the dict will not be filled). Regular expressions, strings and lists or dicts of such objects are also allowed.

inplace : boolean, default False

If True, in place. Note: this will modify any other views on this object (e.g. a column from a DataFrame). Returns the caller if this is True.

limit : int, default None

Maximum size gap to forward or backward fill

regex : bool or same types as *to_replace*, default False

Whether to interpret *to_replace* and/or *value* as regular expressions. If this is `True` then *to_replace must* be a string. Otherwise, *to_replace* must be `None` because this parameter will be interpreted as a regular expression or a list, dict, or array of regular expressions.

method : string, optional, {'pad', 'ffill', 'bfill'}

The method to use when for replacement, when `to_replace` is a `list`.

Returns filled : NDFrame

Raises AssertionError

- If *regex* is not a `bool` and *to_replace* is not `None`.

TypeError

- If *to_replace* is a `dict` and *value* is not a `list`, `dict`, `ndarray`, or `Series`
- If *to_replace* is `None` and *regex* is not compilable into a regular expression or is a list, dict, ndarray, or Series.

ValueError

- If *to_replace* and *value* are `list` s or `ndarray` s, but they are not the same length.

See also:

`NDFrame.reindex`, `NDFrame.asfreq`, `NDFrame.fillna`

Notes

- Regex substitution is performed under the hood with `re.sub`. The rules for substitution for `re.sub` are the same.
- Regular expressions will only substitute on strings, meaning you cannot provide, for example, a regular expression matching floating point numbers and expect the columns in your frame that have a numeric dtype to be matched. However, if those floating point numbers *are* strings, then you can do this.
- This method has *a lot* of options. You are encouraged to experiment and play with this method to gain intuition about how it works.

pandas.Series.resample

`Series.resample(rule, how=None, axis=0, fill_method=None, closed=None, label=None, convention='start', kind=None, loffset=None, limit=None, base=0, on=None, level=None)`

Convenience method for frequency conversion and resampling of time series. Object must have a datetime-like index (DatetimeIndex, PeriodIndex, or TimedeltaIndex), or pass datetime-like values to the on or level keyword.

Parameters **rule** : string

the offset string or object representing target conversion

axis : int, optional, default 0

closed : {'right', 'left'}

Which side of bin interval is closed. The default is 'left' for all frequency offsets except for 'M', 'A', 'Q', 'BM', 'BA', 'BQ', and 'W' which all have a default of 'right'.

label : {'right', 'left'}

Which bin edge label to label bucket with. The default is 'left' for all frequency offsets except for 'M', 'A', 'Q', 'BM', 'BA', 'BQ', and 'W' which all have a default of 'right'.

convention : {'start', 'end', 's', 'e'}

For PeriodIndex only, controls whether to use the start or end of *rule*

loffset : timedelta

Adjust the resampled time labels

base : int, default 0

For frequencies that evenly subdivide 1 day, the "origin" of the aggregated intervals. For example, for '5min' frequency, base could range from 0 through 4. Defaults to 0

on : string, optional

For a DataFrame, column to use instead of index for resampling. Column must be datetime-like.

New in version 0.19.0.

level : string or int, optional

For a MultiIndex, level (name or number) to use for resampling. Level must be datetime-like.

New in version 0.19.0.

Notes

To learn more about the offset strings, please see this link.

Examples

Start by creating a series with 9 one minute timestamps.

```
>>> index = pd.date_range('1/1/2000', periods=9, freq='T')
>>> series = pd.Series(range(9), index=index)
>>> series
2000-01-01 00:00:00    0
2000-01-01 00:01:00    1
2000-01-01 00:02:00    2
2000-01-01 00:03:00    3
2000-01-01 00:04:00    4
2000-01-01 00:05:00    5
2000-01-01 00:06:00    6
2000-01-01 00:07:00    7
2000-01-01 00:08:00    8
Freq: T, dtype: int64
```

Downsample the series into 3 minute bins and sum the values of the timestamps falling into a bin.

```
>>> series.resample('3T').sum()
2000-01-01 00:00:00     3
2000-01-01 00:03:00    12
2000-01-01 00:06:00    21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but label each bin using the right edge instead of the left. Please note that the value in the bucket used as the label is not included in the bucket, which it labels. For example, in the original series the bucket `2000-01-01 00:03:00` contains the value 3, but the summed value in the resampled bucket with the label `2000-01-01 00:03:00` does not include 3 (if it did, the summed value would be 6, not 3). To include this value close the right side of the bin interval as illustrated in the example below this one.

```
>>> series.resample('3T', label='right').sum()
2000-01-01 00:03:00     3
2000-01-01 00:06:00    12
2000-01-01 00:09:00    21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but close the right side of the bin interval.

```
>>> series.resample('3T', label='right', closed='right').sum()
2000-01-01 00:00:00     0
2000-01-01 00:03:00     6
2000-01-01 00:06:00    15
2000-01-01 00:09:00    15
Freq: 3T, dtype: int64
```

Upsample the series into 30 second bins.

```
>>> series.resample('30S').asfreq()[0:5] #select first 5 rows
2000-01-01 00:00:00   0.0
2000-01-01 00:00:30   NaN
2000-01-01 00:01:00   1.0
2000-01-01 00:01:30   NaN
2000-01-01 00:02:00   2.0
Freq: 30S, dtype: float64
```

Upsample the series into 30 second bins and fill the `NaN` values using the `pad` method.

```
>>> series.resample('30S').pad()[0:5]
2000-01-01 00:00:00    0
2000-01-01 00:00:30    0
2000-01-01 00:01:00    1
2000-01-01 00:01:30    1
2000-01-01 00:02:00    2
Freq: 30S, dtype: int64
```

Upsample the series into 30 second bins and fill the `NaN` values using the `bfill` method.

```
>>> series.resample('30S').bfill()[0:5]
2000-01-01 00:00:00    0
2000-01-01 00:00:30    1
2000-01-01 00:01:00    1
2000-01-01 00:01:30    2
2000-01-01 00:02:00    2
Freq: 30S, dtype: int64
```

Pass a custom function via `apply`

```
>>> def custom_resampler(array_like):
...     return np.sum(array_like)+5
```

```
>>> series.resample('3T').apply(custom_resampler)
2000-01-01 00:00:00     8
2000-01-01 00:03:00    17
2000-01-01 00:06:00    26
Freq: 3T, dtype: int64
```

For a Series with a PeriodIndex, the keyword *convention* can be used to control whether to use the start or end of *rule*.

```
>>> s = pd.Series([1, 2], index=pd.period_range('2012-01-01',
                                                 freq='A',
                                                 periods=2))
>>> s
2012    1
2013    2
Freq: A-DEC, dtype: int64
```

Resample by month using 'start' *convention*. Values are assigned to the first month of the period.

```
>>> s.resample('M', convention='start').asfreq().head()
2012-01    1.0
2012-02    NaN
2012-03    NaN
2012-04    NaN
2012-05    NaN
Freq: M, dtype: float64
```

Resample by month using 'end' *convention*. Values are assigned to the last month of the period.

```
>>> s.resample('M', convention='end').asfreq()
2012-12    1.0
2013-01    NaN
2013-02    NaN
```

```
2013-03    NaN
2013-04    NaN
2013-05    NaN
2013-06    NaN
2013-07    NaN
2013-08    NaN
2013-09    NaN
2013-10    NaN
2013-11    NaN
2013-12    2.0
Freq: M, dtype: float64
```

For DataFrame objects, the keyword `on` can be used to specify the column instead of the index for resampling.

```
>>> df = pd.DataFrame(data=9*[range(4)], columns=['a', 'b', 'c', 'd'])
>>> df['time'] = pd.date_range('1/1/2000', periods=9, freq='T')
>>> df.resample('3T', on='time').sum()
                     a  b  c  d
time
2000-01-01 00:00:00  0  3  6  9
2000-01-01 00:03:00  0  3  6  9
2000-01-01 00:06:00  0  3  6  9
```

For a DataFrame with MultiIndex, the keyword `level` can be used to specify on level the resampling needs to take place.

```
>>> time = pd.date_range('1/1/2000', periods=5, freq='T')
>>> df2 = pd.DataFrame(data=10*[range(4)],
                       columns=['a', 'b', 'c', 'd'],
                       index=pd.MultiIndex.from_product([time, [1, 2]])
                       )
>>> df2.resample('3T', level=0).sum()
                     a  b   c   d
2000-01-01 00:00:00  0  6  12  18
2000-01-01 00:03:00  0  4   8  12
```

pandas.Series.reset_index

`Series.reset_index`(*level=None*, *drop=False*, *name=None*, *inplace=False*)

Analogous to the *`pandas.DataFrame.reset_index()`* function, see docstring there.

Parameters **level** : int, str, tuple, or list, default None

Only remove the given levels from the index. Removes all levels by default

drop : boolean, default False

Do not try to insert index into dataframe columns

name : object, default None

The name of the column corresponding to the Series values

inplace : boolean, default False

Modify the Series in place (do not create a new object)

Returns **resetted** : DataFrame, or Series if drop == True

Examples

```
>>> s = pd.Series([1, 2, 3, 4], index=pd.Index(['a', 'b', 'c', 'd'],
...                                            name = 'idx'))
>>> s.reset_index()
   index  0
0      0  1
1      1  2
2      2  3
3      3  4
```

```
>>> arrays = [np.array(['bar', 'bar', 'baz', 'baz', 'foo',
...                     'foo', 'qux', 'qux']),
...           np.array(['one', 'two', 'one', 'two', 'one', 'two',
...                     'one', 'two'])]
>>> s2 = pd.Series(
...     np.random.randn(8),
...     index=pd.MultiIndex.from_arrays(arrays,
...                                     names=['a', 'b']))
>>> s2.reset_index(level='a')
       a         0
b
one  bar -0.286320
two  bar -0.587934
one  baz  0.710491
two  baz -1.429006
one  foo  0.790700
two  foo  0.824863
one  qux -0.718963
two  qux -0.055028
```

pandas.Series.reshape

`Series.reshape`(**args*, ***kwargs*)

Deprecated since version 0.19.0: Calling this method will raise an error. Please call `.values.reshape(...)` instead.

return an ndarray with the values shape if the specified shape matches exactly the current shape, then return self (for compat)

See also:

`numpy.ndarray.reshape`

pandas.Series.rfloordiv

`Series.rfloordiv`(*other*, *level=None*, *fill_value=None*, *axis=0*)

Integer division of series and other, element-wise (binary operator *rfloordiv*).

Equivalent to `other // series`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns result : Series

See also:

Series.floordiv

pandas.Series.rmod

`Series.rmod(other, level=None, fill_value=None, axis=0)`

Modulo of series and other, element-wise (binary operator *rmod*).

Equivalent to `other % series`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters other : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns result : Series

See also:

Series.mod

pandas.Series.rmul

`Series.rmul(other, level=None, fill_value=None, axis=0)`

Multiplication of series and other, element-wise (binary operator *rmul*).

Equivalent to `other * series`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters other : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns result : Series

See also:

Series.mul

pandas.Series.rolling

`Series.rolling(window, min_periods=None, freq=None, center=False, win_type=None, on=None, axis=0, closed=None)`

Provides rolling window calculations.

New in version 0.18.0.

Parameters **window** : int, or offset

Size of the moving window. This is the number of observations used for calculating the statistic. Each window will be a fixed size.

If its an offset then this will be the time period of each window. Each window will be a variable sized based on the observations included in the time-period. This is only valid for datetimelike indexes. This is new in 0.19.0

min_periods : int, default None

Minimum number of observations in window required to have a value (otherwise result is NA). For a window that is specified by an offset, this will default to 1.

freq : string or DateOffset object, optional (default None)

Deprecated since version 0.18.0: Frequency to conform the data to before computing the statistic. Specified as a frequency string or DateOffset object.

center : boolean, default False

Set the labels at the center of the window.

win_type : string, default None

Provide a window type. See the notes below.

on : string, optional

For a DataFrame, column on which to calculate the rolling window, rather than the index

closed : string, default None

Make the interval closed on the 'right', 'left', 'both' or 'neither' endpoints. For offset-based windows, it defaults to 'right'. For fixed windows, defaults to 'both'. Remaining cases not implemented for fixed windows.

New in version 0.20.0.

axis : int or string, default 0

Returns a Window or Rolling sub-classed for the particular operation

Notes

By default, the result is set to the right edge of the window. This can be changed to the center of the window by setting `center=True`.

The *freq* keyword is used to conform time series data to a specified frequency by resampling the data. This is done with the default parameters of `resample()` (i.e. using the *mean*).

To learn more about the offsets & frequency strings, please see this link.

The recognized win_types are:

- `boxcar`
- `triang`
- `blackman`
- `hamming`
- `bartlett`
- `parzen`
- `bohman`
- `blackmanharris`
- `nuttall`
- `barthann`
- `kaiser` (needs beta)
- `gaussian` (needs std)
- `general_gaussian` (needs power, width)
- `slepian` (needs width).

Examples

```
>>> df = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]})
>>> df
     B
0  0.0
1  1.0
2  2.0
3  NaN
4  4.0
```

Rolling sum with a window length of 2, using the 'triang' window type.

```
>>> df.rolling(2, win_type='triang').sum()
     B
0  NaN
1  1.0
2  2.5
3  NaN
4  NaN
```

Rolling sum with a window length of 2, min_periods defaults to the window length.

```
>>> df.rolling(2).sum()
     B
0  NaN
1  1.0
2  3.0
3  NaN
4  NaN
```

Same as above, but explicity set the min_periods

```
>>> df.rolling(2, min_periods=1).sum()
     B
0  0.0
1  1.0
2  3.0
3  2.0
4  4.0
```

A ragged (meaning not-a-regular frequency), time-indexed DataFrame

```
>>> df = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]},
....:                 index = [pd.Timestamp('20130101 09:00:00'),
....:                          pd.Timestamp('20130101 09:00:02'),
....:                          pd.Timestamp('20130101 09:00:03'),
....:                          pd.Timestamp('20130101 09:00:05'),
....:                          pd.Timestamp('20130101 09:00:06')])
```

```
>>> df
                      B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  2.0
2013-01-01 09:00:05  NaN
2013-01-01 09:00:06  4.0
```

Contrasting to an integer rolling window, this will roll a variable length window corresponding to the time period. The default for min_periods is 1.

```
>>> df.rolling('2s').sum()
                      B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  3.0
2013-01-01 09:00:05  NaN
2013-01-01 09:00:06  4.0
```

pandas.Series.round

`Series.round`(*decimals=0*, **args*, ***kwargs*)

Round each value in a Series to the given number of decimals.

Parameters **decimals** : int

Number of decimal places to round to (default: 0). If decimals is negative, it specifies the number of positions to the left of the decimal point.

Returns Series object

See also:

`numpy.around`, *`DataFrame.round`*

pandas.Series.rpow

`Series.rpow`(*other*, *level=None*, *fill_value=None*, *axis=0*)

Exponential power of series and other, element-wise (binary operator *rpow*).

Equivalent to `other ** series`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.pow

pandas.Series.rsub

`Series.rsub(other, level=None, fill_value=None, axis=0)`

Subtraction of series and other, element-wise (binary operator *rsub*).

Equivalent to `other - series`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.sub

pandas.Series.rtruediv

`Series.rtruediv(other, level=None, fill_value=None, axis=0)`

Floating division of series and other, element-wise (binary operator *rtruediv*).

Equivalent to `other / series`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.truediv

pandas.Series.sample

`Series.sample(n=None, frac=None, replace=False, weights=None, random_state=None, axis=None)`

Returns a random sample of items from an axis of object.

Parameters **n** : int, optional

Number of items from axis to return. Cannot be used with *frac*. Default = 1 if *frac* = None.

frac : float, optional

Fraction of axis items to return. Cannot be used with *n*.

replace : boolean, optional

Sample with or without replacement. Default = False.

weights : str or ndarray-like, optional

Default 'None' results in equal probability weighting. If passed a Series, will align with target object on index. Index values in weights not found in sampled object will be ignored and index values in sampled object not in weights will be assigned weights of zero. If called on a DataFrame, will accept the name of a column when axis = 0. Unless weights are a Series, weights must be same length as axis being sampled. If weights do not sum to 1, they will be normalized to sum to 1. Missing values in the weights column will be treated as zero. inf and -inf values not allowed.

random_state : int or numpy.random.RandomState, optional

Seed for the random number generator (if int), or numpy RandomState object.

axis : int or string, optional

Axis to sample. Accepts axis number or name. Default is stat axis for given data type (0 for Series and DataFrames, 1 for Panels).

Returns A new object of same type as caller.

Examples

Generate an example `Series` and `DataFrame`:

```
>>> s = pd.Series(np.random.randn(50))
>>> s.head()
0   -0.038497
1    1.820773
2   -0.972766
3   -1.598270
4   -1.095526
dtype: float64
>>> df = pd.DataFrame(np.random.randn(50, 4), columns=list('ABCD'))
```

```
>>> df.head()
          A         B         C         D
0  0.016443 -2.318952 -0.566372 -1.028078
1 -1.051921  0.438836  0.658280 -0.175797
2 -1.243569 -0.364626 -0.215065  0.057736
3  1.768216  0.404512 -0.385604 -1.457834
4  1.072446 -1.137172  0.314194 -0.046661
```

Next extract a random sample from both of these objects...

3 random elements from the `Series`:

```
>>> s.sample(n=3)
27   -0.994689
55   -1.049016
67   -0.224565
dtype: float64
```

And a random 10% of the `DataFrame` with replacement:

```
>>> df.sample(frac=0.1, replace=True)
           A         B         C         D
35  1.981780  0.142106  1.817165 -0.290805
49 -1.336199 -0.448634 -0.789640  0.217116
40  0.823173 -0.078816  1.009536  1.015108
15  1.421154 -0.055301 -1.922594 -0.019696
6  -0.148339  0.832938  1.787600 -1.383767
```

pandas.Series.searchsorted

`Series.searchsorted(value, side='left', sorter=None)`

Find indices where elements should be inserted to maintain order.

Find the indices into a sorted Series *self* such that, if the corresponding elements in *value* were inserted before the indices, the order of *self* would be preserved.

Parameters **value** : array_like

Values to insert into *self*.

side : {'left', 'right'}, optional

If 'left', the index of the first suitable location found is given. If 'right', return the last such index. If there is no suitable index, return either 0 or N (where N is the length of *self*).

sorter : 1-D array_like, optional

Optional array of integer indices that sort *self* into ascending order. They are typically the result of `np.argsort`.

Returns **indices** : array of ints

Array of insertion points with the same shape as *value*.

See also:

`numpy.searchsorted`

Notes

Binary search is used to find the required insertion points.

Examples

```
>>> x = pd.Series([1, 2, 3])
>>> x
0    1
1    2
2    3
dtype: int64
```

```
>>> x.searchsorted(4)
array([3])
```

```
>>> x.searchsorted([0, 4])
array([0, 3])
```

```
>>> x.searchsorted([1, 3], side='left')
array([0, 2])
```

```
>>> x.searchsorted([1, 3], side='right')
array([1, 3])
```

```
>>> x = pd.Categorical(['apple', 'bread', 'bread', 'cheese', 'milk' ])
[apple, bread, bread, cheese, milk]
Categories (4, object): [apple < bread < cheese < milk]
```

```
>>> x.searchsorted('bread')
array([1])     # Note: an array, not a scalar
```

```
>>> x.searchsorted(['bread'])
array([1])
```

```
>>> x.searchsorted(['bread', 'eggs'])
array([1, 4])
```

```
>>> x.searchsorted(['bread', 'eggs'], side='right')
array([3, 4])    # eggs before milk
```

pandas.Series.select

`Series.select(crit, axis=0)`

Return data corresponding to axis labels matching criteria

DEPRECATED: use df.loc[df.index.map(crit)] to select via labels

Parameters **crit** : function

To be called on each index (label). Should return True or False

axis : int

Returns selection : type of caller

pandas.Series.sem

`Series.sem(axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)`

Return unbiased standard error of the mean over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters axis : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

ddof : int, default 1

degrees of freedom

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns sem : scalar or Series (if level specified)

pandas.Series.set_axis

`Series.set_axis(labels, axis=0, inplace=None)`

Assign desired index to given axis

Parameters labels: list-like or Index

The values for the new index

axis : int or string, default 0

inplace : boolean, default None

Whether to return a new NDFrame instance.

WARNING: inplace=None currently falls back to to True, but in a future version, will default to False. Use inplace=True explicitly rather than relying on the default.

.. versionadded:: 0.21.0

The signature is make consistent to the rest of the API. Previously, the "axis" and "labels" arguments were respectively the first and second positional arguments.

Returns renamed : NDFrame or None

An object of same type as caller if inplace=False, None otherwise.

See also:

`pandas.NDFrame.rename`

Examples

```
>>> s = pd.Series([1, 2, 3])
>>> s
0    1
1    2
2    3
dtype: int64
>>> s.set_axis(['a', 'b', 'c'], axis=0, inplace=False)
a    1
b    2
c    3
dtype: int64
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.set_axis(['a', 'b', 'c'], axis=0, inplace=False)
   A  B
a  1  4
b  2  5
c  3  6
>>> df.set_axis(['I', 'II'], axis=1, inplace=False)
   I  II
0  1   4
1  2   5
2  3   6
>>> df.set_axis(['i', 'ii'], axis=1, inplace=True)
>>> df
   i  ii
0  1   4
1  2   5
2  3   6
```

pandas.Series.set_value

`Series.set_value`(*label*, *value*, *takeable=False*)

Quickly set single value at passed label. If label is not contained, a new object is created with the label placed at the end of the result index

Deprecated since version 0.21.0.

Please use .at[] or .iat[] accessors.

Parameters **label** : object

Partial indexing with MultiIndex not allowed

value : object

Scalar value

takeable : interpret the index as indexers, default False

Returns **series** : Series

If label is contained, will be reference to calling Series, otherwise a new object

pandas.Series.shift

`Series.shift`(*periods=1*, *freq=None*, *axis=0*)

Shift index by desired number of periods with an optional time freq

Parameters **periods** : int

Number of periods to move, can be positive or negative

freq : DateOffset, timedelta, or time rule string, optional

Increment to use from the tseries module or time rule (e.g. 'EOM'). See Notes.

axis : {0, 'index'}

Returns **shifted** : Series

Notes

If freq is specified then the index values are shifted but the data is not realigned. That is, use freq if you would like to extend the index when shifting and preserve the original data.

pandas.Series.skew

`Series.skew`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return unbiased skew over requested axis Normalized by N-1

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **skew** : scalar or Series (if level specified)

pandas.Series.slice_shift

`Series.slice_shift`(*periods=1*, *axis=0*)

Equivalent to *shift* without copying data. The shifted data will not include the dropped periods and the shifted axis will be smaller than the original.

Parameters **periods** : int

Number of periods to move, can be positive or negative

Returns **shifted** : same type as caller

Notes

While the *slice_shift* is faster than *shift*, you may pay for it later during alignment.

pandas.Series.sort_index

`Series.sort_index(axis=0, level=None, ascending=True, inplace=False, kind='quicksort', na_position='last', sort_remaining=True)`

Sort object by labels (along an axis)

Parameters **axis** : index to direct sorting

level : int or level name or list of ints or list of level names

if not None, sort on values in specified index level(s)

ascending : boolean, default True

Sort ascending vs. descending

inplace : bool, default False

if True, perform operation in-place

kind : {'quicksort', 'mergesort', 'heapsort'}, default 'quicksort'

Choice of sorting algorithm. See also ndarray.np.sort for more information. *mergesort* is the only stable algorithm. For DataFrames, this option is only applied when sorting on a single column or label.

na_position : {'first', 'last'}, default 'last'

first puts NaNs at the beginning, *last* puts NaNs at the end. Not implemented for MultiIndex.

sort_remaining : bool, default True

if true and sorting by level and index is multilevel, sort by other levels too (in order) after sorting by specified level

Returns **sorted_obj** : Series

pandas.Series.sort_values

`Series.sort_values(axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last')`

Sort by the values along either axis

New in version 0.17.0.

Parameters **axis** : {0, 'index'}, default 0

Axis to direct sorting

ascending : bool or list of bool, default True

Sort ascending vs. descending. Specify list for multiple sort orders. If this is a list of bools, must match the length of the by.

inplace : bool, default False

if True, perform operation in-place

kind : {'quicksort', 'mergesort', 'heapsort'}, default 'quicksort'

Choice of sorting algorithm. See also ndarray.np.sort for more information. *mergesort* is the only stable algorithm. For DataFrames, this option is only applied when sorting on a single column or label.

na_position : {'first', 'last'}, default 'last'

first puts NaNs at the beginning, *last* puts NaNs at the end

Returns **sorted_obj** : Series

Examples

```
>>> df = pd.DataFrame({
...     'col1' : ['A', 'A', 'B', np.nan, 'D', 'C'],
...     'col2' : [2, 1, 9, 8, 7, 4],
...     'col3': [0, 1, 9, 4, 2, 3],
... })
>>> df
    col1 col2 col3
0   A    2    0
1   A    1    1
2   B    9    9
3   NaN  8    4
4   D    7    2
5   C    4    3
```

Sort by col1

```
>>> df.sort_values(by=['col1'])
    col1 col2 col3
0   A    2    0
1   A    1    1
2   B    9    9
5   C    4    3
4   D    7    2
3   NaN  8    4
```

Sort by multiple columns

```
>>> df.sort_values(by=['col1', 'col2'])
    col1 col2 col3
1   A    1    1
0   A    2    0
2   B    9    9
5   C    4    3
4   D    7    2
3   NaN  8    4
```

Sort Descending

```
>>> df.sort_values(by='col1', ascending=False)
    col1 col2 col3
4   D    7    2
5   C    4    3
2   B    9    9
0   A    2    0
```

```
1   A    1    1
3   NaN  8    4
```

Putting NAs first

```
>>> df.sort_values(by='col1', ascending=False, na_position='first')
    col1 col2 col3
3   NaN  8    4
4   D    7    2
5   C    4    3
2   B    9    9
0   A    2    0
1   A    1    1
```

pandas.Series.sortlevel

`Series.sortlevel`(*level=0*, *ascending=True*, *sort_remaining=True*)

DEPRECATED: use `Series.sort_index()`

Sort Series with MultiIndex by chosen level. Data will be lexicographically sorted by the chosen level followed by the other levels (in order)

Parameters **level** : int or level name, default None

ascending : bool, default True

Returns **sorted** : Series

See also:

`Series.sort_index`

pandas.Series.squeeze

`Series.squeeze`(*axis=None*)

Squeeze length 1 dimensions.

Parameters **axis** : None, integer or string axis name, optional

The axis to squeeze if 1-sized.

New in version 0.20.0.

Returns scalar if 1-sized, else original object

pandas.Series.std

`Series.std`(*axis=None*, *skipna=None*, *level=None*, *ddof=1*, *numeric_only=None*, ***kwargs*)

Return sample standard deviation over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

ddof : int, default 1

degrees of freedom

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **std** : scalar or Series (if level specified)

pandas.Series.str

`Series.str()`

Vectorized string functions for Series and Index. NAs stay NA unless handled otherwise by a particular method. Patterned after Python's string methods, with some inspiration from R's stringr package.

Examples

```
>>> s.str.split('_')
>>> s.str.replace('_', '')
```

pandas.Series.sub

`Series.sub(other, level=None, fill_value=None, axis=0)`

Subtraction of series and other, element-wise (binary operator *sub*).

Equivalent to `series - other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.rsub

pandas.Series.subtract

`Series.subtract(other, level=None, fill_value=None, axis=0)`

Subtraction of series and other, element-wise (binary operator *sub*).

Equivalent to `series - other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

Series.rsub

pandas.Series.sum

`Series.sum`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the sum of the values for the requested axis

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **sum** : scalar or Series (if level specified)

pandas.Series.swapaxes

`Series.swapaxes`(*axis1*, *axis2*, *copy=True*)

Interchange axes and swap values axes appropriately

Returns **y** : same as input

pandas.Series.swaplevel

`Series.swaplevel`(*i=-2*, *j=-1*, *copy=True*)

Swap levels i and j in a MultiIndex

Parameters **i, j** : int, string (can be mixed)

Level of index to be swapped. Can pass level name as string.

Returns swapped : Series

Changed in version 0.18.1: The indexes `i` and `j` are now optional, and default to the two innermost levels of the index.

pandas.Series.tail

`Series.tail(n=5)`

Return the last n rows.

Parameters n : int, default 5

Number of rows to select.

Returns obj_tail : type of caller

The last n rows of the caller object.

pandas.Series.take

`Series.take(indices, axis=0, convert=None, is_copy=True, **kwargs)`

Return the elements in the given *positional* indices along an axis.

This means that we are not indexing according to actual values in the index attribute of the object. We are indexing according to the actual position of the element in the object.

Parameters indices : array-like

An array of ints indicating which positions to take.

axis : int, default 0

The axis on which to select elements. "0" means that we are selecting rows, "1" means that we are selecting columns, etc.

convert : bool, default True

Deprecated since version 0.21.0: In the future, negative indices will always be converted.

Whether to convert negative indices into positive ones. For example, `-1` would map to the `len(axis) - 1`. The conversions are similar to the behavior of indexing a regular Python list.

is_copy : bool, default True

Whether to return a copy of the original object or not.

Returns taken : type of caller

An array-like containing the elements taken from the object.

See also:

`numpy.ndarray.take`, `numpy.take`

Examples

```
>>> df = pd.DataFrame([('falcon', 'bird',    389.0),
                       ('parrot', 'bird',     24.0),
                       ('lion',   'mammal',   80.5),
                       ('monkey', 'mammal', np.nan)],
                      columns=('name', 'class', 'max_speed'),
                      index=[0, 2, 3, 1])
>>> df
     name   class  max_speed
0  falcon    bird      389.0
2  parrot    bird       24.0
3    lion  mammal       80.5
1  monkey  mammal        NaN
```

Take elements at positions 0 and 3 along the axis 0 (default).

Note how the actual indices selected (0 and 1) do not correspond to our selected indices 0 and 3. That's because we are selecting the 0th and 3rd rows, not rows whose indices equal 0 and 3.

```
>>> df.take([0, 3])
0  falcon    bird      389.0
1  monkey  mammal        NaN
```

Take elements at indices 1 and 2 along the axis 1 (column selection).

```
>>> df.take([1, 2], axis=1)
    class  max_speed
0    bird      389.0
2    bird       24.0
3  mammal       80.5
1  mammal        NaN
```

We may take elements using negative integers for positive indices, starting from the end of the object, just like with Python lists.

```
>>> df.take([-1, -2])
     name   class  max_speed
1  monkey  mammal        NaN
3    lion  mammal       80.5
```

pandas.Series.to_clipboard

`Series.to_clipboard`(*excel=None*, *sep=None*, ***kwargs*)

Attempt to write text representation of object to the system clipboard This can be pasted into Excel, for example.

Parameters **excel** : boolean, defaults to True

if True, use the provided separator, writing in a csv format for allowing easy pasting into excel. if False, write a string representation of the object to the clipboard

sep : optional, defaults to tab

other keywords are passed to to_csv

Notes

Requirements for your platform

- Linux: xclip, or xsel (with gtk or PyQt4 modules)
- Windows: none
- OS X: none

pandas.Series.to_csv

`Series.to_csv`(*path=None*, *index=True*, *sep=',', na_rep='', float_format=None*, *header=False*, *index_label=None*, *mode='w'*, *encoding=None*, *date_format=None*, *decimal='.'*)

Write Series to a comma-separated values (csv) file

Parameters **path** : string or file handle, default None

File path or object, if None is provided the result is returned as a string.

na_rep : string, default ''

Missing data representation

float_format : string, default None

Format string for floating point numbers

header : boolean, default False

Write out series name

index : boolean, default True

Write row names (index)

index_label : string or sequence, default None

Column label for index column(s) if desired. If None is given, and *header* and *index* are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

mode : Python write mode, default 'w'

sep : character, default ","

Field delimiter for the output file.

encoding : string, optional

a string representing the encoding to use if the contents are non-ascii, for python versions prior to 3

date_format: string, default None

Format string for datetime objects.

decimal: string, default '.'

Character recognized as decimal separator. E.g. use ',' for European data

pandas.Series.to_dense

`Series.to_dense()`

Return dense representation of NDFrame (as opposed to sparse)

pandas.Series.to_dict

`Series.to_dict(into=<class 'dict'>)`

Convert Series to {label -> value} dict or dict-like object.

Parameters **into** : class, default dict

The collections.Mapping subclass to use as the return object. Can be the actual class or an empty instance of the mapping type you want. If you want a collections.defaultdict, you must pass it initialized.

New in version 0.21.0.

Returns **value_dict** : collections.Mapping

Examples

```
>>> s = pd.Series([1, 2, 3, 4])
>>> s.to_dict()
{0: 1, 1: 2, 2: 3, 3: 4}
>>> from collections import OrderedDict, defaultdict
>>> s.to_dict(OrderedDict)
OrderedDict([(0, 1), (1, 2), (2, 3), (3, 4)])
>>> dd = defaultdict(list)
>>> s.to_dict(dd)
defaultdict(<type 'list'>, {0: 1, 1: 2, 2: 3, 3: 4})
```

pandas.Series.to_excel

`Series.to_excel(excel_writer, sheet_name='Sheet1', na_rep='', float_format=None, columns=None, header=True, index=True, index_label=None, startrow=0, startcol=0, engine=None, merge_cells=True, encoding=None, inf_rep='inf', verbose=True)`

Write Series to an excel sheet

New in version 0.20.0.

Parameters **excel_writer** : string or ExcelWriter object

File path or existing ExcelWriter

sheet_name : string, default 'Sheet1'

Name of sheet which will contain DataFrame

na_rep : string, default ''

Missing data representation

float_format : string, default None

Format string for floating point numbers

columns : sequence, optional

Columns to write

header : boolean or list of string, default True

Write out the column names. If a list of strings is given it is assumed to be aliases for the column names

index : boolean, default True

Write row names (index)

index_label : string or sequence, default None

Column label for index column(s) if desired. If None is given, and *header* and *index* are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

startrow :

upper left cell row to dump data frame

startcol :

upper left cell column to dump data frame

engine : string, default None

write engine to use - you can also set this via the options `io.excel.xlsx.writer`, `io.excel.xls.writer`, and `io.excel.xlsm.writer`.

merge_cells : boolean, default True

Write MultiIndex and Hierarchical Rows as merged cells.

encoding: string, default None

encoding of the resulting excel file. Only necessary for xlwt, other writers support unicode natively.

inf_rep : string, default 'inf'

Representation for infinity (there is no native representation for infinity in Excel)

freeze_panes : tuple of integer (length 2), default None

Specifies the one-based bottommost row and rightmost column that is to be frozen

New in version 0.20.0.

Notes

If passing an existing ExcelWriter object, then the sheet will be added to the existing workbook. This can be used to save different DataFrames to one workbook:

```
>>> writer = pd.ExcelWriter('output.xlsx')
>>> df1.to_excel(writer,'Sheet1')
>>> df2.to_excel(writer,'Sheet2')
>>> writer.save()
```

For compatibility with to_csv, to_excel serializes lists and dicts to strings before writing.

pandas.Series.to_frame

`Series.to_frame(name=None)`

Convert Series to DataFrame

Parameters **name** : object, default None

The passed name should substitute for the series name (if it has one).

Returns **data_frame** : DataFrame

pandas.Series.to_hdf

`Series.to_hdf(path_or_buf, key, **kwargs)`

Write the contained data to an HDF5 file using HDFStore.

Parameters **path_or_buf** : the path (string) or HDFStore object

key : string

identifier for the group in the store

mode : optional, {'a', 'w', 'r+'}, default 'a'

'w' Write; a new file is created (an existing file with the same name would be deleted).

'a' Append; an existing file is opened for reading and writing, and if the file does not exist it is created.

'r+' It is similar to `'a'`, but the file must already exist.

format : 'fixed(f)|table(t)', default is 'fixed'

fixed(f) [Fixed format] Fast writing/reading. Not-appendable, nor searchable

table(t) [Table format] Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data

append : boolean, default False

For Table formats, append the input data to the existing

data_columns : list of columns, or True, default None

List of columns to create as indexed data columns for on-disk queries, or True to use all columns. By default only the axes of the object are indexed. See here.

Applicable only to format='table'.

complevel : int, 0-9, default None

Specifies a compression level for data. A value of 0 disables compression.

complib : {'zlib', 'lzo', 'bzip2', 'blosc'}, default 'zlib'

Specifies the compression library to be used. As of v0.20.2 these additional compressors for Blosc are supported (default if no compressor specified: 'blosc:blosclz'): {'blosc:blosclz', 'blosc:lz4', 'blosc:lz4hc', 'blosc:snappy', 'blosc:zlib', 'blosc:zstd'}. Specifying a compression library which is not available issues a ValueError.

fletcher32 : bool, default False

If applying compression use the fletcher32 checksum

dropna : boolean, default False.

If true, ALL nan rows will not be written to store.

pandas.Series.to_json

`Series.to_json(path_or_buf=None, orient=None, date_format=None, double_precision=10, force_ascii=True, date_unit='ms', default_handler=None, lines=False, compression=None)`

Convert the object to a JSON string.

Note NaN's and None will be converted to null and datetime objects will be converted to UNIX timestamps.

Parameters **path_or_buf** : the path or buffer to write the result string

if this is None, return the converted string

orient : string

- Series
  - default is 'index'
  - allowed values are: {'split','records','index'}
- DataFrame
  - default is 'columns'
  - allowed values are: {'split','records','index','columns','values'}
- The format of the JSON string
  - split : dict like {index -> [index], columns -> [columns], data -> [values]}
  - records : list like [{column -> value}, ... , {column -> value}]
  - index : dict like {index -> {column -> value}}
  - columns : dict like {column -> {index -> value}}
  - values : just the values array
  - table : dict like {'schema': {schema}, 'data': {data}} describing the data, and the data component is like `orient='records'`.

    Changed in version 0.20.0.

date_format : {None, 'epoch', 'iso'}

Type of date conversion. *epoch* = epoch milliseconds, *iso* = ISO8601. The default depends on the *orient*. For *orient='table'*, the default is *'iso'*. For all other orients, the default is *'epoch'*.

double_precision : The number of decimal places to use when encoding

floating point values, default 10.

force_ascii : force encoded string to be ASCII, default True.

date_unit : string, default 'ms' (milliseconds)

The time unit to encode to, governs timestamp and ISO8601 precision. One of 's', 'ms', 'us', 'ns' for second, millisecond, microsecond, and nanosecond respectively.

default_handler : callable, default None

Handler to call if object cannot otherwise be converted to a suitable format for JSON. Should receive a single argument which is the object to convert and return a serialisable object.

lines : boolean, default False

If 'orient' is 'records' write out line delimited json format. Will throw ValueError if incorrect 'orient' since others are not list like.

New in version 0.19.0.

compression : {None, 'gzip', 'bz2', 'xz'}

A string representing the compression to use in the output file, only used when the first argument is a filename

New in version 0.21.0.

Returns same type as input object with filtered info axis

See also:

`pd.read_json`

Examples

```
>>> df = pd.DataFrame([['a', 'b'], ['c', 'd']],
...                   index=['row 1', 'row 2'],
...                   columns=['col 1', 'col 2'])
>>> df.to_json(orient='split')
'{"columns":["col 1","col 2"],
  "index":["row 1","row 2"],
  "data":[["a","b"],["c","d"]]}'
```

Encoding/decoding a Dataframe using `'index'` formatted JSON:

```
>>> df.to_json(orient='index')
'{"row 1":{"col 1":"a","col 2":"b"},"row 2":{"col 1":"c","col 2":"d"}}'
```

Encoding/decoding a Dataframe using `'records'` formatted JSON. Note that index labels are not preserved with this encoding.

```
>>> df.to_json(orient='records')
'[{"col 1":"a","col 2":"b"},{"col 1":"c","col 2":"d"}]'
```

Encoding with Table Schema

```
>>> df.to_json(orient='table')
'{"schema": {"fields": [{"name": "index", "type": "string"},
                        {"name": "col 1", "type": "string"},
                        {"name": "col 2", "type": "string"}],
             "primaryKey": "index",
             "pandas_version": "0.20.0"},
```

```
"data": [{"index": "row 1", "col 1": "a", "col 2": "b"},
         {"index": "row 2", "col 1": "c", "col 2": "d"}]}'
```

pandas.Series.to_latex

`Series.to_latex(buf=None, columns=None, col_space=None, header=True, index=True, na_rep='NaN', formatters=None, float_format=None, sparsify=None, index_names=True, bold_rows=False, column_format=None, longtable=None, escape=None, encoding=None, decimal='.', multicolumn=None, multicolumn_format=None, multirow=None)`

Render an object to a tabular environment table. You can splice this into a LaTeX document. Requires \usepackage{booktabs}.

Changed in version 0.20.2: Added to Series

to_latex-specific options:

bold_rows [boolean, default False] Make the row labels bold in the output

column_format [str, default None] The columns format as specified in LaTeX table format e.g 'rcl' for 3 columns

longtable [boolean, default will be read from the pandas config module] Default: False. Use a longtable environment instead of tabular. Requires adding a \usepackage{longtable} to your LaTeX preamble.

escape [boolean, default will be read from the pandas config module] Default: True. When set to False prevents from escaping latex special characters in column names.

encoding [str, default None] A string representing the encoding to use in the output file, defaults to 'ascii' on Python 2 and 'utf-8' on Python 3.

decimal [string, default '.'] Character recognized as decimal separator, e.g. ',' in Europe.

New in version 0.18.0.

multicolumn [boolean, default True] Use multicolumn to enhance MultiIndex columns. The default will be read from the config module.

New in version 0.20.0.

multicolumn_format [str, default 'l'] The alignment for multicolumns, similar to *column_format* The default will be read from the config module.

New in version 0.20.0.

multirow [boolean, default False] Use multirow to enhance MultiIndex rows. Requires adding a \usepackage{multirow} to your LaTeX preamble. Will print centered labels (instead of top-aligned) across the contained rows, separating groups via clines. The default will be read from the pandas config module.

New in version 0.20.0.

pandas.Series.to_msgpack

`Series.to_msgpack(path_or_buf=None, encoding='utf-8', **kwargs)`

msgpack (serialize) object to input file path

THIS IS AN EXPERIMENTAL LIBRARY and the storage format may not be stable until a future release.

Parameters **path** : string File path, buffer-like, or None

if None, return generated string

append : boolean whether to append to an existing msgpack

(default is False)

compress : type of compressor (zlib or blosc), default to None (no

compression)

pandas.Series.to_period

`Series.to_period`(*freq=None*, *copy=True*)

Convert Series from DatetimeIndex to PeriodIndex with desired frequency (inferred from index if not passed)

Parameters **freq** : string, default

Returns **ts** : Series with PeriodIndex

pandas.Series.to_pickle

`Series.to_pickle`(*path*, *compression='infer'*, *protocol=4*)

Pickle (serialize) object to input file path.

Parameters **path** : string

File path

compression : {'infer', 'gzip', 'bz2', 'xz', None}, default 'infer'

a string representing the compression to use in the output file

New in version 0.20.0.

protocol : int

Int which indicates which protocol should be used by the pickler, default HIGHEST_PROTOCOL (see [1], paragraph 12.1.2). The possible values for this parameter depend on the version of Python. For Python 2.x, possible values are 0, 1, 2. For Python>=3.0, 3 is a valid value. For Python >= 3.4, 4 is a valid value.A negative value for the protocol parameter is equivalent to setting its value to HIGHEST_PROTOCOL.

New in version 0.21.0.

pandas.Series.to_sparse

`Series.to_sparse`(*kind='block'*, *fill_value=None*)

Convert Series to SparseSeries

Parameters **kind** : {'block', 'integer'}

fill_value : float, defaults to NaN (missing)

Returns **sp** : SparseSeries

pandas.Series.to_sql

`Series.to_sql(name, con, flavor=None, schema=None, if_exists='fail', index=True, index_label=None, chunksize=None, dtype=None)`

Write records stored in a DataFrame to a SQL database.

Parameters **name** : string

Name of SQL table

con : SQLAlchemy engine or DBAPI2 connection (legacy mode)

Using SQLAlchemy makes it possible to use any DB supported by that library. If a DBAPI2 object, only sqlite3 is supported.

flavor : 'sqlite', default None

Deprecated since version 0.19.0: 'sqlite' is the only supported option if SQLAlchemy is not used.

schema : string, default None

Specify the schema (if database flavor supports this). If None, use default schema.

if_exists : {'fail', 'replace', 'append'}, default 'fail'

- fail: If table exists, do nothing.
- replace: If table exists, drop it, recreate it, and insert data.
- append: If table exists, insert data. Create if does not exist.

index : boolean, default True

Write DataFrame index as a column.

index_label : string or sequence, default None

Column label for index column(s). If None is given (default) and *index* is True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

chunksize : int, default None

If not None, then rows will be written in batches of this size at a time. If None, all rows will be written at once.

dtype : dict of column name to SQL type, default None

Optional specifying the datatype for columns. The SQL type should be a SQLAlchemy type, or a string for sqlite3 fallback connection.

pandas.Series.to_string

`Series.to_string(buf=None, na_rep='NaN', float_format=None, header=True, index=True, length=False, dtype=False, name=False, max_rows=None)`

Render a string representation of the Series

Parameters **buf** : StringIO-like, optional

buffer to write to

na_rep : string, optional

string representation of NAN to use, default 'NaN'

float_format : one-parameter function, optional

formatter function to apply to columns' elements if they are floats default None

header: boolean, default True

Add the Series header (index name)

index : bool, optional

Add index (row) labels, default True

length : boolean, default False

Add the Series length

dtype : boolean, default False

Add the Series dtype

name : boolean, default False

Add the Series name if not None

max_rows : int, optional

Maximum number of rows to show before truncating. If None, show all.

Returns **formatted** : string (if not buffer passed)

pandas.Series.to_timestamp

`Series.to_timestamp`(*freq=None*, *how='start'*, *copy=True*)

Cast to datetimeindex of timestamps, at *beginning* of period

Parameters **freq** : string, default frequency of PeriodIndex

Desired frequency

how : {'s', 'e', 'start', 'end'}

Convention for converting period to timestamp; start of period vs. end

Returns **ts** : Series with DatetimeIndex

pandas.Series.to_xarray

`Series.to_xarray`()

Return an xarray object from the pandas object.

Returns a DataArray for a Series

a Dataset for a DataFrame

a DataArray for higher dims

Notes

See the xarray docs

Examples

```
>>> df = pd.DataFrame({'A' : [1, 1, 2],
                       'B' : ['foo', 'bar', 'foo'],
                       'C' : np.arange(4.,7)})
>>> df
   A    B    C
0  1  foo  4.0
1  1  bar  5.0
2  2  foo  6.0
```

```
>>> df.to_xarray()
<xarray.Dataset>
Dimensions:  (index: 3)
Coordinates:
  * index    (index) int64 0 1 2
Data variables:
    A        (index) int64 1 1 2
    B        (index) object 'foo' 'bar' 'foo'
    C        (index) float64 4.0 5.0 6.0
```

```
>>> df = pd.DataFrame({'A' : [1, 1, 2],
                       'B' : ['foo', 'bar', 'foo'],
                       'C' : np.arange(4.,7)}
                     ).set_index(['B','A'])
>>> df
         C
B   A
foo 1  4.0
bar 1  5.0
foo 2  6.0
```

```
>>> df.to_xarray()
<xarray.Dataset>
Dimensions:  (A: 2, B: 2)
Coordinates:
  * B        (B) object 'bar' 'foo'
  * A        (A) int64 1 2
Data variables:
    C        (B, A) float64 5.0 nan 4.0 6.0
```

```
>>> p = pd.Panel(np.arange(24).reshape(4,3,2),
                 items=list('ABCD'),
                 major_axis=pd.date_range('20130101', periods=3),
                 minor_axis=['first', 'second'])
>>> p
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: A to D
Major_axis axis: 2013-01-01 00:00:00 to 2013-01-03 00:00:00
Minor_axis axis: first to second
```

```
>>> p.to_xarray()
<xarray.DataArray (items: 4, major_axis: 3, minor_axis: 2)>
array([[[ 0,  1],
        [ 2,  3],
```

```
        [ 4,  5]],
       [[ 6,  7],
        [ 8,  9],
        [10, 11]],
       [[12, 13],
        [14, 15],
        [16, 17]],
       [[18, 19],
        [20, 21],
        [22, 23]]])
Coordinates:
  * items       (items) object 'A' 'B' 'C' 'D'
  * major_axis  (major_axis) datetime64[ns] 2013-01-01 2013-01-02 2013-01-03␣
↪ # noqa
  * minor_axis  (minor_axis) object 'first' 'second'
```

pandas.Series.tolist

`Series.tolist()`

Return a list of the values.

These are each a scalar type, which is a Python scalar (for str, int, float) or a pandas scalar (for Timestamp/Timedelta/Interval/Period)

See also:

`numpy.ndarray.tolist`

pandas.Series.transform

`Series.transform(func, *args, **kwargs)`

Call function producing a like-indexed NDFrame and return a NDFrame with the transformed values

New in version 0.20.0.

Parameters **func** : callable, string, dictionary, or list of string/callables

To apply to column

Accepted Combinations are:

- string function name
- function
- list of functions
- dict of column names -> functions (or list of functions)

Returns **transformed** : NDFrame

See also:

`pandas.NDFrame.aggregate`, `pandas.NDFrame.apply`

Examples

```
>>> df = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
...                   index=pd.date_range('1/1/2000', periods=10))
df.iloc[3:7] = np.nan
```

```
>>> df.transform(lambda x: (x - x.mean()) / x.std())
                   A         B         C
2000-01-01  0.579457  1.236184  0.123424
2000-01-02  0.370357 -0.605875 -1.231325
2000-01-03  1.455756 -0.277446  0.288967
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08 -0.498658  1.274522  1.642524
2000-01-09 -0.540524 -1.012676 -0.828968
2000-01-10 -1.366388 -0.614710  0.005378
```

pandas.Series.transpose

`Series.transpose`(**args*, ***kwargs*)

return the transpose, which is by definition self

pandas.Series.truediv

`Series.truediv`(*other*, *level=None*, *fill_value=None*, *axis=0*)

Floating division of series and other, element-wise (binary operator *truediv*).

Equivalent to `series / other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series or scalar value

fill_value : None or float value, default None (NaN)

Fill missing (NaN) values with this value. If both Series are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : Series

See also:

`Series.rtruediv`

pandas.Series.truncate

`Series.truncate`(*before=None*, *after=None*, *axis=None*, *copy=True*)

Truncates a sorted DataFrame/Series before and/or after some particular index value. If the axis contains only datetime values, before/after parameters are converted to datetime values.

Parameters **before** : date, string, int

Truncate all rows before this index value

after : date, string, int

Truncate all rows after this index value

axis : {0 or 'index', 1 or 'columns'}

- 0 or 'index': apply truncation to rows
- 1 or 'columns': apply truncation to columns

Default is stat axis for given data type (0 for Series and DataFrames, 1 for Panels)

copy : boolean, default is True,

return a copy of the truncated section

Returns truncated : type of caller

Examples

```
>>> df = pd.DataFrame({'A': ['a', 'b', 'c', 'd', 'e'],
...                    'B': ['f', 'g', 'h', 'i', 'j'],
...                    'C': ['k', 'l', 'm', 'n', 'o']},
...                    index=[1, 2, 3, 4, 5])
>>> df.truncate(before=2, after=4)
   A  B  C
2  b  g  l
3  c  h  m
4  d  i  n
>>> df = pd.DataFrame({'A': [1, 2, 3, 4, 5],
...                    'B': [6, 7, 8, 9, 10],
...                    'C': [11, 12, 13, 14, 15]},
...                    index=['a', 'b', 'c', 'd', 'e'])
>>> df.truncate(before='b', after='d')
   A  B   C
b  2  7  12
c  3  8  13
d  4  9  14
```

The index values in `truncate` can be datetimes or string dates. Note that `truncate` assumes a 0 value for any unspecified date component in a `DatetimeIndex` in contrast to slicing which returns any partially matching dates.

```
>>> dates = pd.date_range('2016-01-01', '2016-02-01', freq='s')
>>> df = pd.DataFrame(index=dates, data={'A': 1})
>>> df.truncate('2016-01-05', '2016-01-10').tail()
                     A
2016-01-09 23:59:56  1
2016-01-09 23:59:57  1
2016-01-09 23:59:58  1
2016-01-09 23:59:59  1
2016-01-10 00:00:00  1
>>> df.loc['2016-01-05':'2016-01-10', :].tail()
                     A
2016-01-10 23:59:55  1
2016-01-10 23:59:56  1
2016-01-10 23:59:57  1
```

```
2016-01-10 23:59:58  1
2016-01-10 23:59:59  1
```

pandas.Series.tshift

`Series.tshift`(*periods=1*, *freq=None*, *axis=0*)

Shift the time index, using the index's frequency if available.

Parameters **periods** : int

Number of periods to move, can be positive or negative

freq : DateOffset, timedelta, or time rule string, default None

Increment to use from the tseries module or time rule (e.g. 'EOM')

axis : int or basestring

Corresponds to the axis that contains the Index

Returns **shifted** : NDFrame

Notes

If freq is not specified then tries to use the freq or inferred_freq attributes of the index. If neither of those attributes exist, a ValueError is thrown

pandas.Series.tz_convert

`Series.tz_convert`(*tz*, *axis=0*, *level=None*, *copy=True*)

Convert tz-aware axis to target time zone.

Parameters **tz** : string or pytz.timezone object

axis : the axis to convert

level : int, str, default None

If axis ia a MultiIndex, convert a specific level. Otherwise must be None

copy : boolean, default True

Also make a copy of the underlying data

Raises **TypeError**

If the axis is tz-naive.

pandas.Series.tz_localize

`Series.tz_localize`(*tz*, *axis=0*, *level=None*, *copy=True*, *ambiguous='raise'*)

Localize tz-naive TimeSeries to target time zone.

Parameters **tz** : string or pytz.timezone object

axis : the axis to localize

level : int, str, default None

If axis ia a MultiIndex, localize a specific level. Otherwise must be None

copy : boolean, default True

Also make a copy of the underlying data

ambiguous : 'infer', bool-ndarray, 'NaT', default 'raise'

- 'infer' will attempt to infer fall dst-transition hours based on order
- bool-ndarray where True signifies a DST time, False designates a non-DST time (note that this flag is only applicable for ambiguous times)
- 'NaT' will return NaT where there are ambiguous times
- 'raise' will raise an AmbiguousTimeError if there are ambiguous times

infer_dst : boolean, default False

Deprecated since version 0.15.0: Attempt to infer fall dst-transition hours based on order

Raises **TypeError**

If the TimeSeries is tz-aware and tz is not None.

pandas.Series.unique

`Series.unique()`

Return unique values in the object. Uniques are returned in order of appearance, this does NOT sort. Hash table-based unique.

Parameters **values** : 1d array-like

Returns unique values.

- If the input is an Index, the return is an Index
- If the input is a Categorical dtype, the return is a Categorical
- If the input is a Series/ndarray, the return will be an ndarray

See also:

unique, *Index.unique*, *Series.unique*

pandas.Series.unstack

`Series.unstack(level=-1, fill_value=None)`

Unstack, a.k.a. pivot, Series with MultiIndex to produce DataFrame. The level involved will automatically get sorted.

Parameters **level** : int, string, or list of these, default last level

Level(s) to unstack, can pass level name

fill_value : replace NaN with this value if the unstack produces

missing values

Returns **unstacked** : DataFrame

Examples

```
>>> s = pd.Series([1, 2, 3, 4],
...     index=pd.MultiIndex.from_product([['one', 'two'], ['a', 'b']]))
>>> s
one  a    1
     b    2
two  a    3
     b    4
dtype: int64
```

```
>>> s.unstack(level=-1)
     a  b
one  1  2
two  3  4
```

```
>>> s.unstack(level=0)
   one  two
a    1    3
b    2    4
```

pandas.Series.update

`Series.update(other)`

Modify Series in place using non-NA values from passed Series. Aligns on index

Parameters **other** : Series

Examples

```
>>> s = pd.Series([1, 2, 3])
>>> s.update(pd.Series([4, 5, 6]))
>>> s
0    4
1    5
2    6
dtype: int64
```

```
>>> s = pd.Series(['a', 'b', 'c'])
>>> s.update(pd.Series(['d', 'e'], index=[0, 2]))
>>> s
0    d
1    b
2    e
dtype: object
```

```
>>> s = pd.Series([1, 2, 3])
>>> s.update(pd.Series([4, 5, 6, 7, 8]))
>>> s
0    4
1    5
2    6
dtype: int64
```

If `other` contains NaNs the corresponding values are not updated in the original Series.

```
>>> s = pd.Series([1, 2, 3])
>>> s.update(pd.Series([4, np.nan, 6]))
>>> s
0    4
1    2
2    6
dtype: int64
```

pandas.Series.valid

`Series.valid(inplace=False, **kwargs)`

pandas.Series.value_counts

`Series.value_counts(normalize=False, sort=True, ascending=False, bins=None, dropna=True)`

Returns object containing counts of unique values.

The resulting object will be in descending order so that the first element is the most frequently-occurring element. Excludes NA values by default.

Parameters **normalize** : boolean, default False

If True then the object returned will contain the relative frequencies of the unique values.

sort : boolean, default True

Sort by values

ascending : boolean, default False

Sort in ascending order

bins : integer, optional

Rather than count values, group them into half-open bins, a convenience for pd.cut, only works with numeric data

dropna : boolean, default True

Don't include counts of NaN.

Returns **counts** : Series

pandas.Series.var

`Series.var(axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)`

Return unbiased variance over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters **axis** : {index (0)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

ddof : int, default 1

degrees of freedom

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **var** : scalar or Series (if level specified)

pandas.Series.view

`Series.view(dtype=None)`

pandas.Series.where

`Series.where(cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)`

Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.

Parameters **cond** : boolean NDFrame, array-like, or callable

Where *cond* is True, keep the original value. Where False, replace with corresponding value from *other*. If *cond* is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as cond.

other : scalar, NDFrame, or callable

Entries where *cond* is False are replaced with corresponding value from *other*. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as other.

inplace : boolean, default False

Whether to perform the operation in place on the data

axis : alignment axis if needed, default None

level : alignment level if needed, default None

errors : str, {'raise', 'ignore'}, default 'raise'

- `raise` : allow exceptions to be raised
- `ignore` : suppress exceptions. On error return original object

Note that currently this parameter won't affect the results and will always coerce to a suitable dtype.

try_cast : boolean, default False

try to cast the result back to the input type (if possible),

raise_on_error : boolean, default True

Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.

Returns **wh** : same type as caller

See also:

DataFrame.mask()

Notes

The where method is an application of the if-then idiom. For each element in the calling DataFrame, if `cond` is `True` the element is used; otherwise the corresponding element from the DataFrame `other` is used.

The signature for *DataFrame.where()* differs from `numpy.where()`. Roughly `df1.where(m, df2)` is equivalent to `np.where(m, df1, df2)`.

For further details and examples see the `where` documentation in *indexing*.

Examples

```
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0    NaN
1    1.0
2    2.0
3    3.0
4    4.0
```

```
>>> s.mask(s > 0)
0    0.0
1    NaN
2    NaN
3    NaN
4    NaN
```

```
>>> s.where(s > 1, 10)
0    10.0
1    10.0
2    2.0
3    3.0
4    4.0
```

```
>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
   A  B
0  0 -1
1 -2  3
2 -4 -5
3  6 -7
```

```
4 -8  9
>>> df.where(m, -df) == np.where(m, df, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
>>> df.where(m, -df) == df.mask(~m, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
```

pandas.Series.xs

`Series.xs(key, axis=0, level=None, drop_level=True)`

Returns a cross-section (row(s) or column(s)) from the Series/DataFrame. Defaults to cross-section on the rows (axis=0).

Parameters **key** : object

Some label contained in the index, or partially in a MultiIndex

axis : int, default 0

Axis to retrieve cross-section on

level : object, defaults to first n levels (n=1 or len(key))

In case of a key partially contained in a MultiIndex, indicate which levels are used. Levels can be referred by label or position.

drop_level : boolean, default True

If False, returns object with same levels as self.

Returns **xs** : Series or DataFrame

Notes

xs is only for getting, not setting values.

MultiIndex Slicers is a generic way to get/set values on any level or levels. It is a superset of xs functionality, see *MultiIndex Slicers*

Examples

```
>>> df
   A  B  C
a  4  5  2
b  4  0  9
c  9  7  3
>>> df.xs('a')
```

```
A    4
B    5
C    2
Name: a
>>> df.xs('C', axis=1)
a    2
b    9
c    3
Name: C
```

```
>>> df
                    A  B  C  D
first second third
bar   one    1      4  1  8  9
      two    1      7  5  5  0
baz   one    1      6  6  8  0
      three  2      5  3  5  3
>>> df.xs(('baz', 'three'))
       A  B  C  D
third
2      5  3  5  3
>>> df.xs('one', level=1)
             A  B  C  D
first third
bar   1      4  1  8  9
baz   1      6  6  8  0
>>> df.xs(('baz', 2), level=[0, 'third'])
        A  B  C  D
second
three   5  3  5  3
```

34.3.2 Attributes

Axes

- **index**: axis labels

Series.values	Return Series as ndarray or ndarray-like
Series.dtype	return the dtype object of the underlying data
Series.ftype	return if the data is sparseldense
Series.shape	return a tuple of the shape of the underlying data
Series.nbytes	return the number of bytes in the underlying data
Series.ndim	return the number of dimensions of the underlying data,
Series.size	return the number of elements in the underlying data
Series.strides	return the strides of the underlying data
Series.itemsize	return the size of the dtype of the item of the underlying data
Series.base	return the base object if the memory of the underlying data is
Series.T	return the transpose, which is by definition self
Series.memory_usage([index, deep])	Memory usage of the Series

34.3.3 Conversion

`Series.astype`(dtype[, copy, errors])	Cast a pandas object to a specified dtype `dtype`.
`Series.infer_objects`()	Attempt to infer better dtypes for object columns.
`Series.copy`([deep])	Make a copy of this objects data.
`Series.isna`()	Return a boolean same-sized object indicating if the values are NA.
`Series.notna`()	Return a boolean same-sized object indicating if the values are not NA.

34.3.4 Indexing, iteration

`Series.get`(key[, default])	Get item from object for given key (DataFrame column, Panel slice, etc.).
`Series.at`	Fast label-based scalar accessor
`Series.iat`	Fast integer location scalar accessor.
`Series.loc`	Purely label-location based indexer for selection by label.
`Series.iloc`	Purely integer-location based indexing for selection by position.
`Series.__iter__`()	Return an iterator of the values.
`Series.iteritems`()	Lazily iterate over (index, value) tuples

34.3.4.1 pandas.Series.__iter__

`Series.__iter__()`

Return an iterator of the values.

These are each a scalar type, which is a Python scalar (for str, int, float) or a pandas scalar (for Timestamp/Timedelta/Interval/Period)

For more information on `.at`, `.iat`, `.loc`, and `.iloc`, see the *indexing documentation*.

34.3.5 Binary operator functions

`Series.add`(other[, level, fill_value, axis])	Addition of series and other, element-wise (binary operator *add*).
`Series.sub`(other[, level, fill_value, axis])	Subtraction of series and other, element-wise (binary operator *sub*).
`Series.mul`(other[, level, fill_value, axis])	Multiplication of series and other, element-wise (binary operator *mul*).
`Series.div`(other[, level, fill_value, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
`Series.truediv`(other[, level, fill_value, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
`Series.floordiv`(other[, level, fill_value, axis])	Integer division of series and other, element-wise (binary operator *floordiv*).
`Series.mod`(other[, level, fill_value, axis])	Modulo of series and other, element-wise (binary operator *mod*).

Continued on next page

Table 34.29 – continued from previous page

Series.pow(other[, level, fill_value, axis])	Exponential power of series and other, element-wise (binary operator *pow*).
Series.radd(other[, level, fill_value, axis])	Addition of series and other, element-wise (binary operator *radd*).
Series.rsub(other[, level, fill_value, axis])	Subtraction of series and other, element-wise (binary operator *rsub*).
Series.rmul(other[, level, fill_value, axis])	Multiplication of series and other, element-wise (binary operator *rmul*).
Series.rdiv(other[, level, fill_value, axis])	Floating division of series and other, element-wise (binary operator *rtruediv*).
Series.rtruediv(other[, level, fill_value, axis])	Floating division of series and other, element-wise (binary operator *rtruediv*).
Series.rfloordiv(other[, level, fill_value, ...])	Integer division of series and other, element-wise (binary operator *rfloordiv*).
Series.rmod(other[, level, fill_value, axis])	Modulo of series and other, element-wise (binary operator *rmod*).
Series.rpow(other[, level, fill_value, axis])	Exponential power of series and other, element-wise (binary operator *rpow*).
Series.combine(other, func[, fill_value])	Perform elementwise binary operation on two Series using given function
Series.combine_first(other)	Combine Series values, choosing the calling Series's values first.
Series.round([decimals])	Round each value in a Series to the given number of decimals.
Series.lt(other[, level, fill_value, axis])	Less than of series and other, element-wise (binary operator *lt*).
Series.gt(other[, level, fill_value, axis])	Greater than of series and other, element-wise (binary operator *gt*).
Series.le(other[, level, fill_value, axis])	Less than or equal to of series and other, element-wise (binary operator *le*).
Series.ge(other[, level, fill_value, axis])	Greater than or equal to of series and other, element-wise (binary operator *ge*).
Series.ne(other[, level, fill_value, axis])	Not equal to of series and other, element-wise (binary operator *ne*).
Series.eq(other[, level, fill_value, axis])	Equal to of series and other, element-wise (binary operator *eq*).

34.3.6 Function application, GroupBy & Window

Series.apply(func[, convert_dtype, args])	Invoke function on values of Series.
Series.aggregate(func[, axis])	Aggregate using callable, string, dict, or list of string/callables
Series.transform(func, *args, **kwargs)	Call function producing a like-indexed NDFrame
Series.map(arg[, na_action])	Map values of Series using input correspondence (which can be
Series.groupby([by, axis, level, as_index, ...])	Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.
Series.rolling(window[, min_periods, freq, ...])	Provides rolling window calculations.
Series.expanding([min_periods, freq, ...])	Provides expanding transformations.

Continued on next page

Table 34.30 – continued from previous page

Series.ewm([com, span, halflife, alpha, ...])	Provides exponential weighted functions

34.3.7 Computations / Descriptive Stats

Series.abs()	Return an object with absolute value taken–only applicable to objects that are all numeric.
Series.all([axis, bool_only, skipna, level])	Return whether all elements are True over requested axis
Series.any([axis, bool_only, skipna, level])	Return whether any element is True over requested axis
Series.autocorr([lag])	Lag-N autocorrelation
Series.between(left, right[, inclusive])	Return boolean Series equivalent to left <= series <= right.
Series.clip([lower, upper, axis, inplace])	Trim values at input threshold(s).
Series.clip_lower(threshold[, axis, inplace])	Return copy of the input with values below given value(s) truncated.
Series.clip_upper(threshold[, axis, inplace])	Return copy of input with values above given value(s) truncated.
Series.corr(other[, method, min_periods])	Compute correlation with *other* Series, excluding missing values
Series.count([level])	Return number of non-NA/null observations in the Series
Series.cov(other[, min_periods])	Compute covariance with Series, excluding missing values
Series.cummax([axis, skipna])	Return cumulative max over requested axis.
Series.cummin([axis, skipna])	Return cumulative minimum over requested axis.
Series.cumprod([axis, skipna])	Return cumulative product over requested axis.
Series.cumsum([axis, skipna])	Return cumulative sum over requested axis.
Series.describe([percentiles, include, exclude])	Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding `NaN` values.
Series.diff([periods])	1st discrete difference of object
Series.factorize([sort, na_sentinel])	Encode the object as an enumerated type or categorical variable
Series.kurt([axis, skipna, level, numeric_only])	Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0).
Series.mad([axis, skipna, level])	Return the mean absolute deviation of the values for the requested axis
Series.max([axis, skipna, level, numeric_only])	This method returns the maximum of the values in the object.
Series.mean([axis, skipna, level, numeric_only])	Return the mean of the values for the requested axis
Series.median([axis, skipna, level, ...])	Return the median of the values for the requested axis
Series.min([axis, skipna, level, numeric_only])	This method returns the minimum of the values in the object.
Series.mode()	Return the mode(s) of the dataset.
Series.nlargest([n, keep])	Return the largest *n* elements.
Series.nsmallest([n, keep])	Return the smallest *n* elements.
Series.pct_change([periods, fill_method, ...])	Percent change over given number of periods.
Series.prod([axis, skipna, level, numeric_only])	Return the product of the values for the requested axis
Series.quantile([q, interpolation])	Return value at the given quantile, a la numpy.percentile.
Series.rank([axis, method, numeric_only, ...])	Compute numerical data ranks (1 through n) along axis.
Series.sem([axis, skipna, level, ddof, ...])	Return unbiased standard error of the mean over requested axis.
Series.skew([axis, skipna, level, numeric_only])	Return unbiased skew over requested axis

Continued on next page

Table 34.31 – continued from previous page

`Series.std`([axis, skipna, level, ddof, ...])	Return sample standard deviation over requested axis.
`Series.sum`([axis, skipna, level, numeric_only])	Return the sum of the values for the requested axis
`Series.var`([axis, skipna, level, ddof, ...])	Return unbiased variance over requested axis.
`Series.unique`()	Return unique values in the object.
`Series.nunique`([dropna])	Return number of unique elements in the object.
`Series.is_unique`	Return boolean if values in the object are unique
`Series.is_monotonic`	Return boolean if values in the object are
`Series.is_monotonic_increasing`	Return boolean if values in the object are
`Series.is_monotonic_decreasing`	Return boolean if values in the object are
`Series.value_counts`([normalize, sort, ...])	Returns object containing counts of unique values.

34.3.8 Reindexing / Selection / Label manipulation

`Series.align`(other[, join, axis, level, ...])	Align two objects on their axes with the
`Series.drop`([labels, axis, index, columns, ...])	Return new object with labels in requested axis removed.
`Series.drop_duplicates`([keep, inplace])	Return Series with duplicate values removed
`Series.duplicated`([keep])	Return boolean Series denoting duplicate values
`Series.equals`(other)	Determines if two NDFrame objects contain the same elements.
`Series.first`(offset)	Convenience method for subsetting initial periods of time series data based on a date offset.
`Series.head`([n])	Return the first n rows.
`Series.idxmax`([axis, skipna])	Index *label* of the first occurrence of maximum of values.
`Series.idxmin`([axis, skipna])	Index *label* of the first occurrence of minimum of values.
`Series.isin`(values)	Return a boolean `Series` showing whether each element in the `Series` is exactly contained in the passed sequence of `values`.
`Series.last`(offset)	Convenience method for subsetting final periods of time series data based on a date offset.
`Series.reindex`([index])	Conform Series to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
`Series.reindex_like`(other[, method, copy, ...])	Return an object with matching indices to myself.
`Series.rename`([index])	Alter Series index labels or name
`Series.rename_axis`(mapper[, axis, copy, inplace])	Alter the name of the index or columns.
`Series.reset_index`([level, drop, name, inplace])	Analogous to the `pandas.DataFrame.reset_index()` function, see docstring there.
`Series.sample`([n, frac, replace, weights, ...])	Returns a random sample of items from an axis of object.
`Series.select`(crit[, axis])	Return data corresponding to axis labels matching criteria
`Series.set_axis`(labels[, axis, inplace])	Assign desired index to given axis
`Series.take`(indices[, axis, convert, is_copy])	Return the elements in the given *positional* indices along an axis.
`Series.tail`([n])	Return the last n rows.
`Series.truncate`([before, after, axis, copy])	Truncates a sorted DataFrame/Series before and/or after some particular index value.
`Series.where`(cond[, other, inplace, axis, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.

Continued on next page

Table 34.32 – continued from previous page

`Series.mask`(cond[, other, inplace, axis, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.

34.3.9 Missing data handling

`Series.dropna`([axis, inplace])	Return Series without null values
`Series.fillna`([value, method, axis, ...])	Fill NA/NaN values using the specified method
`Series.interpolate`([method, axis, limit, ...])	Interpolate values according to different methods.

34.3.10 Reshaping, sorting

`Series.argsort`([axis, kind, order])	Overrides ndarray.argsort.
`Series.reorder_levels`(order)	Rearrange index levels using input order.
`Series.sort_values`([axis, ascending, ...])	Sort by the values along either axis
`Series.sort_index`([axis, level, ascending, ...])	Sort object by labels (along an axis)
`Series.swaplevel`([i, j, copy])	Swap levels i and j in a MultiIndex
`Series.unstack`([level, fill_value])	Unstack, a.k.a.
`Series.searchsorted`(value[, side, sorter])	Find indices where elements should be inserted to maintain order.

34.3.11 Combining / joining / merging

`Series.append`(to_append[, ignore_index, ...])	Concatenate two or more Series.
`Series.replace`([to_replace, value, inplace, ...])	Replace values given in 'to_replace' with 'value'.
`Series.update`(other)	Modify Series in place using non-NA values from passed Series.

34.3.12 Time series-related

`Series.asfreq`(freq[, method, how, ...])	Convert TimeSeries to specified frequency.
`Series.asof`(where[, subset])	The last row without any NaN is taken (or the last row without
`Series.shift`([periods, freq, axis])	Shift index by desired number of periods with an optional time freq
`Series.first_valid_index`()	Return index for first non-NA/null value.
`Series.last_valid_index`()	Return index for last non-NA/null value.
`Series.resample`(rule[, how, axis, ...])	Convenience method for frequency conversion and resampling of time series.
`Series.tz_convert`(tz[, axis, level, copy])	Convert tz-aware axis to target time zone.
`Series.tz_localize`(tz[, axis, level, copy, ...])	Localize tz-naive TimeSeries to target time zone.

34.3.13 Datetimelike Properties

`Series.dt` can be used to access the values of the series as datetimelike and return several properties. These can be

accessed like `Series.dt.<property>`.

Datetime Properties

Series.dt.date	Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without timezone information).
Series.dt.time	Returns numpy array of datetime.time.
Series.dt.year	The year of the datetime
Series.dt.month	The month as January=1, December=12
Series.dt.day	The days of the datetime
Series.dt.hour	The hours of the datetime
Series.dt.minute	The minutes of the datetime
Series.dt.second	The seconds of the datetime
Series.dt.microsecond	The microseconds of the datetime
Series.dt.nanosecond	The nanoseconds of the datetime
Series.dt.week	The week ordinal of the year
Series.dt.weekofyear	The week ordinal of the year
Series.dt.dayofweek	The day of the week with Monday=0, Sunday=6
Series.dt.weekday	The day of the week with Monday=0, Sunday=6
Series.dt.weekday_name	The name of day in a week (ex: Friday)
Series.dt.dayofyear	The ordinal day of the year
Series.dt.quarter	The quarter of the date
Series.dt.is_month_start	Logical indicating if first day of month (defined by frequency)
Series.dt.is_month_end	Logical indicating if last day of month (defined by frequency)
Series.dt.is_quarter_start	Logical indicating if first day of quarter (defined by frequency)
Series.dt.is_quarter_end	Logical indicating if last day of quarter (defined by frequency)
Series.dt.is_year_start	Logical indicating if first day of year (defined by frequency)
Series.dt.is_year_end	Logical indicating if last day of year (defined by frequency)
Series.dt.is_leap_year	Logical indicating if the date belongs to a leap year
Series.dt.daysinmonth	The number of days in the month
Series.dt.days_in_month	The number of days in the month
Series.dt.tz	
Series.dt.freq	

34.3.13.1 pandas.Series.dt.date

`Series.dt.`**`date`**

Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without timezone information).

34.3.13.2 pandas.Series.dt.time

`Series.dt.`**`time`**

Returns numpy array of datetime.time. The time part of the Timestamps.

34.3.13.3 pandas.Series.dt.year

`Series.dt.year`
The year of the datetime

34.3.13.4 pandas.Series.dt.month

`Series.dt.month`
The month as January=1, December=12

34.3.13.5 pandas.Series.dt.day

`Series.dt.day`
The days of the datetime

34.3.13.6 pandas.Series.dt.hour

`Series.dt.hour`
The hours of the datetime

34.3.13.7 pandas.Series.dt.minute

`Series.dt.minute`
The minutes of the datetime

34.3.13.8 pandas.Series.dt.second

`Series.dt.second`
The seconds of the datetime

34.3.13.9 pandas.Series.dt.microsecond

`Series.dt.microsecond`
The microseconds of the datetime

34.3.13.10 pandas.Series.dt.nanosecond

`Series.dt.nanosecond`
The nanoseconds of the datetime

34.3.13.11 pandas.Series.dt.week

`Series.dt.week`
The week ordinal of the year

34.3.13.12 pandas.Series.dt.weekofyear

`Series.dt.`**`weekofyear`**

The week ordinal of the year

34.3.13.13 pandas.Series.dt.dayofweek

`Series.dt.`**`dayofweek`**

The day of the week with Monday=0, Sunday=6

34.3.13.14 pandas.Series.dt.weekday

`Series.dt.`**`weekday`**

The day of the week with Monday=0, Sunday=6

34.3.13.15 pandas.Series.dt.weekday_name

`Series.dt.`**`weekday_name`**

The name of day in a week (ex: Friday)

New in version 0.18.1.

34.3.13.16 pandas.Series.dt.dayofyear

`Series.dt.`**`dayofyear`**

The ordinal day of the year

34.3.13.17 pandas.Series.dt.quarter

`Series.dt.`**`quarter`**

The quarter of the date

34.3.13.18 pandas.Series.dt.is_month_start

`Series.dt.`**`is_month_start`**

Logical indicating if first day of month (defined by frequency)

34.3.13.19 pandas.Series.dt.is_month_end

`Series.dt.`**`is_month_end`**

Logical indicating if last day of month (defined by frequency)

34.3.13.20 pandas.Series.dt.is_quarter_start

`Series.dt.`**`is_quarter_start`**

Logical indicating if first day of quarter (defined by frequency)

34.3.13.21 pandas.Series.dt.is_quarter_end

`Series.dt.`**`is_quarter_end`**

Logical indicating if last day of quarter (defined by frequency)

34.3.13.22 pandas.Series.dt.is_year_start

`Series.dt.`**`is_year_start`**

Logical indicating if first day of year (defined by frequency)

34.3.13.23 pandas.Series.dt.is_year_end

`Series.dt.`**`is_year_end`**

Logical indicating if last day of year (defined by frequency)

34.3.13.24 pandas.Series.dt.is_leap_year

`Series.dt.`**`is_leap_year`**

Logical indicating if the date belongs to a leap year

34.3.13.25 pandas.Series.dt.daysinmonth

`Series.dt.`**`daysinmonth`**

The number of days in the month

34.3.13.26 pandas.Series.dt.days_in_month

`Series.dt.`**`days_in_month`**

The number of days in the month

34.3.13.27 pandas.Series.dt.tz

`Series.dt.`**`tz`**

34.3.13.28 pandas.Series.dt.freq

`Series.dt.`**`freq`**

Datetime Methods

Series.dt.to_period(*args, **kwargs)	Cast to PeriodIndex at a particular frequency
Series.dt.to_pydatetime()	
Series.dt.tz_localize(*args, **kwargs)	Localize tz-naive DatetimeIndex to given time zone (using
Series.dt.tz_convert(*args, **kwargs)	Convert tz-aware DatetimeIndex from one time zone to another (using
Series.dt.normalize(*args, **kwargs)	Return DatetimeIndex with times to midnight.

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Table 34.38 – continued from previous page

`Series.dt.strftime`(*args, **kwargs)	Return an array of formatted strings specified by date_format, which supports the same string format as the python standard library.
`Series.dt.round`(*args, **kwargs)	round the index to the specified freq
`Series.dt.floor`(*args, **kwargs)	floor the index to the specified freq
`Series.dt.ceil`(*args, **kwargs)	ceil the index to the specified freq

34.3.13.29 pandas.Series.dt.to_period

`Series.dt.`**`to_period`**(**args*, ***kwargs*)

Cast to PeriodIndex at a particular frequency

34.3.13.30 pandas.Series.dt.to_pydatetime

`Series.dt.`**`to_pydatetime`**()

34.3.13.31 pandas.Series.dt.tz_localize

`Series.dt.`**`tz_localize`**(**args*, ***kwargs*)

Localize tz-naive DatetimeIndex to given time zone (using pytz/dateutil), or remove timezone from tz-aware DatetimeIndex

Parameters **tz** : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time. Corresponding timestamps would be converted to time zone of the TimeSeries. None will remove timezone holding local time.

ambiguous : 'infer', bool-ndarray, 'NaT', default 'raise'

- 'infer' will attempt to infer fall dst-transition hours based on order
- bool-ndarray where True signifies a DST time, False signifies a non-DST time (note that this flag is only applicable for ambiguous times)
- 'NaT' will return NaT where there are ambiguous times
- 'raise' will raise an AmbiguousTimeError if there are ambiguous times

errors : 'raise', 'coerce', default 'raise'

- **'raise' will raise a NonExistentTimeError if a timestamp is not** valid in the specified timezone (e.g. due to a transition from or to DST time)
- 'coerce' will return NaT if the timestamp can not be converted into the specified timezone

New in version 0.19.0.

infer_dst : boolean, default False

Deprecated since version 0.15.0: Attempt to infer fall dst-transition hours based on order

Returns **localized** : DatetimeIndex

Raises **TypeError**

If the DatetimeIndex is tz-aware and tz is not None.

34.3.13.32 pandas.Series.dt.tz_convert

`Series.dt.tz_convert(*args, **kwargs)`

Convert tz-aware DatetimeIndex from one time zone to another (using pytz/dateutil)

Parameters **tz** : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time. Corresponding timestamps would be converted to time zone of the TimeSeries. None will remove timezone holding UTC time.

Returns **normalized** : DatetimeIndex

Raises **TypeError**

If DatetimeIndex is tz-naive.

34.3.13.33 pandas.Series.dt.normalize

`Series.dt.normalize(*args, **kwargs)`

Return DatetimeIndex with times to midnight. Length is unaltered

Returns **normalized** : DatetimeIndex

34.3.13.34 pandas.Series.dt.strftime

`Series.dt.strftime(*args, **kwargs)`

Return an array of formatted strings specified by date_format, which supports the same string format as the python standard library. Details of the string format can be found in python string format doc

New in version 0.17.0.

Parameters **date_format** : str

date format string (e.g. "%Y-%m-%d")

Returns ndarray of formatted strings

34.3.13.35 pandas.Series.dt.round

`Series.dt.round(*args, **kwargs)`

round the index to the specified freq

Parameters **freq** : freq string/object

Returns index of same type

Raises **ValueError if the freq cannot be converted**

34.3.13.36 pandas.Series.dt.floor

`Series.dt.floor(*args, **kwargs)`

floor the index to the specified freq

Parameters **freq** : freq string/object

Returns index of same type

Raises **ValueError if the freq cannot be converted**

34.3.13.37 pandas.Series.dt.ceil

`Series.dt.ceil(*args, **kwargs)`

ceil the index to the specified freq

Parameters **freq** : freq string/object

Returns index of same type

Raises **ValueError if the freq cannot be converted**

Timedelta Properties

Series.dt.days	Number of days for each element.
Series.dt.seconds	Number of seconds (>= 0 and less than 1 day) for each element.
Series.dt.microseconds	Number of microseconds (>= 0 and less than 1 second) for each element.
Series.dt.nanoseconds	Number of nanoseconds (>= 0 and less than 1 microsecond) for each element.
Series.dt.components	Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.

34.3.13.38 pandas.Series.dt.days

`Series.dt.days`

Number of days for each element.

34.3.13.39 pandas.Series.dt.seconds

`Series.dt.seconds`

Number of seconds (>= 0 and less than 1 day) for each element.

34.3.13.40 pandas.Series.dt.microseconds

`Series.dt.microseconds`

Number of microseconds (>= 0 and less than 1 second) for each element.

34.3.13.41 pandas.Series.dt.nanoseconds

`Series.dt.nanoseconds`

Number of nanoseconds (>= 0 and less than 1 microsecond) for each element.

34.3.13.42 pandas.Series.dt.components

`Series.dt.components`

Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.

Returns a DataFrame

Timedelta Methods

Series.dt.to_pytimedelta()	
Series.dt.total_seconds(*args, **kwargs)	Total duration of each element expressed in seconds.

34.3.13.43 pandas.Series.dt.to_pytimedelta

Series.dt.**to_pytimedelta**()

34.3.13.44 pandas.Series.dt.total_seconds

Series.dt.**total_seconds**(**args*, ***kwargs*)

Total duration of each element expressed in seconds.

New in version 0.17.0.

34.3.14 String handling

Series.str can be used to access the values of the series as strings and apply several methods to it. These can be accessed like Series.str.<function/property>.

Series.str.capitalize()	Convert strings in the Series/Index to be capitalized.
Series.str.cat([others, sep, na_rep])	Concatenate strings in the Series/Index with given separator.
Series.str.center(width[, fillchar])	Filling left and right side of strings in the Series/Index with an additional character.
Series.str.contains(pat[, case, flags, na, ...])	Return boolean Series/array whether given pattern/regex is contained in each string in the Series/Index.
Series.str.count(pat[, flags])	Count occurrences of pattern in each string of the Series/Index.
Series.str.decode(encoding[, errors])	Decode character string in the Series/Index using indicated encoding.
Series.str.encode(encoding[, errors])	Encode character string in the Series/Index using indicated encoding.
Series.str.endswith(pat[, na])	Return boolean Series indicating whether each string in the Series/Index ends with passed pattern.
Series.str.extract(pat[, flags, expand])	For each subject string in the Series, extract groups from the first match of regular expression pat.
Series.str.extractall(pat[, flags])	For each subject string in the Series, extract groups from all matches of regular expression pat.
Series.str.find(sub[, start, end])	Return lowest indexes in each strings in the Series/Index where the substring is fully contained between [start:end].
Series.str.findall(pat[, flags])	Find all occurrences of pattern or regular expression in the Series/Index.
Series.str.get(i)	Extract element from lists, tuples, or strings in each element in the Series/Index.
Series.str.index(sub[, start, end])	Return lowest indexes in each strings where the substring is fully contained between [start:end].
Series.str.join(sep)	Join lists contained as elements in the Series/Index with passed delimiter.
Series.str.len()	Compute length of each string in the Series/Index.

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Series.str.ljust(width[, fillchar])	Filling right side of strings in the Series/Index with an additional character.
Series.str.lower()	Convert strings in the Series/Index to lowercase.
Series.str.lstrip([to_strip])	Strip whitespace (including newlines) from each string in the Series/Index from left side.
Series.str.match(pat[, case, flags, na, ...])	Determine if each string matches a regular expression.
Series.str.normalize(form)	Return the Unicode normal form for the strings in the Series/Index.
Series.str.pad(width[, side, fillchar])	Pad strings in the Series/Index with an additional character to specified side.
Series.str.partition([pat, expand])	Split the string at the first occurrence of *sep*, and return 3 elements containing the part before the separator, the separator itself, and the part after the separator.
Series.str.repeat(repeats)	Duplicate each string in the Series/Index by indicated number of times.
Series.str.replace(pat, repl[, n, case, flags])	Replace occurrences of pattern/regex in the Series/Index with some other string.
Series.str.rfind(sub[, start, end])	Return highest indexes in each strings in the Series/Index where the substring is fully contained between [start:end].
Series.str.rindex(sub[, start, end])	Return highest indexes in each strings where the substring is fully contained between [start:end].
Series.str.rjust(width[, fillchar])	Filling left side of strings in the Series/Index with an additional character.
Series.str.rpartition([pat, expand])	Split the string at the last occurrence of *sep*, and return 3 elements containing the part before the separator, the separator itself, and the part after the separator.
Series.str.rstrip([to_strip])	Strip whitespace (including newlines) from each string in the Series/Index from right side.
Series.str.slice([start, stop, step])	Slice substrings from each element in the Series/Index
Series.str.slice_replace([start, stop, repl])	Replace a slice of each string in the Series/Index with another string.
Series.str.split([pat, n, expand])	Split each string (a la re.split) in the Series/Index by given pattern, propagating NA values.
Series.str.rsplit([pat, n, expand])	Split each string in the Series/Index by the given delimiter string, starting at the end of the string and working to the front.
Series.str.startswith(pat[, na])	Return boolean Series/`array` indicating whether each string in the Series/Index starts with passed pattern.
Series.str.strip([to_strip])	Strip whitespace (including newlines) from each string in the Series/Index from left and right sides.
Series.str.swapcase()	Convert strings in the Series/Index to be swapcased.
Series.str.title()	Convert strings in the Series/Index to titlecase.
Series.str.translate(table[, deletechars])	Map all characters in the string through the given mapping table.
Series.str.upper()	Convert strings in the Series/Index to uppercase.
Series.str.wrap(width, **kwargs)	Wrap long strings in the Series/Index to be formatted in paragraphs with length less than a given width.
Series.str.zfill(width)	Filling left side of strings in the Series/Index with 0.
Series.str.isalnum()	Check whether all characters in each string in the Series/Index are alphanumeric.

Continued on next page

Table 34.41 – continued from previous page

Series.str.isalpha()	Check whether all characters in each string in the Series/Index are alphabetic.
Series.str.isdigit()	Check whether all characters in each string in the Series/Index are digits.
Series.str.isspace()	Check whether all characters in each string in the Series/Index are whitespace.
Series.str.islower()	Check whether all characters in each string in the Series/Index are lowercase.
Series.str.isupper()	Check whether all characters in each string in the Series/Index are uppercase.
Series.str.istitle()	Check whether all characters in each string in the Series/Index are titlecase.
Series.str.isnumeric()	Check whether all characters in each string in the Series/Index are numeric.
Series.str.isdecimal()	Check whether all characters in each string in the Series/Index are decimal.
Series.str.get_dummies([sep])	Split each string in the Series by sep and return a frame of dummy/indicator variables.

34.3.14.1 pandas.Series.str.capitalize

`Series.str.capitalize()`

Convert strings in the Series/Index to be capitalized. Equivalent to `str.capitalize()`.

Returns **converted** : Series/Index of objects

34.3.14.2 pandas.Series.str.cat

`Series.str.cat(others=None, sep=None, na_rep=None)`

Concatenate strings in the Series/Index with given separator.

Parameters **others** : list-like, or list of list-likes

If None, returns str concatenating strings of the Series

sep : string or None, default None

na_rep : string or None, default None

If None, NA in the series are ignored.

Returns **concat** : Series/Index of objects or str

Examples

When `na_rep` is *None* (default behavior), NaN value(s) in the Series are ignored.

```
>>> Series(['a','b',np.nan,'c']).str.cat(sep=' ')
'a b c'
```

```
>>> Series(['a','b',np.nan,'c']).str.cat(sep=' ', na_rep='?')
'a b ? c'
```

If `others` is specified, corresponding values are concatenated with the separator. Result will be a Series of strings.

```
>>> Series(['a', 'b', 'c']).str.cat(['A', 'B', 'C'], sep=',')
0    a,A
1    b,B
2    c,C
dtype: object
```

Otherwise, strings in the Series are concatenated. Result will be a string.

```
>>> Series(['a', 'b', 'c']).str.cat(sep=',')
'a,b,c'
```

Also, you can pass a list of list-likes.

```
>>> Series(['a', 'b']).str.cat([['x', 'y'], ['1', '2']], sep=',')
0    a,x,1
1    b,y,2
dtype: object
```

34.3.14.3 pandas.Series.str.center

`Series.str.center`(*width*, *fillchar=' '*)

Filling left and right side of strings in the Series/Index with an additional character. Equivalent to `str.center()`.

Parameters **width** : int

Minimum width of resulting string; additional characters will be filled with `fillchar`

fillchar : str

Additional character for filling, default is whitespace

Returns **filled** : Series/Index of objects

34.3.14.4 pandas.Series.str.contains

`Series.str.contains`(*pat*, *case=True*, *flags=0*, *na=nan*, *regex=True*)

Return boolean Series/`array` whether given pattern/regex is contained in each string in the Series/Index.

Parameters **pat** : string

Character sequence or regular expression

case : boolean, default True

If True, case sensitive

flags : int, default 0 (no flags)

re module flags, e.g. re.IGNORECASE

na : default NaN, fill value for missing values.

regex : bool, default True

If True use re.search, otherwise use Python in operator

Returns **contained** : Series/array of boolean values

See also:

match analogous, but stricter, relying on re.match instead of re.search

34.3.14.5 pandas.Series.str.count

`Series.str.`**`count`**(*pat*, *flags=0*, ***kwargs*)

Count occurrences of pattern in each string of the Series/Index.

Parameters **pat** : string, valid regular expression

flags : int, default 0 (no flags)

re module flags, e.g. re.IGNORECASE

Returns **counts** : Series/Index of integer values

34.3.14.6 pandas.Series.str.decode

`Series.str.`**`decode`**(*encoding*, *errors='strict'*)

Decode character string in the Series/Index using indicated encoding. Equivalent to `str.decode()` in python2 and `bytes.decode()` in python3.

Parameters **encoding** : str

errors : str, optional

Returns **decoded** : Series/Index of objects

34.3.14.7 pandas.Series.str.encode

`Series.str.`**`encode`**(*encoding*, *errors='strict'*)

Encode character string in the Series/Index using indicated encoding. Equivalent to `str.encode()`.

Parameters **encoding** : str

errors : str, optional

Returns **encoded** : Series/Index of objects

34.3.14.8 pandas.Series.str.endswith

`Series.str.`**`endswith`**(*pat*, *na=nan*)

Return boolean Series indicating whether each string in the Series/Index ends with passed pattern. Equivalent to `str.endswith()`.

Parameters **pat** : string

Character sequence

na : bool, default NaN

Returns **endswith** : Series/array of boolean values

34.3.14.9 pandas.Series.str.extract

`Series.str.extract`(*pat*, *flags=0*, *expand=None*)

For each subject string in the Series, extract groups from the first match of regular expression pat.

Parameters **pat** : string

Regular expression pattern with capturing groups

flags : int, default 0 (no flags)

re module flags, e.g. re.IGNORECASE

expand : bool, default False

- If True, return DataFrame.
- If False, return Series/Index/DataFrame.

New in version 0.18.0.

Returns DataFrame with one row for each subject string, and one column for each group. Any capture group names in regular expression pat will be used for column names; otherwise capture group numbers will be used. The dtype of each result column is always object, even when no match is found. If expand=False and pat has only one capture group, then return a Series (if subject is a Series) or Index (if subject is an Index).

See also:

extractall returns all matches (not just the first match)

Examples

A pattern with two groups will return a DataFrame with two columns. Non-matches will be NaN.

```
>>> s = Series(['a1', 'b2', 'c3'])
>>> s.str.extract('([ab])(\d)')
     0    1
0    a    1
1    b    2
2  NaN  NaN
```

A pattern may contain optional groups.

```
>>> s.str.extract('([ab])?(\d)')
     0  1
0    a  1
1    b  2
2  NaN  3
```

Named groups will become column names in the result.

```
>>> s.str.extract('(?P<letter>[ab])(?P<digit>\d)')
  letter digit
0      a     1
1      b     2
2    NaN   NaN
```

A pattern with one group will return a DataFrame with one column if expand=True.

```
>>> s.str.extract('[ab](\d)', expand=True)
     0
0    1
1    2
2  NaN
```

A pattern with one group will return a Series if expand=False.

```
>>> s.str.extract('[ab](\d)', expand=False)
0      1
1      2
2    NaN
dtype: object
```

34.3.14.10 pandas.Series.str.extractall

`Series.str.`**`extractall`**(*pat*, *flags=0*)

For each subject string in the Series, extract groups from all matches of regular expression pat. When each subject string in the Series has exactly one match, extractall(pat).xs(0, level='match') is the same as extract(pat).

New in version 0.18.0.

Parameters **pat** : string

Regular expression pattern with capturing groups

flags : int, default 0 (no flags)

re module flags, e.g. re.IGNORECASE

Returns A DataFrame with one row for each match, and one column for each group. Its rows have a MultiIndex with first levels that come from the subject Series. The last level is named 'match' and indicates the order in the subject. Any capture group names in regular expression pat will be used for column names; otherwise capture group numbers will be used.

See also:

extract returns first match only (not all matches)

Examples

A pattern with one group will return a DataFrame with one column. Indices with no matches will not appear in the result.

```
>>> s = Series(["a1a2", "b1", "c1"], index=["A", "B", "C"])
>>> s.str.extractall("[ab](\d)")
         0
  match
A 0      1
  1      2
B 0      1
```

Capture group names are used for column names of the result.

```
>>> s.str.extractall("[ab](?P<digit>\d)")
        digit
  match
A 0         1
  1         2
B 0         1
```

A pattern with two groups will return a DataFrame with two columns.

```
>>> s.str.extractall("(?P<letter>[ab])(?P<digit>\d)")
        letter digit
  match
A 0          a     1
  1          a     2
B 0          b     1
```

Optional groups that do not match are NaN in the result.

```
>>> s.str.extractall("(?P<letter>[ab])?(?P<digit>\d)")
        letter digit
  match
A 0          a     1
  1          a     2
B 0          b     1
C 0        NaN     1
```

34.3.14.11 pandas.Series.str.find

`Series.str.find`(*sub*, *start=0*, *end=None*)

Return lowest indexes in each strings in the Series/Index where the substring is fully contained between [start:end]. Return -1 on failure. Equivalent to standard `str.find()`.

Parameters **sub** : str

Substring being searched

start : int

Left edge index

end : int

Right edge index

Returns **found** : Series/Index of integer values

See also:

rfind Return highest indexes in each strings

34.3.14.12 pandas.Series.str.findall

`Series.str.findall(pat, flags=0, **kwargs)`

Find all occurrences of pattern or regular expression in the Series/Index. Equivalent to `re.findall()`.

Parameters **pat** : string

Pattern or regular expression

flags : int, default 0 (no flags)

re module flags, e.g. re.IGNORECASE

Returns **matches** : Series/Index of lists

See also:

extractall returns DataFrame with one column per capture group

34.3.14.13 pandas.Series.str.get

`Series.str.get(i)`

Extract element from lists, tuples, or strings in each element in the Series/Index.

Parameters **i** : int

Integer index (location)

Returns **items** : Series/Index of objects

34.3.14.14 pandas.Series.str.index

`Series.str.index(sub, start=0, end=None)`

Return lowest indexes in each strings where the substring is fully contained between [start:end]. This is the same as `str.find` except instead of returning -1, it raises a ValueError when the substring is not found. Equivalent to standard `str.index`.

Parameters **sub** : str

Substring being searched

start : int

Left edge index

end : int

Right edge index

Returns **found** : Series/Index of objects

See also:

rindex Return highest indexes in each strings

34.3.14.15 pandas.Series.str.join

`Series.str.join(sep)`

Join lists contained as elements in the Series/Index with passed delimiter. Equivalent to `str.join()`.

Parameters **sep** : string

Delimiter

Returns **joined** : Series/Index of objects

34.3.14.16 pandas.Series.str.len

`Series.str.`**`len`**`()`

Compute length of each string in the Series/Index.

Returns **lengths** : Series/Index of integer values

34.3.14.17 pandas.Series.str.ljust

`Series.str.`**`ljust`**`(`*width*, *fillchar=' '*`)`

Filling right side of strings in the Series/Index with an additional character. Equivalent to `str.ljust()`.

Parameters **width** : int

Minimum width of resulting string; additional characters will be filled with `fillchar`

fillchar : str

Additional character for filling, default is whitespace

Returns **filled** : Series/Index of objects

34.3.14.18 pandas.Series.str.lower

`Series.str.`**`lower`**`()`

Convert strings in the Series/Index to lowercase. Equivalent to `str.lower()`.

Returns **converted** : Series/Index of objects

34.3.14.19 pandas.Series.str.lstrip

`Series.str.`**`lstrip`**`(`*to_strip=None*`)`

Strip whitespace (including newlines) from each string in the Series/Index from left side. Equivalent to `str.lstrip()`.

Returns **stripped** : Series/Index of objects

34.3.14.20 pandas.Series.str.match

`Series.str.`**`match`**`(`*pat*, *case=True*, *flags=0*, *na=nan*, *as_indexer=None*`)`

Determine if each string matches a regular expression.

Parameters **pat** : string

Character sequence or regular expression

case : boolean, default True

If True, case sensitive

flags : int, default 0 (no flags)

re module flags, e.g. re.IGNORECASE

na : default NaN, fill value for missing values.

as_indexer : DEPRECATED - Keyword is ignored.

Returns Series/array of boolean values

See also:

contains analogous, but less strict, relying on re.search instead of re.match

extract extract matched groups

34.3.14.21 pandas.Series.str.normalize

`Series.str.normalize(form)`

Return the Unicode normal form for the strings in the Series/Index. For more information on the forms, see the `unicodedata.normalize()`.

Parameters **form** : {'NFC', 'NFKC', 'NFD', 'NFKD'}

Unicode form

Returns **normalized** : Series/Index of objects

34.3.14.22 pandas.Series.str.pad

`Series.str.pad(width, side='left', fillchar=' ')`

Pad strings in the Series/Index with an additional character to specified side.

Parameters **width** : int

Minimum width of resulting string; additional characters will be filled with spaces

side : {'left', 'right', 'both'}, default 'left'

fillchar : str

Additional character for filling, default is whitespace

Returns **padded** : Series/Index of objects

34.3.14.23 pandas.Series.str.partition

`Series.str.partition(pat=' ', expand=True)`

Split the string at the first occurrence of *sep*, and return 3 elements containing the part before the separator, the separator itself, and the part after the separator. If the separator is not found, return 3 elements containing the string itself, followed by two empty strings.

Parameters **pat** : string, default whitespace

String to split on.

expand : bool, default True

- If True, return DataFrame/MultiIndex expanding dimensionality.
- If False, return Series/Index.

Returns **split** : DataFrame/MultiIndex or Series/Index of objects

See also:

rpartition Split the string at the last occurrence of *sep*

Examples

```
>>> s = Series(['A_B_C', 'D_E_F', 'X'])
0    A_B_C
1    D_E_F
2        X
dtype: object
```

```
>>> s.str.partition('_')
   0  1    2
0  A  _  B_C
1  D  _  E_F
2  X
```

```
>>> s.str.rpartition('_')
     0  1  2
0  A_B  _  C
1  D_E  _  F
2          X
```

34.3.14.24 pandas.Series.str.repeat

`Series.str.`**`repeat`**(*repeats*)

Duplicate each string in the Series/Index by indicated number of times.

Parameters **repeats** : int or array

Same value for all (int) or different value per (array)

Returns **repeated** : Series/Index of objects

34.3.14.25 pandas.Series.str.replace

`Series.str.`**`replace`**(*pat*, *repl*, *n=-1*, *case=None*, *flags=0*)

Replace occurrences of pattern/regex in the Series/Index with some other string. Equivalent to `str.replace()` or `re.sub()`.

Parameters **pat** : string or compiled regex

String can be a character sequence or regular expression.

New in version 0.20.0: *pat* also accepts a compiled regex.

repl : string or callable

Replacement string or a callable. The callable is passed the regex match object and must return a replacement string to be used. See `re.sub()`.

New in version 0.20.0: *repl* also accepts a callable.

n : int, default -1 (all)

Number of replacements to make from start

case : boolean, default None

- If True, case sensitive (the default if *pat* is a string)
- Set to False for case insensitive
- Cannot be set if *pat* is a compiled regex

flags : int, default 0 (no flags)

- re module flags, e.g. re.IGNORECASE
- Cannot be set if *pat* is a compiled regex

Returns **replaced** : Series/Index of objects

Notes

When *pat* is a compiled regex, all flags should be included in the compiled regex. Use of *case* or *flags* with a compiled regex will raise an error.

Examples

When *repl* is a string, every *pat* is replaced as with `str.replace()`. NaN value(s) in the Series are left as is.

```
>>> pd.Series(['foo', 'fuz', np.nan]).str.replace('f', 'b')
0    boo
1    buz
2    NaN
dtype: object
```

When *repl* is a callable, it is called on every *pat* using `re.sub()`. The callable should expect one positional argument (a regex object) and return a string.

To get the idea:

```
>>> pd.Series(['foo', 'fuz', np.nan]).str.replace('f', repr)
0    <_sre.SRE_Match object; span=(0, 1), match='f'>oo
1    <_sre.SRE_Match object; span=(0, 1), match='f'>uz
2                                                  NaN
dtype: object
```

Reverse every lowercase alphabetic word:

```
>>> repl = lambda m: m.group(0)[::-1]
>>> pd.Series(['foo 123', 'bar baz', np.nan]).str.replace(r'[a-z]+', repl)
0    oof 123
1    rab zab
2        NaN
dtype: object
```

Using regex groups (extract second group and swap case):

```
>>> pat = r"(?P<one>\w+) (?P<two>\w+) (?P<three>\w+)"
>>> repl = lambda m: m.group('two').swapcase()
>>> pd.Series(['One Two Three', 'Foo Bar Baz']).str.replace(pat, repl)
0    tWO
1    bAR
dtype: object
```

Using a compiled regex with flags

```
>>> regex_pat = re.compile(r'FUZ', flags=re.IGNORECASE)
>>> pd.Series(['foo', 'fuz', np.nan]).str.replace(regex_pat, 'bar')
0    foo
1    bar
2    NaN
dtype: object
```

34.3.14.26 pandas.Series.str.rfind

`Series.str.rfind(sub, start=0, end=None)`

Return highest indexes in each strings in the Series/Index where the substring is fully contained between [start:end]. Return -1 on failure. Equivalent to standard `str.rfind()`.

Parameters **sub** : str

Substring being searched

start : int

Left edge index

end : int

Right edge index

Returns **found** : Series/Index of integer values

See also:

find Return lowest indexes in each strings

34.3.14.27 pandas.Series.str.rindex

`Series.str.rindex(sub, start=0, end=None)`

Return highest indexes in each strings where the substring is fully contained between [start:end]. This is the same as `str.rfind` except instead of returning -1, it raises a ValueError when the substring is not found. Equivalent to standard `str.rindex`.

Parameters **sub** : str

Substring being searched

start : int

Left edge index

end : int

Right edge index

Returns **found** : Series/Index of objects

See also:

index Return lowest indexes in each strings

34.3.14.28 pandas.Series.str.rjust

`Series.str.rjust(width, fillchar=' ')`

Filling left side of strings in the Series/Index with an additional character. Equivalent to `str.rjust()`.

Parameters **width** : int

Minimum width of resulting string; additional characters will be filled with `fillchar`

fillchar : str

Additional character for filling, default is whitespace

Returns **filled** : Series/Index of objects

34.3.14.29 pandas.Series.str.rpartition

`Series.str.rpartition(pat=' ', expand=True)`

Split the string at the last occurrence of *sep*, and return 3 elements containing the part before the separator, the separator itself, and the part after the separator. If the separator is not found, return 3 elements containing two empty strings, followed by the string itself.

Parameters **pat** : string, default whitespace

String to split on.

expand : bool, default True

- If True, return DataFrame/MultiIndex expanding dimensionality.
- If False, return Series/Index.

Returns **split** : DataFrame/MultiIndex or Series/Index of objects

See also:

partition Split the string at the first occurrence of *sep*

Examples

```
>>> s = Series(['A_B_C', 'D_E_F', 'X'])
0    A_B_C
1    D_E_F
2        X
dtype: object
```

```
>>> s.str.partition('_')
   0  1    2
0  A  _  B_C
1  D  _  E_F
2  X
```

```
>>> s.str.rpartition('_')
     0  1  2
0  A_B  _  C
1  D_E  _  F
2          X
```

34.3.14.30 pandas.Series.str.rstrip

`Series.str.rstrip(to_strip=None)`

Strip whitespace (including newlines) from each string in the Series/Index from right side. Equivalent to `str.rstrip()`.

Returns **stripped** : Series/Index of objects

34.3.14.31 pandas.Series.str.slice

`Series.str.slice(start=None, stop=None, step=None)`

Slice substrings from each element in the Series/Index

Parameters **start** : int or None

stop : int or None

step : int or None

Returns **sliced** : Series/Index of objects

34.3.14.32 pandas.Series.str.slice_replace

`Series.str.slice_replace(start=None, stop=None, repl=None)`

Replace a slice of each string in the Series/Index with another string.

Parameters **start** : int or None

stop : int or None

repl : str or None

String for replacement

Returns **replaced** : Series/Index of objects

34.3.14.33 pandas.Series.str.split

`Series.str.split(pat=None, n=-1, expand=False)`

Split each string (a la re.split) in the Series/Index by given pattern, propagating NA values. Equivalent to `str.split()`.

Parameters **pat** : string, default None

String or regular expression to split on. If None, splits on whitespace

n : int, default -1 (all)

None, 0 and -1 will be interpreted as return all splits

expand : bool, default False

- If True, return DataFrame/MultiIndex expanding dimensionality.
- If False, return Series/Index.

return_type : deprecated, use *expand*

Returns **split** : Series/Index or DataFrame/MultiIndex of objects

34.3.14.34 pandas.Series.str.rsplit

`Series.str.rsplit(pat=None, n=-1, expand=False)`

Split each string in the Series/Index by the given delimiter string, starting at the end of the string and working to the front. Equivalent to `str.rsplit()`.

Parameters **pat** : string, default None

Separator to split on. If None, splits on whitespace

n : int, default -1 (all)

None, 0 and -1 will be interpreted as return all splits

expand : bool, default False

- If True, return DataFrame/MultiIndex expanding dimensionality.
- If False, return Series/Index.

Returns **split** : Series/Index or DataFrame/MultiIndex of objects

34.3.14.35 pandas.Series.str.startswith

`Series.str.startswith(pat, na=nan)`

Return boolean Series/`array` indicating whether each string in the Series/Index starts with passed pattern. Equivalent to `str.startswith()`.

Parameters **pat** : string

Character sequence

na : bool, default NaN

Returns **startswith** : Series/array of boolean values

34.3.14.36 pandas.Series.str.strip

`Series.str.strip(to_strip=None)`

Strip whitespace (including newlines) from each string in the Series/Index from left and right sides. Equivalent to `str.strip()`.

Returns **stripped** : Series/Index of objects

34.3.14.37 pandas.Series.str.swapcase

`Series.str.swapcase()`

Convert strings in the Series/Index to be swapcased. Equivalent to `str.swapcase()`.

Returns **converted** : Series/Index of objects

34.3.14.38 pandas.Series.str.title

`Series.str.title()`

Convert strings in the Series/Index to titlecase. Equivalent to `str.title()`.

Returns **converted** : Series/Index of objects

34.3.14.39 pandas.Series.str.translate

`Series.str.translate(table, deletechars=None)`

Map all characters in the string through the given mapping table. Equivalent to standard `str.translate()`. Note that the optional argument deletechars is only valid if you are using python 2. For python 3, character deletion should be specified via the table argument.

Parameters **table** : dict (python 3), str or None (python 2)

In python 3, table is a mapping of Unicode ordinals to Unicode ordinals, strings, or None. Unmapped characters are left untouched. Characters mapped to None are deleted. `str.maketrans()` is a helper function for making translation tables. In python 2, table is either a string of length 256 or None. If the table argument is None, no translation is applied and the operation simply removes the characters in deletechars. `string.maketrans()` is a helper function for making translation tables.

deletechars : str, optional (python 2)

A string of characters to delete. This argument is only valid in python 2.

Returns **translated** : Series/Index of objects

34.3.14.40 pandas.Series.str.upper

`Series.str.upper()`

Convert strings in the Series/Index to uppercase. Equivalent to `str.upper()`.

Returns **converted** : Series/Index of objects

34.3.14.41 pandas.Series.str.wrap

`Series.str.wrap(width, **kwargs)`

Wrap long strings in the Series/Index to be formatted in paragraphs with length less than a given width.

This method has the same keyword parameters and defaults as `textwrap.TextWrapper`.

Parameters **width** : int

Maximum line-width

expand_tabs : bool, optional

If true, tab characters will be expanded to spaces (default: True)

replace_whitespace : bool, optional

If true, each whitespace character (as defined by string.whitespace) remaining after tab expansion will be replaced by a single space (default: True)

drop_whitespace : bool, optional

If true, whitespace that, after wrapping, happens to end up at the beginning or end of a line is dropped (default: True)

break_long_words : bool, optional

If true, then words longer than width will be broken in order to ensure that no lines are longer than width. If it is false, long words will not be broken, and some lines may be longer than width. (default: True)

break_on_hyphens : bool, optional

If true, wrapping will occur preferably on whitespace and right after hyphens in compound words, as it is customary in English. If false, only whitespaces will be considered as potentially good places for line breaks, but you need to set break_long_words to false if you want truly insecable words. (default: True)

Returns **wrapped** : Series/Index of objects

Notes

Internally, this method uses a `textwrap.TextWrapper` instance with default settings. To achieve behavior matching R's stringr library str_wrap function, use the arguments:

- expand_tabs = False
- replace_whitespace = True
- drop_whitespace = True
- break_long_words = False
- break_on_hyphens = False

Examples

```
>>> s = pd.Series(['line to be wrapped', 'another line to be wrapped'])
>>> s.str.wrap(12)
0             line to be\nwrapped
1    another line\nto be\nwrapped
```

34.3.14.42 pandas.Series.str.zfill

`Series.str.`**`zfill`**(*width*)

Filling left side of strings in the Series/Index with 0. Equivalent to `str.zfill()`.

Parameters **width** : int

Minimum width of resulting string; additional characters will be filled with 0

Returns **filled** : Series/Index of objects

34.3.14.43 pandas.Series.str.isalnum

`Series.str.`**`isalnum`**()

Check whether all characters in each string in the Series/Index are alphanumeric. Equivalent to `str.isalnum()`.

Returns **is** : Series/array of boolean values

34.3.14.44 pandas.Series.str.isalpha

`Series.str.`**`isalpha`**()

Check whether all characters in each string in the Series/Index are alphabetic. Equivalent to `str.isalpha()`.

Returns **is** : Series/array of boolean values

34.3.14.45 pandas.Series.str.isdigit

`Series.str.isdigit()`

Check whether all characters in each string in the Series/Index are digits. Equivalent to `str.isdigit()`.

Returns is : Series/array of boolean values

34.3.14.46 pandas.Series.str.isspace

`Series.str.isspace()`

Check whether all characters in each string in the Series/Index are whitespace. Equivalent to `str.isspace()`.

Returns is : Series/array of boolean values

34.3.14.47 pandas.Series.str.islower

`Series.str.islower()`

Check whether all characters in each string in the Series/Index are lowercase. Equivalent to `str.islower()`.

Returns is : Series/array of boolean values

34.3.14.48 pandas.Series.str.isupper

`Series.str.isupper()`

Check whether all characters in each string in the Series/Index are uppercase. Equivalent to `str.isupper()`.

Returns is : Series/array of boolean values

34.3.14.49 pandas.Series.str.istitle

`Series.str.istitle()`

Check whether all characters in each string in the Series/Index are titlecase. Equivalent to `str.istitle()`.

Returns is : Series/array of boolean values

34.3.14.50 pandas.Series.str.isnumeric

`Series.str.isnumeric()`

Check whether all characters in each string in the Series/Index are numeric. Equivalent to `str.isnumeric()`.

Returns is : Series/array of boolean values

34.3.14.51 pandas.Series.str.isdecimal

`Series.str.isdecimal()`

Check whether all characters in each string in the Series/Index are decimal. Equivalent to `str.isdecimal()`.

Returns is : Series/array of boolean values

34.3.14.52 pandas.Series.str.get_dummies

`Series.str.get_dummies(sep='|')`

Split each string in the Series by sep and return a frame of dummy/indicator variables.

Parameters **sep** : string, default "|"

String to split on.

Returns **dummies** : DataFrame

See also:

pandas.get_dummies

Examples

```
>>> Series(['a|b', 'a', 'a|c']).str.get_dummies()
   a  b  c
0  1  1  0
1  1  0  0
2  1  0  1
```

```
>>> Series(['a|b', np.nan, 'a|c']).str.get_dummies()
   a  b  c
0  1  1  0
1  0  0  0
2  1  0  1
```

34.3.15 Categorical

The dtype of a `Categorical` can be described by a *pandas.api.types.CategoricalDtype*.

api.types.CategoricalDtype([categories, ordered])	Type for categorical data with the categories and orderedness

34.3.15.1 pandas.api.types.CategoricalDtype

class `pandas.api.types.CategoricalDtype(categories=None, ordered=False)`

Type for categorical data with the categories and orderedness

Changed in version 0.21.0.

Parameters **categories** : sequence, optional

Must be unique, and must not contain any nulls.

ordered : bool, default False

See also:

pandas.Categorical

Notes

This class is useful for specifying the type of a `Categorical` independent of the values. See *CategoricalDtype* for more.

Examples

```
>>> t = CategoricalDtype(categories=['b', 'a'], ordered=True)
>>> pd.Series(['a', 'b', 'a', 'c'], dtype=t)
0      a
1      b
2      a
3    NaN
dtype: category
Categories (2, object): [b < a]
```

If the Series is of dtype `CategoricalDtype`, `Series.cat` can be used to change the categorical data. This accessor is similar to the `Series.dt` or `Series.str` and has the following usable methods and properties:

Series.cat.categories	The categories of this categorical.
Series.cat.ordered	Whether the categories have an ordered relationship
Series.cat.codes	

34.3.15.2 pandas.Series.cat.categories

`Series.cat.`**`categories`**

The categories of this categorical.

Setting assigns new values to each category (effectively a rename of each individual category).

The assigned value has to be a list-like object. All items must be unique and the number of items in the new categories must be the same as the number of items in the old categories.

Assigning to *categories* is a inplace operation!

Raises ValueError

If the new categories do not validate as categories or if the number of new categories is unequal the number of old categories

See also:

rename_categories, *reorder_categories*, *add_categories*, *remove_categories*, *remove_unused_categories*, *set_categories*

34.3.15.3 pandas.Series.cat.ordered

`Series.cat.`**`ordered`**

Whether the categories have an ordered relationship

34.3.15.4 pandas.Series.cat.codes

`Series.cat.`**`codes`**

Series.cat.rename_categories(*args, **kwargs)	Renames categories.
Series.cat.reorder_categories(*args, **kwargs)	Reorders categories as specified in new_categories.
Series.cat.add_categories(*args, **kwargs)	Add new categories.
Series.cat.remove_categories(*args, **kwargs)	Removes the specified categories.
Series.cat.remove_unused_categories(*args, ...)	Removes categories which are not used.
Series.cat.set_categories(*args, **kwargs)	Sets the categories to the specified new_categories.
Series.cat.as_ordered(*args, **kwargs)	Sets the Categorical to be ordered
Series.cat.as_unordered(*args, **kwargs)	Sets the Categorical to be unordered

34.3.15.5 pandas.Series.cat.rename_categories

`Series.cat.`**`rename_categories`**(**args*, ***kwargs*)

Renames categories.

Parameters **new_categories** : list-like or dict-like

- list-like: all items must be unique and the number of items in the new categories must match the existing number of categories.
- dict-like: specifies a mapping from old categories to new. Categories not contained in the mapping are passed through and extra categories in the mapping are ignored. *New in version 0.21.0*.

> **Warning:** Currently, Series are considered list like. In a future version of pandas they'll be considered dict-like.

inplace : boolean (default: False)

Whether or not to rename the categories inplace or return a copy of this categorical with renamed categories.

Returns **cat** : Categorical or None

With `inplace=False`, the new categorical is returned. With `inplace=True`, there is no return value.

Raises **ValueError**

If new categories are list-like and do not have the same number of items than the current categories or do not validate as categories

See also:

reorder_categories, *add_categories*, *remove_categories*, *remove_unused_categories*, *set_categories*

Examples

```
>>> c = Categorical(['a', 'a', 'b'])
>>> c.rename_categories([0, 1])
[0, 0, 1]
Categories (2, int64): [0, 1]
```

For dict-like `new_categories`, extra keys are ignored and categories not in the dictionary are passed through

```
>>> c.rename_categories({'a': 'A', 'c': 'C'})
[A, A, b]
Categories (2, object): [A, b]
```

34.3.15.6 pandas.Series.cat.reorder_categories

`Series.cat.`**`reorder_categories`**(**args*, ***kwargs*)

Reorders categories as specified in new_categories.

new_categories need to include all old categories and no new category items.

Parameters **new_categories** : Index-like

The categories in new order.

ordered : boolean, optional

Whether or not the categorical is treated as a ordered categorical. If not given, do not change the ordered information.

inplace : boolean (default: False)

Whether or not to reorder the categories inplace or return a copy of this categorical with reordered categories.

Returns **cat** : Categorical with reordered categories or None if inplace.

Raises **ValueError**

If the new categories do not contain all old category items or any new ones

See also:

rename_categories, *add_categories*, *remove_categories*, *remove_unused_categories*, *set_categories*

34.3.15.7 pandas.Series.cat.add_categories

`Series.cat.`**`add_categories`**(**args*, ***kwargs*)

Add new categories.

new_categories will be included at the last/highest place in the categories and will be unused directly after this call.

Parameters **new_categories** : category or list-like of category

The new categories to be included.

inplace : boolean (default: False)

Whether or not to add the categories inplace or return a copy of this categorical with added categories.

Returns **cat** : Categorical with new categories added or None if inplace.

Raises **ValueError**

If the new categories include old categories or do not validate as categories

See also:

rename_categories, *reorder_categories*, *remove_categories*, *remove_unused_categories*, *set_categories*

34.3.15.8 pandas.Series.cat.remove_categories

`Series.cat.`**`remove_categories`**(**args*, ***kwargs*)

Removes the specified categories.

removals must be included in the old categories. Values which were in the removed categories will be set to NaN

Parameters **removals** : category or list of categories

The categories which should be removed.

inplace : boolean (default: False)

Whether or not to remove the categories inplace or return a copy of this categorical with removed categories.

Returns **cat** : Categorical with removed categories or None if inplace.

Raises **ValueError**

If the removals are not contained in the categories

See also:

rename_categories, *reorder_categories*, *add_categories*, *remove_unused_categories*, *set_categories*

34.3.15.9 pandas.Series.cat.remove_unused_categories

`Series.cat.`**`remove_unused_categories`**(**args*, ***kwargs*)

Removes categories which are not used.

Parameters **inplace** : boolean (default: False)

Whether or not to drop unused categories inplace or return a copy of this categorical with unused categories dropped.

Returns **cat** : Categorical with unused categories dropped or None if inplace.

See also:

rename_categories, *reorder_categories*, *add_categories*, *remove_categories*, *set_categories*

34.3.15.10 pandas.Series.cat.set_categories

`Series.cat.`**`set_categories`**(**args*, ***kwargs*)

Sets the categories to the specified new_categories.

new_categories can include new categories (which will result in unused categories) or remove old categories (which results in values set to NaN). If *rename==True*, the categories will simple be renamed (less or more items than in old categories will result in values set to NaN or in unused categories respectively).

This method can be used to perform more than one action of adding, removing, and reordering simultaneously and is therefore faster than performing the individual steps via the more specialised methods.

On the other hand this methods does not do checks (e.g., whether the old categories are included in the new categories on a reorder), which can result in surprising changes, for example when using special string dtypes on python3, which does not considers a S1 string equal to a single char python string.

Parameters **new_categories** : Index-like

The categories in new order.

ordered : boolean, (default: False)

Whether or not the categorical is treated as a ordered categorical. If not given, do not change the ordered information.

rename : boolean (default: False)

Whether or not the new_categories should be considered as a rename of the old categories or as reordered categories.

inplace : boolean (default: False)

Whether or not to reorder the categories inplace or return a copy of this categorical with reordered categories.

Returns **cat** : Categorical with reordered categories or None if inplace.

Raises **ValueError**

If new_categories does not validate as categories

See also:

`rename_categories`, `reorder_categories`, `add_categories`, `remove_categories`, `remove_unused_categories`

34.3.15.11 pandas.Series.cat.as_ordered

`Series.cat.`**`as_ordered`**(**args*, ***kwargs*)

Sets the Categorical to be ordered

Parameters **inplace** : boolean (default: False)

Whether or not to set the ordered attribute inplace or return a copy of this categorical with ordered set to True

34.3.15.12 pandas.Series.cat.as_unordered

`Series.cat.`**`as_unordered`**(**args*, ***kwargs*)

Sets the Categorical to be unordered

Parameters **inplace** : boolean (default: False)

Whether or not to set the ordered attribute inplace or return a copy of this categorical with ordered set to False

To create a Series of dtype `category`, use `cat = s.astype("category")`.

The following two `Categorical` constructors are considered API but should only be used when adding ordering information or special categories is need at creation time of the categorical data:

`Categorical`(values[, categories, ordered, ...])	Represents a categorical variable in classic R / S-plus fashion

34.3.15.13 pandas.Categorical

class `pandas.`**`Categorical`**(*values*, *categories=None*, *ordered=None*, *dtype=None*, *fastpath=False*)

Represents a categorical variable in classic R / S-plus fashion

Categoricals can only take on only a limited, and usually fixed, number of possible values (*categories*). In contrast to statistical categorical variables, a *Categorical* might have an order, but numerical operations (additions, divisions, ...) are not possible.

All values of the *Categorical* are either in *categories* or *np.nan*. Assigning values outside of *categories* will raise a *ValueError*. Order is defined by the order of the *categories*, not lexical order of the values.

Parameters **values** : list-like

The values of the categorical. If categories are given, values not in categories will be replaced with NaN.

categories : Index-like (unique), optional

The unique categories for this categorical. If not given, the categories are assumed to be the unique values of values.

ordered : boolean, (default False)

Whether or not this categorical is treated as a ordered categorical. If not given, the resulting categorical will not be ordered.

dtype : CategoricalDtype

An instance of `CategoricalDtype` to use for this categorical

New in version 0.21.0.

Raises **ValueError**

If the categories do not validate.

TypeError

If an explicit `ordered=True` is given but no *categories* and the *values* are not sortable.

See also:

`pandas.api.types.CategoricalDtype` Type for categorical data

`CategoricalIndex` An Index with an underlying `Categorical`

Notes

See the user guide for more.

Examples

```
>>> pd.Categorical([1, 2, 3, 1, 2, 3])
[1, 2, 3, 1, 2, 3]
Categories (3, int64): [1, 2, 3]
```

```
>>> pd.Categorical(['a', 'b', 'c', 'a', 'b', 'c'])
[a, b, c, a, b, c]
Categories (3, object): [a, b, c]
```

Ordered *Categoricals* can be sorted according to the custom order of the categories and can have a min and max value.

```
>>> c = pd.Categorical(['a','b','c','a','b','c'], ordered=True,
...                    categories=['c', 'b', 'a'])
>>> c
[a, b, c, a, b, c]
Categories (3, object): [c < b < a]
>>> c.min()
'c'
```

`Categorical.from_codes`(codes, categories[, ...])	Make a Categorical type from codes and categories arrays.

34.3.15.14 pandas.Categorical.from_codes

classmethod `Categorical.`**`from_codes`**(*codes*, *categories*, *ordered=False*)

Make a Categorical type from codes and categories arrays.

This constructor is useful if you already have codes and categories and so do not need the (computation intensive) factorization step, which is usually done on the constructor.

If your data does not follow this convention, please use the normal constructor.

Parameters **codes** : array-like, integers

An integer array, where each integer points to a category in categories or -1 for NaN

categories : index-like

The categories for the categorical. Items need to be unique.

ordered : boolean, (default False)

Whether or not this categorical is treated as a ordered categorical. If not given, the resulting categorical will be unordered.

`np.asarray(categorical)` works by implementing the array interface. Be aware, that this converts the Categorical back to a numpy array, so categories and order information is not preserved!

`Categorical.__array__`([dtype])	The numpy array interface.

34.3.15.15 pandas.Categorical.__array__

`Categorical.`**`__array__`**(*dtype=None*)

The numpy array interface.

Returns **values** : numpy array

A numpy array of either the specified dtype or, if dtype==None (default), the same dtype as categorical.categories.dtype

34.3.16 Plotting

`Series.plot` is both a callable method and a namespace attribute for specific plotting methods of the form `Series.plot.<kind>`.

`Series.plot`([kind, ax, figsize, ...])	Series plotting accessor and method

`Series.plot.area`(**kwds)	Area plot
`Series.plot.bar`(**kwds)	Vertical bar plot
`Series.plot.barh`(**kwds)	Horizontal bar plot
`Series.plot.box`(**kwds)	Boxplot
`Series.plot.density`(**kwds)	Kernel Density Estimate plot
`Series.plot.hist`([bins])	Histogram
`Series.plot.kde`(**kwds)	Kernel Density Estimate plot
`Series.plot.line`(**kwds)	Line plot
`Series.plot.pie`(**kwds)	Pie chart

34.3.16.1 pandas.Series.plot.area

`Series.plot.`**`area`**(***kwds*)

Area plot

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.Series.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.3.16.2 pandas.Series.plot.bar

`Series.plot.`**`bar`**(***kwds*)

Vertical bar plot

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.Series.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.3.16.3 pandas.Series.plot.barh

`Series.plot.`**`barh`**(***kwds*)

Horizontal bar plot

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.Series.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.3.16.4 pandas.Series.plot.box

`Series.plot.box(**kwds)`

Boxplot

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.Series.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.3.16.5 pandas.Series.plot.density

`Series.plot.density(**kwds)`

Kernel Density Estimate plot

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.Series.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.3.16.6 pandas.Series.plot.hist

`Series.plot.hist(bins=10, **kwds)`

Histogram

New in version 0.17.0.

Parameters **bins: integer, default 10**

Number of histogram bins to be used

****kwds** : optional

Keyword arguments to pass on to `pandas.Series.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.3.16.7 pandas.Series.plot.kde

`Series.plot.kde(**kwds)`

Kernel Density Estimate plot

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.Series.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.3.16.8 pandas.Series.plot.line

`Series.plot.line(**kwds)`

Line plot

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.Series.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.3.16.9 pandas.Series.plot.pie

`Series.plot.pie(**kwds)`

Pie chart

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.Series.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

`Series.hist`([by, ax, grid, xlabelsize, ...])	Draw histogram of the input series using matplotlib

34.3.17 Serialization / IO / Conversion

`Series.from_csv`(path[, sep, parse_dates, ...])	Read CSV file (DEPRECATED, please use `pandas.read_csv()` instead).
`Series.to_pickle`(path[, compression, protocol])	Pickle (serialize) object to input file path.
`Series.to_csv`([path, index, sep, na_rep, ...])	Write Series to a comma-separated values (csv) file
`Series.to_dict`([into])	Convert Series to {label -> value} dict or dict-like object.
`Series.to_excel`(excel_writer[, sheet_name, ...])	Write Series to an excel sheet
`Series.to_frame`([name])	Convert Series to DataFrame
`Series.to_xarray`()	Return an xarray object from the pandas object.
`Series.to_hdf`(path_or_buf, key, **kwargs)	Write the contained data to an HDF5 file using HDFStore.
`Series.to_sql`(name, con[, flavor, schema, ...])	Write records stored in a DataFrame to a SQL database.
`Series.to_msgpack`([path_or_buf, encoding])	msgpack (serialize) object to input file path
`Series.to_json`([path_or_buf, orient, ...])	Convert the object to a JSON string.
`Series.to_sparse`([kind, fill_value])	Convert Series to SparseSeries
`Series.to_dense`()	Return dense representation of NDFrame (as opposed to sparse)
`Series.to_string`([buf, na_rep, ...])	Render a string representation of the Series
`Series.to_clipboard`([excel, sep])	Attempt to write text representation of object to the system clipboard This can be pasted into Excel, for example.
`Series.to_latex`([buf, columns, col_space, ...])	Render an object to a tabular environment table.

34.3.18 Sparse

SparseSeries.to_coo([row_levels, ...])	Create a scipy.sparse.coo_matrix from a SparseSeries with MultiIndex.
SparseSeries.from_coo(A[, dense_index])	Create a SparseSeries from a scipy.sparse.coo_matrix.

34.3.18.1 pandas.SparseSeries.to_coo

`SparseSeries.to_coo`(*row_levels=(0,)*, *column_levels=(1,)*, *sort_labels=False*)

Create a scipy.sparse.coo_matrix from a SparseSeries with MultiIndex.

Use row_levels and column_levels to determine the row and column coordinates respectively. row_levels and column_levels are the names (labels) or numbers of the levels. {row_levels, column_levels} must be a partition of the MultiIndex level names (or numbers).

Parameters **row_levels** : tuple/list

column_levels : tuple/list

sort_labels : bool, default False

Sort the row and column labels before forming the sparse matrix.

Returns **y** : scipy.sparse.coo_matrix

rows : list (row labels)

columns : list (column labels)

Examples

```
>>> from numpy import nan
>>> s = Series([3.0, nan, 1.0, 3.0, nan, nan])
>>> s.index = MultiIndex.from_tuples([(1, 2, 'a', 0),
                                      (1, 2, 'a', 1),
                                      (1, 1, 'b', 0),
                                      (1, 1, 'b', 1),
                                      (2, 1, 'b', 0),
                                      (2, 1, 'b', 1)],
                                     names=['A', 'B', 'C', 'D'])
>>> ss = s.to_sparse()
>>> A, rows, columns = ss.to_coo(row_levels=['A', 'B'],
                                 column_levels=['C', 'D'],
                                 sort_labels=True)
>>> A
<3x4 sparse matrix of type '<class 'numpy.float64'>'
        with 3 stored elements in COOrdinate format>
>>> A.todense()
matrix([[ 0.,  0.,  1.,  3.],
[ 3.,  0.,  0.,  0.],
[ 0.,  0.,  0.,  0.]])
>>> rows
[(1, 1), (1, 2), (2, 1)]
>>> columns
[('a', 0), ('a', 1), ('b', 0), ('b', 1)]
```

34.3.18.2 pandas.SparseSeries.from_coo

classmethod `SparseSeries.from_coo`(*A*, *dense_index=False*)

Create a SparseSeries from a scipy.sparse.coo_matrix.

Parameters **A** : scipy.sparse.coo_matrix

dense_index : bool, default False

If False (default), the SparseSeries index consists of only the coords of the non-null entries of the original coo_matrix. If True, the SparseSeries index consists of the full sorted (row, col) coordinates of the coo_matrix.

Returns **s** : SparseSeries

Examples

```
>>> from scipy import sparse
>>> A = sparse.coo_matrix(([3.0, 1.0, 2.0], ([1, 0, 0], [0, 2, 3])),
                          shape=(3, 4))
>>> A
<3x4 sparse matrix of type '<class 'numpy.float64'>'
        with 3 stored elements in COOrdinate format>
>>> A.todense()
matrix([[ 0.,  0.,  1.,  2.],
        [ 3.,  0.,  0.,  0.],
        [ 0.,  0.,  0.,  0.]])
>>> ss = SparseSeries.from_coo(A)
>>> ss
0  2    1
   3    2
1  0    3
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([3], dtype=int32)
```

34.4 DataFrame

34.4.1 Constructor

`DataFrame`([data, index, columns, dtype, copy])	Two-dimensional size-mutable, potentially heterogeneous tabular data structure with labeled axes (rows and columns).

34.4.1.1 pandas.DataFrame

class `pandas.DataFrame`(*data=None*, *index=None*, *columns=None*, *dtype=None*, *copy=False*)

Two-dimensional size-mutable, potentially heterogeneous tabular data structure with labeled axes (rows and columns). Arithmetic operations align on both row and column labels. Can be thought of as a dict-like container for Series objects. The primary pandas data structure

Parameters **data** : numpy ndarray (structured or homogeneous), dict, or DataFrame

Dict can contain Series, arrays, constants, or list-like objects

index : Index or array-like

Index to use for resulting frame. Will default to np.arange(n) if no indexing information part of input data and no index provided

columns : Index or array-like

Column labels to use for resulting frame. Will default to np.arange(n) if no column labels are provided

dtype : dtype, default None

Data type to force. Only a single dtype is allowed. If None, infer

copy : boolean, default False

Copy data from inputs. Only affects DataFrame / 2d ndarray input

See also:

DataFrame.from_records constructor from tuples, also record arrays

DataFrame.from_dict from dicts of Series, arrays, or dicts

DataFrame.from_items from sequence of (key, value) pairs

pandas.read_csv, *pandas.read_table*, *pandas.read_clipboard*

Examples

Constructing DataFrame from a dictionary.

```
>>> d = {'col1': [1, 2], 'col2': [3, 4]}
>>> df = pd.DataFrame(data=d)
>>> df
   col1  col2
0     1     3
1     2     4
```

Notice that the inferred dtype is int64.

```
>>> df.dtypes
col1    int64
col2    int64
dtype: object
```

To enforce a single dtype:

```
>>> df = pd.DataFrame(data=d, dtype=np.int8)
>>> df.dtypes
col1    int8
col2    int8
dtype: object
```

Constructing DataFrame from numpy ndarray:

```
>>> df2 = pd.DataFrame(np.random.randint(low=0, high=10, size=(5, 5)),
...                    columns=['a', 'b', 'c', 'd', 'e'])
>>> df2
   a  b  c  d  e
0  2  8  8  3  4
1  4  2  9  0  9
2  1  0  7  8  0
3  5  1  7  1  3
4  6  0  2  4  2
```

Attributes

T	Transpose index and columns
at	Fast label-based scalar accessor
axes	Return a list with the row axis labels and column axis labels as the only members.
blocks	Internal property, property synonym for as_blocks()
dtypes	Return the dtypes in this object.
empty	True if NDFrame is entirely empty [no items], meaning any of the axes are of length 0.
ftypes	Return the ftypes (indication of sparse/dense and dtype) in this object.
iat	Fast integer location scalar accessor.
iloc	Purely integer-location based indexing for selection by position.
is_copy	
ix	A primarily label-location based indexer, with integer position fallback.
loc	Purely label-location based indexer for selection by label.
ndim	Number of axes / array dimensions
shape	Return a tuple representing the dimensionality of the DataFrame.
size	number of elements in the NDFrame
style	Property returning a Styler object containing methods for building a styled HTML representation fo the DataFrame.
values	Numpy representation of NDFrame

pandas.DataFrame.T

`DataFrame.T`

Transpose index and columns

pandas.DataFrame.at

`DataFrame.at`

Fast label-based scalar accessor

Similarly to `loc`, `at` provides **label** based scalar lookups. You can also set using these indexers.

pandas.DataFrame.axes

`DataFrame.axes`

Return a list with the row axis labels and column axis labels as the only members. They are returned in that order.

pandas.DataFrame.blocks

`DataFrame.blocks`

Internal property, property synonym for as_blocks()

Deprecated since version 0.21.0.

pandas.DataFrame.dtypes

`DataFrame.dtypes`

Return the dtypes in this object.

pandas.DataFrame.empty

`DataFrame.empty`

True if NDFrame is entirely empty [no items], meaning any of the axes are of length 0.

See also:

pandas.Series.dropna, *pandas.DataFrame.dropna*

Notes

If NDFrame contains only NaNs, it is still not considered empty. See the example below.

Examples

An example of an actual empty DataFrame. Notice the index is empty:

```
>>> df_empty = pd.DataFrame({'A' : []})
>>> df_empty
Empty DataFrame
Columns: [A]
Index: []
>>> df_empty.empty
True
```

If we only have NaNs in our DataFrame, it is not considered empty! We will need to drop the NaNs to make the DataFrame empty:

```
>>> df = pd.DataFrame({'A' : [np.nan]})
>>> df
    A
0 NaN
>>> df.empty
```

```
False
>>> df.dropna().empty
True
```

pandas.DataFrame.ftypes

`DataFrame.ftypes`

Return the ftypes (indication of sparse/dense and dtype) in this object.

pandas.DataFrame.iat

`DataFrame.iat`

Fast integer location scalar accessor.

Similarly to `iloc`, `iat` provides **integer** based lookups. You can also set using these indexers.

pandas.DataFrame.iloc

`DataFrame.iloc`

Purely integer-location based indexing for selection by position.

`.iloc[]` is primarily integer position based (from `0` to `length-1` of the axis), but may also be used with a boolean array.

Allowed inputs are:

- An integer, e.g. `5`.
- A list or array of integers, e.g. `[4, 3, 0]`.
- A slice object with ints, e.g. `1:7`.
- A boolean array.
- A `callable` function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

`.iloc` will raise `IndexError` if a requested indexer is out-of-bounds, except *slice* indexers which allow out-of-bounds indexing (this conforms with python/numpy *slice* semantics).

See more at *Selection by Position*

pandas.DataFrame.is_copy

`DataFrame.is_copy` = **None**

pandas.DataFrame.ix

`DataFrame.ix`

A primarily label-location based indexer, with integer position fallback.

`.ix[]` supports mixed integer and label based access. It is primarily label based, but will fall back to integer positional access unless the corresponding axis is of integer type.

`.ix` is the most general indexer and will support any of the inputs in `.loc` and `.iloc`. `.ix` also supports floating point label schemes. `.ix` is exceptionally useful when dealing with mixed positional and label based hierachical indexes.

However, when an axis is integer based, ONLY label based access and not positional access is supported. Thus, in such cases, it's usually better to be explicit and use `.iloc` or `.loc`.

See more at *Advanced Indexing*.

pandas.DataFrame.loc

`DataFrame.`**`loc`**

Purely label-location based indexer for selection by label.

`.loc[]` is primarily label based, but may also be used with a boolean array.

Allowed inputs are:

- A single label, e.g. `5` or `'a'`, (note that `5` is interpreted as a *label* of the index, and **never** as an integer position along the index).
- A list or array of labels, e.g. `['a', 'b', 'c']`.
- A slice object with labels, e.g. `'a':'f'` (note that contrary to usual python slices, **both** the start and the stop are included!).
- A boolean array.
- A `callable` function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

`.loc` will raise a `KeyError` when the items are not found.

See more at *Selection by Label*

pandas.DataFrame.ndim

`DataFrame.`**`ndim`**

Number of axes / array dimensions

pandas.DataFrame.shape

`DataFrame.`**`shape`**

Return a tuple representing the dimensionality of the DataFrame.

pandas.DataFrame.size

`DataFrame.`**`size`**

number of elements in the NDFrame

pandas.DataFrame.style

`DataFrame.`**`style`**

Property returning a Styler object containing methods for building a styled HTML representation fo the DataFrame.

See also:

pandas.io.formats.style.Styler

pandas.DataFrame.values

DataFrame.**values**

Numpy representation of NDFrame

Notes

The dtype will be a lower-common-denominator dtype (implicit upcasting); that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen. Use this with care if you are not dealing with the blocks.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. If dtypes are int32 and uint8, dtype will be upcast to int32. By numpy.find_common_type convention, mixing int64 and uint64 will result in a flot64 dtype.

Methods

abs()	Return an object with absolute value taken–only applicable to objects that are all numeric.
add(other[, axis, level, fill_value])	Addition of dataframe and other, element-wise (binary operator *add*).
add_prefix(prefix)	Concatenate prefix string with panel items names.
add_suffix(suffix)	Concatenate suffix string with panel items names.
agg(func[, axis])	Aggregate using callable, string, dict, or list of string/callables
aggregate(func[, axis])	Aggregate using callable, string, dict, or list of string/callables
align(other[, join, axis, level, copy, ...])	Align two objects on their axes with the
all([axis, bool_only, skipna, level])	Return whether all elements are True over requested axis
any([axis, bool_only, skipna, level])	Return whether any element is True over requested axis
append(other[, ignore_index, verify_integrity])	Append rows of *other* to the end of this frame, returning a new object.
apply(func[, axis, broadcast, raw, reduce, args])	Applies function along input axis of DataFrame.
applymap(func)	Apply a function to a DataFrame that is intended to operate elementwise, i.e.
as_blocks([copy])	Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.
as_matrix([columns])	Convert the frame to its Numpy-array representation.
asfreq(freq[, method, how, normalize, ...])	Convert TimeSeries to specified frequency.
asof(where[, subset])	The last row without any NaN is taken (or the last row without
assign(**kwargs)	Assign new columns to a DataFrame, returning a new object (a copy) with all the original columns in addition to the new ones.
astype(dtype[, copy, errors])	Cast a pandas object to a specified dtype `dtype`.

Continued on next page

Table 34.55 – continued from previous page

at_time(time[, asof])	Select values at particular time of day (e.g.
between_time(start_time, end_time[, ...])	Select values between particular times of the day (e.g., 9:00-9:30 AM).
bfill([axis, inplace, limit, downcast])	Synonym for DataFrame.fillna(method='bfill')
bool()	Return the bool of a single element PandasObject.
boxplot([column, by, ax, fontsize, rot, ...])	Make a box plot from DataFrame column optionally grouped by some columns or
clip([lower, upper, axis, inplace])	Trim values at input threshold(s).
clip_lower(threshold[, axis, inplace])	Return copy of the input with values below given value(s) truncated.
clip_upper(threshold[, axis, inplace])	Return copy of input with values above given value(s) truncated.
combine(other, func[, fill_value, overwrite])	Add two DataFrame objects and do not propagate NaN values, so if for a
combine_first(other)	Combine two DataFrame objects and default to non-null values in frame calling the method.
compound([axis, skipna, level])	Return the compound percentage of the values for the requested axis
consolidate([inplace])	DEPRECATED: consolidate will be an internal implementation only.
convert_objects([convert_dates, ...])	Deprecated.
copy([deep])	Make a copy of this objects data.
corr([method, min_periods])	Compute pairwise correlation of columns, excluding NA/null values
corrwith(other[, axis, drop])	Compute pairwise correlation between rows or columns of two DataFrame objects.
count([axis, level, numeric_only])	Return Series with number of non-NA/null observations over requested axis.
cov([min_periods])	Compute pairwise covariance of columns, excluding NA/null values
cummax([axis, skipna])	Return cumulative max over requested axis.
cummin([axis, skipna])	Return cumulative minimum over requested axis.
cumprod([axis, skipna])	Return cumulative product over requested axis.
cumsum([axis, skipna])	Return cumulative sum over requested axis.
describe([percentiles, include, exclude])	Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding NaN values.
diff([periods, axis])	1st discrete difference of object
div(other[, axis, level, fill_value])	Floating division of dataframe and other, element-wise (binary operator *truediv*).
divide(other[, axis, level, fill_value])	Floating division of dataframe and other, element-wise (binary operator *truediv*).
dot(other)	Matrix multiplication with DataFrame or Series objects
drop([labels, axis, index, columns, level, ...])	Return new object with labels in requested axis removed.
drop_duplicates([subset, keep, inplace])	Return DataFrame with duplicate rows removed, optionally only
dropna([axis, how, thresh, subset, inplace])	Return object with labels on given axis omitted where alternately any

Continued on next page

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duplicated([subset, keep])	Return boolean Series denoting duplicate rows, optionally only
eq(other[, axis, level])	Wrapper for flexible comparison methods eq
equals(other)	Determines if two NDFrame objects contain the same elements.
eval(expr[, inplace])	Evaluate an expression in the context of the calling DataFrame instance.
ewm([com, span, halflife, alpha, ...])	Provides exponential weighted functions
expanding([min_periods, freq, center, axis])	Provides expanding transformations.
ffill([axis, inplace, limit, downcast])	Synonym for DataFrame.fillna(method='ffill')
fillna([value, method, axis, inplace, ...])	Fill NA/NaN values using the specified method
filter([items, like, regex, axis])	Subset rows or columns of dataframe according to labels in the specified index.
first(offset)	Convenience method for subsetting initial periods of time series data based on a date offset.
first_valid_index()	Return index for first non-NA/null value.
floordiv(other[, axis, level, fill_value])	Integer division of dataframe and other, element-wise (binary operator *floordiv*).
from_csv(path[, header, sep, index_col, ...])	Read CSV file (DEPRECATED, please use pandas.read_csv() instead).
from_dict(data[, orient, dtype])	Construct DataFrame from dict of array-like or dicts
from_items(items[, columns, orient])	Convert (key, value) pairs to DataFrame.
from_records(data[, index, exclude, ...])	Convert structured or record ndarray to DataFrame
ge(other[, axis, level])	Wrapper for flexible comparison methods ge
get(key[, default])	Get item from object for given key (DataFrame column, Panel slice, etc.).
get_dtype_counts()	Return the counts of dtypes in this object.
get_ftype_counts()	Return the counts of ftypes in this object.
get_value(index, col[, takeable])	Quickly retrieve single value at passed column and index
get_values()	same as values (but handles sparseness conversions)
groupby([by, axis, level, as_index, sort, ...])	Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.
gt(other[, axis, level])	Wrapper for flexible comparison methods gt
head([n])	Return the first n rows.
hist(data[, column, by, grid, xlabelsize, ...])	Draw histogram of the DataFrame's series using matplotlib / pylab.
idxmax([axis, skipna])	Return index of first occurrence of maximum over requested axis.
idxmin([axis, skipna])	Return index of first occurrence of minimum over requested axis.
infer_objects()	Attempt to infer better dtypes for object columns.
info([verbose, buf, max_cols, memory_usage, ...])	Concise summary of a DataFrame.
insert(loc, column, value[, allow_duplicates])	Insert column into DataFrame at specified location.
interpolate([method, axis, limit, inplace, ...])	Interpolate values according to different methods.
isin(values)	Return boolean DataFrame showing whether each element in the DataFrame is contained in values.

Continued on next page

Table 34.55 – continued from previous page

isna()	Return a boolean same-sized object indicating if the values are NA.
isnull()	Return a boolean same-sized object indicating if the values are NA.
items()	Iterator over (column name, Series) pairs.
iteritems()	Iterator over (column name, Series) pairs.
iterrows()	Iterate over DataFrame rows as (index, Series) pairs.
itertuples([index, name])	Iterate over DataFrame rows as namedtuples, with index value as first element of the tuple.
join(other[, on, how, lsuffix, rsuffix, sort])	Join columns with other DataFrame either on index or on a key column.
keys()	Get the 'info axis' (see Indexing for more)
kurt([axis, skipna, level, numeric_only])	Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0).
kurtosis([axis, skipna, level, numeric_only])	Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0).
last(offset)	Convenience method for subsetting final periods of time series data based on a date offset.
last_valid_index()	Return index for first non-NA/null value.
le(other[, axis, level])	Wrapper for flexible comparison methods le
lookup(row_labels, col_labels)	Label-based "fancy indexing" function for DataFrame.
lt(other[, axis, level])	Wrapper for flexible comparison methods lt
mad([axis, skipna, level])	Return the mean absolute deviation of the values for the requested axis
mask(cond[, other, inplace, axis, level, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.
max([axis, skipna, level, numeric_only])	This method returns the maximum of the values in the object.
mean([axis, skipna, level, numeric_only])	Return the mean of the values for the requested axis
median([axis, skipna, level, numeric_only])	Return the median of the values for the requested axis
melt([id_vars, value_vars, var_name, ...])	"Unpivots" a DataFrame from wide format to long format, optionally
memory_usage([index, deep])	Memory usage of DataFrame columns.
merge(right[, how, on, left_on, right_on, ...])	Merge DataFrame objects by performing a database-style join operation by columns or indexes.
min([axis, skipna, level, numeric_only])	This method returns the minimum of the values in the object.
mod(other[, axis, level, fill_value])	Modulo of dataframe and other, element-wise (binary operator *mod*).
mode([axis, numeric_only])	Gets the mode(s) of each element along the axis selected.
mul(other[, axis, level, fill_value])	Multiplication of dataframe and other, element-wise (binary operator *mul*).
multiply(other[, axis, level, fill_value])	Multiplication of dataframe and other, element-wise (binary operator *mul*).
ne(other[, axis, level])	Wrapper for flexible comparison methods ne
nlargest(n, columns[, keep])	Get the rows of a DataFrame sorted by the *n* largest values of *columns*.

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Table 34.55 – continued from previous page

notna()	Return a boolean same-sized object indicating if the values are not NA.
notnull()	Return a boolean same-sized object indicating if the values are not NA.
nsmallest(n, columns[, keep])	Get the rows of a DataFrame sorted by the *n* smallest values of *columns*.
nunique([axis, dropna])	Return Series with number of distinct observations over requested axis.
pct_change([periods, fill_method, limit, freq])	Percent change over given number of periods.
pipe(func, *args, **kwargs)	Apply func(self, *args, **kwargs)
pivot([index, columns, values])	Reshape data (produce a "pivot" table) based on column values.
pivot_table([values, index, columns, ...])	Create a spreadsheet-style pivot table as a DataFrame.
plot	alias of `FramePlotMethods`
pop(item)	Return item and drop from frame.
pow(other[, axis, level, fill_value])	Exponential power of dataframe and other, element-wise (binary operator *pow*).
prod([axis, skipna, level, numeric_only])	Return the product of the values for the requested axis
product([axis, skipna, level, numeric_only])	Return the product of the values for the requested axis
quantile([q, axis, numeric_only, interpolation])	Return values at the given quantile over requested axis, a la numpy.percentile.
query(expr[, inplace])	Query the columns of a frame with a boolean expression.
radd(other[, axis, level, fill_value])	Addition of dataframe and other, element-wise (binary operator *radd*).
rank([axis, method, numeric_only, ...])	Compute numerical data ranks (1 through n) along axis.
rdiv(other[, axis, level, fill_value])	Floating division of dataframe and other, element-wise (binary operator *rtruediv*).
reindex([labels, index, columns, axis, ...])	Conform DataFrame to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
reindex_axis(labels[, axis, method, level, ...])	Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
reindex_like(other[, method, copy, limit, ...])	Return an object with matching indices to myself.
rename([mapper, index, columns, axis, copy, ...])	Alter axes labels.
rename_axis(mapper[, axis, copy, inplace])	Alter the name of the index or columns.
reorder_levels(order[, axis])	Rearrange index levels using input order.
replace([to_replace, value, inplace, limit, ...])	Replace values given in 'to_replace' with 'value'.
resample(rule[, how, axis, fill_method, ...])	Convenience method for frequency conversion and resampling of time series.
reset_index([level, drop, inplace, ...])	For DataFrame with multi-level index, return new DataFrame with labeling information in the columns under the index names, defaulting to 'level_0', 'level_1', etc.
rfloordiv(other[, axis, level, fill_value])	Integer division of dataframe and other, element-wise (binary operator *rfloordiv*).
rmod(other[, axis, level, fill_value])	Modulo of dataframe and other, element-wise (binary operator *rmod*).
rmul(other[, axis, level, fill_value])	Multiplication of dataframe and other, element-wise (binary operator *rmul*).

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Table 34.55 – continued from previous page

rolling(window[, min_periods, freq, center, ...])	Provides rolling window calculations.
round([decimals])	Round a DataFrame to a variable number of decimal places.
rpow(other[, axis, level, fill_value])	Exponential power of dataframe and other, element-wise (binary operator *rpow*).
rsub(other[, axis, level, fill_value])	Subtraction of dataframe and other, element-wise (binary operator *rsub*).
rtruediv(other[, axis, level, fill_value])	Floating division of dataframe and other, element-wise (binary operator *rtruediv*).
sample([n, frac, replace, weights, ...])	Returns a random sample of items from an axis of object.
select(crit[, axis])	Return data corresponding to axis labels matching criteria
select_dtypes([include, exclude])	Return a subset of a DataFrame including/excluding columns based on their `dtype`.
sem([axis, skipna, level, ddof, numeric_only])	Return unbiased standard error of the mean over requested axis.
set_axis(labels[, axis, inplace])	Assign desired index to given axis
set_index(keys[, drop, append, inplace, ...])	Set the DataFrame index (row labels) using one or more existing columns.
set_value(index, col, value[, takeable])	Put single value at passed column and index
shift([periods, freq, axis])	Shift index by desired number of periods with an optional time freq
skew([axis, skipna, level, numeric_only])	Return unbiased skew over requested axis
slice_shift([periods, axis])	Equivalent to *shift* without copying data.
sort_index([axis, level, ascending, ...])	Sort object by labels (along an axis)
sort_values(by[, axis, ascending, inplace, ...])	Sort by the values along either axis
sortlevel([level, axis, ascending, inplace, ...])	DEPRECATED: use `DataFrame.sort_index()`
squeeze([axis])	Squeeze length 1 dimensions.
stack([level, dropna])	Pivot a level of the (possibly hierarchical) column labels, returning a DataFrame (or Series in the case of an object with a single level of column labels) having a hierarchical index with a new inner-most level of row labels.
std([axis, skipna, level, ddof, numeric_only])	Return sample standard deviation over requested axis.
sub(other[, axis, level, fill_value])	Subtraction of dataframe and other, element-wise (binary operator *sub*).
subtract(other[, axis, level, fill_value])	Subtraction of dataframe and other, element-wise (binary operator *sub*).
sum([axis, skipna, level, numeric_only])	Return the sum of the values for the requested axis
swapaxes(axis1, axis2[, copy])	Interchange axes and swap values axes appropriately
swaplevel([i, j, axis])	Swap levels i and j in a MultiIndex on a particular axis
tail([n])	Return the last n rows.
take(indices[, axis, convert, is_copy])	Return the elements in the given *positional* indices along an axis.
to_clipboard([excel, sep])	Attempt to write text representation of object to the system clipboard This can be pasted into Excel, for example.
to_csv([path_or_buf, sep, na_rep, ...])	Write DataFrame to a comma-separated values (csv) file
to_dense()	Return dense representation of NDFrame (as opposed to sparse)

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Table 34.55 – continued from previous page

to_dict([orient, into])	Convert DataFrame to dictionary.
to_excel(excel_writer[, sheet_name, na_rep, ...])	Write DataFrame to an excel sheet
to_feather(fname)	write out the binary feather-format for DataFrames
to_gbq(destination_table, project_id[, ...])	Write a DataFrame to a Google BigQuery table.
to_hdf(path_or_buf, key, **kwargs)	Write the contained data to an HDF5 file using HDFStore.
to_html([buf, columns, col_space, header, ...])	Render a DataFrame as an HTML table.
to_json([path_or_buf, orient, date_format, ...])	Convert the object to a JSON string.
to_latex([buf, columns, col_space, header, ...])	Render an object to a tabular environment table.
to_msgpack([path_or_buf, encoding])	msgpack (serialize) object to input file path
to_panel()	Transform long (stacked) format (DataFrame) into wide (3D, Panel) format.
to_parquet(fname[, engine, compression])	Write a DataFrame to the binary parquet format.
to_period([freq, axis, copy])	Convert DataFrame from DatetimeIndex to PeriodIndex with desired
to_pickle(path[, compression, protocol])	Pickle (serialize) object to input file path.
to_records([index, convert_datetime64])	Convert DataFrame to record array.
to_sparse([fill_value, kind])	Convert to SparseDataFrame
to_sql(name, con[, flavor, schema, ...])	Write records stored in a DataFrame to a SQL database.
to_stata(fname[, convert_dates, ...])	A class for writing Stata binary dta files from array-like objects
to_string([buf, columns, col_space, header, ...])	Render a DataFrame to a console-friendly tabular output.
to_timestamp([freq, how, axis, copy])	Cast to DatetimeIndex of timestamps, at *beginning* of period
to_xarray()	Return an xarray object from the pandas object.
transform(func, *args, **kwargs)	Call function producing a like-indexed NDFrame
transpose(*args, **kwargs)	Transpose index and columns
truediv(other[, axis, level, fill_value])	Floating division of dataframe and other, element-wise (binary operator *truediv*).
truncate([before, after, axis, copy])	Truncates a sorted DataFrame/Series before and/or after some particular index value.
tshift([periods, freq, axis])	Shift the time index, using the index's frequency if available.
tz_convert(tz[, axis, level, copy])	Convert tz-aware axis to target time zone.
tz_localize(tz[, axis, level, copy, ambiguous])	Localize tz-naive TimeSeries to target time zone.
unstack([level, fill_value])	Pivot a level of the (necessarily hierarchical) index labels, returning a DataFrame having a new level of column labels whose inner-most level consists of the pivoted index labels.
update(other[, join, overwrite, ...])	Modify DataFrame in place using non-NA values from passed DataFrame.
var([axis, skipna, level, ddof, numeric_only])	Return unbiased variance over requested axis.
where(cond[, other, inplace, axis, level, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.
xs(key[, axis, level, drop_level])	Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.

pandas.DataFrame.abs

`DataFrame.abs()`

Return an object with absolute value taken–only applicable to objects that are all numeric.

Returns abs: type of caller

pandas.DataFrame.add

`DataFrame.add(other, axis='columns', level=None, fill_value=None)`

Addition of dataframe and other, element-wise (binary operator *add*).

Equivalent to `dataframe + other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

`DataFrame.radd`

Notes

Mismatched indices will be unioned together

pandas.DataFrame.add_prefix

`DataFrame.add_prefix(prefix)`

Concatenate prefix string with panel items names.

Parameters **prefix** : string

Returns **with_prefix** : type of caller

pandas.DataFrame.add_suffix

`DataFrame.add_suffix(suffix)`

Concatenate suffix string with panel items names.

Parameters **suffix** : string

Returns **with_suffix** : type of caller

pandas.DataFrame.agg

`DataFrame.agg`(*func*, *axis=0*, **args*, ***kwargs*)

Aggregate using callable, string, dict, or list of string/callables

New in version 0.20.0.

Parameters **func** : callable, string, dictionary, or list of string/callables

Function to use for aggregating the data. If a function, must either work when passed a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted Combinations are:

- string function name
- function
- list of functions
- dict of column names -> functions (or list of functions)

Returns **aggregated** : DataFrame

See also:

pandas.DataFrame.apply, *pandas.DataFrame.transform*, pandas.DataFrame.groupby.aggregate, pandas.DataFrame.resample.aggregate, pandas.DataFrame.rolling.aggregate

Notes

Numpy functions mean/median/prod/sum/std/var are special cased so the default behavior is applying the function along axis=0 (e.g., np.mean(arr_2d, axis=0)) as opposed to mimicking the default Numpy behavior (e.g., np.mean(arr_2d)).

agg is an alias for *aggregate*. Use the alias.

Examples

```
>>> df = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
...                   index=pd.date_range('1/1/2000', periods=10))
>>> df.iloc[3:7] = np.nan
```

Aggregate these functions across all columns

```
>>> df.agg(['sum', 'min'])
            A         B         C
sum -0.182253 -0.614014 -2.909534
min -1.916563 -1.460076 -1.568297
```

Different aggregations per column

```
>>> df.agg({'A' : ['sum', 'min'], 'B' : ['min', 'max']})
            A         B
max       NaN  1.514318
min -1.916563 -1.460076
sum -0.182253       NaN
```

pandas.DataFrame.aggregate

`DataFrame.aggregate`(*func*, *axis=0*, **args*, ***kwargs*)

Aggregate using callable, string, dict, or list of string/callables

New in version 0.20.0.

Parameters **func** : callable, string, dictionary, or list of string/callables

Function to use for aggregating the data. If a function, must either work when passed a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted Combinations are:

- string function name
- function
- list of functions
- dict of column names -> functions (or list of functions)

Returns **aggregated** : DataFrame

See also:

pandas.DataFrame.apply, *pandas.DataFrame.transform*, pandas.DataFrame.groupby.aggregate, pandas.DataFrame.resample.aggregate, pandas.DataFrame.rolling.aggregate

Notes

Numpy functions mean/median/prod/sum/std/var are special cased so the default behavior is applying the function along axis=0 (e.g., np.mean(arr_2d, axis=0)) as opposed to mimicking the default Numpy behavior (e.g., np.mean(arr_2d)).

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Examples

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            A         B
max       NaN  1.514318
min -1.916563 -1.460076
sum -0.182253       NaN
```

pandas.DataFrame.align

`DataFrame.align`(*other*, *join='outer'*, *axis=None*, *level=None*, *copy=True*, *fill_value=None*, *method=None*, *limit=None*, *fill_axis=0*, *broadcast_axis=None*)

Align two objects on their axes with the specified join method for each axis Index

Parameters **other** : DataFrame or Series

join : {'outer', 'inner', 'left', 'right'}, default 'outer'

axis : allowed axis of the other object, default None

Align on index (0), columns (1), or both (None)

level : int or level name, default None

Broadcast across a level, matching Index values on the passed MultiIndex level

copy : boolean, default True

Always returns new objects. If copy=False and no reindexing is required then original objects are returned.

fill_value : scalar, default np.NaN

Value to use for missing values. Defaults to NaN, but can be any "compatible" value

method : str, default None

limit : int, default None

fill_axis : {0 or 'index', 1 or 'columns'}, default 0

Filling axis, method and limit

broadcast_axis : {0 or 'index', 1 or 'columns'}, default None

Broadcast values along this axis, if aligning two objects of different dimensions

New in version 0.17.0.

Returns **(left, right)** : (DataFrame, type of other)

Aligned objects

pandas.DataFrame.all

`DataFrame.all`(*axis=None*, *bool_only=None*, *skipna=None*, *level=None*, ***kwargs*)

Return whether all elements are True over requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

bool_only : boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

Returns **all** : Series or DataFrame (if level specified)

pandas.DataFrame.any

`DataFrame.`**`any`**(*axis=None*, *bool_only=None*, *skipna=None*, *level=None*, ***kwargs*)

Return whether any element is True over requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

bool_only : boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

Returns **any** : Series or DataFrame (if level specified)

pandas.DataFrame.append

`DataFrame.`**`append`**(*other*, *ignore_index=False*, *verify_integrity=False*)

Append rows of *other* to the end of this frame, returning a new object. Columns not in this frame are added as new columns.

Parameters **other** : DataFrame or Series/dict-like object, or list of these

The data to append.

ignore_index : boolean, default False

If True, do not use the index labels.

verify_integrity : boolean, default False

If True, raise ValueError on creating index with duplicates.

Returns **appended** : DataFrame

See also:

`pandas.concat` General function to concatenate DataFrame, Series or Panel objects

Notes

If a list of dict/series is passed and the keys are all contained in the DataFrame's index, the order of the columns in the resulting DataFrame will be unchanged.

Iteratively appending rows to a DataFrame can be more computationally intensive than a single concatenate. A better solution is to append those rows to a list and then concatenate the list with the original DataFrame all at once.

Examples

```
>>> df = pd.DataFrame([[1, 2], [3, 4]], columns=list('AB'))
>>> df
   A  B
0  1  2
1  3  4
>>> df2 = pd.DataFrame([[5, 6], [7, 8]], columns=list('AB'))
>>> df.append(df2)
   A  B
0  1  2
1  3  4
0  5  6
1  7  8
```

With *ignore_index* set to True:

```
>>> df.append(df2, ignore_index=True)
   A  B
0  1  2
1  3  4
2  5  6
3  7  8
```

The following, while not recommended methods for generating DataFrames, show two ways to generate a DataFrame from multiple data sources.

Less efficient:

```
>>> df = pd.DataFrame(columns=['A'])
>>> for i in range(5):
...     df = df.append({'A': i}, ignore_index=True)
>>> df
   A
0  0
1  1
2  2
3  3
4  4
```

More efficient:

```
>>> pd.concat([pd.DataFrame([i], columns=['A']) for i in range(5)],
...           ignore_index=True)
   A
0  0
1  1
2  2
```

```
3   3
4   4
```

pandas.DataFrame.apply

`DataFrame.apply`(*func*, *axis=0*, *broadcast=False*, *raw=False*, *reduce=None*, *args=()*, ***kwds*)

Applies function along input axis of DataFrame.

Objects passed to functions are Series objects having index either the DataFrame's index (axis=0) or the columns (axis=1). Return type depends on whether passed function aggregates, or the reduce argument if the DataFrame is empty.

Parameters **func** : function

Function to apply to each column/row

axis : {0 or 'index', 1 or 'columns'}, default 0

- 0 or 'index': apply function to each column
- 1 or 'columns': apply function to each row

broadcast : boolean, default False

For aggregation functions, return object of same size with values propagated

raw : boolean, default False

If False, convert each row or column into a Series. If raw=True the passed function will receive ndarray objects instead. If you are just applying a NumPy reduction function this will achieve much better performance

reduce : boolean or None, default None

Try to apply reduction procedures. If the DataFrame is empty, apply will use reduce to determine whether the result should be a Series or a DataFrame. If reduce is None (the default), apply's return value will be guessed by calling func an empty Series (note: while guessing, exceptions raised by func will be ignored). If reduce is True a Series will always be returned, and if False a DataFrame will always be returned.

args : tuple

Positional arguments to pass to function in addition to the array/series

Additional keyword arguments will be passed as keywords to the function

Returns **applied** : Series or DataFrame

See also:

`DataFrame.applymap` For elementwise operations

`DataFrame.aggregate` only perform aggregating type operations

`DataFrame.transform` only perform transformating type operations

Notes

In the current implementation apply calls func twice on the first column/row to decide whether it can take a fast or slow code path. This can lead to unexpected behavior if func has side-effects, as they will take effect twice for the first column/row.

Examples

```
>>> df.apply(numpy.sqrt) # returns DataFrame
>>> df.apply(numpy.sum, axis=0) # equiv to df.sum(0)
>>> df.apply(numpy.sum, axis=1) # equiv to df.sum(1)
```

pandas.DataFrame.applymap

`DataFrame.applymap(func)`

Apply a function to a DataFrame that is intended to operate elementwise, i.e. like doing map(func, series) for each series in the DataFrame

Parameters **func** : function

Python function, returns a single value from a single value

Returns **applied** : DataFrame

See also:

DataFrame.apply For operations on rows/columns

Examples

```
>>> df = pd.DataFrame(np.random.randn(3, 3))
>>> df
    0         1          2
0  -0.029638  1.081563   1.280300
1   0.647747  0.831136  -1.549481
2   0.513416 -0.884417   0.195343
>>> df = df.applymap(lambda x: '%.2f' % x)
>>> df
    0         1          2
0  -0.03      1.08       1.28
1   0.65      0.83      -1.55
2   0.51     -0.88       0.20
```

pandas.DataFrame.as_blocks

`DataFrame.as_blocks(copy=True)`

Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.

Deprecated since version 0.21.0.

NOTE: the dtypes of the blocks WILL BE PRESERVED HERE (unlike in as_matrix)

Parameters **copy** : boolean, default True

Returns **values** : a dict of dtype -> Constructor Types

pandas.DataFrame.as_matrix

`DataFrame.as_matrix(columns=None)`

Convert the frame to its Numpy-array representation.

Parameters **columns: list, optional, default:None**

If None, return all columns, otherwise, returns specified columns.

Returns **values** : ndarray

If the caller is heterogeneous and contains booleans or objects, the result will be of dtype=object. See Notes.

See also:

pandas.DataFrame.values

Notes

Return is NOT a Numpy-matrix, rather, a Numpy-array.

The dtype will be a lower-common-denominator dtype (implicit upcasting); that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen. Use this with care if you are not dealing with the blocks.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. If dtypes are int32 and uint8, dtype will be upcase to int32. By numpy.find_common_type convention, mixing int64 and uint64 will result in a flot64 dtype.

This method is provided for backwards compatibility. Generally, it is recommended to use '.values'.

pandas.DataFrame.asfreq

`DataFrame.asfreq(freq, method=None, how=None, normalize=False, fill_value=None)`

Convert TimeSeries to specified frequency.

Optionally provide filling method to pad/backfill missing values.

Returns the original data conformed to a new index with the specified frequency. `resample` is more appropriate if an operation, such as summarization, is necessary to represent the data at the new frequency.

Parameters **freq** : DateOffset object, or string

method : {'backfill'/'bfill', 'pad'/'ffill'}, default None

Method to use for filling holes in reindexed Series (note this does not fill NaNs that already were present):

- 'pad' / 'ffill': propagate last valid observation forward to next valid
- 'backfill' / 'bfill': use NEXT valid observation to fill

how : {'start', 'end'}, default end

For PeriodIndex only, see PeriodIndex.asfreq

normalize : bool, default False

Whether to reset output index to midnight

fill_value: scalar, optional

Value to use for missing values, applied during upsampling (note this does not fill NaNs that already were present).

New in version 0.20.0.

Returns converted : type of caller

See also:

reindex

Notes

To learn more about the frequency strings, please see this link.

Examples

Start by creating a series with 4 one minute timestamps.

```
>>> index = pd.date_range('1/1/2000', periods=4, freq='T')
>>> series = pd.Series([0.0, None, 2.0, 3.0], index=index)
>>> df = pd.DataFrame({'s':series})
>>> df
                     s
2000-01-01 00:00:00    0.0
2000-01-01 00:01:00    NaN
2000-01-01 00:02:00    2.0
2000-01-01 00:03:00    3.0
```

Upsample the series into 30 second bins.

```
>>> df.asfreq(freq='30S')
                     s
2000-01-01 00:00:00    0.0
2000-01-01 00:00:30    NaN
2000-01-01 00:01:00    NaN
2000-01-01 00:01:30    NaN
2000-01-01 00:02:00    2.0
2000-01-01 00:02:30    NaN
2000-01-01 00:03:00    3.0
```

Upsample again, providing a `fill value`.

```
>>> df.asfreq(freq='30S', fill_value=9.0)
                     s
2000-01-01 00:00:00    0.0
2000-01-01 00:00:30    9.0
2000-01-01 00:01:00    NaN
2000-01-01 00:01:30    9.0
2000-01-01 00:02:00    2.0
2000-01-01 00:02:30    9.0
2000-01-01 00:03:00    3.0
```

Upsample again, providing a `method`.

```
>>> df.asfreq(freq='30S', method='bfill')
                     s
2000-01-01 00:00:00  0.0
2000-01-01 00:00:30  NaN
2000-01-01 00:01:00  NaN
2000-01-01 00:01:30  2.0
2000-01-01 00:02:00  2.0
2000-01-01 00:02:30  3.0
2000-01-01 00:03:00  3.0
```

pandas.DataFrame.asof

`DataFrame.asof(where, subset=None)`

The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)

New in version 0.19.0: For DataFrame

If there is no good value, NaN is returned for a Series a Series of NaN values for a DataFrame

Parameters **where** : date or array of dates

subset : string or list of strings, default None

if not None use these columns for NaN propagation

Returns where is scalar

- value or NaN if input is Series
- Series if input is DataFrame

where is Index: same shape object as input

See also:

merge_asof

Notes

Dates are assumed to be sorted Raises if this is not the case

pandas.DataFrame.assign

`DataFrame.assign(**kwargs)`

Assign new columns to a DataFrame, returning a new object (a copy) with all the original columns in addition to the new ones.

Parameters **kwargs** : keyword, value pairs

keywords are the column names. If the values are callable, they are computed on the DataFrame and assigned to the new columns. The callable must not change input DataFrame (though pandas doesn't check it). If the values are not callable, (e.g. a Series, scalar, or array), they are simply assigned.

Returns **df** : DataFrame

A new DataFrame with the new columns in addition to all the existing columns.

Notes

For python 3.6 and above, the columns are inserted in the order of **kwargs. For python 3.5 and earlier, since **kwargs is unordered, the columns are inserted in alphabetical order at the end of your DataFrame. Assigning multiple columns within the same `assign` is possible, but you cannot reference other columns created within the same `assign` call.

Examples

```
>>> df = DataFrame({'A': range(1, 11), 'B': np.random.randn(10)})
```

Where the value is a callable, evaluated on *df*:

```
>>> df.assign(ln_A = lambda x: np.log(x.A))
    A         B      ln_A
0   1  0.426905  0.000000
1   2 -0.780949  0.693147
2   3 -0.418711  1.098612
3   4 -0.269708  1.386294
4   5 -0.274002  1.609438
5   6 -0.500792  1.791759
6   7  1.649697  1.945910
7   8 -1.495604  2.079442
8   9  0.549296  2.197225
9  10 -0.758542  2.302585
```

Where the value already exists and is inserted:

```
>>> newcol = np.log(df['A'])
>>> df.assign(ln_A=newcol)
    A         B      ln_A
0   1  0.426905  0.000000
1   2 -0.780949  0.693147
2   3 -0.418711  1.098612
3   4 -0.269708  1.386294
4   5 -0.274002  1.609438
5   6 -0.500792  1.791759
6   7  1.649697  1.945910
7   8 -1.495604  2.079442
8   9  0.549296  2.197225
9  10 -0.758542  2.302585
```

pandas.DataFrame.astype

`DataFrame.astype`(*dtype*, *copy=True*, *errors='raise'*, ***kwargs*)

Cast a pandas object to a specified dtype `dtype`.

Parameters **dtype** : data type, or dict of column name -> data type

Use a numpy.dtype or Python type to cast entire pandas object to the same type. Alternatively, use {col: dtype, ...}, where col is a column label and dtype is a

numpy.dtype or Python type to cast one or more of the DataFrame's columns to column-specific types.

copy : bool, default True.

Return a copy when `copy=True` (be very careful setting `copy=False` as changes to values then may propagate to other pandas objects).

errors : {'raise', 'ignore'}, default 'raise'.

Control raising of exceptions on invalid data for provided dtype.

- `raise` : allow exceptions to be raised
- `ignore` : suppress exceptions. On error return original object

New in version 0.20.0.

raise_on_error : raise on invalid input

Deprecated since version 0.20.0: Use `errors` instead

kwargs : keyword arguments to pass on to the constructor

Returns casted : type of caller

See also:

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

pandas.to_numeric Convert argument to a numeric type.

numpy.ndarray.astype Cast a numpy array to a specified type.

Examples

```
>>> ser = pd.Series([1, 2], dtype='int32')
>>> ser
0    1
1    2
dtype: int32
>>> ser.astype('int64')
0    1
1    2
dtype: int64
```

Convert to categorical type:

```
>>> ser.astype('category')
0    1
1    2
dtype: category
Categories (2, int64): [1, 2]
```

Convert to ordered categorical type with custom ordering:

```
>>> ser.astype('category', ordered=True, categories=[2, 1])
0    1
1    2
```

```
dtype: category
Categories (2, int64): [2 < 1]
```

Note that using `copy=False` and changing data on a new pandas object may propagate changes:

```
>>> s1 = pd.Series([1,2])
>>> s2 = s1.astype('int', copy=False)
>>> s2[0] = 10
>>> s1  # note that s1[0] has changed too
0    10
1     2
dtype: int64
```

pandas.DataFrame.at_time

`DataFrame.at_time(time, asof=False)`

Select values at particular time of day (e.g. 9:30AM).

Parameters **time** : datetime.time or string

Returns **values_at_time** : type of caller

pandas.DataFrame.between_time

`DataFrame.between_time(start_time, end_time, include_start=True, include_end=True)`

Select values between particular times of the day (e.g., 9:00-9:30 AM).

Parameters **start_time** : datetime.time or string

end_time : datetime.time or string

include_start : boolean, default True

include_end : boolean, default True

Returns **values_between_time** : type of caller

pandas.DataFrame.bfill

`DataFrame.bfill(axis=None, inplace=False, limit=None, downcast=None)`

Synonym for `DataFrame.fillna(method='bfill')`

pandas.DataFrame.bool

`DataFrame.bool()`

Return the bool of a single element PandasObject.

This must be a boolean scalar value, either True or False. Raise a ValueError if the PandasObject does not have exactly 1 element, or that element is not boolean

pandas.DataFrame.boxplot

`DataFrame.boxplot`(*column=None*, *by=None*, *ax=None*, *fontsize=None*, *rot=0*, *grid=True*, *figsize=None*, *layout=None*, *return_type=None*, ***kwds*)

Make a box plot from DataFrame column optionally grouped by some columns or other inputs

Parameters **data** : the pandas object holding the data

column : column name or list of names, or vector

Can be any valid input to groupby

by : string or sequence

Column in the DataFrame to group by

ax : Matplotlib axes object, optional

fontsize : int or string

rot : label rotation angle

figsize : A tuple (width, height) in inches

grid : Setting this to True will show the grid

layout : tuple (optional)

(rows, columns) for the layout of the plot

return_type : {None, 'axes', 'dict', 'both'}, default None

The kind of object to return. The default is `axes` 'axes' returns the matplotlib axes the boxplot is drawn on; 'dict' returns a dictionary whose values are the matplotlib Lines of the boxplot; 'both' returns a namedtuple with the axes and dict.

When grouping with `by`, a Series mapping columns to `return_type` is returned, unless `return_type` is None, in which case a NumPy array of axes is returned with the same shape as `layout`. See the prose documentation for more.

kwds : other plotting keyword arguments to be passed to matplotlib boxplot

function

Returns **lines** : dict

ax : matplotlib Axes

(ax, lines): namedtuple

Notes

Use `return_type='dict'` when you want to tweak the appearance of the lines after plotting. In this case a dict containing the Lines making up the boxes, caps, fliers, medians, and whiskers is returned.

pandas.DataFrame.clip

`DataFrame.clip`(*lower=None*, *upper=None*, *axis=None*, *inplace=False*, **args*, ***kwargs*)

Trim values at input threshold(s).

Parameters **lower** : float or array_like, default None

upper : float or array_like, default None

axis : int or string axis name, optional

Align object with lower and upper along the given axis.

inplace : boolean, default False

Whether to perform the operation in place on the data New in version 0.21.0.

Returns **clipped** : Series

Examples

```
>>> df
          0         1
0  0.335232 -1.256177
1 -1.367855  0.746646
2  0.027753 -1.176076
3  0.230930 -0.679613
4  1.261967  0.570967
```

```
>>> df.clip(-1.0, 0.5)
          0         1
0  0.335232 -1.000000
1 -1.000000  0.500000
2  0.027753 -1.000000
3  0.230930 -0.679613
4  0.500000  0.500000
```

```
>>> t
0   -0.3
1   -0.2
2   -0.1
3    0.0
4    0.1
dtype: float64
```

```
>>> df.clip(t, t + 1, axis=0)
          0         1
0  0.335232 -0.300000
1 -0.200000  0.746646
2  0.027753 -0.100000
3  0.230930  0.000000
4  1.100000  0.570967
```

pandas.DataFrame.clip_lower

`DataFrame.clip_lower`(*threshold*, *axis=None*, *inplace=False*)

Return copy of the input with values below given value(s) truncated.

Parameters **threshold** : float or array_like

axis : int or string axis name, optional

Align object with threshold along the given axis.

inplace : boolean, default False

Whether to perform the operation in place on the data New in version 0.21.0.

Returns **clipped** : same type as input

See also:

clip

pandas.DataFrame.clip_upper

`DataFrame.clip_upper`(*threshold*, *axis=None*, *inplace=False*)

Return copy of input with values above given value(s) truncated.

Parameters **threshold** : float or array_like

axis : int or string axis name, optional

Align object with threshold along the given axis.

inplace : boolean, default False

Whether to perform the operation in place on the data New in version 0.21.0.

Returns **clipped** : same type as input

See also:

clip

pandas.DataFrame.combine

`DataFrame.combine`(*other*, *func*, *fill_value=None*, *overwrite=True*)

Add two DataFrame objects and do not propagate NaN values, so if for a (column, time) one frame is missing a value, it will default to the other frame's value (which might be NaN as well)

Parameters **other** : DataFrame

func : function

fill_value : scalar value

overwrite : boolean, default True

If True then overwrite values for common keys in the calling frame

Returns **result** : DataFrame

pandas.DataFrame.combine_first

`DataFrame.combine_first`(*other*)

Combine two DataFrame objects and default to non-null values in frame calling the method. Result index columns will be the union of the respective indexes and columns

Parameters **other** : DataFrame

Returns **combined** : DataFrame

Examples

a's values prioritized, use values from b to fill holes:

```
>>> a.combine_first(b)
```

pandas.DataFrame.compound

`DataFrame.compound(axis=None, skipna=None, level=None)`

Return the compound percentage of the values for the requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **compounded** : Series or DataFrame (if level specified)

pandas.DataFrame.consolidate

`DataFrame.consolidate(inplace=False)`

DEPRECATED: consolidate will be an internal implementation only.

pandas.DataFrame.convert_objects

`DataFrame.convert_objects(convert_dates=True, convert_numeric=False, convert_timedeltas=True, copy=True)`

Deprecated. Attempt to infer better dtype for object columns

Parameters **convert_dates** : boolean, default True

If True, convert to date where possible. If 'coerce', force conversion, with unconvertible values becoming NaT.

convert_numeric : boolean, default False

If True, attempt to coerce to numbers (including strings), with unconvertible values becoming NaN.

convert_timedeltas : boolean, default True

If True, convert to timedelta where possible. If 'coerce', force conversion, with unconvertible values becoming NaT.

copy : boolean, default True

If True, return a copy even if no copy is necessary (e.g. no conversion was done). Note: This is meant for internal use, and should not be confused with inplace.

Returns **converted** : same as input object

See also:

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

pandas.to_numeric Return a fixed frequency timedelta index, with day as the default.

pandas.DataFrame.copy

`DataFrame.copy(deep=True)`

Make a copy of this objects data.

Parameters **deep** : boolean or string, default True

Make a deep copy, including a copy of the data and the indices. With `deep=False` neither the indices or the data are copied.

Note that when `deep=True` data is copied, actual python objects will not be copied recursively, only the reference to the object. This is in contrast to `copy.deepcopy` in the Standard Library, which recursively copies object data.

Returns **copy** : type of caller

pandas.DataFrame.corr

`DataFrame.corr(method='pearson', min_periods=1)`

Compute pairwise correlation of columns, excluding NA/null values

Parameters **method** : {'pearson', 'kendall', 'spearman'}

- pearson : standard correlation coefficient
- kendall : Kendall Tau correlation coefficient
- spearman : Spearman rank correlation

min_periods : int, optional

Minimum number of observations required per pair of columns to have a valid result. Currently only available for pearson and spearman correlation

Returns **y** : DataFrame

pandas.DataFrame.corrwith

`DataFrame.corrwith(other, axis=0, drop=False)`

Compute pairwise correlation between rows or columns of two DataFrame objects.

Parameters **other** : DataFrame

axis : {0 or 'index', 1 or 'columns'}, default 0

0 or 'index' to compute column-wise, 1 or 'columns' for row-wise

drop : boolean, default False

Drop missing indices from result, default returns union of all

Returns **correls** : Series

pandas.DataFrame.count

`DataFrame.count`(*axis=0*, *level=None*, *numeric_only=False*)

Return Series with number of non-NA/null observations over requested axis. Works with non-floating point data as well (detects NaN and None)

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

0 or 'index' for row-wise, 1 or 'columns' for column-wise

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default False

Include only float, int, boolean data

Returns **count** : Series (or DataFrame if level specified)

pandas.DataFrame.cov

`DataFrame.cov`(*min_periods=None*)

Compute pairwise covariance of columns, excluding NA/null values

Parameters **min_periods** : int, optional

Minimum number of observations required per pair of columns to have a valid result.

Returns **y** : DataFrame

Notes

y contains the covariance matrix of the DataFrame's time series. The covariance is normalized by N-1 (unbiased estimator).

pandas.DataFrame.cummax

`DataFrame.cummax`(*axis=None*, *skipna=True*, **args*, ***kwargs*)

Return cumulative max over requested axis.

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cummax** : Series

See also:

pandas.core.window.Expanding.max Similar functionality but ignores NaN values.

pandas.DataFrame.cummin

DataFrame.**cummin**(*axis=None*, *skipna=True*, **args*, ***kwargs*)

Return cumulative minimum over requested axis.

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cummin** : Series

See also:

pandas.core.window.Expanding.min Similar functionality but ignores NaN values.

pandas.DataFrame.cumprod

DataFrame.**cumprod**(*axis=None*, *skipna=True*, **args*, ***kwargs*)

Return cumulative product over requested axis.

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cumprod** : Series

See also:

pandas.core.window.Expanding.prod Similar functionality but ignores NaN values.

pandas.DataFrame.cumsum

DataFrame.**cumsum**(*axis=None*, *skipna=True*, **args*, ***kwargs*)

Return cumulative sum over requested axis.

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cumsum** : Series

See also:

pandas.core.window.Expanding.sum Similar functionality but ignores NaN values.

pandas.DataFrame.describe

`DataFrame.describe`(*percentiles=None*, *include=None*, *exclude=None*)

Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding `NaN` values.

Analyzes both numeric and object series, as well as `DataFrame` column sets of mixed data types. The output will vary depending on what is provided. Refer to the notes below for more detail.

Parameters **percentiles** : list-like of numbers, optional

The percentiles to include in the output. All should fall between 0 and 1. The default is `[.25, .5, .75]`, which returns the 25th, 50th, and 75th percentiles.

include : 'all', list-like of dtypes or None (default), optional

A white list of data types to include in the result. Ignored for `Series`. Here are the options:

- 'all' : All columns of the input will be included in the output.
- A list-like of dtypes : Limits the results to the provided data types. To limit the result to numeric types submit `numpy.number`. To limit it instead to object columns submit the `numpy.object` data type. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To select pandas categorical columns, use `'category'`
- None (default) : The result will include all numeric columns.

exclude : list-like of dtypes or None (default), optional,

A black list of data types to omit from the result. Ignored for `Series`. Here are the options:

- A list-like of dtypes : Excludes the provided data types from the result. To exclude numeric types submit `numpy.number`. To exclude object columns submit the data type `numpy.object`. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To exclude pandas categorical columns, use `'category'`
- None (default) : The result will exclude nothing.

Returns summary: Series/DataFrame of summary statistics

See also:

`DataFrame.count`, *`DataFrame.max`*, *`DataFrame.min`*, *`DataFrame.mean`*, *`DataFrame.std`*, *`DataFrame.select_dtypes`*

Notes

For numeric data, the result's index will include `count`, `mean`, `std`, `min`, `max` as well as lower, `50` and upper percentiles. By default the lower percentile is `25` and the upper percentile is `75`. The `50` percentile is the same as the median.

For object data (e.g. strings or timestamps), the result's index will include `count`, `unique`, `top`, and `freq`. The `top` is the most common value. The `freq` is the most common value's frequency. Timestamps also include the `first` and `last` items.

If multiple object values have the highest count, then the `count` and `top` results will be arbitrarily chosen from among those with the highest count.

For mixed data types provided via a `DataFrame`, the default is to return only an analysis of numeric columns. If the dataframe consists only of object and categorical data without any numeric columns, the default is to return an analysis of both the object and categorical columns. If `include='all'` is provided as an option, the result will include a union of attributes of each type.

The *include* and *exclude* parameters can be used to limit which columns in a `DataFrame` are analyzed for the output. The parameters are ignored when analyzing a `Series`.

Examples

Describing a numeric `Series`.

```
>>> s = pd.Series([1, 2, 3])
>>> s.describe()
count    3.0
mean     2.0
std      1.0
min      1.0
25%      1.5
50%      2.0
75%      2.5
max      3.0
```

Describing a categorical `Series`.

```
>>> s = pd.Series(['a', 'a', 'b', 'c'])
>>> s.describe()
count     4
unique    3
top       a
freq      2
dtype: object
```

Describing a timestamp `Series`.

```
>>> s = pd.Series([
...   np.datetime64("2000-01-01"),
...   np.datetime64("2010-01-01"),
...   np.datetime64("2010-01-01")
... ])
>>> s.describe()
count                       3
unique                      2
top       2010-01-01 00:00:00
freq                        2
first     2000-01-01 00:00:00
last      2010-01-01 00:00:00
dtype: object
```

Describing a `DataFrame`. By default only numeric fields are returned.

```
>>> df = pd.DataFrame({ 'object': ['a', 'b', 'c'],
...                     'numeric': [1, 2, 3],
...                     'categorical': pd.Categorical(['d','e','f'])
...                   })
>>> df.describe()
       numeric
```

```
count      3.0
mean       2.0
std        1.0
min        1.0
25%        1.5
50%        2.0
75%        2.5
max        3.0
```

Describing all columns of a `DataFrame` regardless of data type.

```
>>> df.describe(include='all')
        categorical  numeric object
count             3      3.0      3
unique            3      NaN      3
top               f      NaN      c
freq              1      NaN      1
mean            NaN      2.0    NaN
std             NaN      1.0    NaN
min             NaN      1.0    NaN
25%             NaN      1.5    NaN
50%             NaN      2.0    NaN
75%             NaN      2.5    NaN
max             NaN      3.0    NaN
```

Describing a column from a `DataFrame` by accessing it as an attribute.

```
>>> df.numeric.describe()
count    3.0
mean     2.0
std      1.0
min      1.0
25%      1.5
50%      2.0
75%      2.5
max      3.0
Name: numeric, dtype: float64
```

Including only numeric columns in a `DataFrame` description.

```
>>> df.describe(include=[np.number])
       numeric
count      3.0
mean       2.0
std        1.0
min        1.0
25%        1.5
50%        2.0
75%        2.5
max        3.0
```

Including only string columns in a `DataFrame` description.

```
>>> df.describe(include=[np.object])
       object
count       3
unique      3
```

```
top         c
freq        1
```

Including only categorical columns from a `DataFrame` description.

```
>>> df.describe(include=['category'])
       categorical
count            3
unique           3
top              f
freq             1
```

Excluding numeric columns from a `DataFrame` description.

```
>>> df.describe(exclude=[np.number])
       categorical object
count            3      3
unique           3      3
top              f      c
freq             1      1
```

Excluding object columns from a `DataFrame` description.

```
>>> df.describe(exclude=[np.object])
        categorical  numeric
count            3      3.0
unique           3      NaN
top              f      NaN
freq             1      NaN
mean           NaN      2.0
std            NaN      1.0
min            NaN      1.0
25%            NaN      1.5
50%            NaN      2.0
75%            NaN      2.5
max            NaN      3.0
```

pandas.DataFrame.diff

`DataFrame.`**`diff`**(*periods=1*, *axis=0*)

1st discrete difference of object

Parameters **periods** : int, default 1

Periods to shift for forming difference

axis : {0 or 'index', 1 or 'columns'}, default 0

Take difference over rows (0) or columns (1).

Returns **diffed** : DataFrame

pandas.DataFrame.div

`DataFrame.`**`div`**(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Floating division of dataframe and other, element-wise (binary operator *truediv*).

Equivalent to `dataframe / other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.rtruediv

Notes

Mismatched indices will be unioned together

pandas.DataFrame.divide

`DataFrame.divide`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Floating division of dataframe and other, element-wise (binary operator *truediv*).

Equivalent to `dataframe / other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.rtruediv

Notes

Mismatched indices will be unioned together

pandas.DataFrame.dot

`DataFrame.dot(other)`

Matrix multiplication with DataFrame or Series objects

Parameters **other** : DataFrame or Series

Returns **dot_product** : DataFrame or Series

pandas.DataFrame.drop

`DataFrame.drop(labels=None, axis=0, index=None, columns=None, level=None, inplace=False, errors='raise')`

Return new object with labels in requested axis removed.

Parameters **labels** : single label or list-like

Index or column labels to drop.

axis : int or axis name

Whether to drop labels from the index (0 / 'index') or columns (1 / 'columns').

index, columns : single label or list-like

Alternative to specifying *axis* (`labels, axis=1` is equivalent to `columns=labels`).

New in version 0.21.0.

level : int or level name, default None

For MultiIndex

inplace : bool, default False

If True, do operation inplace and return None.

errors : {'ignore', 'raise'}, default 'raise'

If 'ignore', suppress error and existing labels are dropped.

Returns **dropped** : type of caller

Notes

Specifying both *labels* and *index* or *columns* will raise a ValueError.

Examples

```
>>> df = pd.DataFrame(np.arange(12).reshape(3,4),
                      columns=['A', 'B', 'C', 'D'])
>>> df
   A  B   C   D
0  0  1   2   3
1  4  5   6   7
2  8  9  10  11
```

Drop columns

```
>>> df.drop(['B', 'C'], axis=1)
   A   D
0  0   3
1  4   7
2  8  11
```

```
>>> df.drop(columns=['B', 'C'])
   A   D
0  0   3
1  4   7
2  8  11
```

Drop a row by index

```
>>> df.drop([0, 1])
   A  B   C   D
2  8  9  10  11
```

pandas.DataFrame.drop_duplicates

`DataFrame.drop_duplicates`(*subset=None*, *keep='first'*, *inplace=False*)

Return DataFrame with duplicate rows removed, optionally only considering certain columns

Parameters **subset** : column label or sequence of labels, optional

Only consider certain columns for identifying duplicates, by default use all of the columns

keep : {'first', 'last', False}, default 'first'

- `first` : Drop duplicates except for the first occurrence.
- `last` : Drop duplicates except for the last occurrence.
- False : Drop all duplicates.

inplace : boolean, default False

Whether to drop duplicates in place or to return a copy

Returns **deduplicated** : DataFrame

pandas.DataFrame.dropna

`DataFrame.dropna`(*axis=0*, *how='any'*, *thresh=None*, *subset=None*, *inplace=False*)

Return object with labels on given axis omitted where alternately any or all of the data are missing

Parameters **axis** : {0 or 'index', 1 or 'columns'}, or tuple/list thereof

Pass tuple or list to drop on multiple axes

how : {'any', 'all'}

- any : if any NA values are present, drop that label
- all : if all values are NA, drop that label

thresh : int, default None

int value : require that many non-NA values

subset : array-like

Labels along other axis to consider, e.g. if you are dropping rows these would be a list of columns to include

inplace : boolean, default False

If True, do operation inplace and return None.

Returns **dropped** : DataFrame

Examples

```
>>> df = pd.DataFrame([[np.nan, 2, np.nan, 0], [3, 4, np.nan, 1],
...                    [np.nan, np.nan, np.nan, 5]],
...                   columns=list('ABCD'))
>>> df
     A    B   C  D
0  NaN  2.0 NaN  0
1  3.0  4.0 NaN  1
2  NaN  NaN NaN  5
```

Drop the columns where all elements are nan:

```
>>> df.dropna(axis=1, how='all')
     A    B  D
0  NaN  2.0  0
1  3.0  4.0  1
2  NaN  NaN  5
```

Drop the columns where any of the elements is nan

```
>>> df.dropna(axis=1, how='any')
   D
0  0
1  1
2  5
```

Drop the rows where all of the elements are nan (there is no row to drop, so df stays the same):

```
>>> df.dropna(axis=0, how='all')
     A    B   C  D
0  NaN  2.0 NaN  0
1  3.0  4.0 NaN  1
2  NaN  NaN NaN  5
```

Keep only the rows with at least 2 non-na values:

```
>>> df.dropna(thresh=2)
     A    B   C  D
0  NaN  2.0 NaN  0
1  3.0  4.0 NaN  1
```

pandas.DataFrame.duplicated

`DataFrame.duplicated`(*subset=None*, *keep='first'*)

Return boolean Series denoting duplicate rows, optionally only considering certain columns

Parameters **subset** : column label or sequence of labels, optional

Only consider certain columns for identifying duplicates, by default use all of the columns

keep : {'first', 'last', False}, default 'first'

- `first` : Mark duplicates as `True` except for the first occurrence.
- `last` : Mark duplicates as `True` except for the last occurrence.
- False : Mark all duplicates as `True`.

Returns **duplicated** : Series

pandas.DataFrame.eq

`DataFrame.eq`(*other*, *axis='columns'*, *level=None*)

Wrapper for flexible comparison methods eq

pandas.DataFrame.equals

`DataFrame.equals`(*other*)

Determines if two NDFrame objects contain the same elements. NaNs in the same location are considered equal.

pandas.DataFrame.eval

`DataFrame.eval`(*expr*, *inplace=False*, ***kwargs*)

Evaluate an expression in the context of the calling DataFrame instance.

Parameters **expr** : string

The expression string to evaluate.

inplace : bool, default False

If the expression contains an assignment, whether to perform the operation inplace and mutate the existing DataFrame. Otherwise, a new DataFrame is returned.

New in version 0.18.0.

kwargs : dict

See the documentation for `eval()` for complete details on the keyword arguments accepted by `query()`.

Returns **ret** : ndarray, scalar, or pandas object

See also:

`pandas.DataFrame.query`, `pandas.DataFrame.assign`, `pandas.eval`

Notes

For more details see the API documentation for `eval()`. For detailed examples see *enhancing performance with eval*.

Examples

```
>>> from numpy.random import randn
>>> from pandas import DataFrame
>>> df = DataFrame(randn(10, 2), columns=list('ab'))
>>> df.eval('a + b')
>>> df.eval('c = a + b')
```

pandas.DataFrame.ewm

`DataFrame.ewm`(*com=None*, *span=None*, *halflife=None*, *alpha=None*, *min_periods=0*, *freq=None*, *adjust=True*, *ignore_na=False*, *axis=0*)

Provides exponential weighted functions

New in version 0.18.0.

Parameters **com** : float, optional

Specify decay in terms of center of mass, $\alpha = 1/(1 + com),$ for $com \geq 0$

span : float, optional

Specify decay in terms of span, $\alpha = 2/(span + 1),$ for $span \geq 1$

halflife : float, optional

Specify decay in terms of half-life, $\alpha = 1 - exp(log(0.5)/halflife),$ for $halflife > 0$

alpha : float, optional

Specify smoothing factor α directly, $0 < \alpha \leq 1$

New in version 0.18.0.

min_periods : int, default 0

Minimum number of observations in window required to have a value (otherwise result is NA).

freq : None or string alias / date offset object, default=None

Deprecated since version 0.18.0: Frequency to conform to before computing statistic

adjust : boolean, default True

Divide by decaying adjustment factor in beginning periods to account for imbalance in relative weightings (viewing EWMA as a moving average)

ignore_na : boolean, default False

Ignore missing values when calculating weights; specify True to reproduce pre-0.15.0 behavior

Returns a Window sub-classed for the particular operation

Notes

Exactly one of center of mass, span, half-life, and alpha must be provided. Allowed values and relationship between the parameters are specified in the parameter descriptions above; see the link at the end of this section for a detailed explanation.

The *freq* keyword is used to conform time series data to a specified frequency by resampling the data. This is done with the default parameters of `resample()` (i.e. using the *mean*).

When adjust is True (default), weighted averages are calculated using weights (1-alpha)**(n-1), (1-alpha)**(n-2), ..., 1-alpha, 1.

When adjust is False, weighted averages are calculated recursively as: weighted_average[0] = arg[0]; weighted_average[i] = (1-alpha)*weighted_average[i-1] + alpha*arg[i].

When ignore_na is False (default), weights are based on absolute positions. For example, the weights of x and y used in calculating the final weighted average of [x, None, y] are (1-alpha)**2 and 1 (if adjust is True), and (1-alpha)**2 and alpha (if adjust is False).

When ignore_na is True (reproducing pre-0.15.0 behavior), weights are based on relative positions. For example, the weights of x and y used in calculating the final weighted average of [x, None, y] are 1-alpha and 1 (if adjust is True), and 1-alpha and alpha (if adjust is False).

More details can be found at http://pandas.pydata.org/pandas-docs/stable/computation.html#exponentially-weighted-windows

Examples

```
>>> df = DataFrame({'B': [0, 1, 2, np.nan, 4]})
     B
0  0.0
1  1.0
2  2.0
3  NaN
4  4.0
```

```
>>> df.ewm(com=0.5).mean()
          B
0  0.000000
1  0.750000
2  1.615385
3  1.615385
4  3.670213
```

pandas.DataFrame.expanding

`DataFrame.`**`expanding`**(*min_periods=1*, *freq=None*, *center=False*, *axis=0*)

Provides expanding transformations.

New in version 0.18.0.

Parameters **min_periods** : int, default None

Minimum number of observations in window required to have a value (otherwise result is NA).

freq : string or DateOffset object, optional (default None)

Deprecated since version 0.18.0: Frequency to conform the data to before computing the statistic. Specified as a frequency string or DateOffset object.

center : boolean, default False

Set the labels at the center of the window.

axis : int or string, default 0

Returns a Window sub-classed for the particular operation

Notes

By default, the result is set to the right edge of the window. This can be changed to the center of the window by setting `center=True`.

The *freq* keyword is used to conform time series data to a specified frequency by resampling the data. This is done with the default parameters of `resample()` (i.e. using the *mean*).

Examples

```
>>> df = DataFrame({'B': [0, 1, 2, np.nan, 4]})
     B
0  0.0
1  1.0
2  2.0
3  NaN
4  4.0
```

```
>>> df.expanding(2).sum()
     B
0  NaN
1  1.0
2  3.0
3  3.0
4  7.0
```

pandas.DataFrame.ffill

`DataFrame.ffill`(*axis=None*, *inplace=False*, *limit=None*, *downcast=None*)

Synonym for `DataFrame.fillna(method='ffill')`

pandas.DataFrame.fillna

`DataFrame.fillna`(*value=None*, *method=None*, *axis=None*, *inplace=False*, *limit=None*, *downcast=None*, ***kwargs*)

Fill NA/NaN values using the specified method

Parameters **value** : scalar, dict, Series, or DataFrame

Value to use to fill holes (e.g. 0), alternately a dict/Series/DataFrame of values specifying which value to use for each index (for a Series) or column (for a DataFrame). (values not in the dict/Series/DataFrame will not be filled). This value cannot be a list.

method : {'backfill', 'bfill', 'pad', 'ffill', None}, default None

Method to use for filling holes in reindexed Series pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation to fill gap

axis : {0 or 'index', 1 or 'columns'}

inplace : boolean, default False

If True, fill in place. Note: this will modify any other views on this object, (e.g. a no-copy slice for a column in a DataFrame).

limit : int, default None

If method is specified, this is the maximum number of consecutive NaN values to forward/backward fill. In other words, if there is a gap with more than this number of consecutive NaNs, it will only be partially filled. If method is not specified, this is the maximum number of entries along the entire axis where NaNs will be filled. Must be greater than 0 if not None.

downcast : dict, default is None

a dict of item->dtype of what to downcast if possible, or the string 'infer' which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns filled : DataFrame

See also:

reindex, *asfreq*

Examples

```
>>> df = pd.DataFrame([[np.nan, 2, np.nan, 0],
...                    [3, 4, np.nan, 1],
...                    [np.nan, np.nan, np.nan, 5],
...                    [np.nan, 3, np.nan, 4]],
...                    columns=list('ABCD'))
>>> df
     A    B   C  D
0  NaN  2.0 NaN  0
1  3.0  4.0 NaN  1
2  NaN  NaN NaN  5
3  NaN  3.0 NaN  4
```

Replace all NaN elements with 0s.

```
>>> df.fillna(0)
    A   B   C   D
0   0.0 2.0 0.0 0
1   3.0 4.0 0.0 1
2   0.0 0.0 0.0 5
3   0.0 3.0 0.0 4
```

We can also propagate non-null values forward or backward.

```
>>> df.fillna(method='ffill')
    A   B   C   D
0   NaN 2.0 NaN 0
```

```
1   3.0 4.0 NaN 1
2   3.0 4.0 NaN 5
3   3.0 3.0 NaN 4
```

Replace all NaN elements in column 'A', 'B', 'C', and 'D', with 0, 1, 2, and 3 respectively.

```
>>> values = {'A': 0, 'B': 1, 'C': 2, 'D': 3}
>>> df.fillna(value=values)
    A   B   C   D
0   0.0 2.0 2.0 0
1   3.0 4.0 2.0 1
2   0.0 1.0 2.0 5
3   0.0 3.0 2.0 4
```

Only replace the first NaN element.

```
>>> df.fillna(value=values, limit=1)
    A   B   C   D
0   0.0 2.0 2.0 0
1   3.0 4.0 NaN 1
2   NaN 1.0 NaN 5
3   NaN 3.0 NaN 4
```

pandas.DataFrame.filter

`DataFrame.filter`(*items=None*, *like=None*, *regex=None*, *axis=None*)

Subset rows or columns of dataframe according to labels in the specified index.

Note that this routine does not filter a dataframe on its contents. The filter is applied to the labels of the index.

Parameters **items** : list-like

List of info axis to restrict to (must not all be present)

like : string

Keep info axis where "arg in col == True"

regex : string (regular expression)

Keep info axis with re.search(regex, col) == True

axis : int or string axis name

The axis to filter on. By default this is the info axis, 'index' for Series, 'columns' for DataFrame

Returns same type as input object

See also:

pandas.DataFrame.loc

Notes

The `items`, `like`, and `regex` parameters are enforced to be mutually exclusive.

`axis` defaults to the info axis that is used when indexing with `[]`.

Examples

```
>>> df
one  two  three
mouse     1    2      3
rabbit    4    5      6
```

```
>>> # select columns by name
>>> df.filter(items=['one', 'three'])
one  three
mouse     1      3
rabbit    4      6
```

```
>>> # select columns by regular expression
>>> df.filter(regex='e$', axis=1)
one  three
mouse     1      3
rabbit    4      6
```

```
>>> # select rows containing 'bbi'
>>> df.filter(like='bbi', axis=0)
one  two  three
rabbit    4    5      6
```

pandas.DataFrame.first

`DataFrame.`**`first`**`(`*offset*`)`

Convenience method for subsetting initial periods of time series data based on a date offset.

Parameters **offset** : string, DateOffset, dateutil.relativedelta

Returns **subset** : type of caller

Examples

ts.first('10D') -> First 10 days

pandas.DataFrame.first_valid_index

`DataFrame.`**`first_valid_index`**`()`

Return index for first non-NA/null value.

Returns **scalar** : type of index

Notes

If all elements are non-NA/null, returns None. Also returns None for empty DataFrame.

pandas.DataFrame.floordiv

`DataFrame.floordiv(other, axis='columns', level=None, fill_value=None)`

Integer division of dataframe and other, element-wise (binary operator *floordiv*).

Equivalent to `dataframe // other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.rfloordiv

Notes

Mismatched indices will be unioned together

pandas.DataFrame.from_csv

classmethod `DataFrame.from_csv(path, header=0, sep=', ', index_col=0, parse_dates=True, encoding=None, tupleize_cols=None, infer_datetime_format=False)`

Read CSV file (DEPRECATED, please use *pandas.read_csv()* instead).

It is preferable to use the more powerful *pandas.read_csv()* for most general purposes, but `from_csv` makes for an easy roundtrip to and from a file (the exact counterpart of `to_csv`), especially with a DataFrame of time series data.

This method only differs from the preferred *pandas.read_csv()* in some defaults:

- *index_col* is `0` instead of `None` (take first column as index by default)
- *parse_dates* is `True` instead of `False` (try parsing the index as datetime by default)

So a `pd.DataFrame.from_csv(path)` can be replaced by `pd.read_csv(path, index_col=0, parse_dates=True)`.

Parameters **path** : string file path or file handle / StringIO

header : int, default 0

Row to use as header (skip prior rows)

sep : string, default ','

Field delimiter

index_col : int or sequence, default 0

Column to use for index. If a sequence is given, a MultiIndex is used. Different default from read_table

parse_dates : boolean, default True

Parse dates. Different default from read_table

tupleize_cols : boolean, default False

write multi_index columns as a list of tuples (if True) or new (expanded format) if False)

infer_datetime_format: boolean, default False

If True and *parse_dates* is True for a column, try to infer the datetime format based on the first datetime string. If the format can be inferred, there often will be a large parsing speed-up.

Returns **y** : DataFrame

See also:

pandas.read_csv

pandas.DataFrame.from_dict

classmethod `DataFrame.`**`from_dict`**(*data*, *orient='columns'*, *dtype=None*)

Construct DataFrame from dict of array-like or dicts

Parameters **data** : dict

{field : array-like} or {field : dict}

orient : {'columns', 'index'}, default 'columns'

The "orientation" of the data. If the keys of the passed dict should be the columns of the resulting DataFrame, pass 'columns' (default). Otherwise if the keys should be rows, pass 'index'.

dtype : dtype, default None

Data type to force, otherwise infer

Returns DataFrame

pandas.DataFrame.from_items

classmethod `DataFrame.`**`from_items`**(*items*, *columns=None*, *orient='columns'*)

Convert (key, value) pairs to DataFrame. The keys will be the axis index (usually the columns, but depends on the specified orientation). The values should be arrays or Series.

Parameters **items** : sequence of (key, value) pairs

Values should be arrays or Series.

columns : sequence of column labels, optional

Must be passed if orient='index'.

orient : {'columns', 'index'}, default 'columns'

The "orientation" of the data. If the keys of the input correspond to column labels, pass 'columns' (default). Otherwise if the keys correspond to the index, pass 'index'.

Returns **frame** : DataFrame

pandas.DataFrame.from_records

classmethod `DataFrame.from_records`(*data*, *index=None*, *exclude=None*, *columns=None*, *coerce_float=False*, *nrows=None*)

Convert structured or record ndarray to DataFrame

Parameters **data** : ndarray (structured dtype), list of tuples, dict, or DataFrame

index : string, list of fields, array-like

Field of array to use as the index, alternately a specific set of input labels to use

exclude : sequence, default None

Columns or fields to exclude

columns : sequence, default None

Column names to use. If the passed data do not have names associated with them, this argument provides names for the columns. Otherwise this argument indicates the order of the columns in the result (any names not found in the data will become all-NA columns)

coerce_float : boolean, default False

Attempt to convert values of non-string, non-numeric objects (like decimal.Decimal) to floating point, useful for SQL result sets

Returns **df** : DataFrame

pandas.DataFrame.ge

`DataFrame.ge`(*other*, *axis='columns'*, *level=None*)

Wrapper for flexible comparison methods ge

pandas.DataFrame.get

`DataFrame.get`(*key*, *default=None*)

Get item from object for given key (DataFrame column, Panel slice, etc.). Returns default value if not found.

Parameters **key** : object

Returns **value** : type of items contained in object

pandas.DataFrame.get_dtype_counts

`DataFrame.get_dtype_counts`()

Return the counts of dtypes in this object.

pandas.DataFrame.get_ftype_counts

`DataFrame.get_ftype_counts()`

Return the counts of ftypes in this object.

pandas.DataFrame.get_value

`DataFrame.get_value(index, col, takeable=False)`

Quickly retrieve single value at passed column and index

Deprecated since version 0.21.0.

Please use .at[] or .iat[] accessors.

Parameters **index** : row label

col : column label

takeable : interpret the index/col as indexers, default False

Returns **value** : scalar value

pandas.DataFrame.get_values

`DataFrame.get_values()`

same as values (but handles sparseness conversions)

pandas.DataFrame.groupby

`DataFrame.groupby(by=None, axis=0, level=None, as_index=True, sort=True, group_keys=True, squeeze=False, **kwargs)`

Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.

Parameters **by** : mapping, function, str, or iterable

Used to determine the groups for the groupby. If `by` is a function, it's called on each value of the object's index. If a dict or Series is passed, the Series or dict VALUES will be used to determine the groups (the Series' values are first aligned; see `.align()` method). If an ndarray is passed, the values are used as-is determine the groups. A str or list of strs may be passed to group by the columns in `self`

axis : int, default 0

level : int, level name, or sequence of such, default None

If the axis is a MultiIndex (hierarchical), group by a particular level or levels

as_index : boolean, default True

For aggregated output, return object with group labels as the index. Only relevant for DataFrame input. as_index=False is effectively "SQL-style" grouped output

sort : boolean, default True

Sort group keys. Get better performance by turning this off. Note this does not influence the order of observations within each group. groupby preserves the order of rows within each group.

group_keys : boolean, default True

When calling apply, add group keys to index to identify pieces

squeeze : boolean, default False

reduce the dimensionality of the return type if possible, otherwise return a consistent type

Returns GroupBy object

Examples

DataFrame results

```
>>> data.groupby(func, axis=0).mean()
>>> data.groupby(['col1', 'col2'])['col3'].mean()
```

DataFrame with hierarchical index

```
>>> data.groupby(['col1', 'col2']).mean()
```

pandas.DataFrame.gt

`DataFrame.gt`(*other*, *axis='columns'*, *level=None*)

Wrapper for flexible comparison methods gt

pandas.DataFrame.head

`DataFrame.head`(*n=5*)

Return the first n rows.

Parameters **n** : int, default 5

Number of rows to select.

Returns **obj_head** : type of caller

The first n rows of the caller object.

pandas.DataFrame.hist

`DataFrame.hist`(*data*, *column=None*, *by=None*, *grid=True*, *xlabelsize=None*, *xrot=None*, *ylabelsize=None*, *yrot=None*, *ax=None*, *sharex=False*, *sharey=False*, *figsize=None*, *layout=None*, *bins=10*, ***kwds*)

Draw histogram of the DataFrame's series using matplotlib / pylab.

Parameters **data** : DataFrame

column : string or sequence

If passed, will be used to limit data to a subset of columns

by : object, optional

If passed, then used to form histograms for separate groups

grid : boolean, default True

Whether to show axis grid lines

xlabelsize : int, default None

If specified changes the x-axis label size

xrot : float, default None

rotation of x axis labels

ylabelsize : int, default None

If specified changes the y-axis label size

yrot : float, default None

rotation of y axis labels

ax : matplotlib axes object, default None

sharex : boolean, default True if ax is None else False

In case subplots=True, share x axis and set some x axis labels to invisible; defaults to True if ax is None otherwise False if an ax is passed in; Be aware, that passing in both an ax and sharex=True will alter all x axis labels for all subplots in a figure!

sharey : boolean, default False

In case subplots=True, share y axis and set some y axis labels to invisible

figsize : tuple

The size of the figure to create in inches by default

layout : tuple, optional

Tuple of (rows, columns) for the layout of the histograms

bins : integer, default 10

Number of histogram bins to be used

kwds : other plotting keyword arguments

To be passed to hist function

pandas.DataFrame.idxmax

`DataFrame.`**`idxmax`**(*axis=0*, *skipna=True*)

Return index of first occurrence of maximum over requested axis. NA/null values are excluded.

Parameters axis : {0 or 'index', 1 or 'columns'}, default 0

0 or 'index' for row-wise, 1 or 'columns' for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be first index.

Returns **idxmax** : Series

See also:

Series.idxmax

Notes

This method is the DataFrame version of `ndarray.argmax`.

pandas.DataFrame.idxmin

`DataFrame.`**`idxmin`**(*axis=0*, *skipna=True*)

Return index of first occurrence of minimum over requested axis. NA/null values are excluded.

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

0 or 'index' for row-wise, 1 or 'columns' for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **idxmin** : Series

See also:

Series.idxmin

Notes

This method is the DataFrame version of `ndarray.argmin`.

pandas.DataFrame.infer_objects

`DataFrame.`**`infer_objects`**()

Attempt to infer better dtypes for object columns.

Attempts soft conversion of object-dtyped columns, leaving non-object and unconvertible columns unchanged. The inference rules are the same as during normal Series/DataFrame construction.

New in version 0.21.0.

Returns **converted** : same type as input object

See also:

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

pandas.to_numeric Convert argument to numeric typeR

Examples

```
>>> df = pd.DataFrame({"A": ["a", 1, 2, 3]})
>>> df = df.iloc[1:]
>>> df
   A
1  1
2  2
3  3
```

```
>>> df.dtypes
A    object
dtype: object
```

```
>>> df.infer_objects().dtypes
A    int64
dtype: object
```

pandas.DataFrame.info

`DataFrame.info`(*verbose=None*, *buf=None*, *max_cols=None*, *memory_usage=None*, *null_counts=None*)

Concise summary of a DataFrame.

Parameters **verbose** : {None, True, False}, optional

Whether to print the full summary. None follows the *display.max_info_columns* setting. True or False overrides the *display.max_info_columns* setting.

buf : writable buffer, defaults to sys.stdout

max_cols : int, default None

Determines whether full summary or short summary is printed. None follows the *display.max_info_columns* setting.

memory_usage : boolean/string, default None

Specifies whether total memory usage of the DataFrame elements (including index) should be displayed. None follows the *display.memory_usage* setting. True or False overrides the *display.memory_usage* setting. A value of 'deep' is equivalent of True, with deep introspection. Memory usage is shown in human-readable units (base-2 representation).

null_counts : boolean, default None

Whether to show the non-null counts

- If None, then only show if the frame is smaller than max_info_rows and max_info_columns.
- If True, always show counts.
- If False, never show counts.

pandas.DataFrame.insert

`DataFrame.insert`(*loc*, *column*, *value*, *allow_duplicates=False*)

Insert column into DataFrame at specified location.

Raises a ValueError if *column* is already contained in the DataFrame, unless *allow_duplicates* is set to True.

Parameters **loc** : int

Insertion index. Must verify 0 <= loc <= len(columns)

column : string, number, or hashable object

label of the inserted column

value : int, Series, or array-like

allow_duplicates : bool, optional

pandas.DataFrame.interpolate

`DataFrame.interpolate`(*method='linear'*, *axis=0*, *limit=None*, *inplace=False*, *limit_direction='forward'*, *downcast=None*, ***kwargs*)

Interpolate values according to different methods.

Please note that only `method='linear'` is supported for DataFrames/Series with a MultiIndex.

Parameters **method** : {'linear', 'time', 'index', 'values', 'nearest', 'zero',

'slinear', 'quadratic', 'cubic', 'barycentric', 'krogh', 'polynomial', 'spline', 'piecewise_polynomial', 'from_derivatives', 'pchip', 'akima'}

- 'linear': ignore the index and treat the values as equally spaced. This is the only method supported on MultiIndexes. default
- 'time': interpolation works on daily and higher resolution data to interpolate given length of interval
- 'index', 'values': use the actual numerical values of the index
- 'nearest', 'zero', 'slinear', 'quadratic', 'cubic', 'barycentric', 'polynomial' is passed to `scipy.interpolate.interp1d`. Both 'polynomial' and 'spline' require that you also specify an *order* (int), e.g. df.interpolate(method='polynomial', order=4). These use the actual numerical values of the index.
- 'krogh', 'piecewise_polynomial', 'spline', 'pchip' and 'akima' are all wrappers around the scipy interpolation methods of similar names. These use the actual numerical values of the index. For more information on their behavior, see the scipy documentation and tutorial documentation
- 'from_derivatives' refers to BPoly.from_derivatives which replaces 'piecewise_polynomial' interpolation method in scipy 0.18

New in version 0.18.1: Added support for the 'akima' method Added interpolate method 'from_derivatives' which replaces 'piecewise_polynomial' in scipy 0.18; backwards-compatible with scipy < 0.18

axis : {0, 1}, default 0

- 0: fill column-by-column
- 1: fill row-by-row

limit : int, default None.

Maximum number of consecutive NaNs to fill. Must be greater than 0.

limit_direction : {'forward', 'backward', 'both'}, default 'forward'

If limit is specified, consecutive NaNs will be filled in this direction.

New in version 0.17.0.

inplace : bool, default False

Update the NDFrame in place if possible.

downcast : optional, 'infer' or None, defaults to None

Downcast dtypes if possible.

kwargs : keyword arguments to pass on to the interpolating function.

Returns Series or DataFrame of same shape interpolated at the NaNs

See also:

reindex, *replace*, *fillna*

Examples

Filling in NaNs

```
>>> s = pd.Series([0, 1, np.nan, 3])
>>> s.interpolate()
0    0
1    1
2    2
3    3
dtype: float64
```

pandas.DataFrame.isin

`DataFrame.isin(values)`

Return boolean DataFrame showing whether each element in the DataFrame is contained in values.

Parameters **values** : iterable, Series, DataFrame or dictionary

The result will only be true at a location if all the labels match. If *values* is a Series, that's the index. If *values* is a dictionary, the keys must be the column names, which must match. If *values* is a DataFrame, then both the index and column labels must match.

Returns DataFrame of booleans

Examples

When `values` is a list:

```
>>> df = DataFrame({'A': [1, 2, 3], 'B': ['a', 'b', 'f']})
>>> df.isin([1, 3, 12, 'a'])
       A      B
0   True   True
1  False  False
2   True  False
```

When `values` is a dict:

```
>>> df = DataFrame({'A': [1, 2, 3], 'B': [1, 4, 7]})
>>> df.isin({'A': [1, 3], 'B': [4, 7, 12]})
       A      B
0   True  False  # Note that B didn't match the 1 here.
1  False   True
2   True   True
```

When `values` is a Series or DataFrame:

```
>>> df = DataFrame({'A': [1, 2, 3], 'B': ['a', 'b', 'f']})
>>> other = DataFrame({'A': [1, 3, 3, 2], 'B': ['e', 'f', 'f', 'e']})
>>> df.isin(other)
       A      B
0   True  False
1  False  False  # Column A in `other` has a 3, but not at index 1.
2   True   True
```

pandas.DataFrame.isna

`DataFrame.`**`isna`**`()`

Return a boolean same-sized object indicating if the values are NA.

See also:

DataFrame.notna boolean inverse of isna

DataFrame.isnull alias of isna

isna top-level isna

pandas.DataFrame.isnull

`DataFrame.`**`isnull`**`()`

Return a boolean same-sized object indicating if the values are NA.

See also:

DataFrame.notna boolean inverse of isna

DataFrame.isnull alias of isna

isna top-level isna

pandas.DataFrame.items

`DataFrame.items()`

Iterator over (column name, Series) pairs.

See also:

iterrows Iterate over DataFrame rows as (index, Series) pairs.

itertuples Iterate over DataFrame rows as namedtuples of the values.

pandas.DataFrame.iteritems

`DataFrame.iteritems()`

Iterator over (column name, Series) pairs.

See also:

iterrows Iterate over DataFrame rows as (index, Series) pairs.

itertuples Iterate over DataFrame rows as namedtuples of the values.

pandas.DataFrame.iterrows

`DataFrame.iterrows()`

Iterate over DataFrame rows as (index, Series) pairs.

Returns **it** : generator

A generator that iterates over the rows of the frame.

See also:

itertuples Iterate over DataFrame rows as namedtuples of the values.

iteritems Iterate over (column name, Series) pairs.

Notes

1. Because `iterrows` returns a Series for each row, it does **not** preserve dtypes across the rows (dtypes are preserved across columns for DataFrames). For example,

```
>>> df = pd.DataFrame([[1, 1.5]], columns=['int', 'float'])
>>> row = next(df.iterrows())[1]
>>> row
int      1.0
float    1.5
Name: 0, dtype: float64
>>> print(row['int'].dtype)
float64
>>> print(df['int'].dtype)
int64
```

To preserve dtypes while iterating over the rows, it is better to use *itertuples()* which returns namedtuples of the values and which is generally faster than `iterrows`.

2. You should **never modify** something you are iterating over. This is not guaranteed to work in all cases. Depending on the data types, the iterator returns a copy and not a view, and writing to it will have no effect.

pandas.DataFrame.itertuples

`DataFrame.itertuples`(*index=True*, *name='Pandas'*)

Iterate over DataFrame rows as namedtuples, with index value as first element of the tuple.

Parameters **index** : boolean, default True

If True, return the index as the first element of the tuple.

name : string, default "Pandas"

The name of the returned namedtuples or None to return regular tuples.

See also:

iterrows Iterate over DataFrame rows as (index, Series) pairs.

iteritems Iterate over (column name, Series) pairs.

Notes

The column names will be renamed to positional names if they are invalid Python identifiers, repeated, or start with an underscore. With a large number of columns (>255), regular tuples are returned.

Examples

```
>>> df = pd.DataFrame({'col1': [1, 2], 'col2': [0.1, 0.2]},
                      index=['a', 'b'])
>>> df
   col1  col2
a     1   0.1
b     2   0.2
>>> for row in df.itertuples():
...     print(row)
...
Pandas(Index='a', col1=1, col2=0.10000000000000001)
Pandas(Index='b', col1=2, col2=0.20000000000000001)
```

pandas.DataFrame.join

`DataFrame.join`(*other*, *on=None*, *how='left'*, *lsuffix=''*, *rsuffix=''*, *sort=False*)

Join columns with other DataFrame either on index or on a key column. Efficiently Join multiple DataFrame objects by index at once by passing a list.

Parameters **other** : DataFrame, Series with name field set, or list of DataFrame

Index should be similar to one of the columns in this one. If a Series is passed, its name attribute must be set, and that will be used as the column name in the resulting joined DataFrame

on : column name, tuple/list of column names, or array-like

Column(s) in the caller to join on the index in other, otherwise joins index-on-index. If multiples columns given, the passed DataFrame must have a MultiIndex. Can pass an array as the join key if not already contained in the calling DataFrame. Like an Excel VLOOKUP operation

how : {'left', 'right', 'outer', 'inner'}, default: 'left'

How to handle the operation of the two objects.

- left: use calling frame's index (or column if on is specified)
- right: use other frame's index
- outer: form union of calling frame's index (or column if on is specified) with other frame's index, and sort it lexicographically
- inner: form intersection of calling frame's index (or column if on is specified) with other frame's index, preserving the order of the calling's one

lsuffix : string

Suffix to use from left frame's overlapping columns

rsuffix : string

Suffix to use from right frame's overlapping columns

sort : boolean, default False

Order result DataFrame lexicographically by the join key. If False, the order of the join key depends on the join type (how keyword)

Returns **joined** : DataFrame

See also:

DataFrame.merge For column(s)-on-columns(s) operations

Notes

on, lsuffix, and rsuffix options are not supported when passing a list of DataFrame objects

Examples

```
>>> caller = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3', 'K4', 'K5'],
...                        'A': ['A0', 'A1', 'A2', 'A3', 'A4', 'A5']})
```

```
>>> caller
    A key
0  A0  K0
1  A1  K1
2  A2  K2
3  A3  K3
4  A4  K4
5  A5  K5
```

```
>>> other = pd.DataFrame({'key': ['K0', 'K1', 'K2'],
...                       'B': ['B0', 'B1', 'B2']})
```

```
>>> other
    B key
0  B0  K0
1  B1  K1
2  B2  K2
```

Join DataFrames using their indexes.

```
>>> caller.join(other, lsuffix='_caller', rsuffix='_other')
```

```
>>     A key_caller    B key_other
    0  A0         K0   B0        K0
    1  A1         K1   B1        K1
    2  A2         K2   B2        K2
    3  A3         K3  NaN       NaN
    4  A4         K4  NaN       NaN
    5  A5         K5  NaN       NaN
```

If we want to join using the key columns, we need to set key to be the index in both caller and other. The joined DataFrame will have key as its index.

```
>>> caller.set_index('key').join(other.set_index('key'))
```

```
>>      A    B
    key
    K0   A0   B0
    K1   A1   B1
    K2   A2   B2
    K3   A3  NaN
    K4   A4  NaN
    K5   A5  NaN
```

Another option to join using the key columns is to use the on parameter. DataFrame.join always uses other's index but we can use any column in the caller. This method preserves the original caller's index in the result.

```
>>> caller.join(other.set_index('key'), on='key')
```

```
>>     A key    B
    0  A0  K0   B0
    1  A1  K1   B1
    2  A2  K2   B2
    3  A3  K3  NaN
    4  A4  K4  NaN
    5  A5  K5  NaN
```

pandas.DataFrame.keys

`DataFrame.keys()`

Get the 'info axis' (see Indexing for more)

This is index for Series, columns for DataFrame and major_axis for Panel.

pandas.DataFrame.kurt

`DataFrame.kurt`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **kurt** : Series or DataFrame (if level specified)

pandas.DataFrame.kurtosis

`DataFrame.kurtosis`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **kurt** : Series or DataFrame (if level specified)

pandas.DataFrame.last

`DataFrame.last`(*offset*)

Convenience method for subsetting final periods of time series data based on a date offset.

Parameters **offset** : string, DateOffset, dateutil.relativedelta

Returns **subset** : type of caller

Examples

ts.last('5M') -> Last 5 months

pandas.DataFrame.last_valid_index

`DataFrame.last_valid_index()`

Return index for first non-NA/null value.

Returns **scalar** : type of index

Notes

If all elements are non-NA/null, returns None. Also returns None for empty DataFrame.

pandas.DataFrame.le

`DataFrame.le(other, axis='columns', level=None)`

Wrapper for flexible comparison methods le

pandas.DataFrame.lookup

`DataFrame.lookup(row_labels, col_labels)`

Label-based "fancy indexing" function for DataFrame. Given equal-length arrays of row and column labels, return an array of the values corresponding to each (row, col) pair.

Parameters **row_labels** : sequence

The row labels to use for lookup

col_labels : sequence

The column labels to use for lookup

Notes

Akin to:

```
result = []
for row, col in zip(row_labels, col_labels):
    result.append(df.get_value(row, col))
```

Examples

values [ndarray] The found values

pandas.DataFrame.lt

`DataFrame.lt(other, axis='columns', level=None)`

Wrapper for flexible comparison methods lt

pandas.DataFrame.mad

`DataFrame.mad(axis=None, skipna=None, level=None)`

Return the mean absolute deviation of the values for the requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **mad** : Series or DataFrame (if level specified)

pandas.DataFrame.mask

`DataFrame.mask(cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)`

Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.

Parameters **cond** : boolean NDFrame, array-like, or callable

Where *cond* is False, keep the original value. Where True, replace with corresponding value from *other*. If *cond* is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as cond.

other : scalar, NDFrame, or callable

Entries where *cond* is True are replaced with corresponding value from *other*. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as other.

inplace : boolean, default False

Whether to perform the operation in place on the data

axis : alignment axis if needed, default None

level : alignment level if needed, default None

errors : str, {'raise', 'ignore'}, default 'raise'

- `raise` : allow exceptions to be raised
- `ignore` : suppress exceptions. On error return original object

Note that currently this parameter won't affect the results and will always coerce to a suitable dtype.

try_cast : boolean, default False

try to cast the result back to the input type (if possible),

raise_on_error : boolean, default True

Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.

Returns **wh** : same type as caller

See also:

`DataFrame.where()`

Notes

The mask method is an application of the if-then idiom. For each element in the calling DataFrame, if `cond` is `False` the element is used; otherwise the corresponding element from the DataFrame `other` is used.

The signature for *`DataFrame.where()`* differs from `numpy.where()`. Roughly `df1.where(m, df2)` is equivalent to `np.where(m, df1, df2)`.

For further details and examples see the `mask` documentation in *indexing*.

Examples

```
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0    NaN
1    1.0
2    2.0
3    3.0
4    4.0
```

```
>>> s.mask(s > 0)
0    0.0
1    NaN
2    NaN
3    NaN
4    NaN
```

```
>>> s.where(s > 1, 10)
0    10.0
1    10.0
2    2.0
3    3.0
4    4.0
```

```
>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
   A  B
0  0 -1
1 -2  3
2 -4 -5
3  6 -7
4 -8  9
>>> df.where(m, -df) == np.where(m, df, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
>>> df.where(m, -df) == df.mask(~m, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
```

pandas.DataFrame.max

`DataFrame.max`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

This method returns the maximum of the values in the object. If you want the *index* of the maximum, use `idxmax`. This is the equivalent of the `numpy.ndarray` method `argmax`.

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **max** : Series or DataFrame (if level specified)

pandas.DataFrame.mean

`DataFrame.mean`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the mean of the values for the requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **mean** : Series or DataFrame (if level specified)

pandas.DataFrame.median

`DataFrame.median`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the median of the values for the requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **median** : Series or DataFrame (if level specified)

pandas.DataFrame.melt

`DataFrame.melt`(*id_vars=None*, *value_vars=None*, *var_name=None*, *value_name='value'*, *col_level=None*)

"Unpivots" a DataFrame from wide format to long format, optionally leaving identifier variables set.

This function is useful to massage a DataFrame into a format where one or more columns are identifier variables (*id_vars*), while all other columns, considered measured variables (*value_vars*), are "unpivoted" to the row axis, leaving just two non-identifier columns, 'variable' and 'value'.

New in version 0.20.0.

Parameters **frame** : DataFrame

id_vars : tuple, list, or ndarray, optional

Column(s) to use as identifier variables.

value_vars : tuple, list, or ndarray, optional

Column(s) to unpivot. If not specified, uses all columns that are not set as *id_vars*.

var_name : scalar

Name to use for the 'variable' column. If None it uses `frame.columns.name` or 'variable'.

value_name : scalar, default 'value'

Name to use for the 'value' column.

col_level : int or string, optional

If columns are a MultiIndex then use this level to melt.

See also:

melt, *pivot_table*, *DataFrame.pivot*

Examples

```
>>> import pandas as pd
>>> df = pd.DataFrame({'A': {0: 'a', 1: 'b', 2: 'c'},
...                    'B': {0: 1, 1: 3, 2: 5},
...                    'C': {0: 2, 1: 4, 2: 6}})
>>> df
   A  B  C
0  a  1  2
1  b  3  4
2  c  5  6
```

```
>>> df.melt(id_vars=['A'], value_vars=['B'])
   A variable  value
0  a        B      1
1  b        B      3
2  c        B      5
```

```
>>> df.melt(id_vars=['A'], value_vars=['B', 'C'])
   A variable  value
0  a        B      1
1  b        B      3
2  c        B      5
3  a        C      2
4  b        C      4
5  c        C      6
```

The names of 'variable' and 'value' columns can be customized:

```
>>> df.melt(id_vars=['A'], value_vars=['B'],
...         var_name='myVarname', value_name='myValname')
   A myVarname  myValname
0  a         B          1
```

```
1  b          B           3
2  c          B           5
```

If you have multi-index columns:

```
>>> df.columns = [list('ABC'), list('DEF')]
>>> df
   A  B  C
   D  E  F
0  a  1  2
1  b  3  4
2  c  5  6
```

```
>>> df.melt(col_level=0, id_vars=['A'], value_vars=['B'])
   A variable  value
0  a        B      1
1  b        B      3
2  c        B      5
```

```
>>> df.melt(id_vars=[('A', 'D')], value_vars=[('B', 'E')])
  (A, D) variable_0 variable_1  value
0      a          B          E      1
1      b          B          E      3
2      c          B          E      5
```

pandas.DataFrame.memory_usage

`DataFrame.memory_usage(index=True, deep=False)`

Memory usage of DataFrame columns.

Parameters **index** : bool

Specifies whether to include memory usage of DataFrame's index in returned Series. If *index=True* (default is False) the first index of the Series is *Index*.

deep : bool

Introspect the data deeply, interrogate *object* dtypes for system-level memory consumption

Returns **sizes** : Series

A series with column names as index and memory usage of columns with units of bytes.

See also:

`numpy.ndarray.nbytes`

Notes

Memory usage does not include memory consumed by elements that are not components of the array if deep=False

pandas.DataFrame.merge

`DataFrame.merge`(*right*, *how='inner'*, *on=None*, *left_on=None*, *right_on=None*, *left_index=False*, *right_index=False*, *sort=False*, *suffixes=('_x', '_y')*, *copy=True*, *indicator=False*, *validate=None*)

Merge DataFrame objects by performing a database-style join operation by columns or indexes.

If joining columns on columns, the DataFrame indexes *will be ignored*. Otherwise if joining indexes on indexes or indexes on a column or columns, the index will be passed on.

Parameters **right** : DataFrame

how : {'left', 'right', 'outer', 'inner'}, default 'inner'

- left: use only keys from left frame, similar to a SQL left outer join; preserve key order
- right: use only keys from right frame, similar to a SQL right outer join; preserve key order
- outer: use union of keys from both frames, similar to a SQL full outer join; sort keys lexicographically
- inner: use intersection of keys from both frames, similar to a SQL inner join; preserve the order of the left keys

on : label or list

Field names to join on. Must be found in both DataFrames. If on is None and not merging on indexes, then it merges on the intersection of the columns by default.

left_on : label or list, or array-like

Field names to join on in left DataFrame. Can be a vector or list of vectors of the length of the DataFrame to use a particular vector as the join key instead of columns

right_on : label or list, or array-like

Field names to join on in right DataFrame or vector/list of vectors per left_on docs

left_index : boolean, default False

Use the index from the left DataFrame as the join key(s). If it is a MultiIndex, the number of keys in the other DataFrame (either the index or a number of columns) must match the number of levels

right_index : boolean, default False

Use the index from the right DataFrame as the join key. Same caveats as left_index

sort : boolean, default False

Sort the join keys lexicographically in the result DataFrame. If False, the order of the join keys depends on the join type (how keyword)

suffixes : 2-length sequence (tuple, list, ...)

Suffix to apply to overlapping column names in the left and right side, respectively

copy : boolean, default True

If False, do not copy data unnecessarily

indicator : boolean or string, default False

If True, adds a column to output DataFrame called "_merge" with information on the source of each row. If string, column with information on source of each row will be added to output DataFrame, and column will be named value of string. Information column is Categorical-type and takes on a value of "left_only" for observations whose merge key only appears in 'left' DataFrame, "right_only" for observations whose merge key only appears in 'right' DataFrame, and "both" if the observation's merge key is found in both.

New in version 0.17.0.

validate : string, default None

If specified, checks if merge is of specified type.

- "one_to_one" or "1:1": check if merge keys are unique in both left and right datasets.
- "one_to_many" or "1:m": check if merge keys are unique in left dataset.
- "many_to_one" or "m:1": check if merge keys are unique in right dataset.
- "many_to_many" or "m:m": allowed, but does not result in checks.

New in version 0.21.0.

Returns **merged** : DataFrame

The output type will the be same as 'left', if it is a subclass of DataFrame.

See also:

merge_ordered, *merge_asof*

Examples

```
>>> A                >>> B
    lkey value            rkey value
0   foo  1         0   foo  5
1   bar  2         1   bar  6
2   baz  3         2   qux  7
3   foo  4         3   bar  8
```

```
>>> A.merge(B, left_on='lkey', right_on='rkey', how='outer')
   lkey  value_x  rkey  value_y
0  foo   1        foo   5
1  foo   4        foo   5
2  bar   2        bar   6
3  bar   2        bar   8
4  baz   3        NaN   NaN
5  NaN   NaN      qux   7
```

pandas.DataFrame.min

`DataFrame.min`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

This method returns the minimum of the values in the object. If you want the *index* of the minimum, use `idxmin`. This is the equivalent of the `numpy.ndarray` method `argmin`.

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **min** : Series or DataFrame (if level specified)

pandas.DataFrame.mod

`DataFrame.mod`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Modulo of dataframe and other, element-wise (binary operator *mod*).

Equivalent to `dataframe % other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

`DataFrame.rmod`

Notes

Mismatched indices will be unioned together

pandas.DataFrame.mode

`DataFrame.mode`(*axis=0*, *numeric_only=False*)

Gets the mode(s) of each element along the axis selected. Adds a row for each mode per label, fills in gaps with nan.

Note that there could be multiple values returned for the selected axis (when more than one item share the maximum frequency), which is the reason why a dataframe is returned. If you want to impute missing values with the mode in a dataframe `df`, you can just do this: `df.fillna(df.mode().iloc[0])`

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

- 0 or 'index' : get mode of each column
- 1 or 'columns' : get mode of each row

numeric_only : boolean, default False

if True, only apply to numeric columns

Returns **modes** : DataFrame (sorted)

Examples

```
>>> df = pd.DataFrame({'A': [1, 2, 1, 2, 1, 2, 3]})
>>> df.mode()
   A
0  1
1  2
```

pandas.DataFrame.mul

`DataFrame.mul`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Multiplication of dataframe and other, element-wise (binary operator *mul*).

Equivalent to `dataframe * other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

`DataFrame.rmul`

Notes

Mismatched indices will be unioned together

pandas.DataFrame.multiply

`DataFrame.multiply`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Multiplication of dataframe and other, element-wise (binary operator *mul*).

Equivalent to `dataframe * other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.rmul

Notes

Mismatched indices will be unioned together

pandas.DataFrame.ne

`DataFrame.ne`(*other*, *axis='columns'*, *level=None*)

Wrapper for flexible comparison methods ne

pandas.DataFrame.nlargest

`DataFrame.nlargest`(*n*, *columns*, *keep='first'*)

Get the rows of a DataFrame sorted by the *n* largest values of *columns*.

New in version 0.17.0.

Parameters **n** : int

Number of items to retrieve

columns : list or str

Column name or names to order by

keep : {'first', 'last', False}, default 'first'

Where there are duplicate values: - `first` : take the first occurrence. - `last` : take the last occurrence.

Returns DataFrame

Examples

```
>>> df = DataFrame({'a': [1, 10, 8, 11, -1],
...                 'b': list('abdce'),
...                 'c': [1.0, 2.0, np.nan, 3.0, 4.0]})
>>> df.nlargest(3, 'a')
    a  b   c
3  11  c   3
1  10  b   2
2   8  d NaN
```

pandas.DataFrame.notna

`DataFrame.notna()`

Return a boolean same-sized object indicating if the values are not NA.

See also:

DataFrame.isna boolean inverse of notna

DataFrame.notnull alias of notna

notna top-level notna

pandas.DataFrame.notnull

`DataFrame.notnull()`

Return a boolean same-sized object indicating if the values are not NA.

See also:

DataFrame.isna boolean inverse of notna

DataFrame.notnull alias of notna

notna top-level notna

pandas.DataFrame.nsmallest

`DataFrame.nsmallest(n, columns, keep='first')`

Get the rows of a DataFrame sorted by the *n* smallest values of *columns*.

New in version 0.17.0.

Parameters **n** : int

Number of items to retrieve

columns : list or str

Column name or names to order by

keep : {'first', 'last', False}, default 'first'

Where there are duplicate values: - `first` : take the first occurrence. - `last` : take the last occurrence.

Returns DataFrame

Examples

```
>>> df = DataFrame({'a': [1, 10, 8, 11, -1],
...                 'b': list('abdce'),
...                 'c': [1.0, 2.0, np.nan, 3.0, 4.0]})
>>> df.nsmallest(3, 'a')
   a  b   c
4 -1  e   4
0  1  a   1
2  8  d NaN
```

pandas.DataFrame.nunique

`DataFrame.nunique(axis=0, dropna=True)`

Return Series with number of distinct observations over requested axis.

New in version 0.20.0.

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

dropna : boolean, default True

Don't include NaN in the counts.

Returns **nunique** : Series

Examples

```
>>> df = pd.DataFrame({'A': [1, 2, 3], 'B': [1, 1, 1]})
>>> df.nunique()
A    3
B    1
```

```
>>> df.nunique(axis=1)
0    1
1    2
2    2
```

pandas.DataFrame.pct_change

`DataFrame.pct_change(periods=1, fill_method='pad', limit=None, freq=None, **kwargs)`

Percent change over given number of periods.

Parameters **periods** : int, default 1

Periods to shift for forming percent change

fill_method : str, default 'pad'

How to handle NAs before computing percent changes

limit : int, default None

The number of consecutive NAs to fill before stopping

freq : DateOffset, timedelta, or offset alias string, optional

Increment to use from time series API (e.g. 'M' or BDay())

Returns **chg** : NDFrame

Notes

By default, the percentage change is calculated along the stat axis: 0, or `Index`, for `DataFrame` and 1, or `minor` for `Panel`. You can change this with the `axis` keyword argument.

pandas.DataFrame.pipe

`DataFrame.`**`pipe`**(*func*, **args*, ***kwargs*)

Apply func(self, *args, **kwargs)

Parameters **func** : function

function to apply to the NDFrame. `args`, and `kwargs` are passed into `func`. Alternatively a `(callable, data_keyword)` tuple where `data_keyword` is a string indicating the keyword of `callable` that expects the NDFrame.

args : iterable, optional

positional arguments passed into `func`.

kwargs : mapping, optional

a dictionary of keyword arguments passed into `func`.

Returns **object** : the return type of `func`.

See also:

`pandas.DataFrame.apply`, *`pandas.DataFrame.applymap`*, *`pandas.Series.map`*

Notes

Use `.pipe` when chaining together functions that expect Series, DataFrames or GroupBy objects. Instead of writing

```
>>> f(g(h(df), arg1=a), arg2=b, arg3=c)
```

You can write

```
>>> (df.pipe(h)
...     .pipe(g, arg1=a)
...     .pipe(f, arg2=b, arg3=c)
... )
```

If you have a function that takes the data as (say) the second argument, pass a tuple indicating which keyword expects the data. For example, suppose `f` takes its data as `arg2`:

```
>>> (df.pipe(h)
...     .pipe(g, arg1=a)
...     .pipe((f, 'arg2'), arg1=a, arg3=c)
...  )
```

pandas.DataFrame.pivot

`DataFrame.pivot(index=None, columns=None, values=None)`

Reshape data (produce a "pivot" table) based on column values. Uses unique values from index / columns to form axes of the resulting DataFrame.

Parameters **index** : string or object, optional

Column name to use to make new frame's index. If None, uses existing index.

columns : string or object

Column name to use to make new frame's columns

values : string or object, optional

Column name to use for populating new frame's values. If not specified, all remaining columns will be used and the result will have hierarchically indexed columns

Returns **pivoted** : DataFrame

See also:

DataFrame.pivot_table generalization of pivot that can handle duplicate values for one index/column pair

DataFrame.unstack pivot based on the index values instead of a column

Notes

For finer-tuned control, see hierarchical indexing documentation along with the related stack/unstack methods

Examples

```
>>> df = pd.DataFrame({'foo': ['one','one','one','two','two','two'],
                       'bar': ['A', 'B', 'C', 'A', 'B', 'C'],
                       'baz': [1, 2, 3, 4, 5, 6]})
>>> df
    foo   bar  baz
0   one   A    1
1   one   B    2
2   one   C    3
3   two   A    4
4   two   B    5
5   two   C    6
```

```
>>> df.pivot(index='foo', columns='bar', values='baz')
     A   B   C
one  1   2   3
two  4   5   6
```

```
>>> df.pivot(index='foo', columns='bar')['baz']
     A   B   C
one  1   2   3
two  4   5   6
```

pandas.DataFrame.pivot_table

`DataFrame.pivot_table(values=None, index=None, columns=None, aggfunc='mean', fill_value=None, margins=False, dropna=True, margins_name='All')`

Create a spreadsheet-style pivot table as a DataFrame. The levels in the pivot table will be stored in MultiIndex objects (hierarchical indexes) on the index and columns of the result DataFrame

Parameters **values** : column to aggregate, optional

index : column, Grouper, array, or list of the previous

If an array is passed, it must be the same length as the data. The list can contain any of the other types (except list). Keys to group by on the pivot table index. If an array is passed, it is being used as the same manner as column values.

columns : column, Grouper, array, or list of the previous

If an array is passed, it must be the same length as the data. The list can contain any of the other types (except list). Keys to group by on the pivot table column. If an array is passed, it is being used as the same manner as column values.

aggfunc : function or list of functions, default numpy.mean

If list of functions passed, the resulting pivot table will have hierarchical columns whose top level are the function names (inferred from the function objects themselves)

fill_value : scalar, default None

Value to replace missing values with

margins : boolean, default False

Add all row / columns (e.g. for subtotal / grand totals)

dropna : boolean, default True

Do not include columns whose entries are all NaN

margins_name : string, default 'All'

Name of the row / column that will contain the totals when margins is True.

Returns **table** : DataFrame

See also:

`DataFrame.pivot` pivot without aggregation that can handle non-numeric data

Examples

```
>>> df = pd.DataFrame({"A": ["foo", "foo", "foo", "foo", "foo",
...                          "bar", "bar", "bar", "bar"],
...                    "B": ["one", "one", "one", "two", "two",
...                          "one", "one", "two", "two"],
...                    "C": ["small", "large", "large", "small",
...                          "small", "large", "small", "small",
...                          "large"],
...                    "D": [1, 2, 2, 3, 3, 4, 5, 6, 7]})
```

```
>>> df
     A    B      C  D
0  foo  one  small  1
1  foo  one  large  2
2  foo  one  large  2
3  foo  two  small  3
4  foo  two  small  3
5  bar  one  large  4
6  bar  one  small  5
7  bar  two  small  6
8  bar  two  large  7
```

```
>>> table = pivot_table(df, values='D', index=['A', 'B'],
...                     columns=['C'], aggfunc=np.sum)
>>> table
...
C        large  small
A   B
bar one    4.0    5.0
    two    7.0    6.0
foo one    4.0    1.0
    two    NaN    6.0
```

pandas.DataFrame.plot

`DataFrame.plot`(*x=None*, *y=None*, *kind='line'*, *ax=None*, *subplots=False*, *sharex=None*, *sharey=False*, *layout=None*, *figsize=None*, *use_index=True*, *title=None*, *grid=None*, *legend=True*, *style=None*, *logx=False*, *logy=False*, *loglog=False*, *xticks=None*, *yticks=None*, *xlim=None*, *ylim=None*, *rot=None*, *fontsize=None*, *colormap=None*, *table=False*, *yerr=None*, *xerr=None*, *secondary_y=False*, *sort_columns=False*, ***kwds*)

Make plots of DataFrame using matplotlib / pylab.

New in version 0.17.0: Each plot kind has a corresponding method on the `DataFrame.plot` accessor: `df.plot(kind='line')` is equivalent to `df.plot.line()`.

Parameters **data** : DataFrame

x : label or position, default None

y : label or position, default None

Allows plotting of one column versus another

kind : str

- 'line' : line plot (default)
- 'bar' : vertical bar plot
- 'barh' : horizontal bar plot
- 'hist' : histogram
- 'box' : boxplot
- 'kde' : Kernel Density Estimation plot
- 'density' : same as 'kde'
- 'area' : area plot

- 'pie' : pie plot
- 'scatter' : scatter plot
- 'hexbin' : hexbin plot

ax : matplotlib axes object, default None

subplots : boolean, default False

Make separate subplots for each column

sharex : boolean, default True if ax is None else False

In case subplots=True, share x axis and set some x axis labels to invisible; defaults to True if ax is None otherwise False if an ax is passed in; Be aware, that passing in both an ax and sharex=True will alter all x axis labels for all axis in a figure!

sharey : boolean, default False

In case subplots=True, share y axis and set some y axis labels to invisible

layout : tuple (optional)

(rows, columns) for the layout of subplots

figsize : a tuple (width, height) in inches

use_index : boolean, default True

Use index as ticks for x axis

title : string or list

Title to use for the plot. If a string is passed, print the string at the top of the figure. If a list is passed and *subplots* is True, print each item in the list above the corresponding subplot.

grid : boolean, default None (matlab style default)

Axis grid lines

legend : False/True/'reverse'

Place legend on axis subplots

style : list or dict

matplotlib line style per column

logx : boolean, default False

Use log scaling on x axis

logy : boolean, default False

Use log scaling on y axis

loglog : boolean, default False

Use log scaling on both x and y axes

xticks : sequence

Values to use for the xticks

yticks : sequence

Values to use for the yticks

xlim : 2-tuple/list

ylim : 2-tuple/list

rot : int, default None

Rotation for ticks (xticks for vertical, yticks for horizontal plots)

fontsize : int, default None

Font size for xticks and yticks

colormap : str or matplotlib colormap object, default None

Colormap to select colors from. If string, load colormap with that name from matplotlib.

colorbar : boolean, optional

If True, plot colorbar (only relevant for 'scatter' and 'hexbin' plots)

position : float

Specify relative alignments for bar plot layout. From 0 (left/bottom-end) to 1 (right/top-end). Default is 0.5 (center)

table : boolean, Series or DataFrame, default False

If True, draw a table using the data in the DataFrame and the data will be transposed to meet matplotlib's default layout. If a Series or DataFrame is passed, use passed data to draw a table.

yerr : DataFrame, Series, array-like, dict and str

See *Plotting with Error Bars* for detail.

xerr : same types as yerr.

stacked : boolean, default False in line and

bar plots, and True in area plot. If True, create stacked plot.

sort_columns : boolean, default False

Sort column names to determine plot ordering

secondary_y : boolean or sequence, default False

Whether to plot on the secondary y-axis If a list/tuple, which columns to plot on secondary y-axis

mark_right : boolean, default True

When using a secondary_y axis, automatically mark the column labels with "(right)" in the legend

kwds : keywords

Options to pass to matplotlib plotting method

Returns **axes** : matplotlib.AxesSubplot or np.array of them

Notes

- See matplotlib documentation online for more on this subject

- If *kind* = 'bar' or 'barh', you can specify relative alignments for bar plot layout by *position* keyword. From 0 (left/bottom-end) to 1 (right/top-end). Default is 0.5 (center)
- If *kind* = 'scatter' and the argument *c* is the name of a dataframe column, the values of that column are used to color each point.
- If *kind* = 'hexbin', you can control the size of the bins with the *gridsize* argument. By default, a histogram of the counts around each *(x, y)* point is computed. You can specify alternative aggregations by passing values to the *C* and *reduce_C_function* arguments. *C* specifies the value at each *(x, y)* point and *reduce_C_function* is a function of one argument that reduces all the values in a bin to a single number (e.g. *mean*, *max*, *sum*, *std*).

pandas.DataFrame.pop

`DataFrame.pop(item)`

Return item and drop from frame. Raise KeyError if not found.

Parameters item : str

Column label to be popped

Returns popped : Series

Examples

```
>>> df = pd.DataFrame([('falcon', 'bird',    389.0),
...                    ('parrot', 'bird',     24.0),
...                    ('lion',   'mammal',   80.5),
...                    ('monkey', 'mammal', np.nan)],
...                   columns=('name', 'class', 'max_speed'))
>>> df
     name   class  max_speed
0  falcon    bird      389.0
1  parrot    bird       24.0
2    lion  mammal       80.5
3  monkey  mammal        NaN
```

```
>>> df.pop('class')
0      bird
1      bird
2    mammal
3    mammal
Name: class, dtype: object
```

```
>>> df
     name  max_speed
0  falcon      389.0
1  parrot       24.0
2    lion       80.5
3  monkey        NaN
```

pandas.DataFrame.pow

`DataFrame.pow`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Exponential power of dataframe and other, element-wise (binary operator *pow*).

Equivalent to `dataframe ** other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.rpow

Notes

Mismatched indices will be unioned together

pandas.DataFrame.prod

`DataFrame.prod`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the product of the values for the requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **prod** : Series or DataFrame (if level specified)

pandas.DataFrame.product

`DataFrame.product`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the product of the values for the requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **prod** : Series or DataFrame (if level specified)

pandas.DataFrame.quantile

`DataFrame.quantile`(*q=0.5*, *axis=0*, *numeric_only=True*, *interpolation='linear'*)

Return values at the given quantile over requested axis, a la numpy.percentile.

Parameters **q** : float or array-like, default 0.5 (50% quantile)

0 <= q <= 1, the quantile(s) to compute

axis : {0, 1, 'index', 'columns'} (default 0)

0 or 'index' for row-wise, 1 or 'columns' for column-wise

interpolation : {'linear', 'lower', 'higher', 'midpoint', 'nearest'}

New in version 0.18.0.

This optional parameter specifies the interpolation method to use, when the desired quantile lies between two data points *i* and *j*:

- linear: *i + (j - i) * fraction*, where *fraction* is the fractional part of the index surrounded by *i* and *j*.
- lower: *i*.
- higher: *j*.
- nearest: *i* or *j* whichever is nearest.
- midpoint: (*i* + *j*) / 2.

Returns **quantiles** : Series or DataFrame

- If `q` is an array, a DataFrame will be returned where the index is `q`, the columns are the columns of self, and the values are the quantiles.
- If `q` is a float, a Series will be returned where the index is the columns of self and the values are the quantiles.

Examples

```
>>> df = DataFrame(np.array([[1, 1], [2, 10], [3, 100], [4, 100]]),
                   columns=['a', 'b'])
>>> df.quantile(.1)
a    1.3
b    3.7
dtype: float64
>>> df.quantile([.1, .5])
       a     b
0.1  1.3   3.7
0.5  2.5  55.0
```

pandas.DataFrame.query

`DataFrame.query`(*expr*, *inplace=False*, ***kwargs*)

Query the columns of a frame with a boolean expression.

Parameters **expr** : string

The query string to evaluate. You can refer to variables in the environment by prefixing them with an '@' character like `@a + b`.

inplace : bool

Whether the query should modify the data in place or return a modified copy

New in version 0.18.0.

kwargs : dict

See the documentation for *pandas.eval()* for complete details on the keyword arguments accepted by *DataFrame.query()*.

Returns **q** : DataFrame

See also:

pandas.eval, *DataFrame.eval*

Notes

The result of the evaluation of this expression is first passed to *DataFrame.loc* and if that fails because of a multidimensional key (e.g., a DataFrame) then the result will be passed to `DataFrame.__getitem__()`.

This method uses the top-level *pandas.eval()* function to evaluate the passed query.

The *query()* method uses a slightly modified Python syntax by default. For example, the `&` and `|` (bitwise) operators have the precedence of their boolean cousins, `and` and `or`. This *is* syntactically valid Python, however the semantics are different.

You can change the semantics of the expression by passing the keyword argument `parser='python'`. This enforces the same semantics as evaluation in Python space. Likewise, you can pass `engine='python'` to evaluate an expression using Python itself as a backend. This is not recommended as it is inefficient compared to using `numexpr` as the engine.

The `DataFrame.index` and `DataFrame.columns` attributes of the *DataFrame* instance are placed in the query namespace by default, which allows you to treat both the index and columns of

the frame as a column in the frame. The identifier `index` is used for the frame index; you can also use the name of the index to identify it in a query.

For further details and examples see the `query` documentation in *indexing*.

Examples

```
>>> from numpy.random import randn
>>> from pandas import DataFrame
>>> df = DataFrame(randn(10, 2), columns=list('ab'))
>>> df.query('a > b')
>>> df[df.a > df.b]  # same result as the previous expression
```

pandas.DataFrame.radd

`DataFrame.radd`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Addition of dataframe and other, element-wise (binary operator *radd*).

Equivalent to `other + dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

`DataFrame.add`

Notes

Mismatched indices will be unioned together

pandas.DataFrame.rank

`DataFrame.rank`(*axis=0*, *method='average'*, *numeric_only=None*, *na_option='keep'*, *ascending=True*, *pct=False*)

Compute numerical data ranks (1 through n) along axis. Equal values are assigned a rank that is the average of the ranks of those values

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

index to direct ranking

method : {'average', 'min', 'max', 'first', 'dense'}

- average: average rank of group
- min: lowest rank in group
- max: highest rank in group
- first: ranks assigned in order they appear in the array
- dense: like 'min', but rank always increases by 1 between groups

numeric_only : boolean, default None

Include only float, int, boolean data. Valid only for DataFrame or Panel objects

na_option : {'keep', 'top', 'bottom'}

- keep: leave NA values where they are
- top: smallest rank if ascending
- bottom: smallest rank if descending

ascending : boolean, default True

False for ranks by high (1) to low (N)

pct : boolean, default False

Computes percentage rank of data

Returns **ranks** : same type as caller

pandas.DataFrame.rdiv

`DataFrame.rdiv`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Floating division of dataframe and other, element-wise (binary operator *rtruediv*).

Equivalent to `other / dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.truediv

Notes

Mismatched indices will be unioned together

pandas.DataFrame.reindex

`DataFrame.reindex(labels=None, index=None, columns=None, axis=None, method=None, copy=True, level=None, fill_value=nan, limit=None, tolerance=None)`

Conform DataFrame to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index. A new object is produced unless the new index is equivalent to the current one and copy=False

Parameters **labels** : array-like, optional

New labels / index to conform the axis specified by 'axis' to.

index, columns : array-like, optional (should be specified using keywords)

New labels / index to conform to. Preferably an Index object to avoid duplicating data

axis : int or str, optional

Axis to target. Can be either the axis name ('index', 'columns') or number (0, 1).

method : {None, 'backfill'/'bfill', 'pad'/'ffill', 'nearest'}, optional

method to use for filling holes in reindexed DataFrame. Please note: this is only applicable to DataFrames/Series with a monotonically increasing/decreasing index.

- default: don't fill gaps
- pad / ffill: propagate last valid observation forward to next valid
- backfill / bfill: use next valid observation to fill gap
- nearest: use nearest valid observations to fill gap

copy : boolean, default True

Return a new object, even if the passed indexes are the same

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

fill_value : scalar, default np.NaN

Value to use for missing values. Defaults to NaN, but can be any "compatible" value

limit : int, default None

Maximum number of consecutive elements to forward or backward fill

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list,

tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **reindexed** : DataFrame

Examples

`DataFrame.reindex` supports two calling conventions

- `(index=index_labels, columns=column_labels, ...)`
- `(labels, axis={'index', 'columns'}, ...)`

We *highly* recommend using keyword arguments to clarify your intent.

Create a dataframe with some fictional data.

```
>>> index = ['Firefox', 'Chrome', 'Safari', 'IE10', 'Konqueror']
>>> df = pd.DataFrame({
...      'http_status': [200,200,404,404,301],
...      'response_time': [0.04, 0.02, 0.07, 0.08, 1.0]},
...       index=index)
>>> df
           http_status  response_time
Firefox            200           0.04
Chrome             200           0.02
Safari             404           0.07
IE10               404           0.08
Konqueror          301           1.00
```

Create a new index and reindex the dataframe. By default values in the new index that do not have corresponding records in the dataframe are assigned `NaN`.

```
>>> new_index= ['Safari', 'Iceweasel', 'Comodo Dragon', 'IE10',
...              'Chrome']
>>> df.reindex(new_index)
               http_status  response_time
Safari               404.0           0.07
Iceweasel              NaN            NaN
Comodo Dragon          NaN            NaN
IE10                 404.0           0.08
Chrome               200.0           0.02
```

We can fill in the missing values by passing a value to the keyword `fill_value`. Because the index is not monotonically increasing or decreasing, we cannot use arguments to the keyword `method` to fill the `NaN` values.

```
>>> df.reindex(new_index, fill_value=0)
               http_status  response_time
Safari                 404           0.07
Iceweasel                0           0.00
Comodo Dragon            0           0.00
IE10                   404           0.08
Chrome                 200           0.02
```

```
>>> df.reindex(new_index, fill_value='missing')
              http_status response_time
Safari                404          0.07
Iceweasel         missing       missing
Comodo Dragon     missing       missing
IE10                  404          0.08
Chrome                200          0.02
```

We can also reindex the columns.

```
>>> df.reindex(columns=['http_status', 'user_agent'])
           http_status  user_agent
Firefox            200         NaN
Chrome             200         NaN
Safari             404         NaN
IE10               404         NaN
Konqueror          301         NaN
```

Or we can use "axis-style" keyword arguments

```
>>> df.reindex(['http_status', 'user_agent'], axis="columns")
           http_status  user_agent
Firefox            200         NaN
Chrome             200         NaN
Safari             404         NaN
IE10               404         NaN
Konqueror          301         NaN
```

To further illustrate the filling functionality in `reindex`, we will create a dataframe with a monotonically increasing index (for example, a sequence of dates).

```
>>> date_index = pd.date_range('1/1/2010', periods=6, freq='D')
>>> df2 = pd.DataFrame({"prices": [100, 101, np.nan, 100, 89, 88]},
...                    index=date_index)
>>> df2
            prices
2010-01-01     100
2010-01-02     101
2010-01-03     NaN
2010-01-04     100
2010-01-05      89
2010-01-06      88
```

Suppose we decide to expand the dataframe to cover a wider date range.

```
>>> date_index2 = pd.date_range('12/29/2009', periods=10, freq='D')
>>> df2.reindex(date_index2)
            prices
2009-12-29     NaN
2009-12-30     NaN
2009-12-31     NaN
2010-01-01     100
2010-01-02     101
2010-01-03     NaN
2010-01-04     100
2010-01-05      89
2010-01-06      88
2010-01-07     NaN
```

The index entries that did not have a value in the original data frame (for example, '2009-12-29') are by default filled with NaN. If desired, we can fill in the missing values using one of several options.

For example, to backpropagate the last valid value to fill the NaN values, pass bfill as an argument to the method keyword.

```
>>> df2.reindex(date_index2, method='bfill')
            prices
2009-12-29     100
2009-12-30     100
2009-12-31     100
2010-01-01     100
2010-01-02     101
2010-01-03     NaN
2010-01-04     100
2010-01-05      89
2010-01-06      88
2010-01-07     NaN
```

Please note that the NaN value present in the original dataframe (at index value 2010-01-03) will not be filled by any of the value propagation schemes. This is because filling while reindexing does not look at dataframe values, but only compares the original and desired indexes. If you do want to fill in the NaN values present in the original dataframe, use the fillna() method.

See the *user guide* for more.

pandas.DataFrame.reindex_axis

`DataFrame.reindex_axis`(*labels*, *axis=0*, *method=None*, *level=None*, *copy=True*, *limit=None*, *fill_value=nan*)

Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index. A new object is produced unless the new index is equivalent to the current one and copy=False

Parameters **labels** : array-like

New labels / index to conform to. Preferably an Index object to avoid duplicating data

axis : {0 or 'index', 1 or 'columns'}

method : {None, 'backfill'/'bfill', 'pad'/'ffill', 'nearest'}, optional

Method to use for filling holes in reindexed DataFrame:

- default: don't fill gaps
- pad / ffill: propagate last valid observation forward to next valid
- backfill / bfill: use next valid observation to fill gap
- nearest: use nearest valid observations to fill gap

copy : boolean, default True

Return a new object, even if the passed indexes are the same

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

limit : int, default None

Maximum number of consecutive elements to forward or backward fill

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **reindexed** : DataFrame

See also:

reindex, *reindex_like*

Examples

```
>>> df.reindex_axis(['A', 'B', 'C'], axis=1)
```

pandas.DataFrame.reindex_like

`DataFrame.reindex_like`(*other*, *method=None*, *copy=True*, *limit=None*, *tolerance=None*)

Return an object with matching indices to myself.

Parameters **other** : Object

method : string or None

copy : boolean, default True

limit : int, default None

Maximum number of consecutive labels to fill for inexact matches.

tolerance : optional

Maximum distance between labels of the other object and this object for inexact matches. Can be list-like.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **reindexed** : same as input

Notes

Like calling s.reindex(index=other.index, columns=other.columns, method=...)

pandas.DataFrame.rename

`DataFrame.rename(mapper=None, index=None, columns=None, axis=None, copy=True, inplace=False, level=None)`

Alter axes labels.

Function / dict values must be unique (1-to-1). Labels not contained in a dict / Series will be left as-is. Extra labels listed don't throw an error.

See the *user guide* for more.

Parameters **mapper, index, columns** : dict-like or function, optional

dict-like or functions transformations to apply to that axis' values. Use either `mapper` and `axis` to specify the axis to target with `mapper`, or `index` and `columns`.

axis : int or str, optional

Axis to target with `mapper`. Can be either the axis name ('index', 'columns') or number (0, 1). The default is 'index'.

copy : boolean, default True

Also copy underlying data

inplace : boolean, default False

Whether to return a new %(klass)s. If True then value of copy is ignored.

level : int or level name, default None

In case of a MultiIndex, only rename labels in the specified level.

Returns **renamed** : DataFrame

See also:

pandas.DataFrame.rename_axis

Examples

`DataFrame.rename` supports two calling conventions

- `(index=index_mapper, columns=columns_mapper, ...)`
- `(mapper, axis={'index', 'columns'}, ...)`

We *highly* recommend using keyword arguments to clarify your intent.

```
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.rename(index=str, columns={"A": "a", "B": "c"})
   a  c
0  1  4
1  2  5
2  3  6
```

```
>>> df.rename(index=str, columns={"A": "a", "C": "c"})
   a  B
0  1  4
1  2  5
2  3  6
```

Using axis-style parameters

```
>>> df.rename(str.lower, axis='columns')
   a  b
0  1  4
1  2  5
2  3  6
```

```
>>> df.rename({1: 2, 2: 4}, axis='index')
   A  B
0  1  4
2  2  5
4  3  6
```

pandas.DataFrame.rename_axis

`DataFrame.rename_axis`(*mapper*, *axis=0*, *copy=True*, *inplace=False*)

Alter the name of the index or columns.

Parameters **mapper** : scalar, list-like, optional

Value to set the axis name attribute.

axis : int or string, default 0

copy : boolean, default True

Also copy underlying data

inplace : boolean, default False

Returns **renamed** : type of caller or None if inplace=True

See also:

pandas.Series.rename, *pandas.DataFrame.rename*, *pandas.Index.rename*

Notes

Prior to version 0.21.0, `rename_axis` could also be used to change the axis *labels* by passing a mapping or scalar. This behavior is deprecated and will be removed in a future version. Use `rename` instead.

Examples

```
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.rename_axis("foo")
     A  B
foo
0    1  4
1    2  5
2    3  6
```

```
>>> df.rename_axis("bar", axis="columns")
bar  A  B
0    1  4
```

```
1    2  5
2    3  6
```

pandas.DataFrame.reorder_levels

`DataFrame.reorder_levels(order, axis=0)`

Rearrange index levels using input order. May not drop or duplicate levels

Parameters **order** : list of int or list of str

List representing new level order. Reference level by number (position) or by key (label).

axis : int

Where to reorder levels.

Returns type of caller (new object)

pandas.DataFrame.replace

`DataFrame.replace(to_replace=None, value=None, inplace=False, limit=None, regex=False, method='pad', axis=None)`

Replace values given in 'to_replace' with 'value'.

Parameters **to_replace** : str, regex, list, dict, Series, numeric, or None

- str or regex:
  - str: string exactly matching *to_replace* will be replaced with *value*
  - regex: regexs matching *to_replace* will be replaced with *value*
- list of str, regex, or numeric:
  - First, if *to_replace* and *value* are both lists, they **must** be the same length.
  - Second, if `regex=True` then all of the strings in **both** lists will be interpreted as regexs otherwise they will match directly. This doesn't matter much for *value* since there are only a few possible substitution regexes you can use.
  - str and regex rules apply as above.
- dict:
  - Nested dictionaries, e.g., {'a': {'b': nan}}, are read as follows: look in column 'a' for the value 'b' and replace it with nan. You can nest regular expressions as well. Note that column names (the top-level dictionary keys in a nested dictionary) **cannot** be regular expressions.
  - Keys map to column names and values map to substitution values. You can treat this as a special case of passing two lists except that you are specifying the column to search in.
- None:
  - This means that the `regex` argument must be a string, compiled regular expression, or list, dict, ndarray or Series of such elements. If *value* is also `None` then this **must** be a nested dictionary or `Series`.

See the examples section for examples of each of these.

value : scalar, dict, list, str, regex, default None

Value to use to fill holes (e.g. 0), alternately a dict of values specifying which value to use for each column (columns not in the dict will not be filled). Regular expressions, strings and lists or dicts of such objects are also allowed.

inplace : boolean, default False

If True, in place. Note: this will modify any other views on this object (e.g. a column from a DataFrame). Returns the caller if this is True.

limit : int, default None

Maximum size gap to forward or backward fill

regex : bool or same types as *to_replace*, default False

Whether to interpret *to_replace* and/or *value* as regular expressions. If this is `True` then *to_replace must* be a string. Otherwise, *to_replace* must be `None` because this parameter will be interpreted as a regular expression or a list, dict, or array of regular expressions.

method : string, optional, {'pad', 'ffill', 'bfill'}

The method to use when for replacement, when `to_replace` is a `list`.

Returns filled : NDFrame

Raises AssertionError

- If *regex* is not a `bool` and *to_replace* is not `None`.

TypeError

- If *to_replace* is a `dict` and *value* is not a `list`, `dict`, `ndarray`, or `Series`
- If *to_replace* is `None` and *regex* is not compilable into a regular expression or is a list, dict, ndarray, or Series.

ValueError

- If *to_replace* and *value* are `list` s or `ndarray` s, but they are not the same length.

See also:

`NDFrame.reindex`, `NDFrame.asfreq`, `NDFrame.fillna`

Notes

- Regex substitution is performed under the hood with `re.sub`. The rules for substitution for `re.sub` are the same.
- Regular expressions will only substitute on strings, meaning you cannot provide, for example, a regular expression matching floating point numbers and expect the columns in your frame that have a numeric dtype to be matched. However, if those floating point numbers *are* strings, then you can do this.
- This method has *a lot* of options. You are encouraged to experiment and play with this method to gain intuition about how it works.

pandas.DataFrame.resample

`DataFrame.resample(rule, how=None, axis=0, fill_method=None, closed=None, label=None, convention='start', kind=None, loffset=None, limit=None, base=0, on=None, level=None)`

Convenience method for frequency conversion and resampling of time series. Object must have a datetime-like index (DatetimeIndex, PeriodIndex, or TimedeltaIndex), or pass datetime-like values to the on or level keyword.

Parameters **rule** : string

the offset string or object representing target conversion

axis : int, optional, default 0

closed : {'right', 'left'}

Which side of bin interval is closed. The default is 'left' for all frequency offsets except for 'M', 'A', 'Q', 'BM', 'BA', 'BQ', and 'W' which all have a default of 'right'.

label : {'right', 'left'}

Which bin edge label to label bucket with. The default is 'left' for all frequency offsets except for 'M', 'A', 'Q', 'BM', 'BA', 'BQ', and 'W' which all have a default of 'right'.

convention : {'start', 'end', 's', 'e'}

For PeriodIndex only, controls whether to use the start or end of *rule*

loffset : timedelta

Adjust the resampled time labels

base : int, default 0

For frequencies that evenly subdivide 1 day, the "origin" of the aggregated intervals. For example, for '5min' frequency, base could range from 0 through 4. Defaults to 0

on : string, optional

For a DataFrame, column to use instead of index for resampling. Column must be datetime-like.

New in version 0.19.0.

level : string or int, optional

For a MultiIndex, level (name or number) to use for resampling. Level must be datetime-like.

New in version 0.19.0.

Notes

To learn more about the offset strings, please see this link.

Examples

Start by creating a series with 9 one minute timestamps.

```
>>> index = pd.date_range('1/1/2000', periods=9, freq='T')
>>> series = pd.Series(range(9), index=index)
>>> series
2000-01-01 00:00:00    0
2000-01-01 00:01:00    1
2000-01-01 00:02:00    2
2000-01-01 00:03:00    3
2000-01-01 00:04:00    4
2000-01-01 00:05:00    5
2000-01-01 00:06:00    6
2000-01-01 00:07:00    7
2000-01-01 00:08:00    8
Freq: T, dtype: int64
```

Downsample the series into 3 minute bins and sum the values of the timestamps falling into a bin.

```
>>> series.resample('3T').sum()
2000-01-01 00:00:00     3
2000-01-01 00:03:00    12
2000-01-01 00:06:00    21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but label each bin using the right edge instead of the left. Please note that the value in the bucket used as the label is not included in the bucket, which it labels. For example, in the original series the bucket `2000-01-01 00:03:00` contains the value 3, but the summed value in the resampled bucket with the label `2000-01-01 00:03:00` does not include 3 (if it did, the summed value would be 6, not 3). To include this value close the right side of the bin interval as illustrated in the example below this one.

```
>>> series.resample('3T', label='right').sum()
2000-01-01 00:03:00     3
2000-01-01 00:06:00    12
2000-01-01 00:09:00    21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but close the right side of the bin interval.

```
>>> series.resample('3T', label='right', closed='right').sum()
2000-01-01 00:00:00     0
2000-01-01 00:03:00     6
2000-01-01 00:06:00    15
2000-01-01 00:09:00    15
Freq: 3T, dtype: int64
```

Upsample the series into 30 second bins.

```
>>> series.resample('30S').asfreq()[0:5] #select first 5 rows
2000-01-01 00:00:00   0.0
2000-01-01 00:00:30   NaN
2000-01-01 00:01:00   1.0
2000-01-01 00:01:30   NaN
2000-01-01 00:02:00   2.0
Freq: 30S, dtype: float64
```

Upsample the series into 30 second bins and fill the `NaN` values using the `pad` method.

```
>>> series.resample('30S').pad()[0:5]
2000-01-01 00:00:00    0
2000-01-01 00:00:30    0
2000-01-01 00:01:00    1
2000-01-01 00:01:30    1
2000-01-01 00:02:00    2
Freq: 30S, dtype: int64
```

Upsample the series into 30 second bins and fill the `NaN` values using the `bfill` method.

```
>>> series.resample('30S').bfill()[0:5]
2000-01-01 00:00:00    0
2000-01-01 00:00:30    1
2000-01-01 00:01:00    1
2000-01-01 00:01:30    2
2000-01-01 00:02:00    2
Freq: 30S, dtype: int64
```

Pass a custom function via `apply`

```
>>> def custom_resampler(array_like):
...     return np.sum(array_like)+5
```

```
>>> series.resample('3T').apply(custom_resampler)
2000-01-01 00:00:00     8
2000-01-01 00:03:00    17
2000-01-01 00:06:00    26
Freq: 3T, dtype: int64
```

For a Series with a PeriodIndex, the keyword *convention* can be used to control whether to use the start or end of *rule*.

```
>>> s = pd.Series([1, 2], index=pd.period_range('2012-01-01',
                                                 freq='A',
                                                 periods=2))
>>> s
2012    1
2013    2
Freq: A-DEC, dtype: int64
```

Resample by month using 'start' *convention*. Values are assigned to the first month of the period.

```
>>> s.resample('M', convention='start').asfreq().head()
2012-01    1.0
2012-02    NaN
2012-03    NaN
2012-04    NaN
2012-05    NaN
Freq: M, dtype: float64
```

Resample by month using 'end' *convention*. Values are assigned to the last month of the period.

```
>>> s.resample('M', convention='end').asfreq()
2012-12    1.0
2013-01    NaN
2013-02    NaN
```

```
2013-03    NaN
2013-04    NaN
2013-05    NaN
2013-06    NaN
2013-07    NaN
2013-08    NaN
2013-09    NaN
2013-10    NaN
2013-11    NaN
2013-12    2.0
Freq: M, dtype: float64
```

For DataFrame objects, the keyword `on` can be used to specify the column instead of the index for resampling.

```
>>> df = pd.DataFrame(data=9*[range(4)], columns=['a', 'b', 'c', 'd'])
>>> df['time'] = pd.date_range('1/1/2000', periods=9, freq='T')
>>> df.resample('3T', on='time').sum()
                     a  b  c  d
time
2000-01-01 00:00:00  0  3  6  9
2000-01-01 00:03:00  0  3  6  9
2000-01-01 00:06:00  0  3  6  9
```

For a DataFrame with MultiIndex, the keyword `level` can be used to specify on level the resampling needs to take place.

```
>>> time = pd.date_range('1/1/2000', periods=5, freq='T')
>>> df2 = pd.DataFrame(data=10*[range(4)],
                       columns=['a', 'b', 'c', 'd'],
                       index=pd.MultiIndex.from_product([time, [1, 2]])
                       )
>>> df2.resample('3T', level=0).sum()
                     a  b   c   d
2000-01-01 00:00:00  0  6  12  18
2000-01-01 00:03:00  0  4   8  12
```

pandas.DataFrame.reset_index

`DataFrame.`**`reset_index`**(*level=None*, *drop=False*, *inplace=False*, *col_level=0*, *col_fill=''*)

For DataFrame with multi-level index, return new DataFrame with labeling information in the columns under the index names, defaulting to 'level_0', 'level_1', etc. if any are None. For a standard index, the index name will be used (if set), otherwise a default 'index' or 'level_0' (if 'index' is already taken) will be used.

Parameters **level** : int, str, tuple, or list, default None

Only remove the given levels from the index. Removes all levels by default

drop : boolean, default False

Do not try to insert index into dataframe columns. This resets the index to the default integer index.

inplace : boolean, default False

Modify the DataFrame in place (do not create a new object)

col_level : int or str, default 0

If the columns have multiple levels, determines which level the labels are inserted into. By default it is inserted into the first level.

col_fill : object, default ''

If the columns have multiple levels, determines how the other levels are named. If None then the index name is repeated.

Returns **resetted** : DataFrame

Examples

```
>>> df = pd.DataFrame([('bird',    389.0),
...                    ('bird',     24.0),
...                    ('mammal',   80.5),
...                    ('mammal', np.nan)],
...                   index=['falcon', 'parrot', 'lion', 'monkey'],
...                   columns=('class', 'max_speed'))
>>> df
         class  max_speed
falcon    bird      389.0
parrot    bird       24.0
lion    mammal       80.5
monkey  mammal        NaN
```

When we reset the index, the old index is added as a column, and a new sequential index is used:

```
>>> df.reset_index()
    index   class  max_speed
0  falcon    bird      389.0
1  parrot    bird       24.0
2    lion  mammal       80.5
3  monkey  mammal        NaN
```

We can use the *drop* parameter to avoid the old index being added as a column:

```
>>> df.reset_index(drop=True)
    class  max_speed
0    bird      389.0
1    bird       24.0
2  mammal       80.5
3  mammal        NaN
```

You can also use *reset_index* with *MultiIndex*.

```
>>> index = pd.MultiIndex.from_tuples([('bird', 'falcon'),
...                                    ('bird', 'parrot'),
...                                    ('mammal', 'lion'),
...                                    ('mammal', 'monkey')],
...                                   names=['class', 'name'])
>>> columns = pd.MultiIndex.from_tuples([('speed', 'max'),
...                                      ('species', 'type')])
>>> df = pd.DataFrame([(389.0, 'fly'),
...                    ( 24.0, 'fly'),
...                    ( 80.5, 'run'),
...                    (np.nan, 'jump')],
```

```
...                     index=index,
...                     columns=columns)
>>> df
               speed species
                 max    type
class  name
bird   falcon  389.0     fly
       parrot   24.0     fly
mammal lion     80.5     run
       monkey    NaN    jump
```

If the index has multiple levels, we can reset a subset of them:

```
>>> df.reset_index(level='class')
         class  speed species
                  max    type
name
falcon    bird  389.0     fly
parrot    bird   24.0     fly
lion    mammal   80.5     run
monkey  mammal    NaN    jump
```

If we are not dropping the index, by default, it is placed in the top level. We can place it in another level:

```
>>> df.reset_index(level='class', col_level=1)
                speed species
         class    max    type
name
falcon    bird  389.0     fly
parrot    bird   24.0     fly
lion    mammal   80.5     run
monkey  mammal    NaN    jump
```

When the index is inserted under another level, we can specify under which one with the parameter *col_fill*:

```
>>> df.reset_index(level='class', col_level=1, col_fill='species')
              species  speed species
                class    max    type
name
falcon           bird  389.0     fly
parrot           bird   24.0     fly
lion           mammal   80.5     run
monkey         mammal    NaN    jump
```

If we specify a nonexistent level for *col_fill*, it is created:

```
>>> df.reset_index(level='class', col_level=1, col_fill='genus')
                genus  speed species
                class    max    type
name
falcon           bird  389.0     fly
parrot           bird   24.0     fly
lion           mammal   80.5     run
monkey         mammal    NaN    jump
```

pandas.DataFrame.rfloordiv

`DataFrame.rfloordiv(other, axis='columns', level=None, fill_value=None)`

Integer division of dataframe and other, element-wise (binary operator *rfloordiv*).

Equivalent to `other // dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.floordiv

Notes

Mismatched indices will be unioned together

pandas.DataFrame.rmod

`DataFrame.rmod(other, axis='columns', level=None, fill_value=None)`

Modulo of dataframe and other, element-wise (binary operator *rmod*).

Equivalent to `other % dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.mod

Notes

Mismatched indices will be unioned together

pandas.DataFrame.rmul

`DataFrame.rmul`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Multiplication of dataframe and other, element-wise (binary operator *rmul*).

Equivalent to `other * dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

`DataFrame.mul`

Notes

Mismatched indices will be unioned together

pandas.DataFrame.rolling

`DataFrame.rolling`(*window*, *min_periods=None*, *freq=None*, *center=False*, *win_type=None*, *on=None*, *axis=0*, *closed=None*)

Provides rolling window calculations.

New in version 0.18.0.

Parameters **window** : int, or offset

Size of the moving window. This is the number of observations used for calculating the statistic. Each window will be a fixed size.

If its an offset then this will be the time period of each window. Each window will be a variable sized based on the observations included in the time-period. This is only valid for datetimelike indexes. This is new in 0.19.0

min_periods : int, default None

Minimum number of observations in window required to have a value (otherwise result is NA). For a window that is specified by an offset, this will default to 1.

freq : string or DateOffset object, optional (default None)

Deprecated since version 0.18.0: Frequency to conform the data to before computing the statistic. Specified as a frequency string or DateOffset object.

center : boolean, default False

Set the labels at the center of the window.

win_type : string, default None

Provide a window type. See the notes below.

on : string, optional

For a DataFrame, column on which to calculate the rolling window, rather than the index

closed : string, default None

Make the interval closed on the 'right', 'left', 'both' or 'neither' endpoints. For offset-based windows, it defaults to 'right'. For fixed windows, defaults to 'both'. Remaining cases not implemented for fixed windows.

New in version 0.20.0.

axis : int or string, default 0

Returns a Window or Rolling sub-classed for the particular operation

Notes

By default, the result is set to the right edge of the window. This can be changed to the center of the window by setting `center=True`.

The *freq* keyword is used to conform time series data to a specified frequency by resampling the data. This is done with the default parameters of `resample()` (i.e. using the *mean*).

To learn more about the offsets & frequency strings, please see this link.

The recognized win_types are:

- `boxcar`
- `triang`
- `blackman`
- `hamming`
- `bartlett`
- `parzen`
- `bohman`
- `blackmanharris`
- `nuttall`
- `barthann`
- `kaiser` (needs beta)
- `gaussian` (needs std)
- `general_gaussian` (needs power, width)
- `slepian` (needs width).

Examples

```
>>> df = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]})
>>> df
     B
0  0.0
1  1.0
2  2.0
3  NaN
4  4.0
```

Rolling sum with a window length of 2, using the 'triang' window type.

```
>>> df.rolling(2, win_type='triang').sum()
     B
0  NaN
1  1.0
2  2.5
3  NaN
4  NaN
```

Rolling sum with a window length of 2, min_periods defaults to the window length.

```
>>> df.rolling(2).sum()
     B
0  NaN
1  1.0
2  3.0
3  NaN
4  NaN
```

Same as above, but explicity set the min_periods

```
>>> df.rolling(2, min_periods=1).sum()
     B
0  0.0
1  1.0
2  3.0
3  2.0
4  4.0
```

A ragged (meaning not-a-regular frequency), time-indexed DataFrame

```
>>> df = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]},
....:                 index = [pd.Timestamp('20130101 09:00:00'),
....:                          pd.Timestamp('20130101 09:00:02'),
....:                          pd.Timestamp('20130101 09:00:03'),
....:                          pd.Timestamp('20130101 09:00:05'),
....:                          pd.Timestamp('20130101 09:00:06')])
```

```
>>> df
                      B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  2.0
2013-01-01 09:00:05  NaN
2013-01-01 09:00:06  4.0
```

Contrasting to an integer rolling window, this will roll a variable length window corresponding to the time period. The default for min_periods is 1.

```
>>> df.rolling('2s').sum()
                      B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:02  1.0
2013-01-01 09:00:03  3.0
2013-01-01 09:00:05  NaN
2013-01-01 09:00:06  4.0
```

pandas.DataFrame.round

`DataFrame.round(decimals=0, *args, **kwargs)`

Round a DataFrame to a variable number of decimal places.

New in version 0.17.0.

Parameters **decimals** : int, dict, Series

Number of decimal places to round each column to. If an int is given, round each column to the same number of places. Otherwise dict and Series round to variable numbers of places. Column names should be in the keys if *decimals* is a dict-like, or in the index if *decimals* is a Series. Any columns not included in *decimals* will be left as is. Elements of *decimals* which are not columns of the input will be ignored.

Returns DataFrame object

See also:

`numpy.around`, *`Series.round`*

Examples

```
>>> df = pd.DataFrame(np.random.random([3, 3]),
...     columns=['A', 'B', 'C'], index=['first', 'second', 'third'])
>>> df
               A         B         C
first   0.028208  0.992815  0.173891
second  0.038683  0.645646  0.577595
third   0.877076  0.149370  0.491027
>>> df.round(2)
           A     B     C
first   0.03  0.99  0.17
second  0.04  0.65  0.58
third   0.88  0.15  0.49
>>> df.round({'A': 1, 'C': 2})
          A         B     C
first   0.0  0.992815  0.17
second  0.0  0.645646  0.58
third   0.9  0.149370  0.49
>>> decimals = pd.Series([1, 0, 2], index=['A', 'B', 'C'])
>>> df.round(decimals)
          A  B     C
first   0.0  1  0.17
```

```
second  0.0  1  0.58
third   0.9  0  0.49
```

pandas.DataFrame.rpow

`DataFrame.rpow`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Exponential power of dataframe and other, element-wise (binary operator *rpow*).

Equivalent to `other ** dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.pow

Notes

Mismatched indices will be unioned together

pandas.DataFrame.rsub

`DataFrame.rsub`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Subtraction of dataframe and other, element-wise (binary operator *rsub*).

Equivalent to `other - dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.sub

Notes

Mismatched indices will be unioned together

pandas.DataFrame.rtruediv

`DataFrame.rtruediv(other, axis='columns', level=None, fill_value=None)`

Floating division of dataframe and other, element-wise (binary operator *rtruediv*).

Equivalent to `other / dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.truediv

Notes

Mismatched indices will be unioned together

pandas.DataFrame.sample

`DataFrame.sample(n=None, frac=None, replace=False, weights=None, random_state=None, axis=None)`

Returns a random sample of items from an axis of object.

Parameters **n** : int, optional

Number of items from axis to return. Cannot be used with *frac*. Default = 1 if *frac* = None.

frac : float, optional

Fraction of axis items to return. Cannot be used with *n*.

replace : boolean, optional

Sample with or without replacement. Default = False.

weights : str or ndarray-like, optional

Default 'None' results in equal probability weighting. If passed a Series, will align with target object on index. Index values in weights not found in sampled object will be ignored and index values in sampled object not in weights will be assigned weights of zero. If called on a DataFrame, will accept the name of a column when axis = 0. Unless weights are a Series, weights must be same length as axis being sampled. If weights do not sum to 1, they will be normalized to sum to 1. Missing values in the weights column will be treated as zero. inf and -inf values not allowed.

random_state : int or numpy.random.RandomState, optional

Seed for the random number generator (if int), or numpy RandomState object.

axis : int or string, optional

Axis to sample. Accepts axis number or name. Default is stat axis for given data type (0 for Series and DataFrames, 1 for Panels).

Returns A new object of same type as caller.

Examples

Generate an example `Series` and `DataFrame`:

```
>>> s = pd.Series(np.random.randn(50))
>>> s.head()
0   -0.038497
1    1.820773
2   -0.972766
3   -1.598270
4   -1.095526
dtype: float64
>>> df = pd.DataFrame(np.random.randn(50, 4), columns=list('ABCD'))
>>> df.head()
          A         B         C         D
0  0.016443 -2.318952 -0.566372 -1.028078
1 -1.051921  0.438836  0.658280 -0.175797
2 -1.243569 -0.364626 -0.215065  0.057736
3  1.768216  0.404512 -0.385604 -1.457834
4  1.072446 -1.137172  0.314194 -0.046661
```

Next extract a random sample from both of these objects...

3 random elements from the `Series`:

```
>>> s.sample(n=3)
27   -0.994689
55   -1.049016
67   -0.224565
dtype: float64
```

And a random 10% of the `DataFrame` with replacement:

```
>>> df.sample(frac=0.1, replace=True)
           A         B         C         D
35  1.981780  0.142106  1.817165 -0.290805
49 -1.336199 -0.448634 -0.789640  0.217116
```

```
40  0.823173 -0.078816  1.009536  1.015108
15  1.421154 -0.055301 -1.922594 -0.019696
6  -0.148339  0.832938  1.787600 -1.383767
```

pandas.DataFrame.select

`DataFrame.select`(*crit*, *axis=0*)

Return data corresponding to axis labels matching criteria

DEPRECATED: use df.loc[df.index.map(crit)] to select via labels

Parameters **crit** : function

To be called on each index (label). Should return True or False

axis : int

Returns **selection** : type of caller

pandas.DataFrame.select_dtypes

`DataFrame.select_dtypes`(*include=None*, *exclude=None*)

Return a subset of a DataFrame including/excluding columns based on their `dtype`.

Parameters **include, exclude** : scalar or list-like

A selection of dtypes or strings to be included/excluded. At least one of these parameters must be supplied.

Returns **subset** : DataFrame

The subset of the frame including the dtypes in `include` and excluding the dtypes in `exclude`.

Raises **ValueError**

- If both of `include` and `exclude` are empty
- If `include` and `exclude` have overlapping elements
- If any kind of string dtype is passed in.

Notes

- To select all *numeric* types use the numpy dtype `numpy.number`
- To select strings you must use the `object` dtype, but note that this will return *all* object dtype columns
- See the numpy dtype hierarchy
- To select datetimes, use np.datetime64, 'datetime' or 'datetime64'
- To select timedeltas, use np.timedelta64, 'timedelta' or 'timedelta64'
- To select Pandas categorical dtypes, use 'category'
- To select Pandas datetimetz dtypes, use 'datetimetz' (new in 0.20.0), or a 'datetime64[ns, tz]' string

Examples

```
>>> df = pd.DataFrame({'a': np.random.randn(6).astype('f4'),
...                    'b': [True, False] * 3,
...                    'c': [1.0, 2.0] * 3})
>>> df
        a      b  c
0  0.3962   True  1
1  0.1459  False  2
2  0.2623   True  1
3  0.0764  False  2
4 -0.9703   True  1
5 -1.2094  False  2
>>> df.select_dtypes(include='bool')
   c
0  True
1  False
2  True
3  False
4  True
5  False
>>> df.select_dtypes(include=['float64'])
   c
0  1
1  2
2  1
3  2
4  1
5  2
>>> df.select_dtypes(exclude=['floating'])
       b
0   True
1  False
2   True
3  False
4   True
5  False
```

pandas.DataFrame.sem

`DataFrame.sem`(*axis=None*, *skipna=None*, *level=None*, *ddof=1*, *numeric_only=None*, ***kwargs*)

Return unbiased standard error of the mean over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

ddof : int, default 1

degrees of freedom

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **sem** : Series or DataFrame (if level specified)

pandas.DataFrame.set_axis

`DataFrame.set_axis(labels, axis=0, inplace=None)`

Assign desired index to given axis

Parameters **labels: list-like or Index**

The values for the new index

axis : int or string, default 0

inplace : boolean, default None

Whether to return a new NDFrame instance.

WARNING: inplace=None currently falls back to to True, but in a future version, will default to False. Use inplace=True explicitly rather than relying on the default.

.. versionadded:: 0.21.0

The signature is make consistent to the rest of the API. Previously, the "axis" and "labels" arguments were respectively the first and second positional arguments.

Returns **renamed** : NDFrame or None

An object of same type as caller if inplace=False, None otherwise.

See also:

`pandas.NDFrame.rename`

Examples

```
>>> s = pd.Series([1, 2, 3])
>>> s
0    1
1    2
2    3
dtype: int64
>>> s.set_axis(['a', 'b', 'c'], axis=0, inplace=False)
a    1
b    2
c    3
dtype: int64
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.set_axis(['a', 'b', 'c'], axis=0, inplace=False)
   A  B
a  1  4
b  2  5
c  3  6
>>> df.set_axis(['I', 'II'], axis=1, inplace=False)
   I  II
```

```
0  1   4
1  2   5
2  3   6
>>> df.set_axis(['i', 'ii'], axis=1, inplace=True)
>>> df
   i  ii
0  1   4
1  2   5
2  3   6
```

pandas.DataFrame.set_index

`DataFrame.set_index`(*keys*, *drop=True*, *append=False*, *inplace=False*, *verify_integrity=False*)

Set the DataFrame index (row labels) using one or more existing columns. By default yields a new object.

Parameters **keys** : column label or list of column labels / arrays

drop : boolean, default True

Delete columns to be used as the new index

append : boolean, default False

Whether to append columns to existing index

inplace : boolean, default False

Modify the DataFrame in place (do not create a new object)

verify_integrity : boolean, default False

Check the new index for duplicates. Otherwise defer the check until necessary. Setting to False will improve the performance of this method

Returns **dataframe** : DataFrame

Examples

```
>>> df = pd.DataFrame({'month': [1, 4, 7, 10],
...                    'year': [2012, 2014, 2013, 2014],
...                    'sale':[55, 40, 84, 31]})
   month  sale  year
0  1      55    2012
1  4      40    2014
2  7      84    2013
3  10     31    2014
```

Set the index to become the 'month' column:

```
>>> df.set_index('month')
       sale  year
month
1      55    2012
4      40    2014
7      84    2013
10     31    2014
```

Create a multi-index using columns 'year' and 'month':

```
>>> df.set_index(['year', 'month'])
            sale
year  month
2012  1     55
2014  4     40
2013  7     84
2014  10    31
```

Create a multi-index using a set of values and a column:

```
>>> df.set_index([[1, 2, 3, 4], 'year'])
         month  sale
   year
1  2012  1      55
2  2014  4      40
3  2013  7      84
4  2014  10     31
```

pandas.DataFrame.set_value

`DataFrame.set_value`(*index*, *col*, *value*, *takeable=False*)

Put single value at passed column and index

Deprecated since version 0.21.0.

Please use .at[] or .iat[] accessors.

Parameters **index** : row label

col : column label

value : scalar value

takeable : interpret the index/col as indexers, default False

Returns **frame** : DataFrame

If label pair is contained, will be reference to calling DataFrame, otherwise a new object

pandas.DataFrame.shift

`DataFrame.shift`(*periods=1*, *freq=None*, *axis=0*)

Shift index by desired number of periods with an optional time freq

Parameters **periods** : int

Number of periods to move, can be positive or negative

freq : DateOffset, timedelta, or time rule string, optional

Increment to use from the tseries module or time rule (e.g. 'EOM'). See Notes.

axis : {0 or 'index', 1 or 'columns'}

Returns **shifted** : DataFrame

Notes

If freq is specified then the index values are shifted but the data is not realigned. That is, use freq if you would like to extend the index when shifting and preserve the original data.

pandas.DataFrame.skew

`DataFrame.skew`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return unbiased skew over requested axis Normalized by N-1

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **skew** : Series or DataFrame (if level specified)

pandas.DataFrame.slice_shift

`DataFrame.slice_shift`(*periods=1*, *axis=0*)

Equivalent to *shift* without copying data. The shifted data will not include the dropped periods and the shifted axis will be smaller than the original.

Parameters **periods** : int

Number of periods to move, can be positive or negative

Returns **shifted** : same type as caller

Notes

While the *slice_shift* is faster than *shift*, you may pay for it later during alignment.

pandas.DataFrame.sort_index

`DataFrame.sort_index`(*axis=0*, *level=None*, *ascending=True*, *inplace=False*, *kind='quicksort'*, *na_position='last'*, *sort_remaining=True*, *by=None*)

Sort object by labels (along an axis)

Parameters **axis** : index, columns to direct sorting

level : int or level name or list of ints or list of level names

if not None, sort on values in specified index level(s)

ascending : boolean, default True

Sort ascending vs. descending

inplace : bool, default False

if True, perform operation in-place

kind : {'quicksort', 'mergesort', 'heapsort'}, default 'quicksort'

Choice of sorting algorithm. See also ndarray.np.sort for more information. *mergesort* is the only stable algorithm. For DataFrames, this option is only applied when sorting on a single column or label.

na_position : {'first', 'last'}, default 'last'

first puts NaNs at the beginning, *last* puts NaNs at the end. Not implemented for MultiIndex.

sort_remaining : bool, default True

if true and sorting by level and index is multilevel, sort by other levels too (in order) after sorting by specified level

Returns **sorted_obj** : DataFrame

pandas.DataFrame.sort_values

`DataFrame.sort_values`(*by*, *axis=0*, *ascending=True*, *inplace=False*, *kind='quicksort'*, *na_position='last'*)

Sort by the values along either axis

New in version 0.17.0.

Parameters **by** : str or list of str

Name or list of names which refer to the axis items.

axis : {0 or 'index', 1 or 'columns'}, default 0

Axis to direct sorting

ascending : bool or list of bool, default True

Sort ascending vs. descending. Specify list for multiple sort orders. If this is a list of bools, must match the length of the by.

inplace : bool, default False

if True, perform operation in-place

kind : {'quicksort', 'mergesort', 'heapsort'}, default 'quicksort'

Choice of sorting algorithm. See also ndarray.np.sort for more information. *mergesort* is the only stable algorithm. For DataFrames, this option is only applied when sorting on a single column or label.

na_position : {'first', 'last'}, default 'last'

first puts NaNs at the beginning, *last* puts NaNs at the end

Returns **sorted_obj** : DataFrame

Examples

```
>>> df = pd.DataFrame({
...     'col1' : ['A', 'A', 'B', np.nan, 'D', 'C'],
...     'col2' : [2, 1, 9, 8, 7, 4],
...     'col3': [0, 1, 9, 4, 2, 3],
... })
>>> df
    col1 col2 col3
0   A    2    0
1   A    1    1
2   B    9    9
3   NaN  8    4
4   D    7    2
5   C    4    3
```

Sort by col1

```
>>> df.sort_values(by=['col1'])
    col1 col2 col3
0   A    2    0
1   A    1    1
2   B    9    9
5   C    4    3
4   D    7    2
3   NaN  8    4
```

Sort by multiple columns

```
>>> df.sort_values(by=['col1', 'col2'])
    col1 col2 col3
1   A    1    1
0   A    2    0
2   B    9    9
5   C    4    3
4   D    7    2
3   NaN  8    4
```

Sort Descending

```
>>> df.sort_values(by='col1', ascending=False)
    col1 col2 col3
4   D    7    2
5   C    4    3
2   B    9    9
0   A    2    0
1   A    1    1
3   NaN  8    4
```

Putting NAs first

```
>>> df.sort_values(by='col1', ascending=False, na_position='first')
    col1 col2 col3
3   NaN  8    4
4   D    7    2
5   C    4    3
2   B    9    9
```

```
0   A    2    0
1   A    1    1
```

pandas.DataFrame.sortlevel

`DataFrame.sortlevel`(*level=0, axis=0, ascending=True, inplace=False, sort_remaining=True*)

DEPRECATED: use `DataFrame.sort_index()`

Sort multilevel index by chosen axis and primary level. Data will be lexicographically sorted by the chosen level followed by the other levels (in order)

Parameters **level** : int

axis : {0 or 'index', 1 or 'columns'}, default 0

ascending : boolean, default True

inplace : boolean, default False

Sort the DataFrame without creating a new instance

sort_remaining : boolean, default True

Sort by the other levels too.

Returns **sorted** : DataFrame

See also:

`DataFrame.sort_index`

pandas.DataFrame.squeeze

`DataFrame.squeeze`(*axis=None*)

Squeeze length 1 dimensions.

Parameters **axis** : None, integer or string axis name, optional

The axis to squeeze if 1-sized.

New in version 0.20.0.

Returns scalar if 1-sized, else original object

pandas.DataFrame.stack

`DataFrame.stack`(*level=-1, dropna=True*)

Pivot a level of the (possibly hierarchical) column labels, returning a DataFrame (or Series in the case of an object with a single level of column labels) having a hierarchical index with a new inner-most level of row labels. The level involved will automatically get sorted.

Parameters **level** : int, string, or list of these, default last level

Level(s) to stack, can pass level name

dropna : boolean, default True

Whether to drop rows in the resulting Frame/Series with no valid values

Returns **stacked** : DataFrame or Series

Examples

```
>>> s
     a   b
one  1.  2.
two  3.  4.
```

```
>>> s.stack()
one a    1
    b    2
two a    3
    b    4
```

pandas.DataFrame.std

`DataFrame.std`(*axis=None*, *skipna=None*, *level=None*, *ddof=1*, *numeric_only=None*, ***kwargs*)

Return sample standard deviation over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

ddof : int, default 1

degrees of freedom

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **std** : Series or DataFrame (if level specified)

pandas.DataFrame.sub

`DataFrame.sub`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Subtraction of dataframe and other, element-wise (binary operator *sub*).

Equivalent to `dataframe - other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns result : DataFrame

See also:

DataFrame.rsub

Notes

Mismatched indices will be unioned together

pandas.DataFrame.subtract

`DataFrame.subtract`(*other*, *axis='columns'*, *level=None*, *fill_value=None*)

Subtraction of dataframe and other, element-wise (binary operator *sub*).

Equivalent to `dataframe - other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters other : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns result : DataFrame

See also:

DataFrame.rsub

Notes

Mismatched indices will be unioned together

pandas.DataFrame.sum

`DataFrame.sum`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the sum of the values for the requested axis

Parameters axis : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **sum** : Series or DataFrame (if level specified)

pandas.DataFrame.swapaxes

`DataFrame.swapaxes`(*axis1*, *axis2*, *copy=True*)

Interchange axes and swap values axes appropriately

Returns **y** : same as input

pandas.DataFrame.swaplevel

`DataFrame.swaplevel`(*i=-2*, *j=-1*, *axis=0*)

Swap levels i and j in a MultiIndex on a particular axis

Parameters **i, j** : int, string (can be mixed)

Level of index to be swapped. Can pass level name as string.

Returns **swapped** : type of caller (new object)

Changed in version 0.18.1: The indexes `i` and `j` are now optional, and default to the two innermost levels of the index.

pandas.DataFrame.tail

`DataFrame.tail`(*n=5*)

Return the last n rows.

Parameters **n** : int, default 5

Number of rows to select.

Returns **obj_tail** : type of caller

The last n rows of the caller object.

pandas.DataFrame.take

`DataFrame.take`(*indices*, *axis=0*, *convert=None*, *is_copy=True*, ***kwargs*)

Return the elements in the given *positional* indices along an axis.

This means that we are not indexing according to actual values in the index attribute of the object. We are indexing according to the actual position of the element in the object.

Parameters **indices** : array-like

An array of ints indicating which positions to take.

axis : int, default 0

The axis on which to select elements. "0" means that we are selecting rows, "1" means that we are selecting columns, etc.

convert : bool, default True

Deprecated since version 0.21.0: In the future, negative indices will always be converted.

Whether to convert negative indices into positive ones. For example, `-1` would map to the `len(axis) - 1`. The conversions are similar to the behavior of indexing a regular Python list.

is_copy : bool, default True

Whether to return a copy of the original object or not.

Returns taken : type of caller

An array-like containing the elements taken from the object.

See also:

`numpy.ndarray.take`, `numpy.take`

Examples

```
>>> df = pd.DataFrame([('falcon', 'bird',    389.0),
                       ('parrot', 'bird',     24.0),
                       ('lion',   'mammal',   80.5),
                       ('monkey', 'mammal', np.nan)],
                      columns=('name', 'class', 'max_speed'),
                      index=[0, 2, 3, 1])
>>> df
     name   class  max_speed
0  falcon    bird      389.0
2  parrot    bird       24.0
3    lion  mammal       80.5
1  monkey  mammal        NaN
```

Take elements at positions 0 and 3 along the axis 0 (default).

Note how the actual indices selected (0 and 1) do not correspond to our selected indices 0 and 3. That's because we are selecting the 0th and 3rd rows, not rows whose indices equal 0 and 3.

```
>>> df.take([0, 3])
0  falcon    bird      389.0
1  monkey  mammal        NaN
```

Take elements at indices 1 and 2 along the axis 1 (column selection).

```
>>> df.take([1, 2], axis=1)
    class  max_speed
0    bird      389.0
2    bird       24.0
3  mammal       80.5
1  mammal        NaN
```

We may take elements using negative integers for positive indices, starting from the end of the object, just like with Python lists.

```
>>> df.take([-1, -2])
     name   class  max_speed
1  monkey  mammal        NaN
3    lion  mammal       80.5
```

pandas.DataFrame.to_clipboard

`DataFrame.to_clipboard(excel=None, sep=None, **kwargs)`

Attempt to write text representation of object to the system clipboard This can be pasted into Excel, for example.

Parameters **excel** : boolean, defaults to True

if True, use the provided separator, writing in a csv format for allowing easy pasting into excel. if False, write a string representation of the object to the clipboard

sep : optional, defaults to tab

other keywords are passed to to_csv

Notes

Requirements for your platform

- Linux: xclip, or xsel (with gtk or PyQt4 modules)
- Windows: none
- OS X: none

pandas.DataFrame.to_csv

`DataFrame.to_csv(path_or_buf=None, sep=', ', na_rep='', float_format=None, columns=None, header=True, index=True, index_label=None, mode='w', encoding=None, compression=None, quoting=None, quotechar='"', line_terminator='\n', chunksize=None, tupleize_cols=None, date_format=None, doublequote=True, escapechar=None, decimal='.')`

Write DataFrame to a comma-separated values (csv) file

Parameters **path_or_buf** : string or file handle, default None

File path or object, if None is provided the result is returned as a string.

sep : character, default ','

Field delimiter for the output file.

na_rep : string, default ''

Missing data representation

float_format : string, default None

Format string for floating point numbers

columns : sequence, optional

Columns to write

header : boolean or list of string, default True

Write out the column names. If a list of strings is given it is assumed to be aliases for the column names

index : boolean, default True

Write row names (index)

index_label : string or sequence, or False, default None

Column label for index column(s) if desired. If None is given, and *header* and *index* are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex. If False do not print fields for index names. Use index_label=False for easier importing in R

mode : str

Python write mode, default 'w'

encoding : string, optional

A string representing the encoding to use in the output file, defaults to 'ascii' on Python 2 and 'utf-8' on Python 3.

compression : string, optional

a string representing the compression to use in the output file, allowed values are 'gzip', 'bz2', 'xz', only used when the first argument is a filename

line_terminator : string, default `'\n'`

The newline character or character sequence to use in the output file

quoting : optional constant from csv module

defaults to csv.QUOTE_MINIMAL. If you have set a *float_format* then floats are converted to strings and thus csv.QUOTE_NONNUMERIC will treat them as non-numeric

quotechar : string (length 1), default '"'

character used to quote fields

doublequote : boolean, default True

Control quoting of *quotechar* inside a field

escapechar : string (length 1), default None

character used to escape *sep* and *quotechar* when appropriate

chunksize : int or None

rows to write at a time

tupleize_cols : boolean, default False

Deprecated since version 0.21.0: This argument will be removed and will always write each row of the multi-index as a separate row in the CSV file.

Write MultiIndex columns as a list of tuples (if True) or in the new, expanded format, where each MultiIndex column is a row in the CSV (if False).

date_format : string, default None

Format string for datetime objects

decimal: string, default '.'

Character recognized as decimal separator. E.g. use ',' for European data

pandas.DataFrame.to_dense

`DataFrame.to_dense()`

Return dense representation of NDFrame (as opposed to sparse)

pandas.DataFrame.to_dict

`DataFrame.to_dict(orient='dict', into=<class 'dict'>)`

Convert DataFrame to dictionary.

Parameters **orient** : str {'dict', 'list', 'series', 'split', 'records', 'index'}

Determines the type of the values of the dictionary.

- dict (default) : dict like {column -> {index -> value}}
- list : dict like {column -> [values]}
- series : dict like {column -> Series(values)}
- split : dict like {index -> [index], columns -> [columns], data -> [values]}
- records : list like [{column -> value}, ... , {column -> value}]
- index : dict like {index -> {column -> value}}

New in version 0.17.0.

Abbreviations are allowed. *s* indicates *series* and *sp* indicates *split*.

into : class, default dict

The collections.Mapping subclass used for all Mappings in the return value. Can be the actual class or an empty instance of the mapping type you want. If you want a collections.defaultdict, you must pass it initialized.

New in version 0.21.0.

Returns **result** : collections.Mapping like {column -> {index -> value}}

Examples

```
>>> df = pd.DataFrame(
        {'col1': [1, 2], 'col2': [0.5, 0.75]}, index=['a', 'b'])
>>> df
   col1  col2
a     1   0.1
b     2   0.2
>>> df.to_dict()
{'col1': {'a': 1, 'b': 2}, 'col2': {'a': 0.5, 'b': 0.75}}
```

You can specify the return orientation.

```
>>> df.to_dict('series')
{'col1': a    1
b    2
Name: col1, dtype: int64, 'col2': a    0.50
b    0.75
Name: col2, dtype: float64}
>>> df.to_dict('split')
{'columns': ['col1', 'col2'],
'data': [[1.0, 0.5], [2.0, 0.75]],
'index': ['a', 'b']}
>>> df.to_dict('records')
[{'col1': 1.0, 'col2': 0.5}, {'col1': 2.0, 'col2': 0.75}]
>>> df.to_dict('index')
{'a': {'col1': 1.0, 'col2': 0.5}, 'b': {'col1': 2.0, 'col2': 0.75}}
```

You can also specify the mapping type.

```
>>> from collections import OrderedDict, defaultdict
>>> df.to_dict(into=OrderedDict)
OrderedDict([('col1', OrderedDict([('a', 1), ('b', 2)])),
            ('col2', OrderedDict([('a', 0.5), ('b', 0.75)]))])
```

If you want a *defaultdict*, you need to initialize it:

```
>>> dd = defaultdict(list)
>>> df.to_dict('records', into=dd)
[defaultdict(<type 'list'>, {'col2': 0.5, 'col1': 1.0}),
defaultdict(<type 'list'>, {'col2': 0.75, 'col1': 2.0})]
```

pandas.DataFrame.to_excel

`DataFrame.to_excel`(*excel_writer*, *sheet_name='Sheet1'*, *na_rep=''*, *float_format=None*, *columns=None*, *header=True*, *index=True*, *index_label=None*, *startrow=0*, *startcol=0*, *engine=None*, *merge_cells=True*, *encoding=None*, *inf_rep='inf'*, *verbose=True*, *freeze_panes=None*)

Write DataFrame to an excel sheet

Parameters **excel_writer** : string or ExcelWriter object

File path or existing ExcelWriter

sheet_name : string, default 'Sheet1'

Name of sheet which will contain DataFrame

na_rep : string, default ''

Missing data representation

float_format : string, default None

Format string for floating point numbers

columns : sequence, optional

Columns to write

header : boolean or list of string, default True

Write out the column names. If a list of strings is given it is assumed to be aliases for the column names

index : boolean, default True

Write row names (index)

index_label : string or sequence, default None

Column label for index column(s) if desired. If None is given, and *header* and *index* are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

startrow :

upper left cell row to dump data frame

startcol :

upper left cell column to dump data frame

engine : string, default None

write engine to use - you can also set this via the options `io.excel.xlsx.writer`, `io.excel.xls.writer`, and `io.excel.xlsm.writer`.

merge_cells : boolean, default True

Write MultiIndex and Hierarchical Rows as merged cells.

encoding: string, default None

encoding of the resulting excel file. Only necessary for xlwt, other writers support unicode natively.

inf_rep : string, default 'inf'

Representation for infinity (there is no native representation for infinity in Excel)

freeze_panes : tuple of integer (length 2), default None

Specifies the one-based bottommost row and rightmost column that is to be frozen

New in version 0.20.0.

Notes

If passing an existing ExcelWriter object, then the sheet will be added to the existing workbook. This can be used to save different DataFrames to one workbook:

```
>>> writer = pd.ExcelWriter('output.xlsx')
>>> df1.to_excel(writer,'Sheet1')
>>> df2.to_excel(writer,'Sheet2')
>>> writer.save()
```

For compatibility with to_csv, to_excel serializes lists and dicts to strings before writing.

pandas.DataFrame.to_feather

`DataFrame.to_feather(fname)`

write out the binary feather-format for DataFrames

New in version 0.20.0.

Parameters **fname** : str

string file path

pandas.DataFrame.to_gbq

`DataFrame.to_gbq(destination_table, project_id, chunksize=10000, verbose=True, reauth=False, if_exists='fail', private_key=None)`

Write a DataFrame to a Google BigQuery table.

The main method a user calls to export pandas DataFrame contents to Google BigQuery table.

Google BigQuery API Client Library v2 for Python is used. Documentation is available here

Authentication to the Google BigQuery service is via OAuth 2.0.

- If "private_key" is not provided:

  By default "application default credentials" are used.

  If default application credentials are not found or are restrictive, user account credentials are used. In this case, you will be asked to grant permissions for product name 'pandas GBQ'.

- If "private_key" is provided:

  Service account credentials will be used to authenticate.

Parameters **dataframe** : DataFrame

DataFrame to be written

destination_table : string

Name of table to be written, in the form 'dataset.tablename'

project_id : str

Google BigQuery Account project ID.

chunksize : int (default 10000)

Number of rows to be inserted in each chunk from the dataframe.

verbose : boolean (default True)

Show percentage complete

reauth : boolean (default False)

Force Google BigQuery to reauthenticate the user. This is useful if multiple accounts are used.

if_exists : {'fail', 'replace', 'append'}, default 'fail'

'fail': If table exists, do nothing. 'replace': If table exists, drop it, recreate it, and insert data. 'append': If table exists, insert data. Create if does not exist.

private_key : str (optional)

Service account private key in JSON format. Can be file path or string contents. This is useful for remote server authentication (eg. jupyter iPython notebook on remote host)

pandas.DataFrame.to_hdf

`DataFrame.to_hdf`(*path_or_buf*, *key*, ***kwargs*)

Write the contained data to an HDF5 file using HDFStore.

Parameters **path_or_buf** : the path (string) or HDFStore object

key : string

identifier for the group in the store

mode : optional, {'a', 'w', 'r+'}, default 'a'

'w' Write; a new file is created (an existing file with the same name would be deleted).

'a' Append; an existing file is opened for reading and writing, and if the file does not exist it is created.

'r+' It is similar to `'a'`, but the file must already exist.

format : 'fixed(f)|table(t)', default is 'fixed'

fixed(f) [Fixed format] Fast writing/reading. Not-appendable, nor searchable

table(t) [Table format] Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data

append : boolean, default False

For Table formats, append the input data to the existing

data_columns : list of columns, or True, default None

List of columns to create as indexed data columns for on-disk queries, or True to use all columns. By default only the axes of the object are indexed. See here.

Applicable only to format='table'.

complevel : int, 0-9, default None

Specifies a compression level for data. A value of 0 disables compression.

complib : {'zlib', 'lzo', 'bzip2', 'blosc'}, default 'zlib'

Specifies the compression library to be used. As of v0.20.2 these additional compressors for Blosc are supported (default if no compressor specified: 'blosc:blosclz'): {'blosc:blosclz', 'blosc:lz4', 'blosc:lz4hc', 'blosc:snappy', 'blosc:zlib', 'blosc:zstd'}. Specifying a compression library which is not available issues a ValueError.

fletcher32 : bool, default False

If applying compression use the fletcher32 checksum

dropna : boolean, default False.

If true, ALL nan rows will not be written to store.

pandas.DataFrame.to_html

`DataFrame.to_html(buf=None, columns=None, col_space=None, header=True, index=True, na_rep='NaN', formatters=None, float_format=None, sparsify=None, index_names=True, justify=None, bold_rows=True, classes=None, escape=True, max_rows=None, max_cols=None, show_dimensions=False, notebook=False, decimal='.', border=None)`

Render a DataFrame as an HTML table.

to_html-specific options:

bold_rows [boolean, default True] Make the row labels bold in the output

classes [str or list or tuple, default None] CSS class(es) to apply to the resulting html table

escape [boolean, default True] Convert the characters <, >, and & to HTML-safe sequences.=

max_rows [int, optional] Maximum number of rows to show before truncating. If None, show all.

max_cols [int, optional] Maximum number of columns to show before truncating. If None, show all.

decimal [string, default '.'] Character recognized as decimal separator, e.g. ',' in Europe

New in version 0.18.0.

border [int] A `border=border` attribute is included in the opening <*table*> tag. Default `pd.options.html.border`.

New in version 0.19.0.

Parameters **buf** : StringIO-like, optional

buffer to write to

columns : sequence, optional

the subset of columns to write; default None writes all columns

col_space : int, optional

the minimum width of each column

header : bool, optional

whether to print column labels, default True

index : bool, optional

whether to print index (row) labels, default True

na_rep : string, optional

string representation of NAN to use, default 'NaN'

formatters : list or dict of one-parameter functions, optional

formatter functions to apply to columns' elements by position or name, default None. The result of each function must be a unicode string. List must be of length equal to the number of columns.

float_format : one-parameter function, optional

formatter function to apply to columns' elements if they are floats, default None. The result of this function must be a unicode string.

sparsify : bool, optional

Set to False for a DataFrame with a hierarchical index to print every multiindex key at each row, default True

index_names : bool, optional

Prints the names of the indexes, default True

line_width : int, optional

Width to wrap a line in characters, default no wrap

justify : {'left', 'right', 'center', 'justify',

'justify-all', 'start', 'end', 'inherit', 'match-parent', 'initial', 'unset'}, default None

How to justify the column labels. If None uses the option from the print configuration (controlled by set_option), 'right' out of the box.

Returns **formatted** : string (or unicode, depending on data and options)

pandas.DataFrame.to_json

`DataFrame.to_json`(*path_or_buf=None*, *orient=None*, *date_format=None*, *double_precision=10*, *force_ascii=True*, *date_unit='ms'*, *default_handler=None*, *lines=False*, *compression=None*)

Convert the object to a JSON string.

Note NaN's and None will be converted to null and datetime objects will be converted to UNIX timestamps.

Parameters **path_or_buf** : the path or buffer to write the result string

if this is None, return the converted string

orient : string

- Series
  - default is 'index'
  - allowed values are: {'split','records','index'}
- DataFrame
  - default is 'columns'
  - allowed values are: {'split','records','index','columns','values'}
- The format of the JSON string
  - split : dict like {index -> [index], columns -> [columns], data -> [values]}
  - records : list like [{column -> value}, ... , {column -> value}]
  - index : dict like {index -> {column -> value}}
  - columns : dict like {column -> {index -> value}}
  - values : just the values array
  - table : dict like {'schema': {schema}, 'data': {data}} describing the data, and the data component is like `orient='records'`.

    Changed in version 0.20.0.

date_format : {None, 'epoch', 'iso'}

Type of date conversion. *epoch* = epoch milliseconds, *iso* = ISO8601. The default depends on the *orient*. For *orient='table'*, the default is *'iso'*. For all other orients, the default is *'epoch'*.

double_precision : The number of decimal places to use when encoding

floating point values, default 10.

force_ascii : force encoded string to be ASCII, default True.

date_unit : string, default 'ms' (milliseconds)

The time unit to encode to, governs timestamp and ISO8601 precision. One of 's', 'ms', 'us', 'ns' for second, millisecond, microsecond, and nanosecond respectively.

default_handler : callable, default None

Handler to call if object cannot otherwise be converted to a suitable format for JSON. Should receive a single argument which is the object to convert and return a serialisable object.

lines : boolean, default False

If 'orient' is 'records' write out line delimited json format. Will throw ValueError if incorrect 'orient' since others are not list like.

New in version 0.19.0.

compression : {None, 'gzip', 'bz2', 'xz'}

A string representing the compression to use in the output file, only used when the first argument is a filename

New in version 0.21.0.

Returns same type as input object with filtered info axis

See also:

`pd.read_json`

Examples

```
>>> df = pd.DataFrame([['a', 'b'], ['c', 'd']],
...                   index=['row 1', 'row 2'],
...                   columns=['col 1', 'col 2'])
>>> df.to_json(orient='split')
'{"columns":["col 1","col 2"],
  "index":["row 1","row 2"],
  "data":[["a","b"],["c","d"]]}'
```

Encoding/decoding a Dataframe using `'index'` formatted JSON:

```
>>> df.to_json(orient='index')
'{"row 1":{"col 1":"a","col 2":"b"},"row 2":{"col 1":"c","col 2":"d"}}'
```

Encoding/decoding a Dataframe using `'records'` formatted JSON. Note that index labels are not preserved with this encoding.

```
>>> df.to_json(orient='records')
'[{"col 1":"a","col 2":"b"},{"col 1":"c","col 2":"d"}]'
```

Encoding with Table Schema

```
>>> df.to_json(orient='table')
'{"schema": {"fields": [{"name": "index", "type": "string"},
                        {"name": "col 1", "type": "string"},
                        {"name": "col 2", "type": "string"}],
             "primaryKey": "index",
             "pandas_version": "0.20.0"},
  "data": [{"index": "row 1", "col 1": "a", "col 2": "b"},
           {"index": "row 2", "col 1": "c", "col 2": "d"}]}'
```

pandas.DataFrame.to_latex

`DataFrame.to_latex`(*buf=None*, *columns=None*, *col_space=None*, *header=True*, *index=True*, *na_rep='NaN'*, *formatters=None*, *float_format=None*, *sparsify=None*, *index_names=True*, *bold_rows=False*, *column_format=None*, *longtable=None*, *escape=None*, *encoding=None*, *decimal='.'*, *multicolumn=None*, *multicolumn_format=None*, *multirow=None*)

Render an object to a tabular environment table. You can splice this into a LaTeX document. Requires \usepackage{booktabs}.

Changed in version 0.20.2: Added to Series

to_latex-specific options:

bold_rows [boolean, default False] Make the row labels bold in the output

column_format [str, default None] The columns format as specified in LaTeX table format e.g 'rcl' for 3 columns

longtable [boolean, default will be read from the pandas config module] Default: False. Use a longtable environment instead of tabular. Requires adding a \usepackage{longtable} to your LaTeX preamble.

escape [boolean, default will be read from the pandas config module] Default: True. When set to False prevents from escaping latex special characters in column names.

encoding [str, default None] A string representing the encoding to use in the output file, defaults to 'ascii' on Python 2 and 'utf-8' on Python 3.

decimal [string, default '.'] Character recognized as decimal separator, e.g. ',' in Europe.

New in version 0.18.0.

multicolumn [boolean, default True] Use multicolumn to enhance MultiIndex columns. The default will be read from the config module.

New in version 0.20.0.

multicolumn_format [str, default 'l'] The alignment for multicolumns, similar to *column_format* The default will be read from the config module.

New in version 0.20.0.

multirow [boolean, default False] Use multirow to enhance MultiIndex rows. Requires adding a \usepackage{multirow} to your LaTeX preamble. Will print centered labels (instead of top-aligned) across the contained rows, separating groups via clines. The default will be read from the pandas config module.

New in version 0.20.0.

pandas.DataFrame.to_msgpack

`DataFrame.to_msgpack`(*path_or_buf=None*, *encoding='utf-8'*, ***kwargs*)

msgpack (serialize) object to input file path

THIS IS AN EXPERIMENTAL LIBRARY and the storage format may not be stable until a future release.

Parameters **path** : string File path, buffer-like, or None

if None, return generated string

append : boolean whether to append to an existing msgpack

(default is False)

compress : type of compressor (zlib or blosc), default to None (no

compression)

pandas.DataFrame.to_panel

`DataFrame.to_panel`()

Transform long (stacked) format (DataFrame) into wide (3D, Panel) format.

Currently the index of the DataFrame must be a 2-level MultiIndex. This may be generalized later

Returns **panel** : Panel

pandas.DataFrame.to_parquet

`DataFrame.to_parquet`(*fname*, *engine='auto'*, *compression='snappy'*, ***kwargs*)

Write a DataFrame to the binary parquet format.

New in version 0.21.0.

Parameters **fname** : str

string file path

engine : {'auto', 'pyarrow', 'fastparquet'}, default 'auto'

Parquet reader library to use. If 'auto', then the option 'io.parquet.engine' is used.
If 'auto', then the first library to be installed is used.

compression : str, optional, default 'snappy'

compression method, includes {'gzip', 'snappy', 'brotli'}

kwargs

Additional keyword arguments passed to the engine

pandas.DataFrame.to_period

`DataFrame.to_period`(*freq=None*, *axis=0*, *copy=True*)

Convert DataFrame from DatetimeIndex to PeriodIndex with desired frequency (inferred from index if not passed)

Parameters **freq** : string, default

axis : {0 or 'index', 1 or 'columns'}, default 0

The axis to convert (the index by default)

copy : boolean, default True

If False then underlying input data is not copied

Returns **ts** : TimeSeries with PeriodIndex

pandas.DataFrame.to_pickle

`DataFrame.to_pickle`(*path*, *compression='infer'*, *protocol=4*)

Pickle (serialize) object to input file path.

Parameters **path** : string

File path

compression : {'infer', 'gzip', 'bz2', 'xz', None}, default 'infer'

a string representing the compression to use in the output file

New in version 0.20.0.

protocol : int

Int which indicates which protocol should be used by the pickler, default HIGHEST_PROTOCOL (see [1], paragraph 12.1.2). The possible values for this parameter depend on the version of Python. For Python 2.x, possible values are 0, 1, 2. For Python>=3.0, 3 is a valid value. For Python >= 3.4, 4 is a valid value.A negative value for the protocol parameter is equivalent to setting its value to HIGHEST_PROTOCOL.

New in version 0.21.0.

pandas.DataFrame.to_records

`DataFrame.to_records`(*index=True*, *convert_datetime64=True*)

Convert DataFrame to record array. Index will be put in the 'index' field of the record array if requested

Parameters **index** : boolean, default True

Include index in resulting record array, stored in 'index' field

convert_datetime64 : boolean, default True

Whether to convert the index to datetime.datetime if it is a DatetimeIndex

Returns **y** : recarray

pandas.DataFrame.to_sparse

`DataFrame.to_sparse`(*fill_value=None*, *kind='block'*)

Convert to SparseDataFrame

Parameters **fill_value** : float, default NaN

kind : {'block', 'integer'}

Returns **y** : SparseDataFrame

pandas.DataFrame.to_stata

`DataFrame.to_stata`(*fname*, *convert_dates=None*, *write_index=True*, *encoding='latin-1'*, *byteorder=None*, *time_stamp=None*, *data_label=None*, *variable_labels=None*)

A class for writing Stata binary dta files from array-like objects

Parameters **fname** : str or buffer

String path of file-like object

convert_dates : dict

Dictionary mapping columns containing datetime types to stata internal format to use when wirting the dates. Options are 'tc', 'td', 'tm', 'tw', 'th', 'tq', 'ty'. Column can be either an integer or a name. Datetime columns that do not have a conversion type specified will be converted to 'tc'. Raises NotImplementedError if a datetime column has timezone information

write_index : bool

Write the index to Stata dataset.

encoding : str

Default is latin-1. Unicode is not supported

byteorder : str

Can be ">", "<", "little", or "big". default is *sys.byteorder*

time_stamp : datetime

A datetime to use as file creation date. Default is the current time.

dataset_label : str

A label for the data set. Must be 80 characters or smaller.

variable_labels : dict

Dictionary containing columns as keys and variable labels as values. Each label must be 80 characters or smaller.

New in version 0.19.0.

Raises **NotImplementedError**

- If datetimes contain timezone information
- Column dtype is not representable in Stata

ValueError

- Columns listed in convert_dates are noth either datetime64[ns] or datetime.datetime
- Column listed in convert_dates is not in DataFrame
- Categorical label contains more than 32,000 characters

New in version 0.19.0.

Examples

```
>>> writer = StataWriter('./data_file.dta', data)
>>> writer.write_file()
```

Or with dates

```
>>> writer = StataWriter('./date_data_file.dta', data, {2 : 'tw'})
>>> writer.write_file()
```

pandas.DataFrame.to_string

`DataFrame.to_string`(*buf=None*, *columns=None*, *col_space=None*, *header=True*, *index=True*, *na_rep='NaN'*, *formatters=None*, *float_format=None*, *sparsify=None*, *index_names=True*, *justify=None*, *line_width=None*, *max_rows=None*, *max_cols=None*, *show_dimensions=False*)

Render a DataFrame to a console-friendly tabular output.

Parameters **buf** : StringIO-like, optional

buffer to write to

columns : sequence, optional

the subset of columns to write; default None writes all columns

col_space : int, optional

the minimum width of each column

header : bool, optional

Write out the column names. If a list of strings is given, it is assumed to be aliases for the column names

index : bool, optional

whether to print index (row) labels, default True

na_rep : string, optional

string representation of NAN to use, default 'NaN'

formatters : list or dict of one-parameter functions, optional

formatter functions to apply to columns' elements by position or name, default None. The result of each function must be a unicode string. List must be of length equal to the number of columns.

float_format : one-parameter function, optional

formatter function to apply to columns' elements if they are floats, default None. The result of this function must be a unicode string.

sparsify : bool, optional

Set to False for a DataFrame with a hierarchical index to print every multiindex key at each row, default True

index_names : bool, optional

Prints the names of the indexes, default True

line_width : int, optional

Width to wrap a line in characters, default no wrap

justify : {'left', 'right', 'center', 'justify',

'justify-all', 'start', 'end', 'inherit', 'match-parent', 'initial', 'unset'}, default None

How to justify the column labels. If None uses the option from the print configuration (controlled by set_option), 'right' out of the box.

Returns **formatted** : string (or unicode, depending on data and options)

pandas.DataFrame.to_timestamp

`DataFrame.to_timestamp`(*freq=None*, *how='start'*, *axis=0*, *copy=True*)

Cast to DatetimeIndex of timestamps, at *beginning* of period

Parameters **freq** : string, default frequency of PeriodIndex

Desired frequency

how : {'s', 'e', 'start', 'end'}

Convention for converting period to timestamp; start of period vs. end

axis : {0 or 'index', 1 or 'columns'}, default 0

The axis to convert (the index by default)

copy : boolean, default True

If false then underlying input data is not copied

Returns **df** : DataFrame with DatetimeIndex

pandas.DataFrame.to_xarray

`DataFrame.to_xarray`()

Return an xarray object from the pandas object.

Returns a DataArray for a Series

a Dataset for a DataFrame

a DataArray for higher dims

Notes

See the xarray docs

Examples

```
>>> df = pd.DataFrame({'A' : [1, 1, 2],
                       'B' : ['foo', 'bar', 'foo'],
                       'C' : np.arange(4.,7)})
>>> df
```

```
   A    B    C
0  1  foo  4.0
1  1  bar  5.0
2  2  foo  6.0
```

```
>>> df.to_xarray()
<xarray.Dataset>
Dimensions:  (index: 3)
Coordinates:
  * index    (index) int64 0 1 2
Data variables:
    A        (index) int64 1 1 2
    B        (index) object 'foo' 'bar' 'foo'
    C        (index) float64 4.0 5.0 6.0
```

```
>>> df = pd.DataFrame({'A' : [1, 1, 2],
                       'B' : ['foo', 'bar', 'foo'],
                       'C' : np.arange(4.,7)}
                     ).set_index(['B','A'])
>>> df
         C
B   A
foo 1  4.0
bar 1  5.0
foo 2  6.0
```

```
>>> df.to_xarray()
<xarray.Dataset>
Dimensions:  (A: 2, B: 2)
Coordinates:
  * B        (B) object 'bar' 'foo'
  * A        (A) int64 1 2
Data variables:
    C        (B, A) float64 5.0 nan 4.0 6.0
```

```
>>> p = pd.Panel(np.arange(24).reshape(4,3,2),
                 items=list('ABCD'),
                 major_axis=pd.date_range('20130101', periods=3),
                 minor_axis=['first', 'second'])
>>> p
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: A to D
Major_axis axis: 2013-01-01 00:00:00 to 2013-01-03 00:00:00
Minor_axis axis: first to second
```

```
>>> p.to_xarray()
<xarray.DataArray (items: 4, major_axis: 3, minor_axis: 2)>
array([[[ 0,  1],
        [ 2,  3],
        [ 4,  5]],
       [[ 6,  7],
        [ 8,  9],
        [10, 11]],
       [[12, 13],
        [14, 15],
```

```
        [16, 17]],
       [[18, 19],
        [20, 21],
        [22, 23]]])
Coordinates:
  * items       (items) object 'A' 'B' 'C' 'D'
  * major_axis  (major_axis) datetime64[ns] 2013-01-01 2013-01-02 2013-01-03␣
↪ # noqa
  * minor_axis  (minor_axis) object 'first' 'second'
```

pandas.DataFrame.transform

`DataFrame.transform`(*func*, **args*, ***kwargs*)

Call function producing a like-indexed NDFrame and return a NDFrame with the transformed values

New in version 0.20.0.

Parameters **func** : callable, string, dictionary, or list of string/callables

To apply to column

Accepted Combinations are:

- string function name
- function
- list of functions
- dict of column names -> functions (or list of functions)

Returns **transformed** : NDFrame

See also:

`pandas.NDFrame.aggregate`, `pandas.NDFrame.apply`

Examples

```
>>> df = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
...                   index=pd.date_range('1/1/2000', periods=10))
df.iloc[3:7] = np.nan
```

```
>>> df.transform(lambda x: (x - x.mean()) / x.std())
                   A         B         C
2000-01-01  0.579457  1.236184  0.123424
2000-01-02  0.370357 -0.605875 -1.231325
2000-01-03  1.455756 -0.277446  0.288967
2000-01-04       NaN       NaN       NaN
2000-01-05       NaN       NaN       NaN
2000-01-06       NaN       NaN       NaN
2000-01-07       NaN       NaN       NaN
2000-01-08 -0.498658  1.274522  1.642524
2000-01-09 -0.540524 -1.012676 -0.828968
2000-01-10 -1.366388 -0.614710  0.005378
```

pandas.DataFrame.transpose

`DataFrame.transpose(*args, **kwargs)`

Transpose index and columns

pandas.DataFrame.truediv

`DataFrame.truediv(other, axis='columns', level=None, fill_value=None)`

Floating division of dataframe and other, element-wise (binary operator *truediv*).

Equivalent to `dataframe / other`, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters **other** : Series, DataFrame, or constant

axis : {0, 1, 'index', 'columns'}

For Series input, axis to match Series index on

fill_value : None or float value, default None

Fill missing (NaN) values with this value. If both DataFrame locations are missing, the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns **result** : DataFrame

See also:

DataFrame.rtruediv

Notes

Mismatched indices will be unioned together

pandas.DataFrame.truncate

`DataFrame.truncate(before=None, after=None, axis=None, copy=True)`

Truncates a sorted DataFrame/Series before and/or after some particular index value. If the axis contains only datetime values, before/after parameters are converted to datetime values.

Parameters **before** : date, string, int

Truncate all rows before this index value

after : date, string, int

Truncate all rows after this index value

axis : {0 or 'index', 1 or 'columns'}

- 0 or 'index': apply truncation to rows
- 1 or 'columns': apply truncation to columns

Default is stat axis for given data type (0 for Series and DataFrames, 1 for Panels)

copy : boolean, default is True,

return a copy of the truncated section

Returns **truncated** : type of caller

Examples

```
>>> df = pd.DataFrame({'A': ['a', 'b', 'c', 'd', 'e'],
...                    'B': ['f', 'g', 'h', 'i', 'j'],
...                    'C': ['k', 'l', 'm', 'n', 'o']},
...                    index=[1, 2, 3, 4, 5])
>>> df.truncate(before=2, after=4)
   A  B  C
2  b  g  l
3  c  h  m
4  d  i  n
>>> df = pd.DataFrame({'A': [1, 2, 3, 4, 5],
...                    'B': [6, 7, 8, 9, 10],
...                    'C': [11, 12, 13, 14, 15]},
...                    index=['a', 'b', 'c', 'd', 'e'])
>>> df.truncate(before='b', after='d')
   A  B   C
b  2  7  12
c  3  8  13
d  4  9  14
```

The index values in `truncate` can be datetimes or string dates. Note that `truncate` assumes a 0 value for any unspecified date component in a `DatetimeIndex` in contrast to slicing which returns any partially matching dates.

```
>>> dates = pd.date_range('2016-01-01', '2016-02-01', freq='s')
>>> df = pd.DataFrame(index=dates, data={'A': 1})
>>> df.truncate('2016-01-05', '2016-01-10').tail()
                     A
2016-01-09 23:59:56  1
2016-01-09 23:59:57  1
2016-01-09 23:59:58  1
2016-01-09 23:59:59  1
2016-01-10 00:00:00  1
>>> df.loc['2016-01-05':'2016-01-10', :].tail()
                     A
2016-01-10 23:59:55  1
2016-01-10 23:59:56  1
2016-01-10 23:59:57  1
2016-01-10 23:59:58  1
2016-01-10 23:59:59  1
```

pandas.DataFrame.tshift

`DataFrame.`**`tshift`**(*periods=1*, *freq=None*, *axis=0*)

Shift the time index, using the index's frequency if available.

Parameters **periods** : int

Number of periods to move, can be positive or negative

freq : DateOffset, timedelta, or time rule string, default None

Increment to use from the tseries module or time rule (e.g. 'EOM')

axis : int or basestring

Corresponds to the axis that contains the Index

Returns **shifted** : NDFrame

Notes

If freq is not specified then tries to use the freq or inferred_freq attributes of the index. If neither of those attributes exist, a ValueError is thrown

pandas.DataFrame.tz_convert

`DataFrame.tz_convert`(*tz*, *axis=0*, *level=None*, *copy=True*)

Convert tz-aware axis to target time zone.

Parameters **tz** : string or pytz.timezone object

axis : the axis to convert

level : int, str, default None

If axis ia a MultiIndex, convert a specific level. Otherwise must be None

copy : boolean, default True

Also make a copy of the underlying data

Raises **TypeError**

If the axis is tz-naive.

pandas.DataFrame.tz_localize

`DataFrame.tz_localize`(*tz*, *axis=0*, *level=None*, *copy=True*, *ambiguous='raise'*)

Localize tz-naive TimeSeries to target time zone.

Parameters **tz** : string or pytz.timezone object

axis : the axis to localize

level : int, str, default None

If axis ia a MultiIndex, localize a specific level. Otherwise must be None

copy : boolean, default True

Also make a copy of the underlying data

ambiguous : 'infer', bool-ndarray, 'NaT', default 'raise'

- 'infer' will attempt to infer fall dst-transition hours based on order
- bool-ndarray where True signifies a DST time, False designates a non-DST time (note that this flag is only applicable for ambiguous times)
- 'NaT' will return NaT where there are ambiguous times
- 'raise' will raise an AmbiguousTimeError if there are ambiguous times

infer_dst : boolean, default False

Deprecated since version 0.15.0: Attempt to infer fall dst-transition hours based on order

Raises **TypeError**

If the TimeSeries is tz-aware and tz is not None.

pandas.DataFrame.unstack

`DataFrame.unstack(level=-1, fill_value=None)`

Pivot a level of the (necessarily hierarchical) index labels, returning a DataFrame having a new level of column labels whose inner-most level consists of the pivoted index labels. If the index is not a MultiIndex, the output will be a Series (the analogue of stack when the columns are not a MultiIndex). The level involved will automatically get sorted.

Parameters **level** : int, string, or list of these, default -1 (last level)

Level(s) of index to unstack, can pass level name

fill_value : replace NaN with this value if the unstack produces

missing values

Returns **unstacked** : DataFrame or Series

See also:

DataFrame.pivot Pivot a table based on column values.

DataFrame.stack Pivot a level of the column labels (inverse operation from *unstack*).

Examples

```
>>> index = pd.MultiIndex.from_tuples([('one', 'a'), ('one', 'b'),
...                                    ('two', 'a'), ('two', 'b')])
>>> s = pd.Series(np.arange(1.0, 5.0), index=index)
>>> s
one  a   1.0
     b   2.0
two  a   3.0
     b   4.0
dtype: float64
```

```
>>> s.unstack(level=-1)
     a   b
one  1.0  2.0
two  3.0  4.0
```

```
>>> s.unstack(level=0)
   one  two
a  1.0   3.0
b  2.0   4.0
```

```
>>> df = s.unstack(level=0)
>>> df.unstack()
one  a  1.0
     b  2.0
two  a  3.0
     b  4.0
dtype: float64
```

pandas.DataFrame.update

`DataFrame.update`(*other*, *join='left'*, *overwrite=True*, *filter_func=None*, *raise_conflict=False*)

Modify DataFrame in place using non-NA values from passed DataFrame. Aligns on indices

Parameters **other** : DataFrame, or object coercible into a DataFrame

join : {'left'}, default 'left'

overwrite : boolean, default True

If True then overwrite values for common keys in the calling frame

filter_func : callable(1d-array) -> 1d-array<boolean>, default None

Can choose to replace values other than NA. Return True for values that should be updated

raise_conflict : boolean

If True, will raise an error if the DataFrame and other both contain data in the same place.

Examples

```
>>> df = pd.DataFrame({'A': [1, 2, 3],
...                    'B': [400, 500, 600]})
>>> new_df = pd.DataFrame({'B': [4, 5, 6],
...                        'C': [7, 8, 9]})
>>> df.update(new_df)
>>> df
   A  B
0  1  4
1  2  5
2  3  6
```

```
>>> df = pd.DataFrame({'A': ['a', 'b', 'c'],
...                    'B': ['x', 'y', 'z']})
>>> new_df = pd.DataFrame({'B': ['d', 'e', 'f', 'g', 'h', 'i']})
>>> df.update(new_df)
>>> df
   A  B
0  a  d
1  b  e
2  c  f
```

```
>>> df = pd.DataFrame({'A': ['a', 'b', 'c'],
...                    'B': ['x', 'y', 'z']})
```

```
>>> new_column = pd.Series(['d', 'e'], name='B', index=[0, 2])
>>> df.update(new_column)
>>> df
   A  B
0  a  d
1  b  y
2  c  e
>>> df = pd.DataFrame({'A': ['a', 'b', 'c'],
...                    'B': ['x', 'y', 'z']})
>>> new_df = pd.DataFrame({'B': ['d', 'e']}, index=[1, 2])
>>> df.update(new_df)
>>> df
   A  B
0  a  x
1  b  d
2  c  e
```

If `other` contains NaNs the corresponding values are not updated in the original dataframe.

```
>>> df = pd.DataFrame({'A': [1, 2, 3],
...                    'B': [400, 500, 600]})
>>> new_df = pd.DataFrame({'B': [4, np.nan, 6]})
>>> df.update(new_df)
>>> df
   A      B
0  1    4.0
1  2  500.0
2  3    6.0
```

pandas.DataFrame.var

`DataFrame.var`(*axis=None*, *skipna=None*, *level=None*, *ddof=1*, *numeric_only=None*, ***kwargs*)

Return unbiased variance over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

ddof : int, default 1

degrees of freedom

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **var** : Series or DataFrame (if level specified)

pandas.DataFrame.where

`DataFrame.where(cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)`

Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.

Parameters **cond** : boolean NDFrame, array-like, or callable

Where *cond* is True, keep the original value. Where False, replace with corresponding value from *other*. If *cond* is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as cond.

other : scalar, NDFrame, or callable

Entries where *cond* is False are replaced with corresponding value from *other*. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as other.

inplace : boolean, default False

Whether to perform the operation in place on the data

axis : alignment axis if needed, default None

level : alignment level if needed, default None

errors : str, {'raise', 'ignore'}, default 'raise'

- `raise` : allow exceptions to be raised
- `ignore` : suppress exceptions. On error return original object

Note that currently this parameter won't affect the results and will always coerce to a suitable dtype.

try_cast : boolean, default False

try to cast the result back to the input type (if possible),

raise_on_error : boolean, default True

Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.

Returns **wh** : same type as caller

See also:

`DataFrame.mask()`

Notes

The where method is an application of the if-then idiom. For each element in the calling DataFrame, if `cond` is `True` the element is used; otherwise the corresponding element from the DataFrame `other` is used.

The signature for *DataFrame.where()* differs from numpy.where(). Roughly df1.where(m, df2) is equivalent to np.where(m, df1, df2).

For further details and examples see the where documentation in *indexing*.

Examples

```
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0    NaN
1    1.0
2    2.0
3    3.0
4    4.0
```

```
>>> s.mask(s > 0)
0    0.0
1    NaN
2    NaN
3    NaN
4    NaN
```

```
>>> s.where(s > 1, 10)
0    10.0
1    10.0
2    2.0
3    3.0
4    4.0
```

```
>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
   A  B
0  0 -1
1 -2  3
2 -4 -5
3  6 -7
4 -8  9
>>> df.where(m, -df) == np.where(m, df, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
>>> df.where(m, -df) == df.mask(~m, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
```

pandas.DataFrame.xs

`DataFrame.xs`(*key*, *axis=0*, *level=None*, *drop_level=True*)

Returns a cross-section (row(s) or column(s)) from the Series/DataFrame. Defaults to cross-section on the rows (axis=0).

Parameters **key** : object

Some label contained in the index, or partially in a MultiIndex

axis : int, default 0

Axis to retrieve cross-section on

level : object, defaults to first n levels (n=1 or len(key))

In case of a key partially contained in a MultiIndex, indicate which levels are used. Levels can be referred by label or position.

drop_level : boolean, default True

If False, returns object with same levels as self.

Returns **xs** : Series or DataFrame

Notes

xs is only for getting, not setting values.

MultiIndex Slicers is a generic way to get/set values on any level or levels. It is a superset of xs functionality, see *MultiIndex Slicers*

Examples

```
>>> df
   A  B  C
a  4  5  2
b  4  0  9
c  9  7  3
>>> df.xs('a')
A    4
B    5
C    2
Name: a
>>> df.xs('C', axis=1)
a    2
b    9
c    3
Name: C
```

```
>>> df
                    A  B  C  D
first second third
bar   one    1      4  1  8  9
      two    1      7  5  5  0
baz   one    1      6  6  8  0
      three  2      5  3  5  3
>>> df.xs(('baz', 'three'))
```

```
       A  B  C  D
third
2      5  3  5  3
>>> df.xs('one', level=1)
             A  B  C  D
first third
bar   1      4  1  8  9
baz   1      6  6  8  0
>>> df.xs(('baz', 2), level=[0, 'third'])
        A  B  C  D
second
three   5  3  5  3
```

34.4.2 Attributes and underlying data

Axes

- **index**: row labels
- **columns**: column labels

`DataFrame.as_matrix`([columns])	Convert the frame to its Numpy-array representation.
`DataFrame.dtypes`	Return the dtypes in this object.
`DataFrame.ftypes`	Return the ftypes (indication of sparse/dense and dtype) in this object.
`DataFrame.get_dtype_counts`()	Return the counts of dtypes in this object.
`DataFrame.get_ftype_counts`()	Return the counts of ftypes in this object.
`DataFrame.select_dtypes`([include, exclude])	Return a subset of a DataFrame including/excluding columns based on their `dtype`.
`DataFrame.values`	Numpy representation of NDFrame
`DataFrame.axes`	Return a list with the row axis labels and column axis labels as the only members.
`DataFrame.ndim`	Number of axes / array dimensions
`DataFrame.size`	number of elements in the NDFrame
`DataFrame.shape`	Return a tuple representing the dimensionality of the DataFrame.
`DataFrame.memory_usage`([index, deep])	Memory usage of DataFrame columns.

34.4.3 Conversion

`DataFrame.astype`(dtype[, copy, errors])	Cast a pandas object to a specified dtype `dtype`.
`DataFrame.convert_objects`([convert_dates, ...])	Deprecated.
`DataFrame.infer_objects`()	Attempt to infer better dtypes for object columns.
`DataFrame.copy`([deep])	Make a copy of this objects data.
`DataFrame.isna`()	Return a boolean same-sized object indicating if the values are NA.
`DataFrame.notna`()	Return a boolean same-sized object indicating if the values are not NA.

34.4.4 Indexing, iteration

DataFrame.head([n])	Return the first n rows.
DataFrame.at	Fast label-based scalar accessor
DataFrame.iat	Fast integer location scalar accessor.
DataFrame.loc	Purely label-location based indexer for selection by label.
DataFrame.iloc	Purely integer-location based indexing for selection by position.
DataFrame.insert(loc, column, value[, ...])	Insert column into DataFrame at specified location.
DataFrame.__iter__()	Iterate over infor axis
DataFrame.iteritems()	Iterator over (column name, Series) pairs.
DataFrame.iterrows()	Iterate over DataFrame rows as (index, Series) pairs.
DataFrame.itertuples([index, name])	Iterate over DataFrame rows as namedtuples, with index value as first element of the tuple.
DataFrame.lookup(row_labels, col_labels)	Label-based "fancy indexing" function for DataFrame.
DataFrame.pop(item)	Return item and drop from frame.
DataFrame.tail([n])	Return the last n rows.
DataFrame.xs(key[, axis, level, drop_level])	Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.
DataFrame.isin(values)	Return boolean DataFrame showing whether each element in the DataFrame is contained in values.
DataFrame.where(cond[, other, inplace, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.
DataFrame.mask(cond[, other, inplace, axis, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.
DataFrame.query(expr[, inplace])	Query the columns of a frame with a boolean expression.

34.4.4.1 pandas.DataFrame.__iter__

DataFrame.**__iter__**()

Iterate over infor axis

For more information on `.at`, `.iat`, `.loc`, and `.iloc`, see the *indexing documentation*.

34.4.5 Binary operator functions

DataFrame.add(other[, axis, level, fill_value])	Addition of dataframe and other, element-wise (binary operator *add*).
DataFrame.sub(other[, axis, level, fill_value])	Subtraction of dataframe and other, element-wise (binary operator *sub*).
DataFrame.mul(other[, axis, level, fill_value])	Multiplication of dataframe and other, element-wise (binary operator *mul*).
DataFrame.div(other[, axis, level, fill_value])	Floating division of dataframe and other, element-wise (binary operator *truediv*).
DataFrame.truediv(other[, axis, level, ...])	Floating division of dataframe and other, element-wise (binary operator *truediv*).
DataFrame.floordiv(other[, axis, level, ...])	Integer division of dataframe and other, element-wise (binary operator *floordiv*).
DataFrame.mod(other[, axis, level, fill_value])	Modulo of dataframe and other, element-wise (binary operator *mod*).

Continued on next page

Table 34.59 – continued from previous page

DataFrame.pow(other[, axis, level, fill_value])	Exponential power of dataframe and other, element-wise (binary operator *pow*).
DataFrame.radd(other[, axis, level, fill_value])	Addition of dataframe and other, element-wise (binary operator *radd*).
DataFrame.rsub(other[, axis, level, fill_value])	Subtraction of dataframe and other, element-wise (binary operator *rsub*).
DataFrame.rmul(other[, axis, level, fill_value])	Multiplication of dataframe and other, element-wise (binary operator *rmul*).
DataFrame.rdiv(other[, axis, level, fill_value])	Floating division of dataframe and other, element-wise (binary operator *rtruediv*).
DataFrame.rtruediv(other[, axis, level, ...])	Floating division of dataframe and other, element-wise (binary operator *rtruediv*).
DataFrame.rfloordiv(other[, axis, level, ...])	Integer division of dataframe and other, element-wise (binary operator *rfloordiv*).
DataFrame.rmod(other[, axis, level, fill_value])	Modulo of dataframe and other, element-wise (binary operator *rmod*).
DataFrame.rpow(other[, axis, level, fill_value])	Exponential power of dataframe and other, element-wise (binary operator *rpow*).
DataFrame.lt(other[, axis, level])	Wrapper for flexible comparison methods lt
DataFrame.gt(other[, axis, level])	Wrapper for flexible comparison methods gt
DataFrame.le(other[, axis, level])	Wrapper for flexible comparison methods le
DataFrame.ge(other[, axis, level])	Wrapper for flexible comparison methods ge
DataFrame.ne(other[, axis, level])	Wrapper for flexible comparison methods ne
DataFrame.eq(other[, axis, level])	Wrapper for flexible comparison methods eq
DataFrame.combine(other, func[, fill_value, ...])	Add two DataFrame objects and do not propagate NaN values, so if for a
DataFrame.combine_first(other)	Combine two DataFrame objects and default to non-null values in frame calling the method.

34.4.6 Function application, GroupBy & Window

DataFrame.apply(func[, axis, broadcast, ...])	Applies function along input axis of DataFrame.
DataFrame.applymap(func)	Apply a function to a DataFrame that is intended to operate elementwise, i.e.
DataFrame.aggregate(func[, axis])	Aggregate using callable, string, dict, or list of string/callables
DataFrame.transform(func, *args, **kwargs)	Call function producing a like-indexed NDFrame
DataFrame.groupby([by, axis, level, ...])	Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.
DataFrame.rolling(window[, min_periods, ...])	Provides rolling window calculations.
DataFrame.expanding([min_periods, freq, ...])	Provides expanding transformations.
DataFrame.ewm([com, span, halflife, alpha, ...])	Provides exponential weighted functions

34.4.7 Computations / Descriptive Stats

DataFrame.abs()	Return an object with absolute value taken–only applicable to objects that are all numeric.

Continued on next page

Table 34.61 – continued from previous page

DataFrame.all([axis, bool_only, skipna, level])	Return whether all elements are True over requested axis
DataFrame.any([axis, bool_only, skipna, level])	Return whether any element is True over requested axis
DataFrame.clip([lower, upper, axis, inplace])	Trim values at input threshold(s).
DataFrame.clip_lower(threshold[, axis, inplace])	Return copy of the input with values below given value(s) truncated.
DataFrame.clip_upper(threshold[, axis, inplace])	Return copy of input with values above given value(s) truncated.
DataFrame.corr([method, min_periods])	Compute pairwise correlation of columns, excluding NA/null values
DataFrame.corrwith(other[, axis, drop])	Compute pairwise correlation between rows or columns of two DataFrame objects.
DataFrame.count([axis, level, numeric_only])	Return Series with number of non-NA/null observations over requested axis.
DataFrame.cov([min_periods])	Compute pairwise covariance of columns, excluding NA/null values
DataFrame.cummax([axis, skipna])	Return cumulative max over requested axis.
DataFrame.cummin([axis, skipna])	Return cumulative minimum over requested axis.
DataFrame.cumprod([axis, skipna])	Return cumulative product over requested axis.
DataFrame.cumsum([axis, skipna])	Return cumulative sum over requested axis.
DataFrame.describe([percentiles, include, ...])	Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding NaN values.
DataFrame.diff([periods, axis])	1st discrete difference of object
DataFrame.eval(expr[, inplace])	Evaluate an expression in the context of the calling DataFrame instance.
DataFrame.kurt([axis, skipna, level, ...])	Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0).
DataFrame.mad([axis, skipna, level])	Return the mean absolute deviation of the values for the requested axis
DataFrame.max([axis, skipna, level, ...])	This method returns the maximum of the values in the object.
DataFrame.mean([axis, skipna, level, ...])	Return the mean of the values for the requested axis
DataFrame.median([axis, skipna, level, ...])	Return the median of the values for the requested axis
DataFrame.min([axis, skipna, level, ...])	This method returns the minimum of the values in the object.
DataFrame.mode([axis, numeric_only])	Gets the mode(s) of each element along the axis selected.
DataFrame.pct_change([periods, fill_method, ...])	Percent change over given number of periods.
DataFrame.prod([axis, skipna, level, ...])	Return the product of the values for the requested axis
DataFrame.quantile([q, axis, numeric_only, ...])	Return values at the given quantile over requested axis, a la numpy.percentile.
DataFrame.rank([axis, method, numeric_only, ...])	Compute numerical data ranks (1 through n) along axis.
DataFrame.round([decimals])	Round a DataFrame to a variable number of decimal places.
DataFrame.sem([axis, skipna, level, ddof, ...])	Return unbiased standard error of the mean over requested axis.
DataFrame.skew([axis, skipna, level, ...])	Return unbiased skew over requested axis
DataFrame.sum([axis, skipna, level, ...])	Return the sum of the values for the requested axis
DataFrame.std([axis, skipna, level, ddof, ...])	Return sample standard deviation over requested axis.
DataFrame.var([axis, skipna, level, ddof, ...])	Return unbiased variance over requested axis.

34.4.8 Reindexing / Selection / Label manipulation

DataFrame.add_prefix(prefix)	Concatenate prefix string with panel items names.
DataFrame.add_suffix(suffix)	Concatenate suffix string with panel items names.
DataFrame.align(other[, join, axis, level, ...])	Align two objects on their axes with the
DataFrame.drop([labels, axis, index, ...])	Return new object with labels in requested axis removed.
DataFrame.drop_duplicates([subset, keep, ...])	Return DataFrame with duplicate rows removed, optionally only
DataFrame.duplicated([subset, keep])	Return boolean Series denoting duplicate rows, optionally only
DataFrame.equals(other)	Determines if two NDFrame objects contain the same elements.
DataFrame.filter([items, like, regex, axis])	Subset rows or columns of dataframe according to labels in the specified index.
DataFrame.first(offset)	Convenience method for subsetting initial periods of time series data based on a date offset.
DataFrame.head([n])	Return the first n rows.
DataFrame.idxmax([axis, skipna])	Return index of first occurrence of maximum over requested axis.
DataFrame.idxmin([axis, skipna])	Return index of first occurrence of minimum over requested axis.
DataFrame.last(offset)	Convenience method for subsetting final periods of time series data based on a date offset.
DataFrame.reindex([labels, index, columns, ...])	Conform DataFrame to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
DataFrame.reindex_axis(labels[, axis, ...])	Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
DataFrame.reindex_like(other[, method, ...])	Return an object with matching indices to myself.
DataFrame.rename([mapper, index, columns, ...])	Alter axes labels.
DataFrame.rename_axis(mapper[, axis, copy, ...])	Alter the name of the index or columns.
DataFrame.reset_index([level, drop, ...])	For DataFrame with multi-level index, return new DataFrame with labeling information in the columns under the index names, defaulting to 'level_0', 'level_1', etc.
DataFrame.sample([n, frac, replace, ...])	Returns a random sample of items from an axis of object.
DataFrame.select(crit[, axis])	Return data corresponding to axis labels matching criteria
DataFrame.set_index(keys[, drop, append, ...])	Set the DataFrame index (row labels) using one or more existing columns.
DataFrame.tail([n])	Return the last n rows.
DataFrame.take(indices[, axis, convert, is_copy])	Return the elements in the given *positional* indices along an axis.
DataFrame.truncate([before, after, axis, copy])	Truncates a sorted DataFrame/Series before and/or after some particular index value.

34.4.9 Missing data handling

DataFrame.dropna([axis, how, thresh, ...])	Return object with labels on given axis omitted where alternately any
DataFrame.fillna([value, method, axis, ...])	Fill NA/NaN values using the specified method
DataFrame.replace([to_replace, value, ...])	Replace values given in 'to_replace' with 'value'.

34.4.10 Reshaping, sorting, transposing

`DataFrame.pivot`([index, columns, values])	Reshape data (produce a "pivot" table) based on column values.
`DataFrame.reorder_levels`(order[, axis])	Rearrange index levels using input order.
`DataFrame.sort_values`(by[, axis, ascending, ...])	Sort by the values along either axis
`DataFrame.sort_index`([axis, level, ...])	Sort object by labels (along an axis)
`DataFrame.nlargest`(n, columns[, keep])	Get the rows of a DataFrame sorted by the *n* largest values of *columns*.
`DataFrame.nsmallest`(n, columns[, keep])	Get the rows of a DataFrame sorted by the *n* smallest values of *columns*.
`DataFrame.swaplevel`([i, j, axis])	Swap levels i and j in a MultiIndex on a particular axis
`DataFrame.stack`([level, dropna])	Pivot a level of the (possibly hierarchical) column labels, returning a DataFrame (or Series in the case of an object with a single level of column labels) having a hierarchical index with a new inner-most level of row labels.
`DataFrame.unstack`([level, fill_value])	Pivot a level of the (necessarily hierarchical) index labels, returning a DataFrame having a new level of column labels whose inner-most level consists of the pivoted index labels.
`DataFrame.melt`([id_vars, value_vars, ...])	"Unpivots" a DataFrame from wide format to long format, optionally
`DataFrame.T`	Transpose index and columns
`DataFrame.to_panel`()	Transform long (stacked) format (DataFrame) into wide (3D, Panel) format.
`DataFrame.to_xarray`()	Return an xarray object from the pandas object.
`DataFrame.transpose`(*args, **kwargs)	Transpose index and columns

34.4.11 Combining / joining / merging

`DataFrame.append`(other[, ignore_index, ...])	Append rows of *other* to the end of this frame, returning a new object.
`DataFrame.assign`(**kwargs)	Assign new columns to a DataFrame, returning a new object (a copy) with all the original columns in addition to the new ones.
`DataFrame.join`(other[, on, how, lsuffix, ...])	Join columns with other DataFrame either on index or on a key column.
`DataFrame.merge`(right[, how, on, left_on, ...])	Merge DataFrame objects by performing a database-style join operation by columns or indexes.
`DataFrame.update`(other[, join, overwrite, ...])	Modify DataFrame in place using non-NA values from passed DataFrame.

34.4.12 Time series-related

`DataFrame.asfreq`(freq[, method, how, ...])	Convert TimeSeries to specified frequency.
`DataFrame.asof`(where[, subset])	The last row without any NaN is taken (or the last row without
`DataFrame.shift`([periods, freq, axis])	Shift index by desired number of periods with an optional time freq

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Table 34.66 – continued from previous page

DataFrame.first_valid_index()	Return index for first non-NA/null value.
DataFrame.last_valid_index()	Return index for first non-NA/null value.
DataFrame.resample(rule[, how, axis, ...])	Convenience method for frequency conversion and resampling of time series.
DataFrame.to_period([freq, axis, copy])	Convert DataFrame from DatetimeIndex to PeriodIndex with desired
DataFrame.to_timestamp([freq, how, axis, copy])	Cast to DatetimeIndex of timestamps, at *beginning* of period
DataFrame.tz_convert(tz[, axis, level, copy])	Convert tz-aware axis to target time zone.
DataFrame.tz_localize(tz[, axis, level, ...])	Localize tz-naive TimeSeries to target time zone.

34.4.13 Plotting

`DataFrame.plot` is both a callable method and a namespace attribute for specific plotting methods of the form `DataFrame.plot.<kind>`.

DataFrame.plot([x, y, kind, ax, ...])	DataFrame plotting accessor and method

DataFrame.plot.area([x, y])	Area plot
DataFrame.plot.bar([x, y])	Vertical bar plot
DataFrame.plot.barh([x, y])	Horizontal bar plot
DataFrame.plot.box([by])	Boxplot
DataFrame.plot.density(**kwds)	Kernel Density Estimate plot
DataFrame.plot.hexbin(x, y[, C, ...])	Hexbin plot
DataFrame.plot.hist([by, bins])	Histogram
DataFrame.plot.kde(**kwds)	Kernel Density Estimate plot
DataFrame.plot.line([x, y])	Line plot
DataFrame.plot.pie([y])	Pie chart
DataFrame.plot.scatter(x, y[, s, c])	Scatter plot

34.4.13.1 pandas.DataFrame.plot.area

`DataFrame.plot.`**`area`**(*x=None*, *y=None*, ***kwds*)

Area plot

New in version 0.17.0.

Parameters **x, y** : label or position, optional

Coordinates for each point.

****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.2 pandas.DataFrame.plot.bar

`DataFrame.plot.`**`bar`**(*x=None*, *y=None*, ***kwds*)

Vertical bar plot

New in version 0.17.0.

Parameters **x, y** : label or position, optional

Coordinates for each point.

****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.3 pandas.DataFrame.plot.barh

`DataFrame.plot.barh`(*x=None*, *y=None*, ***kwds*)

Horizontal bar plot

New in version 0.17.0.

Parameters **x, y** : label or position, optional

Coordinates for each point.

****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.4 pandas.DataFrame.plot.box

`DataFrame.plot.box`(*by=None*, ***kwds*)

Boxplot

New in version 0.17.0.

Parameters **by** : string or sequence

Column in the DataFrame to group by.

****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.5 pandas.DataFrame.plot.density

`DataFrame.plot.density`(***kwds*)

Kernel Density Estimate plot

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.6 pandas.DataFrame.plot.hexbin

`DataFrame.plot.hexbin`(*x*, *y*, *C=None*, *reduce_C_function=None*, *gridsize=None*, ***kwds*)

Hexbin plot

New in version 0.17.0.

Parameters **x, y** : label or position, optional

Coordinates for each point.

C : label or position, optional

The value at each *(x, y)* point.

reduce_C_function : callable, optional

Function of one argument that reduces all the values in a bin to a single number (e.g. *mean*, *max*, *sum*, *std*).

gridsize : int, optional

Number of bins.

****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.7 pandas.DataFrame.plot.hist

`DataFrame.plot.hist`(*by=None*, *bins=10*, ***kwds*)

Histogram

New in version 0.17.0.

Parameters **by** : string or sequence

Column in the DataFrame to group by.

bins: integer, default 10

Number of histogram bins to be used

****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.8 pandas.DataFrame.plot.kde

`DataFrame.plot.kde`(***kwds*)

Kernel Density Estimate plot

New in version 0.17.0.

Parameters ****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.9 pandas.DataFrame.plot.line

`DataFrame.plot.line`(*x=None*, *y=None*, ***kwds*)

Line plot

New in version 0.17.0.

Parameters **x, y** : label or position, optional

Coordinates for each point.

****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.10 pandas.DataFrame.plot.pie

`DataFrame.plot.pie`(*y=None*, ***kwds*)

Pie chart

New in version 0.17.0.

Parameters **y** : label or position, optional

Column to plot.

****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

34.4.13.11 pandas.DataFrame.plot.scatter

`DataFrame.plot.scatter`(*x*, *y*, *s=None*, *c=None*, ***kwds*)

Scatter plot

New in version 0.17.0.

Parameters **x, y** : label or position, optional

Coordinates for each point.

s : scalar or array_like, optional

Size of each point.

c : label or position, optional

Color of each point.

****kwds** : optional

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns **axes** : matplotlib.AxesSubplot or np.array of them

`DataFrame.boxplot`([column, by, ax, ...])	Make a box plot from DataFrame column optionally grouped by some columns or
`DataFrame.hist`(data[, column, by, grid, ...])	Draw histogram of the DataFrame's series using matplotlib / pylab.

34.4.14 Serialization / IO / Conversion

DataFrame.from_csv(path[, header, sep, ...])	Read CSV file (DEPRECATED, please use pandas.read_csv() instead).
DataFrame.from_dict(data[, orient, dtype])	Construct DataFrame from dict of array-like or dicts
DataFrame.from_items(items[, columns, orient])	Convert (key, value) pairs to DataFrame.
DataFrame.from_records(data[, index, ...])	Convert structured or record ndarray to DataFrame
DataFrame.info([verbose, buf, max_cols, ...])	Concise summary of a DataFrame.
DataFrame.to_pickle(path[, compression, ...])	Pickle (serialize) object to input file path.
DataFrame.to_csv([path_or_buf, sep, na_rep, ...])	Write DataFrame to a comma-separated values (csv) file
DataFrame.to_hdf(path_or_buf, key, **kwargs)	Write the contained data to an HDF5 file using HDFStore.
DataFrame.to_sql(name, con[, flavor, ...])	Write records stored in a DataFrame to a SQL database.
DataFrame.to_dict([orient, into])	Convert DataFrame to dictionary.
DataFrame.to_excel(excel_writer[, ...])	Write DataFrame to an excel sheet
DataFrame.to_json([path_or_buf, orient, ...])	Convert the object to a JSON string.
DataFrame.to_html([buf, columns, col_space, ...])	Render a DataFrame as an HTML table.
DataFrame.to_feather(fname)	write out the binary feather-format for DataFrames
DataFrame.to_latex([buf, columns, ...])	Render an object to a tabular environment table.
DataFrame.to_stata(fname[, convert_dates, ...])	A class for writing Stata binary dta files from array-like objects
DataFrame.to_msgpack([path_or_buf, encoding])	msgpack (serialize) object to input file path
DataFrame.to_gbq(destination_table, project_id)	Write a DataFrame to a Google BigQuery table.
DataFrame.to_records([index, convert_datetime64])	Convert DataFrame to record array.
DataFrame.to_sparse([fill_value, kind])	Convert to SparseDataFrame
DataFrame.to_dense()	Return dense representation of NDFrame (as opposed to sparse)
DataFrame.to_string([buf, columns, ...])	Render a DataFrame to a console-friendly tabular output.
DataFrame.to_clipboard([excel, sep])	Attempt to write text representation of object to the system clipboard This can be pasted into Excel, for example.

34.4.15 Sparse

SparseDataFrame.to_coo()	Return the contents of the frame as a sparse SciPy COO matrix.

34.4.15.1 pandas.SparseDataFrame.to_coo

SparseDataFrame.**to_coo**()

Return the contents of the frame as a sparse SciPy COO matrix.

New in version 0.20.0.

Returns **coo_matrix** : scipy.sparse.spmatrix

If the caller is heterogeneous and contains booleans or objects, the result will be of dtype=object. See Notes.

Notes

The dtype will be the lowest-common-denominator type (implicit upcasting); that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. By numpy.find_common_type convention, mixing int64 and and uint64 will result in a float64 dtype.

34.5 Panel

34.5.1 Constructor

`Panel`([data, items, major_axis, minor_axis, ...])	Represents wide format panel data, stored as 3-dimensional array

34.5.1.1 pandas.Panel

class `pandas.`**`Panel`**(*data=None*, *items=None*, *major_axis=None*, *minor_axis=None*, *copy=False*, *dtype=None*)

Represents wide format panel data, stored as 3-dimensional array

Parameters **data** : ndarray (items x major x minor), or dict of DataFrames

items : Index or array-like

axis=0

major_axis : Index or array-like

axis=1

minor_axis : Index or array-like

axis=2

dtype : dtype, default None

Data type to force, otherwise infer

copy : boolean, default False

Copy data from inputs. Only affects DataFrame / 2d ndarray input

Attributes

`at`	Fast label-based scalar accessor
`axes`	Return index label(s) of the internal NDFrame
`blocks`	Internal property, property synonym for as_blocks()
`dtypes`	Return the dtypes in this object.
`empty`	True if NDFrame is entirely empty [no items], meaning any of the axes are of length 0.
`ftypes`	Return the ftypes (indication of sparse/dense and dtype) in this object.

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Table 34.73 – continued from previous page

iat	Fast integer location scalar accessor.
iloc	Purely integer-location based indexing for selection by position.
is_copy	
ix	A primarily label-location based indexer, with integer position fallback.
loc	Purely label-location based indexer for selection by label.
ndim	Number of axes / array dimensions
shape	Return a tuple of axis dimensions
size	number of elements in the NDFrame
values	Numpy representation of NDFrame

pandas.Panel.at

`Panel.at`

Fast label-based scalar accessor

Similarly to `loc`, `at` provides **label** based scalar lookups. You can also set using these indexers.

pandas.Panel.axes

`Panel.axes`

Return index label(s) of the internal NDFrame

pandas.Panel.blocks

`Panel.blocks`

Internal property, property synonym for as_blocks()

Deprecated since version 0.21.0.

pandas.Panel.dtypes

`Panel.dtypes`

Return the dtypes in this object.

pandas.Panel.empty

`Panel.empty`

True if NDFrame is entirely empty [no items], meaning any of the axes are of length 0.

See also:

pandas.Series.dropna, *pandas.DataFrame.dropna*

Notes

If NDFrame contains only NaNs, it is still not considered empty. See the example below.

Examples

An example of an actual empty DataFrame. Notice the index is empty:

```
>>> df_empty = pd.DataFrame({'A' : []})
>>> df_empty
Empty DataFrame
Columns: [A]
Index: []
>>> df_empty.empty
True
```

If we only have NaNs in our DataFrame, it is not considered empty! We will need to drop the NaNs to make the DataFrame empty:

```
>>> df = pd.DataFrame({'A' : [np.nan]})
>>> df
    A
0 NaN
>>> df.empty
False
>>> df.dropna().empty
True
```

pandas.Panel.ftypes

`Panel.ftypes`

Return the ftypes (indication of sparse/dense and dtype) in this object.

pandas.Panel.iat

`Panel.iat`

Fast integer location scalar accessor.

Similarly to `iloc`, `iat` provides **integer** based lookups. You can also set using these indexers.

pandas.Panel.iloc

`Panel.iloc`

Purely integer-location based indexing for selection by position.

`.iloc[]` is primarily integer position based (from `0` to `length-1` of the axis), but may also be used with a boolean array.

Allowed inputs are:

- An integer, e.g. `5`.
- A list or array of integers, e.g. `[4, 3, 0]`.
- A slice object with ints, e.g. `1:7`.
- A boolean array.
- A `callable` function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

`.iloc` will raise `IndexError` if a requested indexer is out-of-bounds, except *slice* indexers which allow out-of-bounds indexing (this conforms with python/numpy *slice* semantics).

See more at *Selection by Position*

pandas.Panel.is_copy

`Panel.`**`is_copy`** = **None**

pandas.Panel.ix

`Panel.`**`ix`**

A primarily label-location based indexer, with integer position fallback.

`.ix[]` supports mixed integer and label based access. It is primarily label based, but will fall back to integer positional access unless the corresponding axis is of integer type.

`.ix` is the most general indexer and will support any of the inputs in `.loc` and `.iloc`. `.ix` also supports floating point label schemes. `.ix` is exceptionally useful when dealing with mixed positional and label based hierachical indexes.

However, when an axis is integer based, ONLY label based access and not positional access is supported. Thus, in such cases, it's usually better to be explicit and use `.iloc` or `.loc`.

See more at *Advanced Indexing*.

pandas.Panel.loc

`Panel.`**`loc`**

Purely label-location based indexer for selection by label.

`.loc[]` is primarily label based, but may also be used with a boolean array.

Allowed inputs are:

- A single label, e.g. `5` or `'a'`, (note that `5` is interpreted as a *label* of the index, and **never** as an integer position along the index).
- A list or array of labels, e.g. `['a', 'b', 'c']`.
- A slice object with labels, e.g. `'a':'f'` (note that contrary to usual python slices, **both** the start and the stop are included!).
- A boolean array.
- A `callable` function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

`.loc` will raise a `KeyError` when the items are not found.

See more at *Selection by Label*

pandas.Panel.ndim

`Panel.`**`ndim`**

Number of axes / array dimensions

pandas.Panel.shape

`Panel.shape`
Return a tuple of axis dimensions

pandas.Panel.size

`Panel.size`
number of elements in the NDFrame

pandas.Panel.values

`Panel.values`
Numpy representation of NDFrame

Notes

The dtype will be a lower-common-denominator dtype (implicit upcasting); that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen. Use this with care if you are not dealing with the blocks.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. If dtypes are int32 and uint8, dtype will be upcast to int32. By numpy.find_common_type convention, mixing int64 and uint64 will result in a flot64 dtype.

Methods

abs()	Return an object with absolute value taken–only applicable to objects that are all numeric.
add(other[, axis])	Addition of series and other, element-wise (binary operator *add*).
add_prefix(prefix)	Concatenate prefix string with panel items names.
add_suffix(suffix)	Concatenate suffix string with panel items names.
agg(func, *args, **kwargs)	
aggregate(func, *args, **kwargs)	
align(other, **kwargs)	
all([axis, bool_only, skipna, level])	Return whether all elements are True over requested axis
any([axis, bool_only, skipna, level])	Return whether any element is True over requested axis
apply(func[, axis])	Applies function along axis (or axes) of the Panel
as_blocks([copy])	Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.
as_matrix()	
asfreq(freq[, method, how, normalize, ...])	Convert TimeSeries to specified frequency.
asof(where[, subset])	The last row without any NaN is taken (or the last row without
astype(dtype[, copy, errors])	Cast a pandas object to a specified dtype `dtype`.
at_time(time[, asof])	Select values at particular time of day (e.g.

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`between_time`(start_time, end_time[, ...])	Select values between particular times of the day (e.g., 9:00-9:30 AM).
`bfill`([axis, inplace, limit, downcast])	Synonym for `DataFrame.fillna(method='bfill')`
`bool`()	Return the bool of a single element PandasObject.
`clip`([lower, upper, axis, inplace])	Trim values at input threshold(s).
`clip_lower`(threshold[, axis, inplace])	Return copy of the input with values below given value(s) truncated.
`clip_upper`(threshold[, axis, inplace])	Return copy of input with values above given value(s) truncated.
`compound`([axis, skipna, level])	Return the compound percentage of the values for the requested axis
`conform`(frame[, axis])	Conform input DataFrame to align with chosen axis pair.
`consolidate`([inplace])	DEPRECATED: consolidate will be an internal implementation only.
`convert_objects`([convert_dates, ...])	Deprecated.
`copy`([deep])	Make a copy of this objects data.
`count`([axis])	Return number of observations over requested axis.
`cummax`([axis, skipna])	Return cumulative max over requested axis.
`cummin`([axis, skipna])	Return cumulative minimum over requested axis.
`cumprod`([axis, skipna])	Return cumulative product over requested axis.
`cumsum`([axis, skipna])	Return cumulative sum over requested axis.
`describe`([percentiles, include, exclude])	Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding `NaN` values.
`div`(other[, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
`divide`(other[, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
`drop`([labels, axis, index, columns, level, ...])	Return new object with labels in requested axis removed.
`dropna`([axis, how, inplace])	Drop 2D from panel, holding passed axis constant
`eq`(other[, axis])	Wrapper for comparison method eq
`equals`(other)	Determines if two NDFrame objects contain the same elements.
`ffill`([axis, inplace, limit, downcast])	Synonym for `DataFrame.fillna(method='ffill')`
`fillna`([value, method, axis, inplace, ...])	Fill NA/NaN values using the specified method
`filter`([items, like, regex, axis])	Subset rows or columns of dataframe according to labels in the specified index.
`first`(offset)	Convenience method for subsetting initial periods of time series data based on a date offset.
`floordiv`(other[, axis])	Integer division of series and other, element-wise (binary operator *floordiv*).
`fromDict`(data[, intersect, orient, dtype])	Construct Panel from dict of DataFrame objects
`from_dict`(data[, intersect, orient, dtype])	Construct Panel from dict of DataFrame objects
`ge`(other[, axis])	Wrapper for comparison method ge
`get`(key[, default])	Get item from object for given key (DataFrame column, Panel slice, etc.).
`get_dtype_counts`()	Return the counts of dtypes in this object.

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get_ftype_counts()	Return the counts of ftypes in this object.
get_value(*args, **kwargs)	Quickly retrieve single value at (item, major, minor) location
get_values()	same as values (but handles sparseness conversions)
groupby(function[, axis])	Group data on given axis, returning GroupBy object
gt(other[, axis])	Wrapper for comparison method gt
head([n])	
infer_objects()	Attempt to infer better dtypes for object columns.
interpolate([method, axis, limit, inplace, ...])	Interpolate values according to different methods.
isna()	Return a boolean same-sized object indicating if the values are NA.
isnull()	Return a boolean same-sized object indicating if the values are NA.
iteritems()	Iterate over (label, values) on info axis
join(other[, how, lsuffix, rsuffix])	Join items with other Panel either on major and minor axes column
keys()	Get the 'info axis' (see Indexing for more)
kurt([axis, skipna, level, numeric_only])	Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0).
kurtosis([axis, skipna, level, numeric_only])	Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0).
last(offset)	Convenience method for subsetting final periods of time series data based on a date offset.
le(other[, axis])	Wrapper for comparison method le
lt(other[, axis])	Wrapper for comparison method lt
mad([axis, skipna, level])	Return the mean absolute deviation of the values for the requested axis
major_xs(key)	Return slice of panel along major axis
mask(cond[, other, inplace, axis, level, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.
max([axis, skipna, level, numeric_only])	This method returns the maximum of the values in the object.
mean([axis, skipna, level, numeric_only])	Return the mean of the values for the requested axis
median([axis, skipna, level, numeric_only])	Return the median of the values for the requested axis
min([axis, skipna, level, numeric_only])	This method returns the minimum of the values in the object.
minor_xs(key)	Return slice of panel along minor axis
mod(other[, axis])	Modulo of series and other, element-wise (binary operator *mod*).
mul(other[, axis])	Multiplication of series and other, element-wise (binary operator *mul*).
multiply(other[, axis])	Multiplication of series and other, element-wise (binary operator *mul*).
ne(other[, axis])	Wrapper for comparison method ne
notna()	Return a boolean same-sized object indicating if the values are not NA.
notnull()	Return a boolean same-sized object indicating if the values are not NA.

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pct_change([periods, fill_method, limit, freq])	Percent change over given number of periods.
pipe(func, *args, **kwargs)	Apply func(self, *args, **kwargs)
pop(item)	Return item and drop from frame.
pow(other[, axis])	Exponential power of series and other, element-wise (binary operator *pow*).
prod([axis, skipna, level, numeric_only])	Return the product of the values for the requested axis
product([axis, skipna, level, numeric_only])	Return the product of the values for the requested axis
radd(other[, axis])	Addition of series and other, element-wise (binary operator *radd*).
rank([axis, method, numeric_only, ...])	Compute numerical data ranks (1 through n) along axis.
rdiv(other[, axis])	Floating division of series and other, element-wise (binary operator *rtruediv*).
reindex(*args, **kwargs)	Conform Panel to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
reindex_axis(labels[, axis, method, level, ...])	Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
reindex_like(other[, method, copy, limit, ...])	Return an object with matching indices to myself.
rename([items, major_axis, minor_axis])	Alter axes input function or functions.
rename_axis(mapper[, axis, copy, inplace])	Alter the name of the index or columns.
replace([to_replace, value, inplace, limit, ...])	Replace values given in 'to_replace' with 'value'.
resample(rule[, how, axis, fill_method, ...])	Convenience method for frequency conversion and resampling of time series.
rfloordiv(other[, axis])	Integer division of series and other, element-wise (binary operator *rfloordiv*).
rmod(other[, axis])	Modulo of series and other, element-wise (binary operator *rmod*).
rmul(other[, axis])	Multiplication of series and other, element-wise (binary operator *rmul*).
round([decimals])	Round each value in Panel to a specified number of decimal places.
rpow(other[, axis])	Exponential power of series and other, element-wise (binary operator *rpow*).
rsub(other[, axis])	Subtraction of series and other, element-wise (binary operator *rsub*).
rtruediv(other[, axis])	Floating division of series and other, element-wise (binary operator *rtruediv*).
sample([n, frac, replace, weights, ...])	Returns a random sample of items from an axis of object.
select(crit[, axis])	Return data corresponding to axis labels matching criteria
sem([axis, skipna, level, ddof, numeric_only])	Return unbiased standard error of the mean over requested axis.
set_axis(labels[, axis, inplace])	Assign desired index to given axis
set_value(*args, **kwargs)	Quickly set single value at (item, major, minor) location
shift([periods, freq, axis])	Shift index by desired number of periods with an optional time freq.
skew([axis, skipna, level, numeric_only])	Return unbiased skew over requested axis
slice_shift([periods, axis])	Equivalent to *shift* without copying data.
sort_index([axis, level, ascending, ...])	Sort object by labels (along an axis)

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sort_values([by, axis, ascending, inplace, ...])	NOT IMPLEMENTED: do not call this method, as sorting values is not supported for Panel objects and will raise an error.
squeeze([axis])	Squeeze length 1 dimensions.
std([axis, skipna, level, ddof, numeric_only])	Return sample standard deviation over requested axis.
sub(other[, axis])	Subtraction of series and other, element-wise (binary operator *sub*).
subtract(other[, axis])	Subtraction of series and other, element-wise (binary operator *sub*).
sum([axis, skipna, level, numeric_only])	Return the sum of the values for the requested axis
swapaxes(axis1, axis2[, copy])	Interchange axes and swap values axes appropriately
swaplevel([i, j, axis])	Swap levels i and j in a MultiIndex on a particular axis
tail([n])	
take(indices[, axis, convert, is_copy])	Return the elements in the given *positional* indices along an axis.
toLong(*args, **kwargs)	
to_clipboard([excel, sep])	Attempt to write text representation of object to the system clipboard This can be pasted into Excel, for example.
to_dense()	Return dense representation of NDFrame (as opposed to sparse)
to_excel(path[, na_rep, engine])	Write each DataFrame in Panel to a separate excel sheet
to_frame([filter_observations])	Transform wide format into long (stacked) format as DataFrame whose columns are the Panel's items and whose index is a MultiIndex formed of the Panel's major and minor axes.
to_hdf(path_or_buf, key, **kwargs)	Write the contained data to an HDF5 file using HDFStore.
to_json([path_or_buf, orient, date_format, ...])	Convert the object to a JSON string.
to_latex([buf, columns, col_space, header, ...])	Render an object to a tabular environment table.
to_long(*args, **kwargs)	
to_msgpack([path_or_buf, encoding])	msgpack (serialize) object to input file path
to_pickle(path[, compression, protocol])	Pickle (serialize) object to input file path.
to_sparse(*args, **kwargs)	NOT IMPLEMENTED: do not call this method, as sparsifying is not supported for Panel objects and will raise an error.
to_sql(name, con[, flavor, schema, ...])	Write records stored in a DataFrame to a SQL database.
to_xarray()	Return an xarray object from the pandas object.
transpose(*args, **kwargs)	Permute the dimensions of the Panel
truediv(other[, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
truncate([before, after, axis, copy])	Truncates a sorted DataFrame/Series before and/or after some particular index value.
tshift([periods, freq, axis])	
tz_convert(tz[, axis, level, copy])	Convert tz-aware axis to target time zone.
tz_localize(tz[, axis, level, copy, ambiguous])	Localize tz-naive TimeSeries to target time zone.
update(other[, join, overwrite, ...])	Modify Panel in place using non-NA values from passed Panel, or object coercible to Panel.
var([axis, skipna, level, ddof, numeric_only])	Return unbiased variance over requested axis.

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where(cond[, other, inplace, axis, level, ...])	Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.
xs(key[, axis])	Return slice of panel along selected axis

pandas.Panel.abs

`Panel.abs()`

Return an object with absolute value taken–only applicable to objects that are all numeric.

Returns abs: type of caller

pandas.Panel.add

`Panel.add(other, axis=0)`

Addition of series and other, element-wise (binary operator *add*). Equivalent to `panel + other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

Panel.radd

pandas.Panel.add_prefix

`Panel.add_prefix(prefix)`

Concatenate prefix string with panel items names.

Parameters **prefix** : string

Returns **with_prefix** : type of caller

pandas.Panel.add_suffix

`Panel.add_suffix(suffix)`

Concatenate suffix string with panel items names.

Parameters **suffix** : string

Returns **with_suffix** : type of caller

pandas.Panel.agg

`Panel.agg(func, *args, **kwargs)`

pandas.Panel.aggregate

`Panel.aggregate(func, *args, **kwargs)`

pandas.Panel.align

`Panel.align(other, **kwargs)`

pandas.Panel.all

`Panel.all(axis=None, bool_only=None, skipna=None, level=None, **kwargs)`

Return whether all elements are True over requested axis

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

bool_only : boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

Returns **all** : DataFrame or Panel (if level specified)

pandas.Panel.any

`Panel.any(axis=None, bool_only=None, skipna=None, level=None, **kwargs)`

Return whether any element is True over requested axis

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

bool_only : boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

Returns **any** : DataFrame or Panel (if level specified)

pandas.Panel.apply

`Panel.apply(func, axis='major', **kwargs)`

Applies function along axis (or axes) of the Panel

Parameters **func** : function

Function to apply to each combination of 'other' axes e.g. if axis = 'items', the combination of major_axis/minor_axis will each be passed as a Series; if axis = ('items', 'major'), DataFrames of items & major axis will be passed

axis : {'items', 'minor', 'major'}, or {0, 1, 2}, or a tuple with two

axes

Additional keyword arguments will be passed as keywords to the function

Returns **result** : Panel, DataFrame, or Series

Examples

Returns a Panel with the square root of each element

```
>>> p = pd.Panel(np.random.rand(4,3,2))
>>> p.apply(np.sqrt)
```

Equivalent to p.sum(1), returning a DataFrame

```
>>> p.apply(lambda x: x.sum(), axis=1)
```

Equivalent to previous:

```
>>> p.apply(lambda x: x.sum(), axis='minor')
```

Return the shapes of each DataFrame over axis 2 (i.e the shapes of items x major), as a Series

```
>>> p.apply(lambda x: x.shape, axis=(0,1))
```

pandas.Panel.as_blocks

`Panel.as_blocks(copy=True)`

Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.

Deprecated since version 0.21.0.

NOTE: the dtypes of the blocks WILL BE PRESERVED HERE (unlike in as_matrix)

Parameters **copy** : boolean, default True

Returns **values** : a dict of dtype -> Constructor Types

pandas.Panel.as_matrix

`Panel.as_matrix()`

pandas.Panel.asfreq

`Panel.asfreq`(*freq*, *method=None*, *how=None*, *normalize=False*, *fill_value=None*)

Convert TimeSeries to specified frequency.

Optionally provide filling method to pad/backfill missing values.

Returns the original data conformed to a new index with the specified frequency. `resample` is more appropriate if an operation, such as summarization, is necessary to represent the data at the new frequency.

Parameters **freq** : DateOffset object, or string

method : {'backfill'/'bfill', 'pad'/'ffill'}, default None

Method to use for filling holes in reindexed Series (note this does not fill NaNs that already were present):

- 'pad' / 'ffill': propagate last valid observation forward to next valid
- 'backfill' / 'bfill': use NEXT valid observation to fill

how : {'start', 'end'}, default end

For PeriodIndex only, see PeriodIndex.asfreq

normalize : bool, default False

Whether to reset output index to midnight

fill_value: scalar, optional

Value to use for missing values, applied during upsampling (note this does not fill NaNs that already were present).

New in version 0.20.0.

Returns **converted** : type of caller

See also:

reindex

Notes

To learn more about the frequency strings, please see this link.

Examples

Start by creating a series with 4 one minute timestamps.

```
>>> index = pd.date_range('1/1/2000', periods=4, freq='T')
>>> series = pd.Series([0.0, None, 2.0, 3.0], index=index)
>>> df = pd.DataFrame({'s':series})
>>> df
                     s
2000-01-01 00:00:00    0.0
2000-01-01 00:01:00    NaN
2000-01-01 00:02:00    2.0
2000-01-01 00:03:00    3.0
```

Upsample the series into 30 second bins.

```
>>> df.asfreq(freq='30S')
                     s
2000-01-01 00:00:00  0.0
2000-01-01 00:00:30  NaN
2000-01-01 00:01:00  NaN
2000-01-01 00:01:30  NaN
2000-01-01 00:02:00  2.0
2000-01-01 00:02:30  NaN
2000-01-01 00:03:00  3.0
```

Upsample again, providing a `fill value`.

```
>>> df.asfreq(freq='30S', fill_value=9.0)
                     s
2000-01-01 00:00:00  0.0
2000-01-01 00:00:30  9.0
2000-01-01 00:01:00  NaN
2000-01-01 00:01:30  9.0
2000-01-01 00:02:00  2.0
2000-01-01 00:02:30  9.0
2000-01-01 00:03:00  3.0
```

Upsample again, providing a `method`.

```
>>> df.asfreq(freq='30S', method='bfill')
                     s
2000-01-01 00:00:00  0.0
2000-01-01 00:00:30  NaN
2000-01-01 00:01:00  NaN
2000-01-01 00:01:30  2.0
2000-01-01 00:02:00  2.0
2000-01-01 00:02:30  3.0
2000-01-01 00:03:00  3.0
```

pandas.Panel.asof

`Panel.asof`(*where*, *subset=None*)

The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)

New in version 0.19.0: For DataFrame

If there is no good value, NaN is returned for a Series a Series of NaN values for a DataFrame

Parameters **where** : date or array of dates

subset : string or list of strings, default None

if not None use these columns for NaN propagation

Returns where is scalar

- value or NaN if input is Series
- Series if input is DataFrame

where is Index: same shape object as input

See also:

merge_asof

Notes

Dates are assumed to be sorted Raises if this is not the case

pandas.Panel.astype

`Panel.astype`(*dtype*, *copy=True*, *errors='raise'*, ***kwargs*)

Cast a pandas object to a specified dtype `dtype`.

Parameters **dtype** : data type, or dict of column name -> data type

Use a numpy.dtype or Python type to cast entire pandas object to the same type. Alternatively, use {col: dtype, ...}, where col is a column label and dtype is a numpy.dtype or Python type to cast one or more of the DataFrame's columns to column-specific types.

copy : bool, default True.

Return a copy when `copy=True` (be very careful setting `copy=False` as changes to values then may propagate to other pandas objects).

errors : {'raise', 'ignore'}, default 'raise'.

Control raising of exceptions on invalid data for provided dtype.

- `raise` : allow exceptions to be raised
- `ignore` : suppress exceptions. On error return original object

New in version 0.20.0.

raise_on_error : raise on invalid input

Deprecated since version 0.20.0: Use `errors` instead

kwargs : keyword arguments to pass on to the constructor

Returns **casted** : type of caller

See also:

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

pandas.to_numeric Convert argument to a numeric type.

numpy.ndarray.astype Cast a numpy array to a specified type.

Examples

```
>>> ser = pd.Series([1, 2], dtype='int32')
>>> ser
0    1
1    2
dtype: int32
>>> ser.astype('int64')
```

```
0    1
1    2
dtype: int64
```

Convert to categorical type:

```
>>> ser.astype('category')
0    1
1    2
dtype: category
Categories (2, int64): [1, 2]
```

Convert to ordered categorical type with custom ordering:

```
>>> ser.astype('category', ordered=True, categories=[2, 1])
0    1
1    2
dtype: category
Categories (2, int64): [2 < 1]
```

Note that using `copy=False` and changing data on a new pandas object may propagate changes:

```
>>> s1 = pd.Series([1,2])
>>> s2 = s1.astype('int', copy=False)
>>> s2[0] = 10
>>> s1  # note that s1[0] has changed too
0    10
1     2
dtype: int64
```

pandas.Panel.at_time

`Panel.at_time`(*time*, *asof=False*)

Select values at particular time of day (e.g. 9:30AM).

Parameters **time** : datetime.time or string

Returns **values_at_time** : type of caller

pandas.Panel.between_time

`Panel.between_time`(*start_time*, *end_time*, *include_start=True*, *include_end=True*)

Select values between particular times of the day (e.g., 9:00-9:30 AM).

Parameters **start_time** : datetime.time or string

end_time : datetime.time or string

include_start : boolean, default True

include_end : boolean, default True

Returns **values_between_time** : type of caller

pandas.Panel.bfill

`Panel.bfill(axis=None, inplace=False, limit=None, downcast=None)`

Synonym for `DataFrame.fillna(method='bfill')`

pandas.Panel.bool

`Panel.bool()`

Return the bool of a single element PandasObject.

This must be a boolean scalar value, either True or False. Raise a ValueError if the PandasObject does not have exactly 1 element, or that element is not boolean

pandas.Panel.clip

`Panel.clip(lower=None, upper=None, axis=None, inplace=False, *args, **kwargs)`

Trim values at input threshold(s).

Parameters **lower** : float or array_like, default None

upper : float or array_like, default None

axis : int or string axis name, optional

Align object with lower and upper along the given axis.

inplace : boolean, default False

Whether to perform the operation in place on the data New in version 0.21.0.

Returns **clipped** : Series

Examples

```
>>> df
          0         1
0  0.335232 -1.256177
1 -1.367855  0.746646
2  0.027753 -1.176076
3  0.230930 -0.679613
4  1.261967  0.570967
```

```
>>> df.clip(-1.0, 0.5)
          0         1
0  0.335232 -1.000000
1 -1.000000  0.500000
2  0.027753 -1.000000
3  0.230930 -0.679613
4  0.500000  0.500000
```

```
>>> t
0   -0.3
1   -0.2
2   -0.1
```

```
3    0.0
4    0.1
dtype: float64
```

```
>>> df.clip(t, t + 1, axis=0)
          0         1
0  0.335232 -0.300000
1 -0.200000  0.746646
2  0.027753 -0.100000
3  0.230930  0.000000
4  1.100000  0.570967
```

pandas.Panel.clip_lower

`Panel.clip_lower`(*threshold*, *axis=None*, *inplace=False*)

Return copy of the input with values below given value(s) truncated.

Parameters **threshold** : float or array_like

axis : int or string axis name, optional

Align object with threshold along the given axis.

inplace : boolean, default False

Whether to perform the operation in place on the data New in version 0.21.0.

Returns **clipped** : same type as input

See also:

clip

pandas.Panel.clip_upper

`Panel.clip_upper`(*threshold*, *axis=None*, *inplace=False*)

Return copy of input with values above given value(s) truncated.

Parameters **threshold** : float or array_like

axis : int or string axis name, optional

Align object with threshold along the given axis.

inplace : boolean, default False

Whether to perform the operation in place on the data New in version 0.21.0.

Returns **clipped** : same type as input

See also:

clip

pandas.Panel.compound

`Panel.compound(axis=None, skipna=None, level=None)`

Return the compound percentage of the values for the requested axis

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **compounded** : DataFrame or Panel (if level specified)

pandas.Panel.conform

`Panel.conform(frame, axis='items')`

Conform input DataFrame to align with chosen axis pair.

Parameters **frame** : DataFrame

axis : {'items', 'major', 'minor'}

Axis the input corresponds to. E.g., if axis='major', then the frame's columns would be items, and the index would be values of the minor axis

Returns DataFrame

pandas.Panel.consolidate

`Panel.consolidate(inplace=False)`

DEPRECATED: consolidate will be an internal implementation only.

pandas.Panel.convert_objects

`Panel.convert_objects(convert_dates=True, convert_numeric=False, convert_timedeltas=True, copy=True)`

Deprecated. Attempt to infer better dtype for object columns

Parameters **convert_dates** : boolean, default True

If True, convert to date where possible. If 'coerce', force conversion, with unconvertible values becoming NaT.

convert_numeric : boolean, default False

If True, attempt to coerce to numbers (including strings), with unconvertible values becoming NaN.

convert_timedeltas : boolean, default True

If True, convert to timedelta where possible. If 'coerce', force conversion, with unconvertible values becoming NaT.

copy : boolean, default True

If True, return a copy even if no copy is necessary (e.g. no conversion was done). Note: This is meant for internal use, and should not be confused with inplace.

Returns **converted** : same as input object

See also:

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

pandas.to_numeric Return a fixed frequency timedelta index, with day as the default.

pandas.Panel.copy

`Panel.copy(deep=True)`

Make a copy of this objects data.

Parameters **deep** : boolean or string, default True

Make a deep copy, including a copy of the data and the indices. With `deep=False` neither the indices or the data are copied.

Note that when `deep=True` data is copied, actual python objects will not be copied recursively, only the reference to the object. This is in contrast to `copy.deepcopy` in the Standard Library, which recursively copies object data.

Returns **copy** : type of caller

pandas.Panel.count

`Panel.count(axis='major')`

Return number of observations over requested axis.

Parameters **axis** : {'items', 'major', 'minor'} or {0, 1, 2}

Returns **count** : DataFrame

pandas.Panel.cummax

`Panel.cummax(axis=None, skipna=True, *args, **kwargs)`

Return cumulative max over requested axis.

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cummax** : DataFrame

See also:

pandas.core.window.Expanding.max Similar functionality but ignores NaN values.

pandas.Panel.cummin

Panel.**cummin**(*axis=None*, *skipna=True*, **args*, ***kwargs*)

Return cumulative minimum over requested axis.

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cummin** : DataFrame

See also:

pandas.core.window.Expanding.min Similar functionality but ignores NaN values.

pandas.Panel.cumprod

Panel.**cumprod**(*axis=None*, *skipna=True*, **args*, ***kwargs*)

Return cumulative product over requested axis.

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cumprod** : DataFrame

See also:

pandas.core.window.Expanding.prod Similar functionality but ignores NaN values.

pandas.Panel.cumsum

Panel.**cumsum**(*axis=None*, *skipna=True*, **args*, ***kwargs*)

Return cumulative sum over requested axis.

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **cumsum** : DataFrame

See also:

pandas.core.window.Expanding.sum Similar functionality but ignores NaN values.

pandas.Panel.describe

`Panel.describe`(*percentiles=None*, *include=None*, *exclude=None*)

Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding `NaN` values.

Analyzes both numeric and object series, as well as `DataFrame` column sets of mixed data types. The output will vary depending on what is provided. Refer to the notes below for more detail.

Parameters **percentiles** : list-like of numbers, optional

The percentiles to include in the output. All should fall between 0 and 1. The default is `[.25, .5, .75]`, which returns the 25th, 50th, and 75th percentiles.

include : 'all', list-like of dtypes or None (default), optional

A white list of data types to include in the result. Ignored for `Series`. Here are the options:

- 'all' : All columns of the input will be included in the output.
- A list-like of dtypes : Limits the results to the provided data types. To limit the result to numeric types submit `numpy.number`. To limit it instead to object columns submit the `numpy.object` data type. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To select pandas categorical columns, use `'category'`
- None (default) : The result will include all numeric columns.

exclude : list-like of dtypes or None (default), optional,

A black list of data types to omit from the result. Ignored for `Series`. Here are the options:

- A list-like of dtypes : Excludes the provided data types from the result. To exclude numeric types submit `numpy.number`. To exclude object columns submit the data type `numpy.object`. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To exclude pandas categorical columns, use `'category'`
- None (default) : The result will exclude nothing.

Returns summary: Series/DataFrame of summary statistics

See also:

`DataFrame.count`, *`DataFrame.max`*, *`DataFrame.min`*, *`DataFrame.mean`*, *`DataFrame.std`*, *`DataFrame.select_dtypes`*

Notes

For numeric data, the result's index will include `count`, `mean`, `std`, `min`, `max` as well as lower, `50` and upper percentiles. By default the lower percentile is `25` and the upper percentile is `75`. The `50` percentile is the same as the median.

For object data (e.g. strings or timestamps), the result's index will include `count`, `unique`, `top`, and `freq`. The `top` is the most common value. The `freq` is the most common value's frequency. Timestamps also include the `first` and `last` items.

If multiple object values have the highest count, then the `count` and `top` results will be arbitrarily chosen from among those with the highest count.

For mixed data types provided via a `DataFrame`, the default is to return only an analysis of numeric columns. If the dataframe consists only of object and categorical data without any numeric columns, the default is to return an analysis of both the object and categorical columns. If `include='all'` is provided as an option, the result will include a union of attributes of each type.

The *include* and *exclude* parameters can be used to limit which columns in a `DataFrame` are analyzed for the output. The parameters are ignored when analyzing a `Series`.

Examples

Describing a numeric `Series`.

```
>>> s = pd.Series([1, 2, 3])
>>> s.describe()
count    3.0
mean     2.0
std      1.0
min      1.0
25%      1.5
50%      2.0
75%      2.5
max      3.0
```

Describing a categorical `Series`.

```
>>> s = pd.Series(['a', 'a', 'b', 'c'])
>>> s.describe()
count     4
unique    3
top       a
freq      2
dtype: object
```

Describing a timestamp `Series`.

```
>>> s = pd.Series([
...   np.datetime64("2000-01-01"),
...   np.datetime64("2010-01-01"),
...   np.datetime64("2010-01-01")
... ])
>>> s.describe()
count                       3
unique                      2
top       2010-01-01 00:00:00
freq                        2
first     2000-01-01 00:00:00
last      2010-01-01 00:00:00
dtype: object
```

Describing a `DataFrame`. By default only numeric fields are returned.

```
>>> df = pd.DataFrame({ 'object': ['a', 'b', 'c'],
...                     'numeric': [1, 2, 3],
...                     'categorical': pd.Categorical(['d','e','f'])
...                   })
>>> df.describe()
       numeric
```

```
count      3.0
mean       2.0
std        1.0
min        1.0
25%        1.5
50%        2.0
75%        2.5
max        3.0
```

Describing all columns of a `DataFrame` regardless of data type.

```
>>> df.describe(include='all')
        categorical  numeric object
count             3      3.0      3
unique            3      NaN      3
top               f      NaN      c
freq              1      NaN      1
mean            NaN      2.0    NaN
std             NaN      1.0    NaN
min             NaN      1.0    NaN
25%             NaN      1.5    NaN
50%             NaN      2.0    NaN
75%             NaN      2.5    NaN
max             NaN      3.0    NaN
```

Describing a column from a `DataFrame` by accessing it as an attribute.

```
>>> df.numeric.describe()
count    3.0
mean     2.0
std      1.0
min      1.0
25%      1.5
50%      2.0
75%      2.5
max      3.0
Name: numeric, dtype: float64
```

Including only numeric columns in a `DataFrame` description.

```
>>> df.describe(include=[np.number])
       numeric
count      3.0
mean       2.0
std        1.0
min        1.0
25%        1.5
50%        2.0
75%        2.5
max        3.0
```

Including only string columns in a `DataFrame` description.

```
>>> df.describe(include=[np.object])
       object
count       3
unique      3
```

```
top          c
freq         1
```

Including only categorical columns from a `DataFrame` description.

```
>>> df.describe(include=['category'])
       categorical
count            3
unique           3
top              f
freq             1
```

Excluding numeric columns from a `DataFrame` description.

```
>>> df.describe(exclude=[np.number])
       categorical object
count            3      3
unique           3      3
top              f      c
freq             1      1
```

Excluding object columns from a `DataFrame` description.

```
>>> df.describe(exclude=[np.object])
        categorical  numeric
count            3      3.0
unique           3      NaN
top              f      NaN
freq             1      NaN
mean           NaN      2.0
std            NaN      1.0
min            NaN      1.0
25%            NaN      1.5
50%            NaN      2.0
75%            NaN      2.5
max            NaN      3.0
```

pandas.Panel.div

`Panel.`**`div`**(*other*, *axis=0*)

Floating division of series and other, element-wise (binary operator *truediv*). Equivalent to `panel / other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.rtruediv`

pandas.Panel.divide

`Panel.divide(other, axis=0)`

Floating division of series and other, element-wise (binary operator *truediv*). Equivalent to `panel / other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

Panel.rtruediv

pandas.Panel.drop

`Panel.drop(labels=None, axis=0, index=None, columns=None, level=None, inplace=False, errors='raise')`

Return new object with labels in requested axis removed.

Parameters **labels** : single label or list-like

Index or column labels to drop.

axis : int or axis name

Whether to drop labels from the index (0 / 'index') or columns (1 / 'columns').

index, columns : single label or list-like

Alternative to specifying *axis* (`labels, axis=1` is equivalent to `columns=labels`).

New in version 0.21.0.

level : int or level name, default None

For MultiIndex

inplace : bool, default False

If True, do operation inplace and return None.

errors : {'ignore', 'raise'}, default 'raise'

If 'ignore', suppress error and existing labels are dropped.

Returns **dropped** : type of caller

Notes

Specifying both *labels* and *index* or *columns* will raise a ValueError.

Examples

```
>>> df = pd.DataFrame(np.arange(12).reshape(3,4),
                      columns=['A', 'B', 'C', 'D'])
>>> df
   A  B   C   D
0  0  1   2   3
1  4  5   6   7
2  8  9  10  11
```

Drop columns

```
>>> df.drop(['B', 'C'], axis=1)
   A   D
0  0   3
1  4   7
2  8  11
```

```
>>> df.drop(columns=['B', 'C'])
   A   D
0  0   3
1  4   7
2  8  11
```

Drop a row by index

```
>>> df.drop([0, 1])
   A  B   C   D
2  8  9  10  11
```

pandas.Panel.dropna

`Panel.dropna`(*axis=0*, *how='any'*, *inplace=False*)

Drop 2D from panel, holding passed axis constant

Parameters **axis** : int, default 0

Axis to hold constant. E.g. axis=1 will drop major_axis entries having a certain amount of NA data

how : {'all', 'any'}, default 'any'

'any': one or more values are NA in the DataFrame along the axis. For 'all' they all must be.

inplace : bool, default False

If True, do operation inplace and return None.

Returns **dropped** : Panel

pandas.Panel.eq

`Panel.eq`(*other*, *axis=None*)

Wrapper for comparison method eq

pandas.Panel.equals

`Panel.equals(other)`

Determines if two NDFrame objects contain the same elements. NaNs in the same location are considered equal.

pandas.Panel.ffill

`Panel.ffill(axis=None, inplace=False, limit=None, downcast=None)`

Synonym for `DataFrame.fillna(method='ffill')`

pandas.Panel.fillna

`Panel.fillna(value=None, method=None, axis=None, inplace=False, limit=None, downcast=None, **kwargs)`

Fill NA/NaN values using the specified method

Parameters **value** : scalar, dict, Series, or DataFrame

Value to use to fill holes (e.g. 0), alternately a dict/Series/DataFrame of values specifying which value to use for each index (for a Series) or column (for a DataFrame). (values not in the dict/Series/DataFrame will not be filled). This value cannot be a list.

method : {'backfill', 'bfill', 'pad', 'ffill', None}, default None

Method to use for filling holes in reindexed Series pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation to fill gap

axis : {0, 1, 2, 'items', 'major_axis', 'minor_axis'}

inplace : boolean, default False

If True, fill in place. Note: this will modify any other views on this object, (e.g. a no-copy slice for a column in a DataFrame).

limit : int, default None

If method is specified, this is the maximum number of consecutive NaN values to forward/backward fill. In other words, if there is a gap with more than this number of consecutive NaNs, it will only be partially filled. If method is not specified, this is the maximum number of entries along the entire axis where NaNs will be filled. Must be greater than 0 if not None.

downcast : dict, default is None

a dict of item->dtype of what to downcast if possible, or the string 'infer' which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns **filled** : Panel

See also:

`reindex`, `asfreq`

Examples

```
>>> df = pd.DataFrame([[np.nan, 2, np.nan, 0],
...                    [3, 4, np.nan, 1],
...                    [np.nan, np.nan, np.nan, 5],
...                    [np.nan, 3, np.nan, 4]],
...                    columns=list('ABCD'))
>>> df
     A    B   C  D
0  NaN  2.0 NaN  0
1  3.0  4.0 NaN  1
2  NaN  NaN NaN  5
3  NaN  3.0 NaN  4
```

Replace all NaN elements with 0s.

```
>>> df.fillna(0)
    A   B   C   D
0   0.0 2.0 0.0 0
1   3.0 4.0 0.0 1
2   0.0 0.0 0.0 5
3   0.0 3.0 0.0 4
```

We can also propagate non-null values forward or backward.

```
>>> df.fillna(method='ffill')
    A   B   C   D
0   NaN 2.0 NaN 0
1   3.0 4.0 NaN 1
2   3.0 4.0 NaN 5
3   3.0 3.0 NaN 4
```

Replace all NaN elements in column 'A', 'B', 'C', and 'D', with 0, 1, 2, and 3 respectively.

```
>>> values = {'A': 0, 'B': 1, 'C': 2, 'D': 3}
>>> df.fillna(value=values)
    A   B   C   D
0   0.0 2.0 2.0 0
1   3.0 4.0 2.0 1
2   0.0 1.0 2.0 5
3   0.0 3.0 2.0 4
```

Only replace the first NaN element.

```
>>> df.fillna(value=values, limit=1)
    A   B   C   D
0   0.0 2.0 2.0 0
1   3.0 4.0 NaN 1
2   NaN 1.0 NaN 5
3   NaN 3.0 NaN 4
```

pandas.Panel.filter

`Panel.filter`(*items=None*, *like=None*, *regex=None*, *axis=None*)

Subset rows or columns of dataframe according to labels in the specified index.

Note that this routine does not filter a dataframe on its contents. The filter is applied to the labels of the index.

Parameters **items** : list-like

List of info axis to restrict to (must not all be present)

like : string

Keep info axis where "arg in col == True"

regex : string (regular expression)

Keep info axis with re.search(regex, col) == True

axis : int or string axis name

The axis to filter on. By default this is the info axis, 'index' for Series, 'columns' for DataFrame

Returns same type as input object

See also:

pandas.DataFrame.loc

Notes

The `items`, `like`, and `regex` parameters are enforced to be mutually exclusive.

`axis` defaults to the info axis that is used when indexing with `[]`.

Examples

```
>>> df
one  two  three
mouse     1    2      3
rabbit    4    5      6
```

```
>>> # select columns by name
>>> df.filter(items=['one', 'three'])
one  three
mouse     1      3
rabbit    4      6
```

```
>>> # select columns by regular expression
>>> df.filter(regex='e$', axis=1)
one  three
mouse     1      3
rabbit    4      6
```

```
>>> # select rows containing 'bbi'
>>> df.filter(like='bbi', axis=0)
one  two  three
rabbit    4    5      6
```

pandas.Panel.first

`Panel.first(offset)`

Convenience method for subsetting initial periods of time series data based on a date offset.

Parameters **offset** : string, DateOffset, dateutil.relativedelta

Returns **subset** : type of caller

Examples

ts.first('10D') -> First 10 days

pandas.Panel.floordiv

`Panel.floordiv(other, axis=0)`

Integer division of series and other, element-wise (binary operator *floordiv*). Equivalent to `panel // other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.rfloordiv`

pandas.Panel.fromDict

classmethod `Panel.fromDict(data, intersect=False, orient='items', dtype=None)`

Construct Panel from dict of DataFrame objects

Parameters **data** : dict

{field : DataFrame}

intersect : boolean

Intersect indexes of input DataFrames

orient : {'items', 'minor'}, default 'items'

The "orientation" of the data. If the keys of the passed dict should be the items of the result panel, pass 'items' (default). Otherwise if the columns of the values of the passed DataFrame objects should be the items (which in the case of mixed-dtype data you should do), instead pass 'minor'

dtype : dtype, default None

Data type to force, otherwise infer

Returns Panel

pandas.Panel.from_dict

classmethod `Panel.from_dict(data, intersect=False, orient='items', dtype=None)`

Construct Panel from dict of DataFrame objects

Parameters **data** : dict

{field : DataFrame}

intersect : boolean

Intersect indexes of input DataFrames

orient : {'items', 'minor'}, default 'items'

The "orientation" of the data. If the keys of the passed dict should be the items of the result panel, pass 'items' (default). Otherwise if the columns of the values of the passed DataFrame objects should be the items (which in the case of mixed-dtype data you should do), instead pass 'minor'

dtype : dtype, default None

Data type to force, otherwise infer

Returns Panel

pandas.Panel.ge

`Panel.ge(other, axis=None)`

Wrapper for comparison method ge

pandas.Panel.get

`Panel.get(key, default=None)`

Get item from object for given key (DataFrame column, Panel slice, etc.). Returns default value if not found.

Parameters **key** : object

Returns **value** : type of items contained in object

pandas.Panel.get_dtype_counts

`Panel.get_dtype_counts()`

Return the counts of dtypes in this object.

pandas.Panel.get_ftype_counts

`Panel.get_ftype_counts()`

Return the counts of ftypes in this object.

pandas.Panel.get_value

`Panel.get_value(*args, **kwargs)`

Quickly retrieve single value at (item, major, minor) location

Deprecated since version 0.21.0.

Please use .at[] or .iat[] accessors.

Parameters **item** : item label (panel item)

major : major axis label (panel item row)

minor : minor axis label (panel item column)

takeable : interpret the passed labels as indexers, default False

Returns **value** : scalar value

pandas.Panel.get_values

`Panel.get_values()`

same as values (but handles sparseness conversions)

pandas.Panel.groupby

`Panel.groupby(function, axis='major')`

Group data on given axis, returning GroupBy object

Parameters **function** : callable

Mapping function for chosen access

axis : {'major', 'minor', 'items'}, default 'major'

Returns **grouped** : PanelGroupBy

pandas.Panel.gt

`Panel.gt(other, axis=None)`

Wrapper for comparison method gt

pandas.Panel.head

`Panel.head(n=5)`

pandas.Panel.infer_objects

`Panel.infer_objects()`

Attempt to infer better dtypes for object columns.

Attempts soft conversion of object-dtyped columns, leaving non-object and unconvertible columns unchanged. The inference rules are the same as during normal Series/DataFrame construction.

New in version 0.21.0.

Returns converted : same type as input object

See also:

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

pandas.to_numeric Convert argument to numeric typeR

Examples

```
>>> df = pd.DataFrame({"A": ["a", 1, 2, 3]})
>>> df = df.iloc[1:]
>>> df
   A
1  1
2  2
3  3
```

```
>>> df.dtypes
A    object
dtype: object
```

```
>>> df.infer_objects().dtypes
A    int64
dtype: object
```

pandas.Panel.interpolate

`Panel.`**`interpolate`**(*method='linear', axis=0, limit=None, inplace=False, limit_direction='forward', downcast=None, **kwargs*)

Interpolate values according to different methods.

Please note that only `method='linear'` is supported for DataFrames/Series with a MultiIndex.

Parameters method : {'linear', 'time', 'index', 'values', 'nearest', 'zero', 'slinear', 'quadratic', 'cubic', 'barycentric', 'krogh', 'polynomial', 'spline', 'piecewise_polynomial', 'from_derivatives', 'pchip', 'akima'}

- 'linear': ignore the index and treat the values as equally spaced. This is the only method supported on MultiIndexes. default
- 'time': interpolation works on daily and higher resolution data to interpolate given length of interval
- 'index', 'values': use the actual numerical values of the index
- 'nearest', 'zero', 'slinear', 'quadratic', 'cubic', 'barycentric', 'polynomial' is passed to `scipy.interpolate.interp1d`. Both 'polynomial' and 'spline' require that you also specify an *order* (int), e.g. df.interpolate(method='polynomial', order=4). These use the actual numerical values of the index.

- 'krogh', 'piecewise_polynomial', 'spline', 'pchip' and 'akima' are all wrappers around the scipy interpolation methods of similar names. These use the actual numerical values of the index. For more information on their behavior, see the scipy documentation and tutorial documentation
- 'from_derivatives' refers to BPoly.from_derivatives which replaces 'piecewise_polynomial' interpolation method in scipy 0.18

New in version 0.18.1: Added support for the 'akima' method Added interpolate method 'from_derivatives' which replaces 'piecewise_polynomial' in scipy 0.18; backwards-compatible with scipy < 0.18

axis : {0, 1}, default 0

- 0: fill column-by-column
- 1: fill row-by-row

limit : int, default None.

Maximum number of consecutive NaNs to fill. Must be greater than 0.

limit_direction : {'forward', 'backward', 'both'}, default 'forward'

If limit is specified, consecutive NaNs will be filled in this direction.

New in version 0.17.0.

inplace : bool, default False

Update the NDFrame in place if possible.

downcast : optional, 'infer' or None, defaults to None

Downcast dtypes if possible.

kwargs : keyword arguments to pass on to the interpolating function.

Returns Series or DataFrame of same shape interpolated at the NaNs

See also:

reindex, *replace*, *fillna*

Examples

Filling in NaNs

```
>>> s = pd.Series([0, 1, np.nan, 3])
>>> s.interpolate()
0    0
1    1
2    2
3    3
dtype: float64
```

pandas.Panel.isna

`Panel.isna()`

Return a boolean same-sized object indicating if the values are NA.

See also:

NDFrame.notna boolean inverse of isna

NDFrame.isnull alias of isna

isna top-level isna

pandas.Panel.isnull

`Panel.isnull()`

Return a boolean same-sized object indicating if the values are NA.

See also:

NDFrame.notna boolean inverse of isna

NDFrame.isnull alias of isna

isna top-level isna

pandas.Panel.iteritems

`Panel.iteritems()`

Iterate over (label, values) on info axis

This is index for Series, columns for DataFrame, major_axis for Panel, and so on.

pandas.Panel.join

`Panel.join(other, how='left', lsuffix='', rsuffix='')`

Join items with other Panel either on major and minor axes column

Parameters **other** : Panel or list of Panels

Index should be similar to one of the columns in this one

how : {'left', 'right', 'outer', 'inner'}

How to handle indexes of the two objects. Default: 'left' for joining on index, None otherwise * left: use calling frame's index * right: use input frame's index * outer: form union of indexes * inner: use intersection of indexes

lsuffix : string

Suffix to use from left frame's overlapping columns

rsuffix : string

Suffix to use from right frame's overlapping columns

Returns **joined** : Panel

pandas.Panel.keys

`Panel.keys()`

Get the 'info axis' (see Indexing for more)

This is index for Series, columns for DataFrame and major_axis for Panel.

pandas.Panel.kurt

`Panel.kurt(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **kurt** : DataFrame or Panel (if level specified)

pandas.Panel.kurtosis

`Panel.kurtosis(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

Return unbiased kurtosis over requested axis using Fisher's definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **kurt** : DataFrame or Panel (if level specified)

pandas.Panel.last

`Panel.last(offset)`

Convenience method for subsetting final periods of time series data based on a date offset.

Parameters **offset** : string, DateOffset, dateutil.relativedelta

Returns **subset** : type of caller

Examples

ts.last('5M') -> Last 5 months

pandas.Panel.le

`Panel.le(other, axis=None)`

Wrapper for comparison method le

pandas.Panel.lt

`Panel.lt(other, axis=None)`

Wrapper for comparison method lt

pandas.Panel.mad

`Panel.mad(axis=None, skipna=None, level=None)`

Return the mean absolute deviation of the values for the requested axis

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **mad** : DataFrame or Panel (if level specified)

pandas.Panel.major_xs

`Panel.major_xs(key)`

Return slice of panel along major axis

Parameters **key** : object

Major axis label

Returns **y** : DataFrame

index -> minor axis, columns -> items

Notes

major_xs is only for getting, not setting values.

MultiIndex Slicers is a generic way to get/set values on any level or levels and is a superset of major_xs functionality, see *MultiIndex Slicers*

pandas.Panel.mask

`Panel.mask(cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)`

Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.

Parameters **cond** : boolean NDFrame, array-like, or callable

Where *cond* is False, keep the original value. Where True, replace with corresponding value from *other*. If *cond* is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as cond.

other : scalar, NDFrame, or callable

Entries where *cond* is True are replaced with corresponding value from *other*. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as other.

inplace : boolean, default False

Whether to perform the operation in place on the data

axis : alignment axis if needed, default None

level : alignment level if needed, default None

errors : str, {'raise', 'ignore'}, default 'raise'

- `raise` : allow exceptions to be raised
- `ignore` : suppress exceptions. On error return original object

Note that currently this parameter won't affect the results and will always coerce to a suitable dtype.

try_cast : boolean, default False

try to cast the result back to the input type (if possible),

raise_on_error : boolean, default True

Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.

Returns **wh** : same type as caller

See also:

DataFrame.where()

Notes

The mask method is an application of the if-then idiom. For each element in the calling DataFrame, if `cond` is `False` the element is used; otherwise the corresponding element from the DataFrame `other` is used.

The signature for *DataFrame.where()* differs from `numpy.where()`. Roughly `df1.where(m, df2)` is equivalent to `np.where(m, df1, df2)`.

For further details and examples see the `mask` documentation in *indexing*.

Examples

```
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0    NaN
1    1.0
2    2.0
3    3.0
4    4.0
```

```
>>> s.mask(s > 0)
0    0.0
1    NaN
2    NaN
3    NaN
4    NaN
```

```
>>> s.where(s > 1, 10)
0    10.0
1    10.0
2    2.0
3    3.0
4    4.0
```

```
>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
   A  B
0  0 -1
1 -2  3
2 -4 -5
3  6 -7
4 -8  9
>>> df.where(m, -df) == np.where(m, df, -df)
      A     B
0  True  True
1  True  True
2  True  True
```

```
3  True  True
4  True  True
>>> df.where(m, -df) == df.mask(~m, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
```

pandas.Panel.max

`Panel.max(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

This method returns the maximum of the values in the object. If you want the *index* of the maximum, use `idxmax`. This is the equivalent of the `numpy.ndarray` method `argmax`.

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **max** : DataFrame or Panel (if level specified)

pandas.Panel.mean

`Panel.mean(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

Return the mean of the values for the requested axis

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **mean** : DataFrame or Panel (if level specified)

pandas.Panel.median

`Panel.median`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the median of the values for the requested axis

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **median** : DataFrame or Panel (if level specified)

pandas.Panel.min

`Panel.min`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

This method returns the minimum of the values in the object. If you want the *index* of the minimum, use `idxmin`. This is the equivalent of the `numpy.ndarray` method `argmin`.

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **min** : DataFrame or Panel (if level specified)

pandas.Panel.minor_xs

`Panel.minor_xs`(*key*)

Return slice of panel along minor axis

Parameters **key** : object

Minor axis label

Returns **y** : DataFrame

index -> major axis, columns -> items

Notes

minor_xs is only for getting, not setting values.

MultiIndex Slicers is a generic way to get/set values on any level or levels and is a superset of minor_xs functionality, see *MultiIndex Slicers*

pandas.Panel.mod

`Panel.mod(other, axis=0)`

Modulo of series and other, element-wise (binary operator *mod*). Equivalent to `panel % other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.rmod`

pandas.Panel.mul

`Panel.mul(other, axis=0)`

Multiplication of series and other, element-wise (binary operator *mul*). Equivalent to `panel * other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.rmul`

pandas.Panel.multiply

`Panel.multiply(other, axis=0)`

Multiplication of series and other, element-wise (binary operator *mul*). Equivalent to `panel * other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.rmul`

pandas.Panel.ne

`Panel.ne(other, axis=None)`

Wrapper for comparison method ne

pandas.Panel.notna

`Panel.notna()`

Return a boolean same-sized object indicating if the values are not NA.

See also:

NDFrame.isna boolean inverse of notna

NDFrame.notnull alias of notna

notna top-level notna

pandas.Panel.notnull

`Panel.notnull()`

Return a boolean same-sized object indicating if the values are not NA.

See also:

NDFrame.isna boolean inverse of notna

NDFrame.notnull alias of notna

notna top-level notna

pandas.Panel.pct_change

`Panel.pct_change(periods=1, fill_method='pad', limit=None, freq=None, **kwargs)`

Percent change over given number of periods.

Parameters **periods** : int, default 1

Periods to shift for forming percent change

fill_method : str, default 'pad'

How to handle NAs before computing percent changes

limit : int, default None

The number of consecutive NAs to fill before stopping

freq : DateOffset, timedelta, or offset alias string, optional

Increment to use from time series API (e.g. 'M' or BDay())

Returns **chg** : NDFrame

Notes

By default, the percentage change is calculated along the stat axis: 0, or `Index`, for `DataFrame` and 1, or `minor` for `Panel`. You can change this with the `axis` keyword argument.

pandas.Panel.pipe

`Panel.pipe`(*func*, **args*, ***kwargs*)

Apply func(self, *args, **kwargs)

Parameters **func** : function

function to apply to the NDFrame. `args`, and `kwargs` are passed into `func`. Alternatively a `(callable, data_keyword)` tuple where `data_keyword` is a string indicating the keyword of `callable` that expects the NDFrame.

args : iterable, optional

positional arguments passed into `func`.

kwargs : mapping, optional

a dictionary of keyword arguments passed into `func`.

Returns **object** : the return type of `func`.

See also:

`pandas.DataFrame.apply`, *`pandas.DataFrame.applymap`*, *`pandas.Series.map`*

Notes

Use `.pipe` when chaining together functions that expect Series, DataFrames or GroupBy objects. Instead of writing

```
>>> f(g(h(df), arg1=a), arg2=b, arg3=c)
```

You can write

```
>>> (df.pipe(h)
...     .pipe(g, arg1=a)
...     .pipe(f, arg2=b, arg3=c)
... )
```

If you have a function that takes the data as (say) the second argument, pass a tuple indicating which keyword expects the data. For example, suppose `f` takes its data as `arg2`:

```
>>> (df.pipe(h)
...     .pipe(g, arg1=a)
...     .pipe((f, 'arg2'), arg1=a, arg3=c)
...  )
```

pandas.Panel.pop

`Panel.pop(item)`

Return item and drop from frame. Raise KeyError if not found.

Parameters **item** : str

Column label to be popped

Returns **popped** : Series

Examples

```
>>> df = pd.DataFrame([('falcon', 'bird',    389.0),
...                    ('parrot', 'bird',     24.0),
...                    ('lion',   'mammal',   80.5),
...                    ('monkey', 'mammal', np.nan)],
...                   columns=('name', 'class', 'max_speed'))
>>> df
     name   class  max_speed
0  falcon    bird      389.0
1  parrot    bird       24.0
2    lion  mammal       80.5
3  monkey  mammal        NaN
```

```
>>> df.pop('class')
0      bird
1      bird
2    mammal
3    mammal
Name: class, dtype: object
```

```
>>> df
     name  max_speed
0  falcon      389.0
1  parrot       24.0
2    lion       80.5
3  monkey        NaN
```

pandas.Panel.pow

`Panel.pow(other, axis=0)`

Exponential power of series and other, element-wise (binary operator *pow*). Equivalent to `panel ** other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.rpow`

pandas.Panel.prod

`Panel.prod`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the product of the values for the requested axis

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **prod** : DataFrame or Panel (if level specified)

pandas.Panel.product

`Panel.product`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return the product of the values for the requested axis

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **prod** : DataFrame or Panel (if level specified)

pandas.Panel.radd

`Panel.radd`(*other*, *axis=0*)

Addition of series and other, element-wise (binary operator *radd*). Equivalent to `other + panel`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.add`

pandas.Panel.rank

`Panel.rank(axis=0, method='average', numeric_only=None, na_option='keep', ascending=True, pct=False)`

Compute numerical data ranks (1 through n) along axis. Equal values are assigned a rank that is the average of the ranks of those values

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

index to direct ranking

method : {'average', 'min', 'max', 'first', 'dense'}

- average: average rank of group
- min: lowest rank in group
- max: highest rank in group
- first: ranks assigned in order they appear in the array
- dense: like 'min', but rank always increases by 1 between groups

numeric_only : boolean, default None

Include only float, int, boolean data. Valid only for DataFrame or Panel objects

na_option : {'keep', 'top', 'bottom'}

- keep: leave NA values where they are
- top: smallest rank if ascending
- bottom: smallest rank if descending

ascending : boolean, default True

False for ranks by high (1) to low (N)

pct : boolean, default False

Computes percentage rank of data

Returns **ranks** : same type as caller

pandas.Panel.rdiv

`Panel.rdiv(other, axis=0)`

Floating division of series and other, element-wise (binary operator *rtruediv*). Equivalent to `other / panel`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.truediv`

pandas.Panel.reindex

`Panel.reindex(*args, **kwargs)`

Conform Panel to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index. A new object is produced unless the new index is equivalent to the current one and copy=False

Parameters items, major_axis, minor_axis : array-like, optional (should be specified using keywords)

New labels / index to conform to. Preferably an Index object to avoid duplicating data

method : {None, 'backfill'/'bfill', 'pad'/'ffill', 'nearest'}, optional

method to use for filling holes in reindexed DataFrame. Please note: this is only applicable to DataFrames/Series with a monotonically increasing/decreasing index.

- default: don't fill gaps
- pad / ffill: propagate last valid observation forward to next valid
- backfill / bfill: use next valid observation to fill gap
- nearest: use nearest valid observations to fill gap

copy : boolean, default True

Return a new object, even if the passed indexes are the same

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

fill_value : scalar, default np.NaN

Value to use for missing values. Defaults to NaN, but can be any "compatible" value

limit : int, default None

Maximum number of consecutive elements to forward or backward fill

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns reindexed : Panel

Examples

`DataFrame.reindex` supports two calling conventions

- `(index=index_labels, columns=column_labels, ...)`
- `(labels, axis={'index', 'columns'}, ...)`

We *highly* recommend using keyword arguments to clarify your intent.

Create a dataframe with some fictional data.

```
>>> index = ['Firefox', 'Chrome', 'Safari', 'IE10', 'Konqueror']
>>> df = pd.DataFrame({
...      'http_status': [200,200,404,404,301],
...      'response_time': [0.04, 0.02, 0.07, 0.08, 1.0]},
...       index=index)
>>> df
           http_status  response_time
Firefox            200           0.04
Chrome             200           0.02
Safari             404           0.07
IE10               404           0.08
Konqueror          301           1.00
```

Create a new index and reindex the dataframe. By default values in the new index that do not have corresponding records in the dataframe are assigned `NaN`.

```
>>> new_index= ['Safari', 'Iceweasel', 'Comodo Dragon', 'IE10',
...              'Chrome']
>>> df.reindex(new_index)
               http_status  response_time
Safari               404.0           0.07
Iceweasel              NaN            NaN
Comodo Dragon          NaN            NaN
IE10                 404.0           0.08
Chrome               200.0           0.02
```

We can fill in the missing values by passing a value to the keyword `fill_value`. Because the index is not monotonically increasing or decreasing, we cannot use arguments to the keyword `method` to fill the `NaN` values.

```
>>> df.reindex(new_index, fill_value=0)
               http_status  response_time
Safari                 404           0.07
Iceweasel                0           0.00
Comodo Dragon            0           0.00
IE10                   404           0.08
Chrome                 200           0.02
```

```
>>> df.reindex(new_index, fill_value='missing')
              http_status response_time
Safari                404          0.07
Iceweasel         missing       missing
Comodo Dragon     missing       missing
IE10                  404          0.08
Chrome                200          0.02
```

We can also reindex the columns.

```
>>> df.reindex(columns=['http_status', 'user_agent'])
           http_status  user_agent
Firefox            200         NaN
Chrome             200         NaN
Safari             404         NaN
IE10               404         NaN
Konqueror          301         NaN
```

Or we can use "axis-style" keyword arguments

```
>>> df.reindex(['http_status', 'user_agent'], axis="columns")
           http_status  user_agent
Firefox            200         NaN
Chrome             200         NaN
Safari             404         NaN
IE10               404         NaN
Konqueror          301         NaN
```

To further illustrate the filling functionality in `reindex`, we will create a dataframe with a monotonically increasing index (for example, a sequence of dates).

```
>>> date_index = pd.date_range('1/1/2010', periods=6, freq='D')
>>> df2 = pd.DataFrame({"prices": [100, 101, np.nan, 100, 89, 88]},
...                    index=date_index)
>>> df2
            prices
2010-01-01     100
2010-01-02     101
2010-01-03     NaN
2010-01-04     100
2010-01-05      89
2010-01-06      88
```

Suppose we decide to expand the dataframe to cover a wider date range.

```
>>> date_index2 = pd.date_range('12/29/2009', periods=10, freq='D')
>>> df2.reindex(date_index2)
            prices
2009-12-29     NaN
2009-12-30     NaN
2009-12-31     NaN
2010-01-01     100
2010-01-02     101
2010-01-03     NaN
2010-01-04     100
2010-01-05      89
2010-01-06      88
2010-01-07     NaN
```

The index entries that did not have a value in the original data frame (for example, '2009-12-29') are by default filled with `NaN`. If desired, we can fill in the missing values using one of several options.

For example, to backpropagate the last valid value to fill the `NaN` values, pass `bfill` as an argument to the `method` keyword.

```
>>> df2.reindex(date_index2, method='bfill')
            prices
2009-12-29     100
```

```
2009-12-30     100
2009-12-31     100
2010-01-01     100
2010-01-02     101
2010-01-03     NaN
2010-01-04     100
2010-01-05      89
2010-01-06      88
2010-01-07     NaN
```

Please note that the `NaN` value present in the original dataframe (at index value 2010-01-03) will not be filled by any of the value propagation schemes. This is because filling while reindexing does not look at dataframe values, but only compares the original and desired indexes. If you do want to fill in the `NaN` values present in the original dataframe, use the `fillna()` method.

See the *user guide* for more.

pandas.Panel.reindex_axis

`Panel.`**`reindex_axis`**(*labels*, *axis=0*, *method=None*, *level=None*, *copy=True*, *limit=None*, *fill_value=nan*)

Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index. A new object is produced unless the new index is equivalent to the current one and copy=False

Parameters **labels** : array-like

New labels / index to conform to. Preferably an Index object to avoid duplicating data

axis : {0, 1, 2, 'items', 'major_axis', 'minor_axis'}

method : {None, 'backfill'/'bfill', 'pad'/'ffill', 'nearest'}, optional

Method to use for filling holes in reindexed DataFrame:

- default: don't fill gaps
- pad / ffill: propagate last valid observation forward to next valid
- backfill / bfill: use next valid observation to fill gap
- nearest: use nearest valid observations to fill gap

copy : boolean, default True

Return a new object, even if the passed indexes are the same

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

limit : int, default None

Maximum number of consecutive elements to forward or backward fill

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **reindexed** : Panel

See also:

reindex, *reindex_like*

Examples

```
>>> df.reindex_axis(['A', 'B', 'C'], axis=1)
```

pandas.Panel.reindex_like

`Panel.`**`reindex_like`**(*other*, *method=None*, *copy=True*, *limit=None*, *tolerance=None*)

Return an object with matching indices to myself.

Parameters **other** : Object

method : string or None

copy : boolean, default True

limit : int, default None

Maximum number of consecutive labels to fill for inexact matches.

tolerance : optional

Maximum distance between labels of the other object and this object for inexact matches. Can be list-like.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **reindexed** : same as input

Notes

Like calling s.reindex(index=other.index, columns=other.columns, method=...)

pandas.Panel.rename

`Panel.`**`rename`**(*items=None*, *major_axis=None*, *minor_axis=None*, ***kwargs*)

Alter axes input function or functions. Function / dict values must be unique (1-to-1). Labels not contained in a dict / Series will be left as-is. Extra labels listed don't throw an error. Alternatively, change `Series.name` with a scalar value (Series only).

Parameters **items, major_axis, minor_axis** : scalar, list-like, dict-like or function, optional

Scalar or list-like will alter the `Series.name` attribute, and raise on DataFrame or Panel. dict-like or functions are transformations to apply to that axis' values

copy : boolean, default True

Also copy underlying data

inplace : boolean, default False

Whether to return a new Panel. If True then value of copy is ignored.

level : int or level name, default None

In case of a MultiIndex, only rename labels in the specified level.

Returns renamed : Panel (new object)

See also:

`pandas.NDFrame.rename_axis`

Examples

```
>>> s = pd.Series([1, 2, 3])
>>> s
0    1
1    2
2    3
dtype: int64
>>> s.rename("my_name") # scalar, changes Series.name
0    1
1    2
2    3
Name: my_name, dtype: int64
>>> s.rename(lambda x: x ** 2)  # function, changes labels
0    1
1    2
4    3
dtype: int64
>>> s.rename({1: 3, 2: 5})  # mapping, changes labels
0    1
3    2
5    3
dtype: int64
```

Since `DataFrame` doesn't have a `.name` attribute, only mapping-type arguments are allowed.

```
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.rename(2)
Traceback (most recent call last):
...
TypeError: 'int' object is not callable
```

`DataFrame.rename` supports two calling conventions

- `(index=index_mapper, columns=columns_mapper, ...)`
- `(mapper, axis={'index', 'columns'}, ...)`

We *highly* recommend using keyword arguments to clarify your intent.

```
>>> df.rename(index=str, columns={"A": "a", "B": "c"})
   a  c
0  1  4
1  2  5
2  3  6
```

```
>>> df.rename(index=str, columns={"A": "a", "C": "c"})
   a  B
0  1  4
1  2  5
2  3  6
```

Using axis-style parameters

```
>>> df.rename(str.lower, axis='columns')
   a  b
0  1  4
1  2  5
2  3  6
```

```
>>> df.rename({1: 2, 2: 4}, axis='index')
   A  B
0  1  4
2  2  5
4  3  6
```

See the *user guide* for more.

pandas.Panel.rename_axis

`Panel.`**`rename_axis`**(*mapper*, *axis=0*, *copy=True*, *inplace=False*)

Alter the name of the index or columns.

Parameters **mapper** : scalar, list-like, optional

Value to set the axis name attribute.

axis : int or string, default 0

copy : boolean, default True

Also copy underlying data

inplace : boolean, default False

Returns **renamed** : type of caller or None if inplace=True

See also:

pandas.Series.rename, *pandas.DataFrame.rename*, *pandas.Index.rename*

Notes

Prior to version 0.21.0, `rename_axis` could also be used to change the axis *labels* by passing a mapping or scalar. This behavior is deprecated and will be removed in a future version. Use `rename` instead.

Examples

```
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.rename_axis("foo")
     A  B
foo
0    1  4
1    2  5
2    3  6
```

```
>>> df.rename_axis("bar", axis="columns")
bar  A  B
0    1  4
1    2  5
2    3  6
```

pandas.Panel.replace

`Panel.replace`(*to_replace=None*, *value=None*, *inplace=False*, *limit=None*, *regex=False*, *method='pad'*, *axis=None*)

Replace values given in 'to_replace' with 'value'.

Parameters **to_replace** : str, regex, list, dict, Series, numeric, or None

- str or regex:
  - str: string exactly matching *to_replace* will be replaced with *value*
  - regex: regexs matching *to_replace* will be replaced with *value*
- list of str, regex, or numeric:
  - First, if *to_replace* and *value* are both lists, they **must** be the same length.
  - Second, if `regex=True` then all of the strings in **both** lists will be interpreted as regexs otherwise they will match directly. This doesn't matter much for *value* since there are only a few possible substitution regexes you can use.
  - str and regex rules apply as above.
- dict:
  - Nested dictionaries, e.g., {'a': {'b': nan}}, are read as follows: look in column 'a' for the value 'b' and replace it with nan. You can nest regular expressions as well. Note that column names (the top-level dictionary keys in a nested dictionary) **cannot** be regular expressions.
  - Keys map to column names and values map to substitution values. You can treat this as a special case of passing two lists except that you are specifying the column to search in.
- None:
  - This means that the `regex` argument must be a string, compiled regular expression, or list, dict, ndarray or Series of such elements. If *value* is also `None` then this **must** be a nested dictionary or `Series`.

See the examples section for examples of each of these.

value : scalar, dict, list, str, regex, default None

Value to use to fill holes (e.g. 0), alternately a dict of values specifying which value to use for each column (columns not in the dict will not be filled). Regular expressions, strings and lists or dicts of such objects are also allowed.

inplace : boolean, default False

If True, in place. Note: this will modify any other views on this object (e.g. a column from a DataFrame). Returns the caller if this is True.

limit : int, default None

Maximum size gap to forward or backward fill

regex : bool or same types as *to_replace*, default False

Whether to interpret *to_replace* and/or *value* as regular expressions. If this is `True` then *to_replace must* be a string. Otherwise, *to_replace* must be `None` because this parameter will be interpreted as a regular expression or a list, dict, or array of regular expressions.

method : string, optional, {'pad', 'ffill', 'bfill'}

The method to use when for replacement, when `to_replace` is a `list`.

Returns filled : NDFrame

Raises AssertionError

- If *regex* is not a `bool` and *to_replace* is not `None`.

TypeError

- If *to_replace* is a `dict` and *value* is not a `list`, `dict`, `ndarray`, or `Series`
- If *to_replace* is `None` and *regex* is not compilable into a regular expression or is a list, dict, ndarray, or Series.

ValueError

- If *to_replace* and *value* are `list` s or `ndarray` s, but they are not the same length.

See also:

`NDFrame.reindex`, `NDFrame.asfreq`, `NDFrame.fillna`

Notes

- Regex substitution is performed under the hood with `re.sub`. The rules for substitution for `re.sub` are the same.
- Regular expressions will only substitute on strings, meaning you cannot provide, for example, a regular expression matching floating point numbers and expect the columns in your frame that have a numeric dtype to be matched. However, if those floating point numbers *are* strings, then you can do this.
- This method has *a lot* of options. You are encouraged to experiment and play with this method to gain intuition about how it works.

pandas.Panel.resample

`Panel.resample(rule, how=None, axis=0, fill_method=None, closed=None, label=None, convention='start', kind=None, loffset=None, limit=None, base=0, on=None, level=None)`

Convenience method for frequency conversion and resampling of time series. Object must have a datetime-like index (DatetimeIndex, PeriodIndex, or TimedeltaIndex), or pass datetime-like values to the on or level keyword.

Parameters **rule** : string

the offset string or object representing target conversion

axis : int, optional, default 0

closed : {'right', 'left'}

Which side of bin interval is closed. The default is 'left' for all frequency offsets except for 'M', 'A', 'Q', 'BM', 'BA', 'BQ', and 'W' which all have a default of 'right'.

label : {'right', 'left'}

Which bin edge label to label bucket with. The default is 'left' for all frequency offsets except for 'M', 'A', 'Q', 'BM', 'BA', 'BQ', and 'W' which all have a default of 'right'.

convention : {'start', 'end', 's', 'e'}

For PeriodIndex only, controls whether to use the start or end of *rule*

loffset : timedelta

Adjust the resampled time labels

base : int, default 0

For frequencies that evenly subdivide 1 day, the "origin" of the aggregated intervals. For example, for '5min' frequency, base could range from 0 through 4. Defaults to 0

on : string, optional

For a DataFrame, column to use instead of index for resampling. Column must be datetime-like.

New in version 0.19.0.

level : string or int, optional

For a MultiIndex, level (name or number) to use for resampling. Level must be datetime-like.

New in version 0.19.0.

Notes

To learn more about the offset strings, please see this link.

Examples

Start by creating a series with 9 one minute timestamps.

```
>>> index = pd.date_range('1/1/2000', periods=9, freq='T')
>>> series = pd.Series(range(9), index=index)
>>> series
2000-01-01 00:00:00    0
2000-01-01 00:01:00    1
2000-01-01 00:02:00    2
2000-01-01 00:03:00    3
2000-01-01 00:04:00    4
2000-01-01 00:05:00    5
2000-01-01 00:06:00    6
2000-01-01 00:07:00    7
2000-01-01 00:08:00    8
Freq: T, dtype: int64
```

Downsample the series into 3 minute bins and sum the values of the timestamps falling into a bin.

```
>>> series.resample('3T').sum()
2000-01-01 00:00:00     3
2000-01-01 00:03:00    12
2000-01-01 00:06:00    21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but label each bin using the right edge instead of the left. Please note that the value in the bucket used as the label is not included in the bucket, which it labels. For example, in the original series the bucket `2000-01-01 00:03:00` contains the value 3, but the summed value in the resampled bucket with the label `2000-01-01 00:03:00` does not include 3 (if it did, the summed value would be 6, not 3). To include this value close the right side of the bin interval as illustrated in the example below this one.

```
>>> series.resample('3T', label='right').sum()
2000-01-01 00:03:00     3
2000-01-01 00:06:00    12
2000-01-01 00:09:00    21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but close the right side of the bin interval.

```
>>> series.resample('3T', label='right', closed='right').sum()
2000-01-01 00:00:00     0
2000-01-01 00:03:00     6
2000-01-01 00:06:00    15
2000-01-01 00:09:00    15
Freq: 3T, dtype: int64
```

Upsample the series into 30 second bins.

```
>>> series.resample('30S').asfreq()[0:5] #select first 5 rows
2000-01-01 00:00:00   0.0
2000-01-01 00:00:30   NaN
2000-01-01 00:01:00   1.0
2000-01-01 00:01:30   NaN
2000-01-01 00:02:00   2.0
Freq: 30S, dtype: float64
```

Upsample the series into 30 second bins and fill the `NaN` values using the `pad` method.

```
>>> series.resample('30S').pad()[0:5]
2000-01-01 00:00:00    0
2000-01-01 00:00:30    0
2000-01-01 00:01:00    1
2000-01-01 00:01:30    1
2000-01-01 00:02:00    2
Freq: 30S, dtype: int64
```

Upsample the series into 30 second bins and fill the `NaN` values using the `bfill` method.

```
>>> series.resample('30S').bfill()[0:5]
2000-01-01 00:00:00    0
2000-01-01 00:00:30    1
2000-01-01 00:01:00    1
2000-01-01 00:01:30    2
2000-01-01 00:02:00    2
Freq: 30S, dtype: int64
```

Pass a custom function via `apply`

```
>>> def custom_resampler(array_like):
...     return np.sum(array_like)+5
```

```
>>> series.resample('3T').apply(custom_resampler)
2000-01-01 00:00:00     8
2000-01-01 00:03:00    17
2000-01-01 00:06:00    26
Freq: 3T, dtype: int64
```

For a Series with a PeriodIndex, the keyword *convention* can be used to control whether to use the start or end of *rule*.

```
>>> s = pd.Series([1, 2], index=pd.period_range('2012-01-01',
                                                freq='A',
                                                periods=2))
>>> s
2012    1
2013    2
Freq: A-DEC, dtype: int64
```

Resample by month using 'start' *convention*. Values are assigned to the first month of the period.

```
>>> s.resample('M', convention='start').asfreq().head()
2012-01    1.0
2012-02    NaN
2012-03    NaN
2012-04    NaN
2012-05    NaN
Freq: M, dtype: float64
```

Resample by month using 'end' *convention*. Values are assigned to the last month of the period.

```
>>> s.resample('M', convention='end').asfreq()
2012-12    1.0
2013-01    NaN
2013-02    NaN
```

```
2013-03    NaN
2013-04    NaN
2013-05    NaN
2013-06    NaN
2013-07    NaN
2013-08    NaN
2013-09    NaN
2013-10    NaN
2013-11    NaN
2013-12    2.0
Freq: M, dtype: float64
```

For DataFrame objects, the keyword `on` can be used to specify the column instead of the index for resampling.

```
>>> df = pd.DataFrame(data=9*[range(4)], columns=['a', 'b', 'c', 'd'])
>>> df['time'] = pd.date_range('1/1/2000', periods=9, freq='T')
>>> df.resample('3T', on='time').sum()
                     a  b  c  d
time
2000-01-01 00:00:00  0  3  6  9
2000-01-01 00:03:00  0  3  6  9
2000-01-01 00:06:00  0  3  6  9
```

For a DataFrame with MultiIndex, the keyword `level` can be used to specify on level the resampling needs to take place.

```
>>> time = pd.date_range('1/1/2000', periods=5, freq='T')
>>> df2 = pd.DataFrame(data=10*[range(4)],
                       columns=['a', 'b', 'c', 'd'],
                       index=pd.MultiIndex.from_product([time, [1, 2]])
                       )
>>> df2.resample('3T', level=0).sum()
                     a  b   c   d
2000-01-01 00:00:00  0  6  12  18
2000-01-01 00:03:00  0  4   8  12
```

pandas.Panel.rfloordiv

`Panel.`**`rfloordiv`**(*other*, *axis=0*)

Integer division of series and other, element-wise (binary operator *rfloordiv*). Equivalent to `other // panel`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.floordiv`

pandas.Panel.rmod

`Panel.rmod(other, axis=0)`

Modulo of series and other, element-wise (binary operator *rmod*). Equivalent to `other % panel`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.mod`

pandas.Panel.rmul

`Panel.rmul(other, axis=0)`

Multiplication of series and other, element-wise (binary operator *rmul*). Equivalent to `other * panel`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.mul`

pandas.Panel.round

`Panel.round(decimals=0, *args, **kwargs)`

Round each value in Panel to a specified number of decimal places.

New in version 0.18.0.

Parameters **decimals** : int

Number of decimal places to round to (default: 0). If decimals is negative, it specifies the number of positions to the left of the decimal point.

Returns Panel object

See also:

`numpy.around`

pandas.Panel.rpow

`Panel.rpow(other, axis=0)`

Exponential power of series and other, element-wise (binary operator *rpow*). Equivalent to `other ** panel`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.pow`

pandas.Panel.rsub

`Panel.rsub(other, axis=0)`

Subtraction of series and other, element-wise (binary operator *rsub*). Equivalent to `other - panel`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.sub`

pandas.Panel.rtruediv

`Panel.rtruediv(other, axis=0)`

Floating division of series and other, element-wise (binary operator *rtruediv*). Equivalent to `other / panel`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.truediv`

pandas.Panel.sample

`Panel.sample(n=None, frac=None, replace=False, weights=None, random_state=None, axis=None)`

Returns a random sample of items from an axis of object.

Parameters **n** : int, optional

Number of items from axis to return. Cannot be used with *frac*. Default = 1 if *frac* = None.

frac : float, optional

Fraction of axis items to return. Cannot be used with *n*.

replace : boolean, optional

Sample with or without replacement. Default = False.

weights : str or ndarray-like, optional

Default 'None' results in equal probability weighting. If passed a Series, will align with target object on index. Index values in weights not found in sampled object will be ignored and index values in sampled object not in weights will be assigned weights of zero. If called on a DataFrame, will accept the name of a column when axis = 0. Unless weights are a Series, weights must be same length as axis being sampled. If weights do not sum to 1, they will be normalized to sum to 1. Missing values in the weights column will be treated as zero. inf and -inf values not allowed.

random_state : int or numpy.random.RandomState, optional

Seed for the random number generator (if int), or numpy RandomState object.

axis : int or string, optional

Axis to sample. Accepts axis number or name. Default is stat axis for given data type (0 for Series and DataFrames, 1 for Panels).

Returns A new object of same type as caller.

Examples

Generate an example `Series` and `DataFrame`:

```
>>> s = pd.Series(np.random.randn(50))
>>> s.head()
0   -0.038497
1    1.820773
2   -0.972766
3   -1.598270
4   -1.095526
dtype: float64
>>> df = pd.DataFrame(np.random.randn(50, 4), columns=list('ABCD'))
>>> df.head()
          A         B         C         D
0  0.016443 -2.318952 -0.566372 -1.028078
1 -1.051921  0.438836  0.658280 -0.175797
2 -1.243569 -0.364626 -0.215065  0.057736
3  1.768216  0.404512 -0.385604 -1.457834
4  1.072446 -1.137172  0.314194 -0.046661
```

Next extract a random sample from both of these objects...

3 random elements from the `Series`:

```
>>> s.sample(n=3)
27   -0.994689
55   -1.049016
67   -0.224565
dtype: float64
```

And a random 10% of the `DataFrame` with replacement:

```
>>> df.sample(frac=0.1, replace=True)
           A         B         C         D
35  1.981780  0.142106  1.817165 -0.290805
49 -1.336199 -0.448634 -0.789640  0.217116
```

```
40  0.823173 -0.078816  1.009536  1.015108
15  1.421154 -0.055301 -1.922594 -0.019696
6  -0.148339  0.832938  1.787600 -1.383767
```

pandas.Panel.select

`Panel.select`(*crit*, *axis=0*)

Return data corresponding to axis labels matching criteria

DEPRECATED: use df.loc[df.index.map(crit)] to select via labels

Parameters **crit** : function

To be called on each index (label). Should return True or False

axis : int

Returns **selection** : type of caller

pandas.Panel.sem

`Panel.sem`(*axis=None*, *skipna=None*, *level=None*, *ddof=1*, *numeric_only=None*, ***kwargs*)

Return unbiased standard error of the mean over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

ddof : int, default 1

degrees of freedom

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **sem** : DataFrame or Panel (if level specified)

pandas.Panel.set_axis

`Panel.set_axis`(*labels*, *axis=0*, *inplace=None*)

Assign desired index to given axis

Parameters **labels: list-like or Index**

The values for the new index

axis : int or string, default 0

inplace : boolean, default None

Whether to return a new NDFrame instance.

WARNING: inplace=None currently falls back to to True, but in a future version, will default to False. Use inplace=True explicitly rather than relying on the default.

.. versionadded:: 0.21.0

The signature is make consistent to the rest of the API. Previously, the "axis" and "labels" arguments were respectively the first and second positional arguments.

Returns **renamed** : NDFrame or None

An object of same type as caller if inplace=False, None otherwise.

See also:

`pandas.NDFrame.rename`

Examples

```
>>> s = pd.Series([1, 2, 3])
>>> s
0    1
1    2
2    3
dtype: int64
>>> s.set_axis(['a', 'b', 'c'], axis=0, inplace=False)
a    1
b    2
c    3
dtype: int64
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.set_axis(['a', 'b', 'c'], axis=0, inplace=False)
   A  B
a  1  4
b  2  5
c  3  6
>>> df.set_axis(['I', 'II'], axis=1, inplace=False)
   I  II
0  1   4
1  2   5
2  3   6
>>> df.set_axis(['i', 'ii'], axis=1, inplace=True)
>>> df
   i  ii
0  1   4
1  2   5
2  3   6
```

pandas.Panel.set_value

`Panel.set_value(*args, **kwargs)`

Quickly set single value at (item, major, minor) location

Deprecated since version 0.21.0.

Please use .at[] or .iat[] accessors.

Parameters **item** : item label (panel item)

major : major axis label (panel item row)

minor : minor axis label (panel item column)

value : scalar

takeable : interpret the passed labels as indexers, default False

Returns **panel** : Panel

If label combo is contained, will be reference to calling Panel, otherwise a new object

pandas.Panel.shift

`Panel.shift`(*periods=1*, *freq=None*, *axis='major'*)

Shift index by desired number of periods with an optional time freq. The shifted data will not include the dropped periods and the shifted axis will be smaller than the original. This is different from the behavior of DataFrame.shift()

Parameters **periods** : int

Number of periods to move, can be positive or negative

freq : DateOffset, timedelta, or time rule string, optional

axis : {'items', 'major', 'minor'} or {0, 1, 2}

Returns **shifted** : Panel

pandas.Panel.skew

`Panel.skew`(*axis=None*, *skipna=None*, *level=None*, *numeric_only=None*, ***kwargs*)

Return unbiased skew over requested axis Normalized by N-1

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **skew** : DataFrame or Panel (if level specified)

pandas.Panel.slice_shift

`Panel.slice_shift`(*periods=1*, *axis=0*)

Equivalent to *shift* without copying data. The shifted data will not include the dropped periods and the shifted axis will be smaller than the original.

Parameters **periods** : int

Number of periods to move, can be positive or negative

Returns **shifted** : same type as caller

Notes

While the *slice_shift* is faster than *shift*, you may pay for it later during alignment.

pandas.Panel.sort_index

`Panel.sort_index(axis=0, level=None, ascending=True, inplace=False, kind='quicksort', na_position='last', sort_remaining=True)`

Sort object by labels (along an axis)

Parameters **axis** : axes to direct sorting

level : int or level name or list of ints or list of level names

if not None, sort on values in specified index level(s)

ascending : boolean, default True

Sort ascending vs. descending

inplace : bool, default False

if True, perform operation in-place

kind : {'quicksort', 'mergesort', 'heapsort'}, default 'quicksort'

Choice of sorting algorithm. See also ndarray.np.sort for more information. *mergesort* is the only stable algorithm. For DataFrames, this option is only applied when sorting on a single column or label.

na_position : {'first', 'last'}, default 'last'

first puts NaNs at the beginning, *last* puts NaNs at the end. Not implemented for MultiIndex.

sort_remaining : bool, default True

if true and sorting by level and index is multilevel, sort by other levels too (in order) after sorting by specified level

Returns **sorted_obj** : NDFrame

pandas.Panel.sort_values

`Panel.sort_values(by=None, axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last')`

NOT IMPLEMENTED: do not call this method, as sorting values is not supported for Panel objects and will raise an error.

pandas.Panel.squeeze

`Panel.squeeze(axis=None)`

Squeeze length 1 dimensions.

Parameters **axis** : None, integer or string axis name, optional

The axis to squeeze if 1-sized.

New in version 0.20.0.

Returns scalar if 1-sized, else original object

pandas.Panel.std

`Panel.std(axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)`

Return sample standard deviation over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

ddof : int, default 1

degrees of freedom

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **std** : DataFrame or Panel (if level specified)

pandas.Panel.sub

`Panel.sub(other, axis=0)`

Subtraction of series and other, element-wise (binary operator *sub*). Equivalent to `panel - other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.rsub`

pandas.Panel.subtract

`Panel.subtract(other, axis=0)`

Subtraction of series and other, element-wise (binary operator *sub*). Equivalent to `panel - other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

Panel.rsub

pandas.Panel.sum

`Panel.sum(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

Return the sum of the values for the requested axis

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **sum** : DataFrame or Panel (if level specified)

pandas.Panel.swapaxes

`Panel.swapaxes(axis1, axis2, copy=True)`

Interchange axes and swap values axes appropriately

Returns **y** : same as input

pandas.Panel.swaplevel

`Panel.swaplevel(i=-2, j=-1, axis=0)`

Swap levels i and j in a MultiIndex on a particular axis

Parameters **i, j** : int, string (can be mixed)

Level of index to be swapped. Can pass level name as string.

Returns **swapped** : type of caller (new object)

Changed in version 0.18.1: The indexes `i` and `j` are now optional, and default to the two innermost levels of the index.

pandas.Panel.tail

`Panel.tail(n=5)`

pandas.Panel.take

`Panel.take(indices, axis=0, convert=None, is_copy=True, **kwargs)`

Return the elements in the given *positional* indices along an axis.

This means that we are not indexing according to actual values in the index attribute of the object. We are indexing according to the actual position of the element in the object.

Parameters **indices** : array-like

An array of ints indicating which positions to take.

axis : int, default 0

The axis on which to select elements. "0" means that we are selecting rows, "1" means that we are selecting columns, etc.

convert : bool, default True

Deprecated since version 0.21.0: In the future, negative indices will always be converted.

Whether to convert negative indices into positive ones. For example, `-1` would map to the `len(axis) - 1`. The conversions are similar to the behavior of indexing a regular Python list.

is_copy : bool, default True

Whether to return a copy of the original object or not.

Returns **taken** : type of caller

An array-like containing the elements taken from the object.

See also:

`numpy.ndarray.take`, `numpy.take`

Examples

```
>>> df = pd.DataFrame([('falcon', 'bird',    389.0),
                       ('parrot', 'bird',     24.0),
                       ('lion',   'mammal',   80.5),
                       ('monkey', 'mammal', np.nan)],
                      columns=('name', 'class', 'max_speed'),
                      index=[0, 2, 3, 1])
>>> df
     name   class  max_speed
0  falcon    bird      389.0
2  parrot    bird       24.0
```

```
3    lion  mammal       80.5
1  monkey  mammal        NaN
```

Take elements at positions 0 and 3 along the axis 0 (default).

Note how the actual indices selected (0 and 1) do not correspond to our selected indices 0 and 3. That's because we are selecting the 0th and 3rd rows, not rows whose indices equal 0 and 3.

```
>>> df.take([0, 3])
0  falcon    bird      389.0
1  monkey  mammal        NaN
```

Take elements at indices 1 and 2 along the axis 1 (column selection).

```
>>> df.take([1, 2], axis=1)
    class  max_speed
0    bird      389.0
2    bird       24.0
3  mammal       80.5
1  mammal        NaN
```

We may take elements using negative integers for positive indices, starting from the end of the object, just like with Python lists.

```
>>> df.take([-1, -2])
     name   class  max_speed
1  monkey  mammal        NaN
3    lion  mammal       80.5
```

pandas.Panel.toLong

`Panel.toLong`(**args*, ***kwargs*)

pandas.Panel.to_clipboard

`Panel.to_clipboard`(*excel=None*, *sep=None*, ***kwargs*)

Attempt to write text representation of object to the system clipboard This can be pasted into Excel, for example.

Parameters **excel** : boolean, defaults to True

if True, use the provided separator, writing in a csv format for allowing easy pasting into excel. if False, write a string representation of the object to the clipboard

sep : optional, defaults to tab

other keywords are passed to to_csv

Notes

Requirements for your platform

- Linux: xclip, or xsel (with gtk or PyQt4 modules)
- Windows: none

- OS X: none

pandas.Panel.to_dense

`Panel.to_dense()`

Return dense representation of NDFrame (as opposed to sparse)

pandas.Panel.to_excel

`Panel.to_excel(path, na_rep='', engine=None, **kwargs)`

Write each DataFrame in Panel to a separate excel sheet

Parameters **path** : string or ExcelWriter object

File path or existing ExcelWriter

na_rep : string, default ''

Missing data representation

engine : string, default None

write engine to use - you can also set this via the options `io.excel.xlsx.writer`, `io.excel.xls.writer`, and `io.excel.xlsm.writer`.

Other Parameters **float_format** : string, default None

Format string for floating point numbers

cols : sequence, optional

Columns to write

header : boolean or list of string, default True

Write out column names. If a list of string is given it is assumed to be aliases for the column names

index : boolean, default True

Write row names (index)

index_label : string or sequence, default None

Column label for index column(s) if desired. If None is given, and *header* and *index* are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

startrow : upper left cell row to dump data frame

startcol : upper left cell column to dump data frame

Notes

Keyword arguments (and na_rep) are passed to the `to_excel` method for each DataFrame written.

pandas.Panel.to_frame

`Panel.to_frame`(*filter_observations=True*)

Transform wide format into long (stacked) format as DataFrame whose columns are the Panel's items and whose index is a MultiIndex formed of the Panel's major and minor axes.

Parameters **filter_observations** : boolean, default True

Drop (major, minor) pairs without a complete set of observations across all the items

Returns **y** : DataFrame

pandas.Panel.to_hdf

`Panel.to_hdf`(*path_or_buf*, *key*, ***kwargs*)

Write the contained data to an HDF5 file using HDFStore.

Parameters **path_or_buf** : the path (string) or HDFStore object

key : string

identifier for the group in the store

mode : optional, {'a', 'w', 'r+'}, default 'a'

`'w'` Write; a new file is created (an existing file with the same name would be deleted).

`'a'` Append; an existing file is opened for reading and writing, and if the file does not exist it is created.

`'r+'` It is similar to `'a'`, but the file must already exist.

format : 'fixed(f)|table(t)', default is 'fixed'

fixed(f) [Fixed format] Fast writing/reading. Not-appendable, nor searchable

table(t) [Table format] Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data

append : boolean, default False

For Table formats, append the input data to the existing

data_columns : list of columns, or True, default None

List of columns to create as indexed data columns for on-disk queries, or True to use all columns. By default only the axes of the object are indexed. See here.

Applicable only to format='table'.

complevel : int, 0-9, default None

Specifies a compression level for data. A value of 0 disables compression.

complib : {'zlib', 'lzo', 'bzip2', 'blosc'}, default 'zlib'

Specifies the compression library to be used. As of v0.20.2 these additional compressors for Blosc are supported (default if no compressor specified: 'blosc:blosclz'): {'blosc:blosclz', 'blosc:lz4', 'blosc:lz4hc', 'blosc:snappy', 'blosc:zlib', 'blosc:zstd'}. Specifying a compression library which is not available issues a ValueError.

fletcher32 : bool, default False

If applying compression use the fletcher32 checksum

dropna : boolean, default False.

If true, ALL nan rows will not be written to store.

pandas.Panel.to_json

`Panel.to_json`(*path_or_buf=None*, *orient=None*, *date_format=None*, *double_precision=10*, *force_ascii=True*, *date_unit='ms'*, *default_handler=None*, *lines=False*, *compression=None*)

Convert the object to a JSON string.

Note NaN's and None will be converted to null and datetime objects will be converted to UNIX timestamps.

Parameters **path_or_buf** : the path or buffer to write the result string

if this is None, return the converted string

orient : string

- Series
  - default is 'index'
  - allowed values are: {'split','records','index'}
- DataFrame
  - default is 'columns'
  - allowed values are: {'split','records','index','columns','values'}
- The format of the JSON string
  - split : dict like {index -> [index], columns -> [columns], data -> [values]}
  - records : list like [{column -> value}, ... , {column -> value}]
  - index : dict like {index -> {column -> value}}
  - columns : dict like {column -> {index -> value}}
  - values : just the values array
  - table : dict like {'schema': {schema}, 'data': {data}} describing the data, and the data component is like `orient='records'`.

    Changed in version 0.20.0.

date_format : {None, 'epoch', 'iso'}

Type of date conversion. *epoch* = epoch milliseconds, *iso* = ISO8601. The default depends on the *orient*. For *orient='table'*, the default is *'iso'*. For all other orients, the default is *'epoch'*.

double_precision : The number of decimal places to use when encoding

floating point values, default 10.

force_ascii : force encoded string to be ASCII, default True.

date_unit : string, default 'ms' (milliseconds)

The time unit to encode to, governs timestamp and ISO8601 precision. One of 's', 'ms', 'us', 'ns' for second, millisecond, microsecond, and nanosecond respectively.

default_handler : callable, default None

Handler to call if object cannot otherwise be converted to a suitable format for JSON. Should receive a single argument which is the object to convert and return a serialisable object.

lines : boolean, default False

If 'orient' is 'records' write out line delimited json format. Will throw ValueError if incorrect 'orient' since others are not list like.

New in version 0.19.0.

compression : {None, 'gzip', 'bz2', 'xz'}

A string representing the compression to use in the output file, only used when the first argument is a filename

New in version 0.21.0.

Returns same type as input object with filtered info axis

See also:

`pd.read_json`

Examples

```
>>> df = pd.DataFrame([['a', 'b'], ['c', 'd']],
...                   index=['row 1', 'row 2'],
...                   columns=['col 1', 'col 2'])
>>> df.to_json(orient='split')
'{"columns":["col 1","col 2"],
  "index":["row 1","row 2"],
  "data":[["a","b"],["c","d"]]}'
```

Encoding/decoding a Dataframe using `'index'` formatted JSON:

```
>>> df.to_json(orient='index')
'{"row 1":{"col 1":"a","col 2":"b"},"row 2":{"col 1":"c","col 2":"d"}}'
```

Encoding/decoding a Dataframe using `'records'` formatted JSON. Note that index labels are not preserved with this encoding.

```
>>> df.to_json(orient='records')
'[{"col 1":"a","col 2":"b"},{"col 1":"c","col 2":"d"}]'
```

Encoding with Table Schema

```
>>> df.to_json(orient='table')
'{"schema": {"fields": [{"name": "index", "type": "string"},
                        {"name": "col 1", "type": "string"},
                        {"name": "col 2", "type": "string"}],
             "primaryKey": "index",
             "pandas_version": "0.20.0"},
```

```
  "data": [{"index": "row 1", "col 1": "a", "col 2": "b"},
           {"index": "row 2", "col 1": "c", "col 2": "d"}]}'
```

pandas.Panel.to_latex

`Panel.to_latex`(*buf=None*, *columns=None*, *col_space=None*, *header=True*, *index=True*, *na_rep='NaN'*, *formatters=None*, *float_format=None*, *sparsify=None*, *index_names=True*, *bold_rows=False*, *column_format=None*, *longtable=None*, *escape=None*, *encoding=None*, *decimal='.'*, *multicolumn=None*, *multicolumn_format=None*, *multirow=None*)

Render an object to a tabular environment table. You can splice this into a LaTeX document. Requires \usepackage{booktabs}.

Changed in version 0.20.2: Added to Series

to_latex-specific options:

bold_rows [boolean, default False] Make the row labels bold in the output

column_format [str, default None] The columns format as specified in LaTeX table format e.g 'rcl' for 3 columns

longtable [boolean, default will be read from the pandas config module] Default: False. Use a longtable environment instead of tabular. Requires adding a \usepackage{longtable} to your LaTeX preamble.

escape [boolean, default will be read from the pandas config module] Default: True. When set to False prevents from escaping latex special characters in column names.

encoding [str, default None] A string representing the encoding to use in the output file, defaults to 'ascii' on Python 2 and 'utf-8' on Python 3.

decimal [string, default '.'] Character recognized as decimal separator, e.g. ',' in Europe.

New in version 0.18.0.

multicolumn [boolean, default True] Use multicolumn to enhance MultiIndex columns. The default will be read from the config module.

New in version 0.20.0.

multicolumn_format [str, default 'l'] The alignment for multicolumns, similar to *column_format* The default will be read from the config module.

New in version 0.20.0.

multirow [boolean, default False] Use multirow to enhance MultiIndex rows. Requires adding a \usepackage{multirow} to your LaTeX preamble. Will print centered labels (instead of top-aligned) across the contained rows, separating groups via clines. The default will be read from the pandas config module.

New in version 0.20.0.

pandas.Panel.to_long

`Panel.to_long`(**args*, ***kwargs*)

pandas.Panel.to_msgpack

`Panel.to_msgpack`(*path_or_buf=None*, *encoding='utf-8'*, ***kwargs*)

msgpack (serialize) object to input file path

THIS IS AN EXPERIMENTAL LIBRARY and the storage format may not be stable until a future release.

Parameters **path** : string File path, buffer-like, or None

if None, return generated string

append : boolean whether to append to an existing msgpack

(default is False)

compress : type of compressor (zlib or blosc), default to None (no

compression)

pandas.Panel.to_pickle

`Panel.to_pickle`(*path*, *compression='infer'*, *protocol=4*)

Pickle (serialize) object to input file path.

Parameters **path** : string

File path

compression : {'infer', 'gzip', 'bz2', 'xz', None}, default 'infer'

a string representing the compression to use in the output file

New in version 0.20.0.

protocol : int

Int which indicates which protocol should be used by the pickler, default HIGHEST_PROTOCOL (see [1], paragraph 12.1.2). The possible values for this parameter depend on the version of Python. For Python 2.x, possible values are 0, 1, 2. For Python>=3.0, 3 is a valid value. For Python >= 3.4, 4 is a valid value.A negative value for the protocol parameter is equivalent to setting its value to HIGHEST_PROTOCOL.

New in version 0.21.0.

pandas.Panel.to_sparse

`Panel.to_sparse`(**args*, ***kwargs*)

NOT IMPLEMENTED: do not call this method, as sparsifying is not supported for Panel objects and will raise an error.

Convert to SparsePanel

pandas.Panel.to_sql

`Panel.to_sql`(*name*, *con*, *flavor=None*, *schema=None*, *if_exists='fail'*, *index=True*, *index_label=None*, *chunksize=None*, *dtype=None*)

Write records stored in a DataFrame to a SQL database.

Parameters **name** : string

Name of SQL table

con : SQLAlchemy engine or DBAPI2 connection (legacy mode)

Using SQLAlchemy makes it possible to use any DB supported by that library. If a DBAPI2 object, only sqlite3 is supported.

flavor : 'sqlite', default None

Deprecated since version 0.19.0: 'sqlite' is the only supported option if SQLAlchemy is not used.

schema : string, default None

Specify the schema (if database flavor supports this). If None, use default schema.

if_exists : {'fail', 'replace', 'append'}, default 'fail'

- fail: If table exists, do nothing.
- replace: If table exists, drop it, recreate it, and insert data.
- append: If table exists, insert data. Create if does not exist.

index : boolean, default True

Write DataFrame index as a column.

index_label : string or sequence, default None

Column label for index column(s). If None is given (default) and *index* is True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

chunksize : int, default None

If not None, then rows will be written in batches of this size at a time. If None, all rows will be written at once.

dtype : dict of column name to SQL type, default None

Optional specifying the datatype for columns. The SQL type should be a SQLAlchemy type, or a string for sqlite3 fallback connection.

pandas.Panel.to_xarray

`Panel.to_xarray()`

Return an xarray object from the pandas object.

Returns a DataArray for a Series

a Dataset for a DataFrame

a DataArray for higher dims

Notes

See the xarray docs

Examples

```
>>> df = pd.DataFrame({'A' : [1, 1, 2],
                       'B' : ['foo', 'bar', 'foo'],
                       'C' : np.arange(4.,7)})
>>> df
   A    B    C
0  1  foo  4.0
1  1  bar  5.0
2  2  foo  6.0
```

```
>>> df.to_xarray()
<xarray.Dataset>
Dimensions:  (index: 3)
Coordinates:
  * index    (index) int64 0 1 2
Data variables:
    A        (index) int64 1 1 2
    B        (index) object 'foo' 'bar' 'foo'
    C        (index) float64 4.0 5.0 6.0
```

```
>>> df = pd.DataFrame({'A' : [1, 1, 2],
                       'B' : ['foo', 'bar', 'foo'],
                       'C' : np.arange(4.,7)}
                     ).set_index(['B','A'])
>>> df
         C
B   A
foo 1  4.0
bar 1  5.0
foo 2  6.0
```

```
>>> df.to_xarray()
<xarray.Dataset>
Dimensions:  (A: 2, B: 2)
Coordinates:
  * B        (B) object 'bar' 'foo'
  * A        (A) int64 1 2
Data variables:
    C        (B, A) float64 5.0 nan 4.0 6.0
```

```
>>> p = pd.Panel(np.arange(24).reshape(4,3,2),
                 items=list('ABCD'),
                 major_axis=pd.date_range('20130101', periods=3),
                 minor_axis=['first', 'second'])
>>> p
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: A to D
Major_axis axis: 2013-01-01 00:00:00 to 2013-01-03 00:00:00
Minor_axis axis: first to second
```

```
>>> p.to_xarray()
<xarray.DataArray (items: 4, major_axis: 3, minor_axis: 2)>
array([[[ 0,  1],
        [ 2,  3],
```

```
        [ 4,  5]],
       [[ 6,  7],
        [ 8,  9],
        [10, 11]],
       [[12, 13],
        [14, 15],
        [16, 17]],
       [[18, 19],
        [20, 21],
        [22, 23]]])
Coordinates:
  * items       (items) object 'A' 'B' 'C' 'D'
  * major_axis  (major_axis) datetime64[ns] 2013-01-01 2013-01-02 2013-01-03␣
↪ # noqa
  * minor_axis  (minor_axis) object 'first' 'second'
```

pandas.Panel.transpose

`Panel.transpose`(**args*, ***kwargs*)

Permute the dimensions of the Panel

Parameters **args** : three positional arguments: each oneof

{0, 1, 2, 'items', 'major_axis', 'minor_axis'}

copy [boolean, default False] Make a copy of the underlying data. Mixed-dtype data will always result in a copy

Returns **y** : same as input

Examples

```
>>> p.transpose(2, 0, 1)
>>> p.transpose(2, 0, 1, copy=True)
```

pandas.Panel.truediv

`Panel.truediv`(*other*, *axis=0*)

Floating division of series and other, element-wise (binary operator *truediv*). Equivalent to `panel / other`.

Parameters **other** : DataFrame or Panel

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns Panel

See also:

`Panel.rtruediv`

pandas.Panel.truncate

`Panel.truncate`(*before=None*, *after=None*, *axis=None*, *copy=True*)

Truncates a sorted DataFrame/Series before and/or after some particular index value. If the axis contains only datetime values, before/after parameters are converted to datetime values.

Parameters **before** : date, string, int

Truncate all rows before this index value

after : date, string, int

Truncate all rows after this index value

axis : {0 or 'index', 1 or 'columns'}

- 0 or 'index': apply truncation to rows
- 1 or 'columns': apply truncation to columns

Default is stat axis for given data type (0 for Series and DataFrames, 1 for Panels)

copy : boolean, default is True,

return a copy of the truncated section

Returns **truncated** : type of caller

Examples

```
>>> df = pd.DataFrame({'A': ['a', 'b', 'c', 'd', 'e'],
...                    'B': ['f', 'g', 'h', 'i', 'j'],
...                    'C': ['k', 'l', 'm', 'n', 'o']},
...                    index=[1, 2, 3, 4, 5])
>>> df.truncate(before=2, after=4)
   A  B  C
2  b  g  l
3  c  h  m
4  d  i  n
>>> df = pd.DataFrame({'A': [1, 2, 3, 4, 5],
...                    'B': [6, 7, 8, 9, 10],
...                    'C': [11, 12, 13, 14, 15]},
...                    index=['a', 'b', 'c', 'd', 'e'])
>>> df.truncate(before='b', after='d')
   A  B   C
b  2  7  12
c  3  8  13
d  4  9  14
```

The index values in `truncate` can be datetimes or string dates. Note that `truncate` assumes a 0 value for any unspecified date component in a `DatetimeIndex` in contrast to slicing which returns any partially matching dates.

```
>>> dates = pd.date_range('2016-01-01', '2016-02-01', freq='s')
>>> df = pd.DataFrame(index=dates, data={'A': 1})
>>> df.truncate('2016-01-05', '2016-01-10').tail()
                     A
2016-01-09 23:59:56  1
2016-01-09 23:59:57  1
2016-01-09 23:59:58  1
```

```
2016-01-09 23:59:59  1
2016-01-10 00:00:00  1
>>> df.loc['2016-01-05':'2016-01-10', :].tail()
                     A
2016-01-10 23:59:55  1
2016-01-10 23:59:56  1
2016-01-10 23:59:57  1
2016-01-10 23:59:58  1
2016-01-10 23:59:59  1
```

pandas.Panel.tshift

`Panel.tshift`(*periods=1*, *freq=None*, *axis='major'*)

pandas.Panel.tz_convert

`Panel.tz_convert`(*tz*, *axis=0*, *level=None*, *copy=True*)

Convert tz-aware axis to target time zone.

Parameters **tz** : string or pytz.timezone object

axis : the axis to convert

level : int, str, default None

If axis ia a MultiIndex, convert a specific level. Otherwise must be None

copy : boolean, default True

Also make a copy of the underlying data

Raises **TypeError**

If the axis is tz-naive.

pandas.Panel.tz_localize

`Panel.tz_localize`(*tz*, *axis=0*, *level=None*, *copy=True*, *ambiguous='raise'*)

Localize tz-naive TimeSeries to target time zone.

Parameters **tz** : string or pytz.timezone object

axis : the axis to localize

level : int, str, default None

If axis ia a MultiIndex, localize a specific level. Otherwise must be None

copy : boolean, default True

Also make a copy of the underlying data

ambiguous : 'infer', bool-ndarray, 'NaT', default 'raise'

- 'infer' will attempt to infer fall dst-transition hours based on order
- bool-ndarray where True signifies a DST time, False designates a non-DST time (note that this flag is only applicable for ambiguous times)
- 'NaT' will return NaT where there are ambiguous times

- 'raise' will raise an AmbiguousTimeError if there are ambiguous times

infer_dst : boolean, default False

Deprecated since version 0.15.0: Attempt to infer fall dst-transition hours based on order

Raises **TypeError**

If the TimeSeries is tz-aware and tz is not None.

pandas.Panel.update

`Panel.update`(*other*, *join='left'*, *overwrite=True*, *filter_func=None*, *raise_conflict=False*)

Modify Panel in place using non-NA values from passed Panel, or object coercible to Panel. Aligns on items

Parameters **other** : Panel, or object coercible to Panel

join : How to join individual DataFrames

{'left', 'right', 'outer', 'inner'}, default 'left'

overwrite : boolean, default True

If True then overwrite values for common keys in the calling panel

filter_func : callable(1d-array) -> 1d-array<boolean>, default None

Can choose to replace values other than NA. Return True for values that should be updated

raise_conflict : bool

If True, will raise an error if a DataFrame and other both contain data in the same place.

pandas.Panel.var

`Panel.var`(*axis=None*, *skipna=None*, *level=None*, *ddof=1*, *numeric_only=None*, ***kwargs*)

Return unbiased variance over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters **axis** : {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

ddof : int, default 1

degrees of freedom

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **var** : DataFrame or Panel (if level specified)

pandas.Panel.where

`Panel.where(cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)`

Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.

Parameters **cond** : boolean NDFrame, array-like, or callable

Where *cond* is True, keep the original value. Where False, replace with corresponding value from *other*. If *cond* is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as cond.

other : scalar, NDFrame, or callable

Entries where *cond* is False are replaced with corresponding value from *other*. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn't check it).

New in version 0.18.1: A callable can be used as other.

inplace : boolean, default False

Whether to perform the operation in place on the data

axis : alignment axis if needed, default None

level : alignment level if needed, default None

errors : str, {'raise', 'ignore'}, default 'raise'

- `raise` : allow exceptions to be raised
- `ignore` : suppress exceptions. On error return original object

Note that currently this parameter won't affect the results and will always coerce to a suitable dtype.

try_cast : boolean, default False

try to cast the result back to the input type (if possible),

raise_on_error : boolean, default True

Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.

Returns **wh** : same type as caller

See also:

`DataFrame.mask()`

Notes

The where method is an application of the if-then idiom. For each element in the calling DataFrame, if `cond` is `True` the element is used; otherwise the corresponding element from the DataFrame `other` is used.

The signature for *`DataFrame.where()`* differs from `numpy.where()`. Roughly `df1.where(m, df2)` is equivalent to `np.where(m, df1, df2)`.

For further details and examples see the `where` documentation in *indexing*.

Examples

```
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0    NaN
1    1.0
2    2.0
3    3.0
4    4.0
```

```
>>> s.mask(s > 0)
0    0.0
1    NaN
2    NaN
3    NaN
4    NaN
```

```
>>> s.where(s > 1, 10)
0    10.0
1    10.0
2    2.0
3    3.0
4    4.0
```

```
>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
   A  B
0  0 -1
1 -2  3
2 -4 -5
3  6 -7
4 -8  9
>>> df.where(m, -df) == np.where(m, df, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
>>> df.where(m, -df) == df.mask(~m, -df)
      A     B
0  True  True
1  True  True
2  True  True
```

```
3  True  True
4  True  True
```

pandas.Panel.xs

`Panel.xs(key, axis=1)`

Return slice of panel along selected axis

Parameters **key** : object

Label

axis : {'items', 'major', 'minor}, default 1/'major'

Returns **y** : ndim(self)-1

Notes

xs is only for getting, not setting values.

MultiIndex Slicers is a generic way to get/set values on any level or levels and is a superset of xs functionality, see *MultiIndex Slicers*

34.5.2 Attributes and underlying data

Axes

- **items**: axis 0; each item corresponds to a DataFrame contained inside
- **major_axis**: axis 1; the index (rows) of each of the DataFrames
- **minor_axis**: axis 2; the columns of each of the DataFrames

`Panel.values`	Numpy representation of NDFrame
`Panel.axes`	Return index label(s) of the internal NDFrame
`Panel.ndim`	Number of axes / array dimensions
`Panel.size`	number of elements in the NDFrame
`Panel.shape`	Return a tuple of axis dimensions
`Panel.dtypes`	Return the dtypes in this object.
`Panel.ftypes`	Return the ftypes (indication of sparse/dense and dtype) in this object.
`Panel.get_dtype_counts`()	Return the counts of dtypes in this object.
`Panel.get_ftype_counts`()	Return the counts of ftypes in this object.

34.5.3 Conversion

`Panel.astype`(dtype[, copy, errors])	Cast a pandas object to a specified dtype `dtype`.
`Panel.copy`([deep])	Make a copy of this objects data.
`Panel.isna`()	Return a boolean same-sized object indicating if the values are NA.

Continued on next page

Table 34.76 – continued from previous page

`Panel.notna`()	Return a boolean same-sized object indicating if the values are not NA.

34.5.4 Getting and setting

`Panel.get_value`(*args, **kwargs)	Quickly retrieve single value at (item, major, minor) location
`Panel.set_value`(*args, **kwargs)	Quickly set single value at (item, major, minor) location

34.5.5 Indexing, iteration, slicing

`Panel.at`	Fast label-based scalar accessor
`Panel.iat`	Fast integer location scalar accessor.
`Panel.loc`	Purely label-location based indexer for selection by label.
`Panel.iloc`	Purely integer-location based indexing for selection by position.
`Panel.__iter__`()	Iterate over infor axis
`Panel.iteritems`()	Iterate over (label, values) on info axis
`Panel.pop`(item)	Return item and drop from frame.
`Panel.xs`(key[, axis])	Return slice of panel along selected axis
`Panel.major_xs`(key)	Return slice of panel along major axis
`Panel.minor_xs`(key)	Return slice of panel along minor axis

34.5.5.1 pandas.Panel.__iter__

`Panel.__iter__()`

Iterate over infor axis

For more information on `.at`, `.iat`, `.loc`, and `.iloc`, see the *indexing documentation*.

34.5.6 Binary operator functions

`Panel.add`(other[, axis])	Addition of series and other, element-wise (binary operator *add*).
`Panel.sub`(other[, axis])	Subtraction of series and other, element-wise (binary operator *sub*).
`Panel.mul`(other[, axis])	Multiplication of series and other, element-wise (binary operator *mul*).
`Panel.div`(other[, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
`Panel.truediv`(other[, axis])	Floating division of series and other, element-wise (binary operator *truediv*).
`Panel.floordiv`(other[, axis])	Integer division of series and other, element-wise (binary operator *floordiv*).
`Panel.mod`(other[, axis])	Modulo of series and other, element-wise (binary operator *mod*).

Continued on next page

Table 34.79 – continued from previous page

Panel.pow(other[, axis])	Exponential power of series and other, element-wise (binary operator *pow*).
Panel.radd(other[, axis])	Addition of series and other, element-wise (binary operator *radd*).
Panel.rsub(other[, axis])	Subtraction of series and other, element-wise (binary operator *rsub*).
Panel.rmul(other[, axis])	Multiplication of series and other, element-wise (binary operator *rmul*).
Panel.rdiv(other[, axis])	Floating division of series and other, element-wise (binary operator *rtruediv*).
Panel.rtruediv(other[, axis])	Floating division of series and other, element-wise (binary operator *rtruediv*).
Panel.rfloordiv(other[, axis])	Integer division of series and other, element-wise (binary operator *rfloordiv*).
Panel.rmod(other[, axis])	Modulo of series and other, element-wise (binary operator *rmod*).
Panel.rpow(other[, axis])	Exponential power of series and other, element-wise (binary operator *rpow*).
Panel.lt(other[, axis])	Wrapper for comparison method lt
Panel.gt(other[, axis])	Wrapper for comparison method gt
Panel.le(other[, axis])	Wrapper for comparison method le
Panel.ge(other[, axis])	Wrapper for comparison method ge
Panel.ne(other[, axis])	Wrapper for comparison method ne
Panel.eq(other[, axis])	Wrapper for comparison method eq

34.5.7 Function application, GroupBy

Panel.apply(func[, axis])	Applies function along axis (or axes) of the Panel
Panel.groupby(function[, axis])	Group data on given axis, returning GroupBy object

34.5.8 Computations / Descriptive Stats

Panel.abs()	Return an object with absolute value taken–only applicable to objects that are all numeric.
Panel.clip([lower, upper, axis, inplace])	Trim values at input threshold(s).
Panel.clip_lower(threshold[, axis, inplace])	Return copy of the input with values below given value(s) truncated.
Panel.clip_upper(threshold[, axis, inplace])	Return copy of input with values above given value(s) truncated.
Panel.count([axis])	Return number of observations over requested axis.
Panel.cummax([axis, skipna])	Return cumulative max over requested axis.
Panel.cummin([axis, skipna])	Return cumulative minimum over requested axis.
Panel.cumprod([axis, skipna])	Return cumulative product over requested axis.
Panel.cumsum([axis, skipna])	Return cumulative sum over requested axis.
Panel.max([axis, skipna, level, numeric_only])	This method returns the maximum of the values in the object.
Panel.mean([axis, skipna, level, numeric_only])	Return the mean of the values for the requested axis
Panel.median([axis, skipna, level, numeric_only])	Return the median of the values for the requested axis

Continued on next page

Table 34.81 – continued from previous page

Panel.min([axis, skipna, level, numeric_only])	This method returns the minimum of the values in the object.
Panel.pct_change([periods, fill_method, ...])	Percent change over given number of periods.
Panel.prod([axis, skipna, level, numeric_only])	Return the product of the values for the requested axis
Panel.sem([axis, skipna, level, ddof, ...])	Return unbiased standard error of the mean over requested axis.
Panel.skew([axis, skipna, level, numeric_only])	Return unbiased skew over requested axis
Panel.sum([axis, skipna, level, numeric_only])	Return the sum of the values for the requested axis
Panel.std([axis, skipna, level, ddof, ...])	Return sample standard deviation over requested axis.
Panel.var([axis, skipna, level, ddof, ...])	Return unbiased variance over requested axis.

34.5.9 Reindexing / Selection / Label manipulation

Panel.add_prefix(prefix)	Concatenate prefix string with panel items names.
Panel.add_suffix(suffix)	Concatenate suffix string with panel items names.
Panel.drop([labels, axis, index, columns, ...])	Return new object with labels in requested axis removed.
Panel.equals(other)	Determines if two NDFrame objects contain the same elements.
Panel.filter([items, like, regex, axis])	Subset rows or columns of dataframe according to labels in the specified index.
Panel.first(offset)	Convenience method for subsetting initial periods of time series data based on a date offset.
Panel.last(offset)	Convenience method for subsetting final periods of time series data based on a date offset.
Panel.reindex(*args, **kwargs)	Conform Panel to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
Panel.reindex_axis(labels[, axis, method, ...])	Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.
Panel.reindex_like(other[, method, copy, ...])	Return an object with matching indices to myself.
Panel.rename([items, major_axis, minor_axis])	Alter axes input function or functions.
Panel.sample([n, frac, replace, weights, ...])	Returns a random sample of items from an axis of object.
Panel.select(crit[, axis])	Return data corresponding to axis labels matching criteria
Panel.take(indices[, axis, convert, is_copy])	Return the elements in the given *positional* indices along an axis.
Panel.truncate([before, after, axis, copy])	Truncates a sorted DataFrame/Series before and/or after some particular index value.

34.5.10 Missing data handling

Panel.dropna([axis, how, inplace])	Drop 2D from panel, holding passed axis constant
Panel.fillna([value, method, axis, inplace, ...])	Fill NA/NaN values using the specified method

34.5.11 Reshaping, sorting, transposing

Panel.sort_index([axis, level, ascending, ...])	Sort object by labels (along an axis)

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Table 34.84 – continued from previous page

`Panel.swaplevel`([i, j, axis])	Swap levels i and j in a MultiIndex on a particular axis
`Panel.transpose`(*args, **kwargs)	Permute the dimensions of the Panel
`Panel.swapaxes`(axis1, axis2[, copy])	Interchange axes and swap values axes appropriately
`Panel.conform`(frame[, axis])	Conform input DataFrame to align with chosen axis pair.

34.5.12 Combining / joining / merging

`Panel.join`(other[, how, lsuffix, rsuffix])	Join items with other Panel either on major and minor axes column
`Panel.update`(other[, join, overwrite, ...])	Modify Panel in place using non-NA values from passed Panel, or object coercible to Panel.

34.5.13 Time series-related

`Panel.asfreq`(freq[, method, how, normalize, ...])	Convert TimeSeries to specified frequency.
`Panel.shift`([periods, freq, axis])	Shift index by desired number of periods with an optional time freq.
`Panel.resample`(rule[, how, axis, ...])	Convenience method for frequency conversion and resampling of time series.
`Panel.tz_convert`(tz[, axis, level, copy])	Convert tz-aware axis to target time zone.
`Panel.tz_localize`(tz[, axis, level, copy, ...])	Localize tz-naive TimeSeries to target time zone.

34.5.14 Serialization / IO / Conversion

`Panel.from_dict`(data[, intersect, orient, dtype])	Construct Panel from dict of DataFrame objects
`Panel.to_pickle`(path[, compression, protocol])	Pickle (serialize) object to input file path.
`Panel.to_excel`(path[, na_rep, engine])	Write each DataFrame in Panel to a separate excel sheet
`Panel.to_hdf`(path_or_buf, key, **kwargs)	Write the contained data to an HDF5 file using HDFStore.
`Panel.to_sparse`(*args, **kwargs)	NOT IMPLEMENTED: do not call this method, as sparsifying is not supported for Panel objects and will raise an error.
`Panel.to_frame`([filter_observations])	Transform wide format into long (stacked) format as DataFrame whose columns are the Panel's items and whose index is a MultiIndex formed of the Panel's major and minor axes.
`Panel.to_xarray`()	Return an xarray object from the pandas object.
`Panel.to_clipboard`([excel, sep])	Attempt to write text representation of object to the system clipboard This can be pasted into Excel, for example.

34.6 Index

Many of these methods or variants thereof are available on the objects that contain an index (Series/DataFrame) and those should most likely be used before calling these methods directly.

`Index`	Immutable ndarray implementing an ordered, sliceable set.

34.6.1 pandas.Index

class pandas.**Index**

Immutable ndarray implementing an ordered, sliceable set. The basic object storing axis labels for all pandas objects

Parameters **data** : array-like (1-dimensional)

dtype : NumPy dtype (default: object)

copy : bool

Make a copy of input ndarray

name : object

Name to be stored in the index

tupleize_cols : bool (default: True)

When True, attempt to create a MultiIndex if possible

See also:

RangeIndex Index implementing a monotonic integer range

CategoricalIndex Index of *Categorical* s.

MultiIndex A multi-level, or hierarchical, Index

IntervalIndex an Index of *Interval* s.

DatetimeIndex, *TimedeltaIndex*, *PeriodIndex*, *Int64Index*, *UInt64Index*, *Float64Index*

Notes

An Index instance can **only** contain hashable objects

Examples

```
>>> pd.Index([1, 2, 3])
Int64Index([1, 2, 3], dtype='int64')
```

```
>>> pd.Index(list('abc'))
Index(['a', 'b', 'c'], dtype='object')
```

Attributes

T	return the transpose, which is by definition self
asi8	
base	return the base object if the memory of the underlying data is
data	return the data pointer of the underlying data

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dtype	
dtype_str	
empty	
flags	
has_duplicates	
hasnans	
inferred_type	
is_all_dates	
is_monotonic	alias for is_monotonic_increasing (deprecated)
is_monotonic_decreasing	return if the index is monotonic decreasing (only equal or
is_monotonic_increasing	return if the index is monotonic increasing (only equal or
is_unique	
itemsize	return the size of the dtype of the item of the underlying data
name	
names	
nbytes	return the number of bytes in the underlying data
ndim	return the number of dimensions of the underlying data,
nlevels	
shape	return a tuple of the shape of the underlying data
size	return the number of elements in the underlying data
strides	return the strides of the underlying data
values	return the underlying data as an ndarray

34.6.1.1 pandas.Index.T

`Index.T`

return the transpose, which is by definition self

34.6.1.2 pandas.Index.asi8

`Index.asi8` = None

34.6.1.3 pandas.Index.base

`Index.base`

return the base object if the memory of the underlying data is shared

34.6.1.4 pandas.Index.data

`Index.data`

return the data pointer of the underlying data

34.6.1.5 pandas.Index.dtype

`Index.dtype` = None

34.6.1.6 pandas.Index.dtype_str

`Index.dtype_str` = None

34.6.1.7 pandas.Index.empty

`Index.empty`

34.6.1.8 pandas.Index.flags

`Index.flags`

34.6.1.9 pandas.Index.has_duplicates

`Index.has_duplicates`

34.6.1.10 pandas.Index.hasnans

`Index.hasnans` = None

34.6.1.11 pandas.Index.inferred_type

`Index.inferred_type` = None

34.6.1.12 pandas.Index.is_all_dates

`Index.is_all_dates` = None

34.6.1.13 pandas.Index.is_monotonic

`Index.is_monotonic`

alias for is_monotonic_increasing (deprecated)

34.6.1.14 pandas.Index.is_monotonic_decreasing

`Index.is_monotonic_decreasing`

return if the index is monotonic decreasing (only equal or decreasing) values.

Examples

```
>>> Index([3, 2, 1]).is_monotonic_decreasing
True
>>> Index([3, 2, 2]).is_monotonic_decreasing
True
>>> Index([3, 1, 2]).is_monotonic_decreasing
False
```

34.6.1.15 pandas.Index.is_monotonic_increasing

`Index.is_monotonic_increasing`

return if the index is monotonic increasing (only equal or increasing) values.

Examples

```
>>> Index([1, 2, 3]).is_monotonic_increasing
True
>>> Index([1, 2, 2]).is_monotonic_increasing
True
>>> Index([1, 3, 2]).is_monotonic_increasing
False
```

34.6.1.16 pandas.Index.is_unique

`Index.is_unique` = None

34.6.1.17 pandas.Index.itemsize

`Index.itemsize`

return the size of the dtype of the item of the underlying data

34.6.1.18 pandas.Index.name

`Index.name` = None

34.6.1.19 pandas.Index.names

`Index.names`

34.6.1.20 pandas.Index.nbytes

`Index.nbytes`

return the number of bytes in the underlying data

34.6.1.21 pandas.Index.ndim

`Index.ndim`

return the number of dimensions of the underlying data, by definition 1

34.6.1.22 pandas.Index.nlevels

`Index.nlevels`

34.6.1.23 pandas.Index.shape

`Index.shape`
return a tuple of the shape of the underlying data

34.6.1.24 pandas.Index.size

`Index.size`
return the number of elements in the underlying data

34.6.1.25 pandas.Index.strides

`Index.strides`
return the strides of the underlying data

34.6.1.26 pandas.Index.values

`Index.values`
return the underlying data as an ndarray

Methods

all(*args, **kwargs)	Return whether all elements are True
any(*args, **kwargs)	Return whether any element is True
append(other)	Append a collection of Index options together
argmax([axis])	return a ndarray of the maximum argument indexer
argmin([axis])	return a ndarray of the minimum argument indexer
argsort(*args, **kwargs)	Returns the indices that would sort the index and its underlying data.
asof(label)	For a sorted index, return the most recent label up to and including the passed label.
asof_locs(where, mask)	where : array of timestamps
astype(dtype[, copy])	Create an Index with values cast to dtypes.
contains(key)	return a boolean if this key is IN the index
copy([name, deep, dtype])	Make a copy of this object.
delete(loc)	Make new Index with passed location(-s) deleted
difference(other)	Return a new Index with elements from the index that are not in *other*.
drop(labels[, errors])	Make new Index with passed list of labels deleted
drop_duplicates([keep])	Return Index with duplicate values removed
dropna([how])	Return Index without NA/NaN values
duplicated([keep])	Return boolean np.ndarray denoting duplicate values
equals(other)	Determines if two Index objects contain the same elements.
factorize([sort, na_sentinel])	Encode the object as an enumerated type or categorical variable
fillna([value, downcast])	Fill NA/NaN values with the specified value
format([name, formatter])	Render a string representation of the Index

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Table 34.90 – continued from previous page

get_duplicates()	
get_indexer(target[, method, limit, tolerance])	Compute indexer and mask for new index given the current index.
get_indexer_for(target, **kwargs)	guaranteed return of an indexer even when non-unique
get_indexer_non_unique(target)	Compute indexer and mask for new index given the current index.
get_level_values(level)	Return an Index of values for requested level, equal to the length of the index.
get_loc(key[, method, tolerance])	Get integer location, slice or boolean mask for requested label.
get_slice_bound(label, side, kind)	Calculate slice bound that corresponds to given label.
get_value(series, key)	Fast lookup of value from 1-dimensional ndarray.
get_values()	return the underlying data as an ndarray
groupby(values)	Group the index labels by a given array of values.
holds_integer()	
identical(other)	Similar to equals, but check that other comparable attributes are
insert(loc, item)	Make new Index inserting new item at location.
intersection(other)	Form the intersection of two Index objects.
is_(other)	More flexible, faster check like `is` but that works through views
is_boolean()	
is_categorical()	
is_floating()	
is_integer()	
is_interval()	
is_lexsorted_for_tuple(tup)	
is_mixed()	
is_numeric()	
is_object()	
is_type_compatible(kind)	
isin(values[, level])	Compute boolean array of whether each index value is found in the passed set of values.
isna()	Detect missing values
isnull()	Detect missing values
item()	return the first element of the underlying data as a python
join(other[, how, level, return_indexers, sort])	*this is an internal non-public method*
map(mapper)	Apply mapper function to an index.
max()	The maximum value of the object
memory_usage([deep])	Memory usage of my values
min()	The minimum value of the object
notna()	Inverse of isna
notnull()	Inverse of isna
nunique([dropna])	Return number of unique elements in the object.
putmask(mask, value)	return a new Index of the values set with the mask
ravel([order])	return an ndarray of the flattened values of the underlying data
reindex(target[, method, level, limit, ...])	Create index with target's values (move/add/delete values as necessary)

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rename(name[, inplace])	Set new names on index.
repeat(repeats, *args, **kwargs)	Repeat elements of an Index.
reshape(*args, **kwargs)	NOT IMPLEMENTED: do not call this method, as reshaping is not supported for Index objects and will raise an error.
searchsorted(value[, side, sorter])	Find indices where elements should be inserted to maintain order.
set_names(names[, level, inplace])	Set new names on index.
set_value(arr, key, value)	Fast lookup of value from 1-dimensional ndarray.
shift([periods, freq])	Shift Index containing datetime objects by input number of periods and
slice_indexer([start, end, step, kind])	For an ordered Index, compute the slice indexer for input labels and
slice_locs([start, end, step, kind])	Compute slice locations for input labels.
sort(*args, **kwargs)	
sort_values([return_indexer, ascending])	Return sorted copy of Index
sortlevel([level, ascending, sort_remaining])	For internal compatibility with with the Index API
str	alias of `StringMethods`
summary([name])	
symmetric_difference(other[, result_name])	Compute the symmetric difference of two Index objects.
take(indices[, axis, allow_fill, fill_value])	return a new Index of the values selected by the indices
to_datetime([dayfirst])	DEPRECATED: use `pandas.to_datetime()` instead.
to_frame([index])	Create a DataFrame with a column containing the Index.
to_native_types([slicer])	Format specified values of *self* and return them.
to_series(**kwargs)	Create a Series with both index and values equal to the index keys
tolist()	Return a list of the values.
transpose(*args, **kwargs)	return the transpose, which is by definition self
union(other)	Form the union of two Index objects and sorts if possible.
unique()	Return unique values in the object.
value_counts([normalize, sort, ascending, ...])	Returns object containing counts of unique values.
view([cls])	
where(cond[, other])	New in version 0.19.0.

34.6.1.27 pandas.Index.all

`Index.all(*args, **kwargs)`

Return whether all elements are True

Parameters **All arguments to numpy.all are accepted.**

Returns **all** : bool or array_like (if axis is specified)

A single element array_like may be converted to bool.

34.6.1.28 pandas.Index.any

`Index.any(*args, **kwargs)`

Return whether any element is True

Parameters **All arguments to numpy.any are accepted.**

Returns **any** : bool or array_like (if axis is specified)

A single element array_like may be converted to bool.

34.6.1.29 pandas.Index.append

`Index.append(other)`

Append a collection of Index options together

Parameters **other** : Index or list/tuple of indices

Returns **appended** : Index

34.6.1.30 pandas.Index.argmax

`Index.argmax(axis=None)`

return a ndarray of the maximum argument indexer

See also:

`numpy.ndarray.argmax`

34.6.1.31 pandas.Index.argmin

`Index.argmin(axis=None)`

return a ndarray of the minimum argument indexer

See also:

`numpy.ndarray.argmin`

34.6.1.32 pandas.Index.argsort

`Index.argsort(*args, **kwargs)`

Returns the indices that would sort the index and its underlying data.

Returns **argsorted** : numpy array

See also:

`numpy.ndarray.argsort`

34.6.1.33 pandas.Index.asof

`Index.asof(label)`

For a sorted index, return the most recent label up to and including the passed label. Return NaN if not found.

See also:

`get_loc` asof is a thin wrapper around get_loc with method='pad'

34.6.1.34 pandas.Index.asof_locs

`Index.asof_locs(where, mask)`

where : array of timestamps mask : array of booleans where data is not NA

34.6.1.35 pandas.Index.astype

`Index.astype(dtype, copy=True)`

Create an Index with values cast to dtypes. The class of a new Index is determined by dtype. When conversion is impossible, a ValueError exception is raised.

Parameters **dtype** : numpy dtype or pandas type

copy : bool, default True

By default, astype always returns a newly allocated object. If copy is set to False and internal requirements on dtype are satisfied, the original data is used to create a new Index or the original Index is returned.

New in version 0.19.0.

34.6.1.36 pandas.Index.contains

`Index.contains(key)`

return a boolean if this key is IN the index

Parameters **key** : object

Returns boolean

34.6.1.37 pandas.Index.copy

`Index.copy(name=None, deep=False, dtype=None, **kwargs)`

Make a copy of this object. Name and dtype sets those attributes on the new object.

Parameters **name** : string, optional

deep : boolean, default False

dtype : numpy dtype or pandas type

Returns **copy** : Index

Notes

In most cases, there should be no functional difference from using `deep`, but if `deep` is passed it will attempt to deepcopy.

34.6.1.38 pandas.Index.delete

`Index.delete(loc)`

Make new Index with passed location(-s) deleted

Returns **new_index** : Index

34.6.1.39 pandas.Index.difference

`Index.difference(other)`

Return a new Index with elements from the index that are not in *other*.

This is the set difference of two Index objects. It's sorted if sorting is possible.

Parameters **other** : Index or array-like

Returns **difference** : Index

Examples

```
>>> idx1 = pd.Index([1, 2, 3, 4])
>>> idx2 = pd.Index([3, 4, 5, 6])
>>> idx1.difference(idx2)
Int64Index([1, 2], dtype='int64')
```

34.6.1.40 pandas.Index.drop

`Index.drop(labels, errors='raise')`

Make new Index with passed list of labels deleted

Parameters **labels** : array-like

errors : {'ignore', 'raise'}, default 'raise'

If 'ignore', suppress error and existing labels are dropped.

Returns **dropped** : Index

34.6.1.41 pandas.Index.drop_duplicates

`Index.drop_duplicates(keep='first')`

Return Index with duplicate values removed

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Drop duplicates except for the first occurrence.
- `last` : Drop duplicates except for the last occurrence.
- False : Drop all duplicates.

Returns **deduplicated** : Index

34.6.1.42 pandas.Index.dropna

`Index.dropna(how='any')`

Return Index without NA/NaN values

Parameters **how** : {'any', 'all'}, default 'any'

If the Index is a MultiIndex, drop the value when any or all levels are NaN.

Returns **valid** : Index

34.6.1.43 pandas.Index.duplicated

`Index.duplicated(keep='first')`

Return boolean np.ndarray denoting duplicate values

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Mark duplicates as `True` except for the first occurrence.
- `last` : Mark duplicates as `True` except for the last occurrence.
- False : Mark all duplicates as `True`.

Returns **duplicated** : np.ndarray

34.6.1.44 pandas.Index.equals

`Index.equals(other)`

Determines if two Index objects contain the same elements.

34.6.1.45 pandas.Index.factorize

`Index.factorize(sort=False, na_sentinel=-1)`

Encode the object as an enumerated type or categorical variable

Parameters **sort** : boolean, default False

Sort by values

na_sentinel: int, default -1

Value to mark "not found"

Returns **labels** : the indexer to the original array

uniques : the unique Index

34.6.1.46 pandas.Index.fillna

`Index.fillna(value=None, downcast=None)`

Fill NA/NaN values with the specified value

Parameters **value** : scalar

Scalar value to use to fill holes (e.g. 0). This value cannot be a list-likes.

downcast : dict, default is None

a dict of item->dtype of what to downcast if possible, or the string 'infer' which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns **filled** : %(klass)s

34.6.1.47 pandas.Index.format

`Index.format(name=False, formatter=None, **kwargs)`

Render a string representation of the Index

34.6.1.48 pandas.Index.get_duplicates

`Index.get_duplicates()`

34.6.1.49 pandas.Index.get_indexer

`Index.get_indexer(target, method=None, limit=None, tolerance=None)`

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

Parameters **target** : Index

method : {None, 'pad'/'ffill', 'backfill'/'bfill', 'nearest'}, optional

- default: exact matches only.
- pad / ffill: find the PREVIOUS index value if no exact match.
- backfill / bfill: use NEXT index value if no exact match
- nearest: use the NEAREST index value if no exact match. Tied distances are broken by preferring the larger index value.

limit : int, optional

Maximum number of consecutive labels in `target` to match for inexact matches.

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **indexer** : ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

Examples

```
>>> indexer = index.get_indexer(new_index)
>>> new_values = cur_values.take(indexer)
```

34.6.1.50 pandas.Index.get_indexer_for

`Index.get_indexer_for(target, **kwargs)`

guaranteed return of an indexer even when non-unique This dispatches to get_indexer or get_indexer_nonunique as appropriate

34.6.1.51 pandas.Index.get_indexer_non_unique

`Index.get_indexer_non_unique(target)`

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

Parameters **target** : Index

Returns **indexer** : ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

missing : ndarray of int

An indexer into the target of the values not found. These correspond to the -1 in the indexer array

34.6.1.52 pandas.Index.get_level_values

`Index.get_level_values(level)`

Return an Index of values for requested level, equal to the length of the index.

Parameters **level** : int or str

`level` is either the integer position of the level in the MultiIndex, or the name of the level.

Returns **values** : Index

`self`, as there is only one level in the Index.

See also:

pandas.MultiIndex.get_level_values get values for a level of a MultiIndex

34.6.1.53 pandas.Index.get_loc

`Index.get_loc(key, method=None, tolerance=None)`

Get integer location, slice or boolean mask for requested label.

Parameters **key** : label

method : {None, 'pad'/'ffill', 'backfill'/'bfill', 'nearest'}, optional

- default: exact matches only.
- pad / ffill: find the PREVIOUS index value if no exact match.
- backfill / bfill: use NEXT index value if no exact match
- nearest: use the NEAREST index value if no exact match. Tied distances are broken by preferring the larger index value.

tolerance : optional

Maximum distance from index value for inexact matches. The value of the index at the matching location most satisfy the equation `abs(index[loc] - key) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list,

tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **loc** : int if unique index, slice if monotonic index, else mask

Examples

```
>>> unique_index = pd.Index(list('abc'))
>>> unique_index.get_loc('b')
1
```

```
>>> monotonic_index = pd.Index(list('abbc'))
>>> monotonic_index.get_loc('b')
slice(1, 3, None)
```

```
>>> non_monotonic_index = pd.Index(list('abcb'))
>>> non_monotonic_index.get_loc('b')
array([False,  True, False,  True], dtype=bool)
```

34.6.1.54 pandas.Index.get_slice_bound

`Index.`**`get_slice_bound`**(*label*, *side*, *kind*)

Calculate slice bound that corresponds to given label.

Returns leftmost (one-past-the-rightmost if `side=='right'`) position of given label.

Parameters **label** : object

side : {'left', 'right'}

kind : {'ix', 'loc', 'getitem'}

34.6.1.55 pandas.Index.get_value

`Index.`**`get_value`**(*series*, *key*)

Fast lookup of value from 1-dimensional ndarray. Only use this if you know what you're doing

34.6.1.56 pandas.Index.get_values

`Index.`**`get_values`**()

return the underlying data as an ndarray

34.6.1.57 pandas.Index.groupby

`Index.`**`groupby`**(*values*)

Group the index labels by a given array of values.

Parameters **values** : array

Values used to determine the groups.

Returns **groups** : dict

{group name -> group labels}

34.6.1.58 pandas.Index.holds_integer

`Index.holds_integer()`

34.6.1.59 pandas.Index.identical

`Index.identical(other)`

Similar to equals, but check that other comparable attributes are also equal

34.6.1.60 pandas.Index.insert

`Index.insert(loc, item)`

Make new Index inserting new item at location. Follows Python list.append semantics for negative values

Parameters **loc** : int

item : object

Returns **new_index** : Index

34.6.1.61 pandas.Index.intersection

`Index.intersection(other)`

Form the intersection of two Index objects.

This returns a new Index with elements common to the index and *other*, preserving the order of the calling index.

Parameters **other** : Index or array-like

Returns **intersection** : Index

Examples

```
>>> idx1 = pd.Index([1, 2, 3, 4])
>>> idx2 = pd.Index([3, 4, 5, 6])
>>> idx1.intersection(idx2)
Int64Index([3, 4], dtype='int64')
```

34.6.1.62 pandas.Index.is_

`Index.is_(other)`

More flexible, faster check like `is` but that works through views

Note: this is *not* the same as `Index.identical()`, which checks that metadata is also the same.

Parameters **other** : object

other object to compare against.

Returns **True if both have same underlying data, False otherwise** : bool

34.6.1.63 pandas.Index.is_boolean

`Index.is_boolean()`

34.6.1.64 pandas.Index.is_categorical

`Index.is_categorical()`

34.6.1.65 pandas.Index.is_floating

`Index.is_floating()`

34.6.1.66 pandas.Index.is_integer

`Index.is_integer()`

34.6.1.67 pandas.Index.is_interval

`Index.is_interval()`

34.6.1.68 pandas.Index.is_lexsorted_for_tuple

`Index.is_lexsorted_for_tuple(tup)`

34.6.1.69 pandas.Index.is_mixed

`Index.is_mixed()`

34.6.1.70 pandas.Index.is_numeric

`Index.is_numeric()`

34.6.1.71 pandas.Index.is_object

`Index.is_object()`

34.6.1.72 pandas.Index.is_type_compatible

`Index.is_type_compatible(kind)`

34.6.1.73 pandas.Index.isin

`Index.isin(values, level=None)`

Compute boolean array of whether each index value is found in the passed set of values.

Parameters **values** : set or list-like

Sought values.

New in version 0.18.1.

Support for values as a set

level : str or int, optional

Name or position of the index level to use (if the index is a MultiIndex).

Returns **is_contained** : ndarray (boolean dtype)

Notes

If *level* is specified:

- if it is the name of one *and only one* index level, use that level;
- otherwise it should be a number indicating level position.

34.6.1.74 pandas.Index.isna

`Index.isna()`

Detect missing values

New in version 0.20.0.

Returns a boolean array of whether my values are NA

See also:

isnull alias of isna

pandas.isna top-level isna

34.6.1.75 pandas.Index.isnull

`Index.isnull()`

Detect missing values

New in version 0.20.0.

Returns a boolean array of whether my values are NA

See also:

isnull alias of isna

pandas.isna top-level isna

34.6.1.76 pandas.Index.item

`Index.item()`

return the first element of the underlying data as a python scalar

34.6.1.77 pandas.Index.join

`Index.join(other, how='left', level=None, return_indexers=False, sort=False)`

this is an internal non-public method

Compute join_index and indexers to conform data structures to the new index.

Parameters **other** : Index

how : {'left', 'right', 'inner', 'outer'}

level : int or level name, default None

return_indexers : boolean, default False

sort : boolean, default False

Sort the join keys lexicographically in the result Index. If False, the order of the join keys depends on the join type (how keyword)

New in version 0.20.0.

Returns join_index, (left_indexer, right_indexer)

34.6.1.78 pandas.Index.map

`Index.map(mapper)`

Apply mapper function to an index.

Parameters **mapper** : callable

Function to be applied.

Returns **applied** : Union[Index, MultiIndex], inferred

The output of the mapping function applied to the index. If the function returns a tuple with more than one element a MultiIndex will be returned.

34.6.1.79 pandas.Index.max

`Index.max()`

The maximum value of the object

34.6.1.80 pandas.Index.memory_usage

`Index.memory_usage(deep=False)`

Memory usage of my values

Parameters **deep** : bool

Introspect the data deeply, interrogate *object* dtypes for system-level memory consumption

Returns bytes used

See also:

`numpy.ndarray.nbytes`

Notes

Memory usage does not include memory consumed by elements that are not components of the array if deep=False or if used on PyPy

34.6.1.81 pandas.Index.min

`Index.min()`

The minimum value of the object

34.6.1.82 pandas.Index.notna

`Index.notna()`

Inverse of isna

New in version 0.20.0.

Returns a boolean array of whether my values are not NA

See also:

notnull alias of notna

pandas.notna top-level notna

34.6.1.83 pandas.Index.notnull

`Index.notnull()`

Inverse of isna

New in version 0.20.0.

Returns a boolean array of whether my values are not NA

See also:

notnull alias of notna

pandas.notna top-level notna

34.6.1.84 pandas.Index.nunique

`Index.nunique(dropna=True)`

Return number of unique elements in the object.

Excludes NA values by default.

Parameters **dropna** : boolean, default True

Don't include NaN in the count.

Returns **nunique** : int

34.6.1.85 pandas.Index.putmask

`Index.putmask`(*mask*, *value*)

return a new Index of the values set with the mask

See also:

`numpy.ndarray.putmask`

34.6.1.86 pandas.Index.ravel

`Index.ravel`(*order='C'*)

return an ndarray of the flattened values of the underlying data

See also:

`numpy.ndarray.ravel`

34.6.1.87 pandas.Index.reindex

`Index.reindex`(*target*, *method=None*, *level=None*, *limit=None*, *tolerance=None*)

Create index with target's values (move/add/delete values as necessary)

Parameters **target** : an iterable

Returns **new_index** : pd.Index

Resulting index

indexer : np.ndarray or None

Indices of output values in original index

34.6.1.88 pandas.Index.rename

`Index.rename`(*name*, *inplace=False*)

Set new names on index. Defaults to returning new index.

Parameters **name** : str or list

name to set

inplace : bool

if True, mutates in place

Returns new index (of same type and class...etc) [if inplace, returns None]

34.6.1.89 pandas.Index.repeat

`Index.repeat`(*repeats*, **args*, ***kwargs*)

Repeat elements of an Index. Refer to *numpy.ndarray.repeat* for more information about the *repeats* argument.

See also:

`numpy.ndarray.repeat`

34.6.1.90 pandas.Index.reshape

`Index.reshape(*args, **kwargs)`

NOT IMPLEMENTED: do not call this method, as reshaping is not supported for Index objects and will raise an error.

Reshape an Index.

34.6.1.91 pandas.Index.searchsorted

`Index.searchsorted(value, side='left', sorter=None)`

Find indices where elements should be inserted to maintain order.

Find the indices into a sorted IndexOpsMixin *self* such that, if the corresponding elements in *value* were inserted before the indices, the order of *self* would be preserved.

Parameters **value** : array_like

Values to insert into *self*.

side : {'left', 'right'}, optional

If 'left', the index of the first suitable location found is given. If 'right', return the last such index. If there is no suitable index, return either 0 or N (where N is the length of *self*).

sorter : 1-D array_like, optional

Optional array of integer indices that sort *self* into ascending order. They are typically the result of `np.argsort`.

Returns **indices** : array of ints

Array of insertion points with the same shape as *value*.

See also:

`numpy.searchsorted`

Notes

Binary search is used to find the required insertion points.

Examples

```
>>> x = pd.Series([1, 2, 3])
>>> x
0    1
1    2
2    3
dtype: int64
```

```
>>> x.searchsorted(4)
array([3])
```

```
>>> x.searchsorted([0, 4])
array([0, 3])
```

```
>>> x.searchsorted([1, 3], side='left')
array([0, 2])
```

```
>>> x.searchsorted([1, 3], side='right')
array([1, 3])
```

```
>>> x = pd.Categorical(['apple', 'bread', 'bread', 'cheese', 'milk' ])
[apple, bread, bread, cheese, milk]
Categories (4, object): [apple < bread < cheese < milk]
```

```
>>> x.searchsorted('bread')
array([1])     # Note: an array, not a scalar
```

```
>>> x.searchsorted(['bread'])
array([1])
```

```
>>> x.searchsorted(['bread', 'eggs'])
array([1, 4])
```

```
>>> x.searchsorted(['bread', 'eggs'], side='right')
array([3, 4])    # eggs before milk
```

34.6.1.92 pandas.Index.set_names

`Index.set_names`(*names*, *level=None*, *inplace=False*)

Set new names on index. Defaults to returning new index.

Parameters **names** : str or sequence

name(s) to set

level : int, level name, or sequence of int/level names (default None)

If the index is a MultiIndex (hierarchical), level(s) to set (None for all levels). Otherwise level must be None

inplace : bool

if True, mutates in place

Returns new index (of same type and class...etc) [if inplace, returns None]

Examples

```
>>> Index([1, 2, 3, 4]).set_names('foo')
Int64Index([1, 2, 3, 4], dtype='int64')
>>> Index([1, 2, 3, 4]).set_names(['foo'])
Int64Index([1, 2, 3, 4], dtype='int64')
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                  (2, u'one'), (2, u'two')],
                                  names=['foo', 'bar'])
>>> idx.set_names(['baz', 'quz'])
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
```

```
           names=[u'baz', u'quz'])
>>> idx.set_names('baz', level=0)
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'baz', u'bar'])
```

34.6.1.93 pandas.Index.set_value

`Index.set_value`(*arr*, *key*, *value*)

Fast lookup of value from 1-dimensional ndarray. Only use this if you know what you're doing

34.6.1.94 pandas.Index.shift

`Index.shift`(*periods=1*, *freq=None*)

Shift Index containing datetime objects by input number of periods and DateOffset

Returns **shifted** : Index

34.6.1.95 pandas.Index.slice_indexer

`Index.slice_indexer`(*start=None*, *end=None*, *step=None*, *kind=None*)

For an ordered Index, compute the slice indexer for input labels and step

Parameters **start** : label, default None

If None, defaults to the beginning

end : label, default None

If None, defaults to the end

step : int, default None

kind : string, default None

Returns **indexer** : ndarray or slice

Notes

This function assumes that the data is sorted, so use at your own peril

34.6.1.96 pandas.Index.slice_locs

`Index.slice_locs`(*start=None*, *end=None*, *step=None*, *kind=None*)

Compute slice locations for input labels.

Parameters **start** : label, default None

If None, defaults to the beginning

end : label, default None

If None, defaults to the end

step : int, defaults None

If None, defaults to 1

kind : {'ix', 'loc', 'getitem'} or None

Returns **start, end** : int

See also:

Index.get_loc Get location for a single label

Notes

This method only works if the index is monotonic or unique.

Examples

```
>>> idx = pd.Index(list('abcd'))
>>> idx.slice_locs(start='b', end='c')
(1, 3)
```

34.6.1.97 pandas.Index.sort

`Index.sort(*args, **kwargs)`

34.6.1.98 pandas.Index.sort_values

`Index.sort_values(return_indexer=False, ascending=True)`

Return sorted copy of Index

34.6.1.99 pandas.Index.sortlevel

`Index.sortlevel(level=None, ascending=True, sort_remaining=None)`

For internal compatibility with with the Index API

Sort the Index. This is for compat with MultiIndex

Parameters **ascending** : boolean, default True

False to sort in descending order

level, sort_remaining are compat parameters

Returns **sorted_index** : Index

34.6.1.100 pandas.Index.str

`Index.str()`

Vectorized string functions for Series and Index. NAs stay NA unless handled otherwise by a particular method. Patterned after Python's string methods, with some inspiration from R's stringr package.

Examples

```
>>> s.str.split('_')
>>> s.str.replace('_', '')
```

34.6.1.101 pandas.Index.summary

`Index.summary(name=None)`

34.6.1.102 pandas.Index.symmetric_difference

`Index.symmetric_difference(other, result_name=None)`

Compute the symmetric difference of two Index objects. It's sorted if sorting is possible.

Parameters **other** : Index or array-like

result_name : str

Returns **symmetric_difference** : Index

Notes

`symmetric_difference` contains elements that appear in either `idx1` or `idx2` but not both. Equivalent to the Index created by `idx1.difference(idx2) | idx2.difference(idx1)` with duplicates dropped.

Examples

```
>>> idx1 = Index([1, 2, 3, 4])
>>> idx2 = Index([2, 3, 4, 5])
>>> idx1.symmetric_difference(idx2)
Int64Index([1, 5], dtype='int64')
```

You can also use the ^ operator:

```
>>> idx1 ^ idx2
Int64Index([1, 5], dtype='int64')
```

34.6.1.103 pandas.Index.take

`Index.take(indices, axis=0, allow_fill=True, fill_value=None, **kwargs)`

return a new Index of the values selected by the indices

For internal compatibility with numpy arrays.

Parameters **indices** : list

Indices to be taken

axis : int, optional

The axis over which to select values, always 0.

allow_fill : bool, default True

fill_value : bool, default None

If allow_fill=True and fill_value is not None, indices specified by -1 is regarded as NA. If Index doesn't hold NA, raise ValueError

See also:

`numpy.ndarray.take`

34.6.1.104 pandas.Index.to_datetime

`Index.to_datetime(dayfirst=False)`

DEPRECATED: use `pandas.to_datetime()` instead.

For an Index containing strings or datetime.datetime objects, attempt conversion to DatetimeIndex

34.6.1.105 pandas.Index.to_frame

`Index.to_frame(index=True)`

Create a DataFrame with a column containing the Index.

New in version 0.21.0.

Parameters **index** : boolean, default True

Set the index of the returned DataFrame as the original Index.

Returns **DataFrame** : a DataFrame containing the original Index data.

34.6.1.106 pandas.Index.to_native_types

`Index.to_native_types(slicer=None, **kwargs)`

Format specified values of *self* and return them.

Parameters **slicer** : int, array-like

An indexer into *self* that specifies which values are used in the formatting process.

kwargs : dict

Options for specifying how the values should be formatted. These options include the following:

1. **na_rep** [str] The value that serves as a placeholder for NULL values
2. **quoting** [bool or None] Whether or not there are quoted values in *self*
3. **date_format** [str] The format used to represent date-like values

34.6.1.107 pandas.Index.to_series

`Index.to_series(**kwargs)`

Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index

Returns **Series** : dtype will be based on the type of the Index values.

34.6.1.108 pandas.Index.tolist

`Index.tolist()`

Return a list of the values.

These are each a scalar type, which is a Python scalar (for str, int, float) or a pandas scalar (for Timestamp/Timedelta/Interval/Period)

See also:

`numpy.ndarray.tolist`

34.6.1.109 pandas.Index.transpose

`Index.transpose(*args, **kwargs)`

return the transpose, which is by definition self

34.6.1.110 pandas.Index.union

`Index.union(other)`

Form the union of two Index objects and sorts if possible.

Parameters **other** : Index or array-like

Returns **union** : Index

Examples

```
>>> idx1 = pd.Index([1, 2, 3, 4])
>>> idx2 = pd.Index([3, 4, 5, 6])
>>> idx1.union(idx2)
Int64Index([1, 2, 3, 4, 5, 6], dtype='int64')
```

34.6.1.111 pandas.Index.unique

`Index.unique()`

Return unique values in the object. Uniques are returned in order of appearance, this does NOT sort. Hash table-based unique.

Parameters **values** : 1d array-like

Returns unique values.

- If the input is an Index, the return is an Index
- If the input is a Categorical dtype, the return is a Categorical
- If the input is a Series/ndarray, the return will be an ndarray

See also:

unique, *Index.unique*, *Series.unique*

34.6.1.112 pandas.Index.value_counts

`Index.value_counts(normalize=False, sort=True, ascending=False, bins=None, dropna=True)`

Returns object containing counts of unique values.

The resulting object will be in descending order so that the first element is the most frequently-occurring element. Excludes NA values by default.

Parameters **normalize** : boolean, default False

If True then the object returned will contain the relative frequencies of the unique values.

sort : boolean, default True

Sort by values

ascending : boolean, default False

Sort in ascending order

bins : integer, optional

Rather than count values, group them into half-open bins, a convenience for pd.cut, only works with numeric data

dropna : boolean, default True

Don't include counts of NaN.

Returns **counts** : Series

34.6.1.113 pandas.Index.view

`Index.view(cls=None)`

34.6.1.114 pandas.Index.where

`Index.where(cond, other=None)`

New in version 0.19.0.

Return an Index of same shape as self and whose corresponding entries are from self where cond is True and otherwise are from other.

Parameters **cond** : boolean array-like with the same length as self

other : scalar, or array-like

34.6.2 Attributes

`Index.values`	return the underlying data as an ndarray
`Index.is_monotonic`	alias for is_monotonic_increasing (deprecated)
`Index.is_monotonic_increasing`	return if the index is monotonic increasing (only equal or
`Index.is_monotonic_decreasing`	return if the index is monotonic decreasing (only equal or
`Index.is_unique`	
`Index.has_duplicates`	
`Index.dtype`	

Continued on next page

Table 34.91 – continued from previous page

Index.inferred_type	
Index.is_all_dates	
Index.shape	return a tuple of the shape of the underlying data
Index.nbytes	return the number of bytes in the underlying data
Index.ndim	return the number of dimensions of the underlying data,
Index.size	return the number of elements in the underlying data
Index.empty	
Index.strides	return the strides of the underlying data
Index.itemsize	return the size of the dtype of the item of the underlying data
Index.base	return the base object if the memory of the underlying data is
Index.T	return the transpose, which is by definition self
Index.memory_usage([deep])	Memory usage of my values

34.6.3 Modifying and Computations

Index.all(*args, **kwargs)	Return whether all elements are True
Index.any(*args, **kwargs)	Return whether any element is True
Index.argmin([axis])	return a ndarray of the minimum argument indexer
Index.argmax([axis])	return a ndarray of the maximum argument indexer
Index.copy([name, deep, dtype])	Make a copy of this object.
Index.delete(loc)	Make new Index with passed location(-s) deleted
Index.drop(labels[, errors])	Make new Index with passed list of labels deleted
Index.drop_duplicates([keep])	Return Index with duplicate values removed
Index.duplicated([keep])	Return boolean np.ndarray denoting duplicate values
Index.equals(other)	Determines if two Index objects contain the same elements.
Index.factorize([sort, na_sentinel])	Encode the object as an enumerated type or categorical variable
Index.identical(other)	Similar to equals, but check that other comparable attributes are
Index.insert(loc, item)	Make new Index inserting new item at location.
Index.min()	The minimum value of the object
Index.max()	The maximum value of the object
Index.reindex(target[, method, level, ...])	Create index with target's values (move/add/delete values as necessary)
Index.repeat(repeats, *args, **kwargs)	Repeat elements of an Index.
Index.where(cond[, other])	New in version 0.19.0.
Index.take(indices[, axis, allow_fill, ...])	return a new Index of the values selected by the indices
Index.putmask(mask, value)	return a new Index of the values set with the mask
Index.set_names(names[, level, inplace])	Set new names on index.
Index.unique()	Return unique values in the object.
Index.nunique([dropna])	Return number of unique elements in the object.
Index.value_counts([normalize, sort, ...])	Returns object containing counts of unique values.

34.6.4 Missing Values

`Index.fillna`([value, downcast])	Fill NA/NaN values with the specified value
`Index.dropna`([how])	Return Index without NA/NaN values
`Index.isna`()	Detect missing values
`Index.notna`()	Inverse of isna

34.6.5 Conversion

`Index.astype`(dtype[, copy])	Create an Index with values cast to dtypes.
`Index.tolist`()	Return a list of the values.
`Index.to_datetime`([dayfirst])	DEPRECATED: use `pandas.to_datetime()` instead.
`Index.to_series`(**kwargs)	Create a Series with both index and values equal to the index keys
`Index.to_frame`([index])	Create a DataFrame with a column containing the Index.

34.6.6 Sorting

`Index.argsort`(*args, **kwargs)	Returns the indices that would sort the index and its underlying data.
`Index.sort_values`([return_indexer, ascending])	Return sorted copy of Index

34.6.7 Time-specific operations

`Index.shift`([periods, freq])	Shift Index containing datetime objects by input number of periods and

34.6.8 Combining / joining / set operations

`Index.append`(other)	Append a collection of Index options together
`Index.join`(other[, how, level, ...])	*this is an internal non-public method*
`Index.intersection`(other)	Form the intersection of two Index objects.
`Index.union`(other)	Form the union of two Index objects and sorts if possible.
`Index.difference`(other)	Return a new Index with elements from the index that are not in *other*.
`Index.symmetric_difference`(other[, result_name])	Compute the symmetric difference of two Index objects.

34.6.9 Selecting

`Index.get_indexer`(target[, method, limit, ...])	Compute indexer and mask for new index given the current index.
`Index.get_indexer_non_unique`(target)	Compute indexer and mask for new index given the current index.

Continued on next page

Table 34.98 – continued from previous page

`Index.get_level_values`(level)	Return an Index of values for requested level, equal to the length of the index.
`Index.get_loc`(key[, method, tolerance])	Get integer location, slice or boolean mask for requested label.
`Index.get_value`(series, key)	Fast lookup of value from 1-dimensional ndarray.
`Index.isin`(values[, level])	Compute boolean array of whether each index value is found in the passed set of values.
`Index.slice_indexer`([start, end, step, kind])	For an ordered Index, compute the slice indexer for input labels and
`Index.slice_locs`([start, end, step, kind])	Compute slice locations for input labels.

34.7 Numeric Index

`RangeIndex`	Immutable Index implementing a monotonic integer range.
`Int64Index`	Immutable ndarray implementing an ordered, sliceable set.
`UInt64Index`	Immutable ndarray implementing an ordered, sliceable set.
`Float64Index`	Immutable ndarray implementing an ordered, sliceable set.

34.7.1 pandas.RangeIndex

class pandas.**RangeIndex**

Immutable Index implementing a monotonic integer range.

RangeIndex is a memory-saving special case of Int64Index limited to representing monotonic ranges. Using RangeIndex may in some instances improve computing speed.

This is the default index type used by DataFrame and Series when no explicit index is provided by the user.

Parameters **start** : int (default: 0), or other RangeIndex instance.

If int and "stop" is not given, interpreted as "stop" instead.

stop : int (default: 0)

step : int (default: 1)

name : object, optional

Name to be stored in the index

copy : bool, default False

Unused, accepted for homogeneity with other index types.

See also:

Index The base pandas Index type

Int64Index Index of int64 data

34.7.2 pandas.Int64Index

class pandas.**Int64Index**

Immutable ndarray implementing an ordered, sliceable set. The basic object storing axis labels for all pandas objects. Int64Index is a special case of *Index* with purely integer labels.

Parameters **data** : array-like (1-dimensional)

dtype : NumPy dtype (default: int64)

copy : bool

Make a copy of input ndarray

name : object

Name to be stored in the index

See also:

Index The base pandas Index type

Notes

An Index instance can **only** contain hashable objects.

34.7.3 pandas.UInt64Index

class pandas.**UInt64Index**

Immutable ndarray implementing an ordered, sliceable set. The basic object storing axis labels for all pandas objects. UInt64Index is a special case of *Index* with purely unsigned integer labels.

Parameters **data** : array-like (1-dimensional)

dtype : NumPy dtype (default: uint64)

copy : bool

Make a copy of input ndarray

name : object

Name to be stored in the index

See also:

Index The base pandas Index type

Notes

An Index instance can **only** contain hashable objects.

34.7.4 pandas.Float64Index

class pandas.**Float64Index**

Immutable ndarray implementing an ordered, sliceable set. The basic object storing axis labels for all pandas objects. Float64Index is a special case of *Index* with purely float labels.

Parameters **data** : array-like (1-dimensional)

dtype : NumPy dtype (default: float64)

copy : bool

Make a copy of input ndarray

name : object

Name to be stored in the index

See also:

Index	The base pandas Index type

Notes

An Index instance can **only** contain hashable objects.

34.8 CategoricalIndex

CategoricalIndex	Immutable Index implementing an ordered, sliceable set.

34.8.1 pandas.CategoricalIndex

class pandas.**CategoricalIndex**

Immutable Index implementing an ordered, sliceable set. CategoricalIndex represents a sparsely populated Index with an underlying Categorical.

Parameters **data** : array-like or Categorical, (1-dimensional)

categories : optional, array-like

categories for the CategoricalIndex

ordered : boolean,

designating if the categories are ordered

copy : bool

Make a copy of input ndarray

name : object

Name to be stored in the index

See also:

Categorical, *Index*

34.8.2 Categorical Components

CategoricalIndex.codes	
CategoricalIndex.categories	
CategoricalIndex.ordered	
CategoricalIndex.rename_categories(*args, ...)	Renames categories.
CategoricalIndex.reorder_categories(*args, ...)	Reorders categories as specified in new_categories.

Continued on next page

Table 34.101 – continued from previous page

CategoricalIndex.add_categories(*args, **kwargs)	Add new categories.
CategoricalIndex.remove_categories(*args, ...)	Removes the specified categories.
CategoricalIndex.remove_unused_categories()	Removes categories which are not used.
CategoricalIndex.set_categories(*args, **kwargs)	Sets the categories to the specified new_categories.
CategoricalIndex.as_ordered(*args, **kwargs)	Sets the Categorical to be ordered
CategoricalIndex.as_unordered(*args, **kwargs)	Sets the Categorical to be unordered

34.8.2.1 pandas.CategoricalIndex.codes

`CategoricalIndex.codes`

34.8.2.2 pandas.CategoricalIndex.categories

`CategoricalIndex.categories`

34.8.2.3 pandas.CategoricalIndex.ordered

`CategoricalIndex.ordered`

34.8.2.4 pandas.CategoricalIndex.rename_categories

`CategoricalIndex.rename_categories`(**args*, ***kwargs*)

Renames categories.

Parameters **new_categories** : list-like or dict-like

- list-like: all items must be unique and the number of items in the new categories must match the existing number of categories.
- dict-like: specifies a mapping from old categories to new. Categories not contained in the mapping are passed through and extra categories in the mapping are ignored. *New in version 0.21.0*.

> **Warning:** Currently, Series are considered list like. In a future version of pandas they'll be considered dict-like.

inplace : boolean (default: False)

Whether or not to rename the categories inplace or return a copy of this categorical with renamed categories.

Returns **cat** : Categorical or None

With `inplace=False`, the new categorical is returned. With `inplace=True`, there is no return value.

Raises **ValueError**

If new categories are list-like and do not have the same number of items than the current categories or do not validate as categories

See also:

reorder_categories, *add_categories*, *remove_categories*, *remove_unused_categories*, *set_categories*

Examples

```
>>> c = Categorical(['a', 'a', 'b'])
>>> c.rename_categories([0, 1])
[0, 0, 1]
Categories (2, int64): [0, 1]
```

For dict-like `new_categories`, extra keys are ignored and categories not in the dictionary are passed through

```
>>> c.rename_categories({'a': 'A', 'c': 'C'})
[A, A, b]
Categories (2, object): [A, b]
```

34.8.2.5 pandas.CategoricalIndex.reorder_categories

`CategoricalIndex.`**`reorder_categories`**(**args*, ***kwargs*)

Reorders categories as specified in new_categories.

new_categories need to include all old categories and no new category items.

Parameters **new_categories** : Index-like

The categories in new order.

ordered : boolean, optional

Whether or not the categorical is treated as a ordered categorical. If not given, do not change the ordered information.

inplace : boolean (default: False)

Whether or not to reorder the categories inplace or return a copy of this categorical with reordered categories.

Returns **cat** : Categorical with reordered categories or None if inplace.

Raises **ValueError**

If the new categories do not contain all old category items or any new ones

See also:

rename_categories, *add_categories*, *remove_categories*, *remove_unused_categories*, *set_categories*

34.8.2.6 pandas.CategoricalIndex.add_categories

`CategoricalIndex.`**`add_categories`**(**args*, ***kwargs*)

Add new categories.

new_categories will be included at the last/highest place in the categories and will be unused directly after this call.

Parameters **new_categories** : category or list-like of category

The new categories to be included.

inplace : boolean (default: False)

Whether or not to add the categories inplace or return a copy of this categorical with added categories.

Returns **cat** : Categorical with new categories added or None if inplace.

Raises **ValueError**

If the new categories include old categories or do not validate as categories

See also:

rename_categories, *reorder_categories*, *remove_categories*, *remove_unused_categories*, *set_categories*

34.8.2.7 pandas.CategoricalIndex.remove_categories

`CategoricalIndex.remove_categories(*args, **kwargs)`

Removes the specified categories.

removals must be included in the old categories. Values which were in the removed categories will be set to NaN

Parameters **removals** : category or list of categories

The categories which should be removed.

inplace : boolean (default: False)

Whether or not to remove the categories inplace or return a copy of this categorical with removed categories.

Returns **cat** : Categorical with removed categories or None if inplace.

Raises **ValueError**

If the removals are not contained in the categories

See also:

rename_categories, *reorder_categories*, *add_categories*, *remove_unused_categories*, *set_categories*

34.8.2.8 pandas.CategoricalIndex.remove_unused_categories

`CategoricalIndex.remove_unused_categories(*args, **kwargs)`

Removes categories which are not used.

Parameters **inplace** : boolean (default: False)

Whether or not to drop unused categories inplace or return a copy of this categorical with unused categories dropped.

Returns **cat** : Categorical with unused categories dropped or None if inplace.

See also:

rename_categories, *reorder_categories*, *add_categories*, *remove_categories*, *set_categories*

34.8.2.9 pandas.CategoricalIndex.set_categories

`CategoricalIndex.set_categories`(**args*, ***kwargs*)

Sets the categories to the specified new_categories.

new_categories can include new categories (which will result in unused categories) or remove old categories (which results in values set to NaN). If *rename==True*, the categories will simple be renamed (less or more items than in old categories will result in values set to NaN or in unused categories respectively).

This method can be used to perform more than one action of adding, removing, and reordering simultaneously and is therefore faster than performing the individual steps via the more specialised methods.

On the other hand this methods does not do checks (e.g., whether the old categories are included in the new categories on a reorder), which can result in surprising changes, for example when using special string dtypes on python3, which does not considers a S1 string equal to a single char python string.

Parameters **new_categories** : Index-like

The categories in new order.

ordered : boolean, (default: False)

Whether or not the categorical is treated as a ordered categorical. If not given, do not change the ordered information.

rename : boolean (default: False)

Whether or not the new_categories should be considered as a rename of the old categories or as reordered categories.

inplace : boolean (default: False)

Whether or not to reorder the categories inplace or return a copy of this categorical with reordered categories.

Returns **cat** : Categorical with reordered categories or None if inplace.

Raises **ValueError**

If new_categories does not validate as categories

See also:

rename_categories, *reorder_categories*, *add_categories*, *remove_categories*, *remove_unused_categories*

34.8.2.10 pandas.CategoricalIndex.as_ordered

`CategoricalIndex.as_ordered`(**args*, ***kwargs*)

Sets the Categorical to be ordered

Parameters **inplace** : boolean (default: False)

Whether or not to set the ordered attribute inplace or return a copy of this categorical with ordered set to True

34.8.2.11 pandas.CategoricalIndex.as_unordered

`CategoricalIndex.as_unordered(*args, **kwargs)`

Sets the Categorical to be unordered

Parameters **inplace** : boolean (default: False)

Whether or not to set the ordered attribute inplace or return a copy of this categorical with ordered set to False

34.9 IntervalIndex

IntervalIndex	Immutable Index implementing an ordered, sliceable set.

34.9.1 pandas.IntervalIndex

class `pandas.IntervalIndex`

Immutable Index implementing an ordered, sliceable set. IntervalIndex represents an Index of intervals that are all closed on the same side.

New in version 0.20.0.

> **Warning:** The indexing behaviors are provisional and may change in a future version of pandas.

See also:

Index The base pandas Index type

Interval A bounded slice-like interval

interval_range Function to create a fixed frequency

IntervalIndex, *IntervalIndex.from_arrays*, *IntervalIndex.from_breaks*, *IntervalIndex.from_intervals*, *IntervalIndex.from_tuples*, *cut*, *qcut*

Notes

See the user guide for more.

Examples

A new `IntervalIndex` is typically constructed using *interval_range()*:

```
>>> pd.interval_range(start=0, end=5)
IntervalIndex([(0, 1], (1, 2], (2, 3], (3, 4], (4, 5]]
              closed='right', dtype='interval[int64]')
```

It may also be constructed using one of the constructor methods *IntervalIndex.from_arrays()*, *IntervalIndex.from_breaks()*, *IntervalIndex.from_intervals()* and *IntervalIndex.from_tuples()*.

See further examples in the doc strings of `interval_range` and the mentioned constructor methods.

34.9.2 IntervalIndex Components

IntervalIndex.from_arrays(left, right[, ...])	Construct an IntervalIndex from a a left and right array
IntervalIndex.from_tuples(data[, closed, ...])	Construct an IntervalIndex from a list/array of tuples
IntervalIndex.from_breaks(breaks[, closed, ...])	Construct an IntervalIndex from an array of splits
IntervalIndex.from_intervals(data[, name, copy])	Construct an IntervalIndex from a 1d array of Interval objects

34.9.2.1 pandas.IntervalIndex.from_arrays

classmethod `IntervalIndex.`**`from_arrays`**(*left*, *right*, *closed='right'*, *name=None*, *copy=False*)

Construct an IntervalIndex from a a left and right array

Parameters **left** : array-like (1-dimensional)

Left bounds for each interval.

right : array-like (1-dimensional)

Right bounds for each interval.

closed : {'left', 'right', 'both', 'neither'}, optional

Whether the intervals are closed on the left-side, right-side, both or neither. Defaults to 'right'.

name : object, optional

Name to be stored in the index.

copy : boolean, default False

copy the data

See also:

interval_range Function to create a fixed frequency IntervalIndex

IntervalIndex.from_breaks Construct an IntervalIndex from an array of splits

IntervalIndex.from_intervals Construct an IntervalIndex from an array of Interval objects

IntervalIndex.from_tuples Construct an IntervalIndex from a list/array of tuples

Examples

```
>>> pd.IntervalIndex.from_arrays([0, 1, 2], [1, 2, 3])
IntervalIndex([(0, 1], (1, 2], (2, 3]]
              closed='right',
              dtype='interval[int64]')
```

34.9.2.2 pandas.IntervalIndex.from_tuples

classmethod `IntervalIndex.from_tuples`(*data*, *closed='right'*, *name=None*, *copy=False*)

Construct an IntervalIndex from a list/array of tuples

Parameters **data** : array-like (1-dimensional)

Array of tuples

closed : {'left', 'right', 'both', 'neither'}, optional

Whether the intervals are closed on the left-side, right-side, both or neither. Defaults to 'right'.

name : object, optional

Name to be stored in the index.

copy : boolean, default False

by-default copy the data, this is compat only and ignored

See also:

interval_range Function to create a fixed frequency IntervalIndex

IntervalIndex.from_arrays Construct an IntervalIndex from a left and right array

IntervalIndex.from_breaks Construct an IntervalIndex from an array of splits

IntervalIndex.from_intervals Construct an IntervalIndex from an array of Interval objects

Examples

```
>>>  pd.IntervalIndex.from_tuples([(0, 1), (1,2)])
IntervalIndex([(0, 1], (1, 2]],
              closed='right', dtype='interval[int64]')
```

34.9.2.3 pandas.IntervalIndex.from_breaks

classmethod `IntervalIndex.from_breaks`(*breaks*, *closed='right'*, *name=None*, *copy=False*)

Construct an IntervalIndex from an array of splits

Parameters **breaks** : array-like (1-dimensional)

Left and right bounds for each interval.

closed : {'left', 'right', 'both', 'neither'}, optional

Whether the intervals are closed on the left-side, right-side, both or neither. Defaults to 'right'.

name : object, optional

Name to be stored in the index.

copy : boolean, default False

copy the data

See also:

interval_range Function to create a fixed frequency IntervalIndex

IntervalIndex.from_arrays Construct an IntervalIndex from a left and right array

IntervalIndex.from_intervals Construct an IntervalIndex from an array of Interval objects

IntervalIndex.from_tuples Construct an IntervalIndex from a list/array of tuples

Examples

```
>>> pd.IntervalIndex.from_breaks([0, 1, 2, 3])
IntervalIndex([(0, 1], (1, 2], (2, 3]]
              closed='right',
              dtype='interval[int64]')
```

34.9.2.4 pandas.IntervalIndex.from_intervals

classmethod `IntervalIndex.`**`from_intervals`**(*data*, *name=None*, *copy=False*)

Construct an IntervalIndex from a 1d array of Interval objects

Parameters **data** : array-like (1-dimensional)

Array of Interval objects. All intervals must be closed on the same sides.

name : object, optional

Name to be stored in the index.

copy : boolean, default False

by-default copy the data, this is compat only and ignored

See also:

interval_range Function to create a fixed frequency IntervalIndex

IntervalIndex.from_arrays Construct an IntervalIndex from a left and right array

IntervalIndex.from_breaks Construct an IntervalIndex from an array of splits

IntervalIndex.from_tuples Construct an IntervalIndex from a list/array of tuples

Examples

```
>>> pd.IntervalIndex.from_intervals([pd.Interval(0, 1),
...                                  pd.Interval(1, 2)])
IntervalIndex([(0, 1], (1, 2]]
              closed='right', dtype='interval[int64]')
```

The generic Index constructor work identically when it infers an array of all intervals:

```
>>> pd.Index([pd.Interval(0, 1), pd.Interval(1, 2)])
IntervalIndex([(0, 1], (1, 2]]
              closed='right', dtype='interval[int64]')
```

34.10 MultiIndex

`MultiIndex`	A multi-level, or hierarchical, index object for pandas objects
`IndexSlice`	Create an object to more easily perform multi-index slicing

34.10.1 pandas.MultiIndex

class `pandas.`**`MultiIndex`**

A multi-level, or hierarchical, index object for pandas objects

Parameters **levels** : sequence of arrays

The unique labels for each level

labels : sequence of arrays

Integers for each level designating which label at each location

sortorder : optional int

Level of sortedness (must be lexicographically sorted by that level)

names : optional sequence of objects

Names for each of the index levels. (name is accepted for compat)

copy : boolean, default False

Copy the meta-data

verify_integrity : boolean, default True

Check that the levels/labels are consistent and valid

See also:

`MultiIndex.from_arrays` Convert list of arrays to MultiIndex

`MultiIndex.from_product` Create a MultiIndex from the cartesian product of iterables

`MultiIndex.from_tuples` Convert list of tuples to a MultiIndex

`Index` The base pandas Index type

Notes

See the user guide for more.

Examples

A new `MultiIndex` is typically constructed using one of the helper methods *`MultiIndex.from_arrays()`*, *`MultiIndex.from_product()`* and *`MultiIndex.from_tuples()`*. For example (using `.from_arrays`):

```
>>> arrays = [[1, 1, 2, 2], ['red', 'blue', 'red', 'blue']]
>>> pd.MultiIndex.from_arrays(arrays, names=('number', 'color'))
MultiIndex(levels=[[1, 2], ['blue', 'red']],
       labels=[[0, 0, 1, 1], [1, 0, 1, 0]],
       names=['number', 'color'])
```

See further examples for how to construct a MultiIndex in the doc strings of the mentioned helper methods.

Attributes

T	return the transpose, which is by definition self
asi8	
base	return the base object if the memory of the underlying data is
data	return the data pointer of the underlying data
dtype	
dtype_str	
empty	
flags	
has_duplicates	
hasnans	
inferred_type	
is_all_dates	
is_monotonic	
is_monotonic_decreasing	
is_monotonic_increasing	
is_unique	
itemsize	return the size of the dtype of the item of the underlying data
labels	
levels	
levshape	
lexsort_depth	
name	
names	Names of levels in MultiIndex
nbytes	
ndim	return the number of dimensions of the underlying data,
nlevels	
shape	return a tuple of the shape of the underlying data
size	return the number of elements in the underlying data
strides	return the strides of the underlying data
values	

34.10.1.1 pandas.MultiIndex.T

`MultiIndex.T`

return the transpose, which is by definition self

34.10.1.2 pandas.MultiIndex.asi8

`MultiIndex.asi8` = None

34.10.1.3 pandas.MultiIndex.base

`MultiIndex.base`

return the base object if the memory of the underlying data is shared

34.10.1.4 pandas.MultiIndex.data

`MultiIndex.data`

return the data pointer of the underlying data

34.10.1.5 pandas.MultiIndex.dtype

`MultiIndex.dtype` = None

34.10.1.6 pandas.MultiIndex.dtype_str

`MultiIndex.dtype_str` = None

34.10.1.7 pandas.MultiIndex.empty

`MultiIndex.empty`

34.10.1.8 pandas.MultiIndex.flags

`MultiIndex.flags`

34.10.1.9 pandas.MultiIndex.has_duplicates

`MultiIndex.has_duplicates`

34.10.1.10 pandas.MultiIndex.hasnans

`MultiIndex.hasnans` = None

34.10.1.11 pandas.MultiIndex.inferred_type

`MultiIndex.inferred_type` = None

34.10.1.12 pandas.MultiIndex.is_all_dates

`MultiIndex.is_all_dates`

34.10.1.13 pandas.MultiIndex.is_monotonic

`MultiIndex.is_monotonic` = None

34.10.1.14 pandas.MultiIndex.is_monotonic_decreasing

`MultiIndex.is_monotonic_decreasing` = None

34.10.1.15 pandas.MultiIndex.is_monotonic_increasing

`MultiIndex.is_monotonic_increasing` = None

34.10.1.16 pandas.MultiIndex.is_unique

`MultiIndex.is_unique` = None

34.10.1.17 pandas.MultiIndex.itemsize

`MultiIndex.itemsize`

return the size of the dtype of the item of the underlying data

34.10.1.18 pandas.MultiIndex.labels

`MultiIndex.labels`

34.10.1.19 pandas.MultiIndex.levels

`MultiIndex.levels`

34.10.1.20 pandas.MultiIndex.levshape

`MultiIndex.levshape`

34.10.1.21 pandas.MultiIndex.lexsort_depth

`MultiIndex.lexsort_depth` = None

34.10.1.22 pandas.MultiIndex.name

`MultiIndex.name` = None

34.10.1.23 pandas.MultiIndex.names

`MultiIndex.names`

Names of levels in MultiIndex

34.10.1.24 pandas.MultiIndex.nbytes

`MultiIndex.nbytes` = None

34.10.1.25 pandas.MultiIndex.ndim

`MultiIndex.ndim`

return the number of dimensions of the underlying data, by definition 1

34.10.1.26 pandas.MultiIndex.nlevels

`MultiIndex.nlevels`

34.10.1.27 pandas.MultiIndex.shape

`MultiIndex.shape`

return a tuple of the shape of the underlying data

34.10.1.28 pandas.MultiIndex.size

`MultiIndex.size`

return the number of elements in the underlying data

34.10.1.29 pandas.MultiIndex.strides

`MultiIndex.strides`

return the strides of the underlying data

34.10.1.30 pandas.MultiIndex.values

`MultiIndex.values`

Methods

all([other])	
any([other])	
append(other)	Append a collection of Index options together
argmax([axis])	return a ndarray of the maximum argument indexer
argmin([axis])	return a ndarray of the minimum argument indexer
argsort(*args, **kwargs)	
asof(label)	For a sorted index, return the most recent label up to and including the passed label.
asof_locs(where, mask)	where : array of timestamps
astype(dtype[, copy])	Create an Index with values cast to dtypes.
contains(key)	return a boolean if this key is IN the index
copy([names, dtype, levels, labels, deep, ...])	Make a copy of this object.

Continued on next page

Table 34.106 – continued from previous page

delete(loc)	Make new index with passed location deleted
difference(other)	Compute sorted set difference of two MultiIndex objects
drop(labels[, level, errors])	Make new MultiIndex with passed list of labels deleted
drop_duplicates([keep])	Return Index with duplicate values removed
droplevel([level])	Return Index with requested level removed.
dropna([how])	Return Index without NA/NaN values
duplicated([keep])	Return boolean np.ndarray denoting duplicate values
equal_levels(other)	Return True if the levels of both MultiIndex objects are the same
equals(other)	Determines if two MultiIndex objects have the same labeling information
factorize([sort, na_sentinel])	Encode the object as an enumerated type or categorical variable
fillna([value, downcast])	Fill NA/NaN values with the specified value
format([space, sparsify, adjoin, names, ...])	
from_arrays(arrays[, sortorder, names])	Convert arrays to MultiIndex
from_product(iterables[, sortorder, names])	Make a MultiIndex from the cartesian product of multiple iterables
from_tuples(tuples[, sortorder, names])	Convert list of tuples to MultiIndex
get_duplicates()	
get_indexer(target[, method, limit, tolerance])	Compute indexer and mask for new index given the current index.
get_indexer_for(target, **kwargs)	guaranteed return of an indexer even when non-unique
get_indexer_non_unique(target)	Compute indexer and mask for new index given the current index.
get_level_values(level)	Return vector of label values for requested level, equal to the length of the index.
get_loc(key[, method])	Get location for a label or a tuple of labels as an integer, slice or boolean mask.
get_loc_level(key[, level, drop_level])	Get both the location for the requested label(s) and the resulting sliced index.
get_locs(seq)	Get location for a given label/slice/list/mask or a sequence of such as an array of integers.
get_major_bounds([start, end, step, kind])	For an ordered MultiIndex, compute the slice locations for input labels.
get_slice_bound(label, side, kind)	
get_value(series, key)	
get_values()	return the underlying data as an ndarray
groupby(values)	Group the index labels by a given array of values.
holds_integer()	
identical(other)	Similar to equals, but check that other comparable attributes are
insert(loc, item)	Make new MultiIndex inserting new item at location
intersection(other)	Form the intersection of two MultiIndex objects, sorting if possible
is_(other)	More flexible, faster check like `is` but that works through views
is_boolean()	
is_categorical()	
is_floating()	

Continued on next page

Table 34.106 – continued from previous page

is_integer()	
is_interval()	
is_lexsorted()	Return True if the labels are lexicographically sorted
is_lexsorted_for_tuple(tup)	
is_mixed()	
is_numeric()	
is_object()	
is_type_compatible(kind)	
isin(values[, level])	Compute boolean array of whether each index value is found in the passed set of values.
isna()	Detect missing values
isnull()	Detect missing values
item()	return the first element of the underlying data as a python
join(other[, how, level, return_indexers, sort])	*this is an internal non-public method*
map(mapper)	Apply mapper function to an index.
max()	The maximum value of the object
memory_usage([deep])	Memory usage of my values
min()	The minimum value of the object
notna()	Inverse of isna
notnull()	Inverse of isna
nunique([dropna])	Return number of unique elements in the object.
putmask(mask, value)	return a new Index of the values set with the mask
ravel([order])	return an ndarray of the flattened values of the underlying data
reindex(target[, method, level, limit, ...])	Create index with target's values (move/add/delete values as necessary)
remove_unused_levels()	create a new MultiIndex from the current that removing
rename(names[, level, inplace])	Set new names on index.
reorder_levels(order)	Rearrange levels using input order.
repeat(repeats, *args, **kwargs)	
reshape(*args, **kwargs)	NOT IMPLEMENTED: do not call this method, as reshaping is not supported for Index objects and will raise an error.
searchsorted(value[, side, sorter])	Find indices where elements should be inserted to maintain order.
set_labels(labels[, level, inplace, ...])	Set new labels on MultiIndex.
set_levels(levels[, level, inplace, ...])	Set new levels on MultiIndex.
set_names(names[, level, inplace])	Set new names on index.
set_value(arr, key, value)	Fast lookup of value from 1-dimensional ndarray.
shift([periods, freq])	Shift Index containing datetime objects by input number of periods and
slice_indexer([start, end, step, kind])	For an ordered Index, compute the slice indexer for input labels and
slice_locs([start, end, step, kind])	For an ordered MultiIndex, compute the slice locations for input labels.
sort(*args, **kwargs)	
sort_values([return_indexer, ascending])	Return sorted copy of Index
sortlevel([level, ascending, sort_remaining])	Sort MultiIndex at the requested level.
str	alias of `StringMethods`

Continued on next page

Table 34.106 – continued from previous page

summary([name])	
swaplevel([i, j])	Swap level i with level j.
symmetric_difference(other[, result_name])	Compute the symmetric difference of two Index objects.
take(indices[, axis, allow_fill, fill_value])	return a new MultiIndex of the values selected by the indices
to_datetime([dayfirst])	DEPRECATED: use pandas.to_datetime() instead.
to_frame([index])	Create a DataFrame with the levels of the MultiIndex as columns.
to_hierarchical(n_repeat[, n_shuffle])	Return a MultiIndex reshaped to conform to the shapes given by n_repeat and n_shuffle.
to_native_types([slicer])	Format specified values of *self* and return them.
to_series(**kwargs)	Create a Series with both index and values equal to the index keys
tolist()	Return a list of the values.
transpose(*args, **kwargs)	return the transpose, which is by definition self
truncate([before, after])	Slice index between two labels / tuples, return new MultiIndex
union(other)	Form the union of two MultiIndex objects, sorting if possible
unique()	Return unique values in the object.
value_counts([normalize, sort, ascending, ...])	Returns object containing counts of unique values.
view([cls])	this is defined as a copy with the same identity
where(cond[, other])	

34.10.1.31 pandas.MultiIndex.all

`MultiIndex.all(other=None)`

34.10.1.32 pandas.MultiIndex.any

`MultiIndex.any(other=None)`

34.10.1.33 pandas.MultiIndex.append

`MultiIndex.append(other)`

Append a collection of Index options together

Parameters **other** : Index or list/tuple of indices

Returns **appended** : Index

34.10.1.34 pandas.MultiIndex.argmax

`MultiIndex.argmax(axis=None)`

return a ndarray of the maximum argument indexer

See also:

numpy.ndarray.argmax

34.10.1.35 pandas.MultiIndex.argmin

`MultiIndex.argmin(axis=None)`

return a ndarray of the minimum argument indexer

See also:

`numpy.ndarray.argmin`

34.10.1.36 pandas.MultiIndex.argsort

`MultiIndex.argsort(*args, **kwargs)`

34.10.1.37 pandas.MultiIndex.asof

`MultiIndex.asof(label)`

For a sorted index, return the most recent label up to and including the passed label. Return NaN if not found.

See also:

`get_loc` asof is a thin wrapper around get_loc with method='pad'

34.10.1.38 pandas.MultiIndex.asof_locs

`MultiIndex.asof_locs(where, mask)`

where : array of timestamps mask : array of booleans where data is not NA

34.10.1.39 pandas.MultiIndex.astype

`MultiIndex.astype(dtype, copy=True)`

Create an Index with values cast to dtypes. The class of a new Index is determined by dtype. When conversion is impossible, a ValueError exception is raised.

Parameters **dtype** : numpy dtype or pandas type

copy : bool, default True

By default, astype always returns a newly allocated object. If copy is set to False and internal requirements on dtype are satisfied, the original data is used to create a new Index or the original Index is returned.

New in version 0.19.0.

34.10.1.40 pandas.MultiIndex.contains

`MultiIndex.contains(key)`

return a boolean if this key is IN the index

Parameters **key** : object

Returns boolean

34.10.1.41 pandas.MultiIndex.copy

`MultiIndex.copy`(*names=None*, *dtype=None*, *levels=None*, *labels=None*, *deep=False*, *_set_identity=False*, ***kwargs*)

Make a copy of this object. Names, dtype, levels and labels can be passed and will be set on new copy.

Parameters **names** : sequence, optional

dtype : numpy dtype or pandas type, optional

levels : sequence, optional

labels : sequence, optional

Returns **copy** : MultiIndex

Notes

In most cases, there should be no functional difference from using `deep`, but if `deep` is passed it will attempt to deepcopy. This could be potentially expensive on large MultiIndex objects.

34.10.1.42 pandas.MultiIndex.delete

`MultiIndex.delete`(*loc*)

Make new index with passed location deleted

Returns **new_index** : MultiIndex

34.10.1.43 pandas.MultiIndex.difference

`MultiIndex.difference`(*other*)

Compute sorted set difference of two MultiIndex objects

Returns **diff** : MultiIndex

34.10.1.44 pandas.MultiIndex.drop

`MultiIndex.drop`(*labels*, *level=None*, *errors='raise'*)

Make new MultiIndex with passed list of labels deleted

Parameters **labels** : array-like

Must be a list of tuples

level : int or level name, default None

Returns **dropped** : MultiIndex

34.10.1.45 pandas.MultiIndex.drop_duplicates

`MultiIndex.drop_duplicates`(*keep='first'*)

Return Index with duplicate values removed

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Drop duplicates except for the first occurrence.

- `last` : Drop duplicates except for the last occurrence.
- False : Drop all duplicates.

Returns **deduplicated** : Index

34.10.1.46 pandas.MultiIndex.droplevel

`MultiIndex.droplevel(level=0)`

Return Index with requested level removed. If MultiIndex has only 2 levels, the result will be of Index type not MultiIndex.

Parameters **level** : int/level name or list thereof

Returns **index** : Index or MultiIndex

Notes

Does not check if result index is unique or not

34.10.1.47 pandas.MultiIndex.dropna

`MultiIndex.dropna(how='any')`

Return Index without NA/NaN values

Parameters **how** : {'any', 'all'}, default 'any'

If the Index is a MultiIndex, drop the value when any or all levels are NaN.

Returns **valid** : Index

34.10.1.48 pandas.MultiIndex.duplicated

`MultiIndex.duplicated(keep='first')`

Return boolean np.ndarray denoting duplicate values

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Mark duplicates as `True` except for the first occurrence.
- `last` : Mark duplicates as `True` except for the last occurrence.
- False : Mark all duplicates as `True`.

Returns **duplicated** : np.ndarray

34.10.1.49 pandas.MultiIndex.equal_levels

`MultiIndex.equal_levels(other)`

Return True if the levels of both MultiIndex objects are the same

34.10.1.50 pandas.MultiIndex.equals

`MultiIndex.equals(other)`

Determines if two MultiIndex objects have the same labeling information (the levels themselves do not necessarily have to be the same)

See also:

equal_levels

34.10.1.51 pandas.MultiIndex.factorize

`MultiIndex.factorize(sort=False, na_sentinel=-1)`

Encode the object as an enumerated type or categorical variable

Parameters **sort** : boolean, default False

Sort by values

na_sentinel: int, default -1

Value to mark "not found"

Returns **labels** : the indexer to the original array

uniques : the unique Index

34.10.1.52 pandas.MultiIndex.fillna

`MultiIndex.fillna(value=None, downcast=None)`

Fill NA/NaN values with the specified value

Parameters **value** : scalar

Scalar value to use to fill holes (e.g. 0). This value cannot be a list-likes.

downcast : dict, default is None

a dict of item->dtype of what to downcast if possible, or the string 'infer' which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns **filled** : %(klass)s

34.10.1.53 pandas.MultiIndex.format

`MultiIndex.format(space=2, sparsify=None, adjoin=True, names=False, na_rep=None, formatter=None)`

34.10.1.54 pandas.MultiIndex.from_arrays

classmethod `MultiIndex.from_arrays(arrays, sortorder=None, names=None)`

Convert arrays to MultiIndex

Parameters **arrays** : list / sequence of array-likes

Each array-like gives one level's value for each data point. len(arrays) is the number of levels.

sortorder : int or None

Level of sortedness (must be lexicographically sorted by that level)

Returns **index** : MultiIndex

See also:

MultiIndex.from_tuples Convert list of tuples to MultiIndex

MultiIndex.from_product Make a MultiIndex from cartesian product of iterables

Examples

```
>>> arrays = [[1, 1, 2, 2], ['red', 'blue', 'red', 'blue']]
>>> MultiIndex.from_arrays(arrays, names=('number', 'color'))
```

34.10.1.55 pandas.MultiIndex.from_product

classmethod `MultiIndex.`**`from_product`**(*iterables*, *sortorder=None*, *names=None*)

Make a MultiIndex from the cartesian product of multiple iterables

Parameters **iterables** : list / sequence of iterables

Each iterable has unique labels for each level of the index.

sortorder : int or None

Level of sortedness (must be lexicographically sorted by that level).

names : list / sequence of strings or None

Names for the levels in the index.

Returns **index** : MultiIndex

See also:

MultiIndex.from_arrays Convert list of arrays to MultiIndex

MultiIndex.from_tuples Convert list of tuples to MultiIndex

Examples

```
>>> numbers = [0, 1, 2]
>>> colors = [u'green', u'purple']
>>> MultiIndex.from_product([numbers, colors],
                            names=['number', 'color'])
MultiIndex(levels=[[0, 1, 2], [u'green', u'purple']],
           labels=[[0, 0, 1, 1, 2, 2], [0, 1, 0, 1, 0, 1]],
           names=[u'number', u'color'])
```

34.10.1.56 pandas.MultiIndex.from_tuples

classmethod `MultiIndex.`**`from_tuples`**(*tuples*, *sortorder=None*, *names=None*)

Convert list of tuples to MultiIndex

Parameters **tuples** : list / sequence of tuple-likes

Each tuple is the index of one row/column.

sortorder : int or None

Level of sortedness (must be lexicographically sorted by that level)

Returns index : MultiIndex

See also:

MultiIndex.from_arrays Convert list of arrays to MultiIndex

MultiIndex.from_product Make a MultiIndex from cartesian product of iterables

Examples

```
>>> tuples = [(1, u'red'), (1, u'blue'),
              (2, u'red'), (2, u'blue')]
>>> MultiIndex.from_tuples(tuples, names=('number', 'color'))
```

34.10.1.57 pandas.MultiIndex.get_duplicates

`MultiIndex.get_duplicates()`

34.10.1.58 pandas.MultiIndex.get_indexer

`MultiIndex.get_indexer(target, method=None, limit=None, tolerance=None)`

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

Parameters target : MultiIndex or list of tuples

method : {None, 'pad'/'ffill', 'backfill'/'bfill', 'nearest'}, optional

- default: exact matches only.
- pad / ffill: find the PREVIOUS index value if no exact match.
- backfill / bfill: use NEXT index value if no exact match
- nearest: use the NEAREST index value if no exact match. Tied distances are broken by preferring the larger index value.

limit : int, optional

Maximum number of consecutive labels in `target` to match for inexact matches.

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **indexer** : ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

Examples

```
>>> indexer = index.get_indexer(new_index)
>>> new_values = cur_values.take(indexer)
```

34.10.1.59 pandas.MultiIndex.get_indexer_for

`MultiIndex.`**`get_indexer_for`**(*target*, ***kwargs*)

guaranteed return of an indexer even when non-unique This dispatches to get_indexer or get_indexer_nonunique as appropriate

34.10.1.60 pandas.MultiIndex.get_indexer_non_unique

`MultiIndex.`**`get_indexer_non_unique`**(*target*)

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

Parameters **target** : MultiIndex or list of tuples

Returns **indexer** : ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

missing : ndarray of int

An indexer into the target of the values not found. These correspond to the -1 in the indexer array

34.10.1.61 pandas.MultiIndex.get_level_values

`MultiIndex.`**`get_level_values`**(*level*)

Return vector of label values for requested level, equal to the length of the index.

Parameters **level** : int or str

`level` is either the integer position of the level in the MultiIndex, or the name of the level.

Returns **values** : Index

`values` is a level of this MultiIndex converted to a single *`Index`* (or subclass thereof).

Examples

Create a MultiIndex:

```
>>> mi = pd.MultiIndex.from_arrays((list('abc'), list('def')))
>>> mi.names = ['level_1', 'level_2']
```

Get level values by supplying level as either integer or name:

```
>>> mi.get_level_values(0)
Index(['a', 'b', 'c'], dtype='object', name='level_1')
>>> mi.get_level_values('level_2')
Index(['d', 'e', 'f'], dtype='object', name='level_2')
```

34.10.1.62 pandas.MultiIndex.get_loc

`MultiIndex.get_loc`(*key*, *method=None*)

Get location for a label or a tuple of labels as an integer, slice or boolean mask.

Parameters **key** : label or tuple of labels (one for each level)

method : None

Returns **loc** : int, slice object or boolean mask

If the key is past the lexsort depth, the return may be a boolean mask array, otherwise it is always a slice or int.

See also:

Index.get_loc get_loc method for (single-level) index.

MultiIndex.slice_locs Get slice location given start label(s) and end label(s).

MultiIndex.get_locs Get location for a label/slice/list/mask or a sequence of such.

Notes

The key cannot be a slice, list of same-level labels, a boolean mask, or a sequence of such. If you want to use those, use *MultiIndex.get_locs()* instead.

Examples

```
>>> mi = pd.MultiIndex.from_arrays([list('abb'), list('def')])
```

```
>>> mi.get_loc('b')
slice(1, 3, None)
```

```
>>> mi.get_loc(('b', 'e'))
1
```

34.10.1.63 pandas.MultiIndex.get_loc_level

`MultiIndex.get_loc_level(key, level=0, drop_level=True)`

Get both the location for the requested label(s) and the resulting sliced index.

Parameters **key** : label or sequence of labels

level : int/level name or list thereof, optional

drop_level : bool, default True

if `False`, the resulting index will not drop any level.

Returns **loc** : A 2-tuple where the elements are:

Element 0: int, slice object or boolean array Element 1: The resulting sliced multiindex/index. If the key contains all levels, this will be `None`.

See also:

MultiIndex.get_loc Get location for a label or a tuple of labels.

MultiIndex.get_locs Get location for a label/slice/list/mask or a sequence of such

Examples

```
>>> mi = pd.MultiIndex.from_arrays([list('abb'), list('def')],
...                                names=['A', 'B'])
```

```
>>> mi.get_loc_level('b')
(slice(1, 3, None), Index(['e', 'f'], dtype='object', name='B'))
```

```
>>> mi.get_loc_level('e', level='B')
(array([False,  True, False], dtype=bool),
Index(['b'], dtype='object', name='A'))
```

```
>>> mi.get_loc_level(['b', 'e'])
(1, None)
```

34.10.1.64 pandas.MultiIndex.get_locs

`MultiIndex.get_locs(seq)`

Get location for a given label/slice/list/mask or a sequence of such as an array of integers.

Parameters **seq** : label/slice/list/mask or a sequence of such

You should use one of the above for each level. If a level should not be used, set it to `slice(None)`.

Returns **locs** : array of integers suitable for passing to iloc

See also:

MultiIndex.get_loc Get location for a label or a tuple of labels.

MultiIndex.slice_locs Get slice location given start label(s) and end label(s).

Examples

```
>>> mi = pd.MultiIndex.from_arrays([list('abb'), list('def')])
```

```
>>> mi.get_locs('b')
array([1, 2], dtype=int64)
```

```
>>> mi.get_locs([slice(None), ['e', 'f']])
array([1, 2], dtype=int64)
```

```
>>> mi.get_locs([[True, False, True], slice('e', 'f')])
array([2], dtype=int64)
```

34.10.1.65 pandas.MultiIndex.get_major_bounds

`MultiIndex.get_major_bounds`(*start=None*, *end=None*, *step=None*, *kind=None*)

For an ordered MultiIndex, compute the slice locations for input labels.

The input labels can be tuples representing partial levels, e.g. for a MultiIndex with 3 levels, you can pass a single value (corresponding to the first level), or a 1-, 2-, or 3-tuple.

Parameters **start** : label or tuple, default None

If None, defaults to the beginning

end : label or tuple

If None, defaults to the end

step : int or None

Slice step

kind : string, optional, defaults None

Returns **(start, end)** : (int, int)

See also:

MultiIndex.get_loc Get location for a label or a tuple of labels.

MultiIndex.get_locs Get location for a label/slice/list/mask or a sequence of such.

Notes

This method only works if the MultiIndex is properly lex-sorted. So, if only the first 2 levels of a 3-level MultiIndex are lexsorted, you can only pass two levels to `.slice_locs`.

Examples

```
>>> mi = pd.MultiIndex.from_arrays([list('abbd'), list('deff')],
...                                names=['A', 'B'])
```

Get the slice locations from the beginning of 'b' in the first level until the end of the multiindex:

```
>>> mi.slice_locs(start='b')
(1, 4)
```

Like above, but stop at the end of 'b' in the first level and 'f' in the second level:

```
>>> mi.slice_locs(start='b', end=('b', 'f'))
(1, 3)
```

34.10.1.66 pandas.MultiIndex.get_slice_bound

`MultiIndex.get_slice_bound(label, side, kind)`

34.10.1.67 pandas.MultiIndex.get_value

`MultiIndex.get_value(series, key)`

34.10.1.68 pandas.MultiIndex.get_values

`MultiIndex.get_values()`

return the underlying data as an ndarray

34.10.1.69 pandas.MultiIndex.groupby

`MultiIndex.groupby(values)`

Group the index labels by a given array of values.

Parameters **values** : array

Values used to determine the groups.

Returns **groups** : dict

{group name -> group labels}

34.10.1.70 pandas.MultiIndex.holds_integer

`MultiIndex.holds_integer()`

34.10.1.71 pandas.MultiIndex.identical

`MultiIndex.identical(other)`

Similar to equals, but check that other comparable attributes are also equal

34.10.1.72 pandas.MultiIndex.insert

`MultiIndex.insert(loc, item)`

Make new MultiIndex inserting new item at location

Parameters **loc** : int

item : tuple

Must be same length as number of levels in the MultiIndex

Returns **new_index** : Index

34.10.1.73 pandas.MultiIndex.intersection

`MultiIndex.intersection(other)`

Form the intersection of two MultiIndex objects, sorting if possible

Parameters **other** : MultiIndex or array / Index of tuples

Returns Index

34.10.1.74 pandas.MultiIndex.is_

`MultiIndex.is_(other)`

More flexible, faster check like `is` but that works through views

Note: this is *not* the same as `Index.identical()`, which checks that metadata is also the same.

Parameters **other** : object

other object to compare against.

Returns **True if both have same underlying data, False otherwise** : bool

34.10.1.75 pandas.MultiIndex.is_boolean

`MultiIndex.is_boolean()`

34.10.1.76 pandas.MultiIndex.is_categorical

`MultiIndex.is_categorical()`

34.10.1.77 pandas.MultiIndex.is_floating

`MultiIndex.is_floating()`

34.10.1.78 pandas.MultiIndex.is_integer

`MultiIndex.is_integer()`

34.10.1.79 pandas.MultiIndex.is_interval

`MultiIndex.is_interval()`

34.10.1.80 pandas.MultiIndex.is_lexsorted

`MultiIndex.is_lexsorted()`

Return True if the labels are lexicographically sorted

34.10.1.81 pandas.MultiIndex.is_lexsorted_for_tuple

`MultiIndex.is_lexsorted_for_tuple(tup)`

34.10.1.82 pandas.MultiIndex.is_mixed

`MultiIndex.is_mixed()`

34.10.1.83 pandas.MultiIndex.is_numeric

`MultiIndex.is_numeric()`

34.10.1.84 pandas.MultiIndex.is_object

`MultiIndex.is_object()`

34.10.1.85 pandas.MultiIndex.is_type_compatible

`MultiIndex.is_type_compatible(kind)`

34.10.1.86 pandas.MultiIndex.isin

`MultiIndex.isin(values, level=None)`

Compute boolean array of whether each index value is found in the passed set of values.

Parameters **values** : set or list-like

Sought values.

New in version 0.18.1.

Support for values as a set

level : str or int, optional

Name or position of the index level to use (if the index is a MultiIndex).

Returns **is_contained** : ndarray (boolean dtype)

Notes

If *level* is specified:

- if it is the name of one *and only one* index level, use that level;
- otherwise it should be a number indicating level position.

34.10.1.87 pandas.MultiIndex.isna

`MultiIndex.isna()`

Detect missing values

New in version 0.20.0.

Returns a boolean array of whether my values are NA

See also:

isnull alias of isna

pandas.isna top-level isna

34.10.1.88 pandas.MultiIndex.isnull

`MultiIndex.isnull()`

Detect missing values

New in version 0.20.0.

Returns a boolean array of whether my values are NA

See also:

isnull alias of isna

pandas.isna top-level isna

34.10.1.89 pandas.MultiIndex.item

`MultiIndex.item()`

return the first element of the underlying data as a python scalar

34.10.1.90 pandas.MultiIndex.join

`MultiIndex.join(other, how='left', level=None, return_indexers=False, sort=False)`

this is an internal non-public method

Compute join_index and indexers to conform data structures to the new index.

Parameters **other** : Index

how : {'left', 'right', 'inner', 'outer'}

level : int or level name, default None

return_indexers : boolean, default False

sort : boolean, default False

Sort the join keys lexicographically in the result Index. If False, the order of the join keys depends on the join type (how keyword)

New in version 0.20.0.

Returns join_index, (left_indexer, right_indexer)

34.10.1.91 pandas.MultiIndex.map

`MultiIndex.map(mapper)`

Apply mapper function to an index.

Parameters **mapper** : callable

Function to be applied.

Returns **applied** : Union[Index, MultiIndex], inferred

The output of the mapping function applied to the index. If the function returns a tuple with more than one element a MultiIndex will be returned.

34.10.1.92 pandas.MultiIndex.max

`MultiIndex.max()`

The maximum value of the object

34.10.1.93 pandas.MultiIndex.memory_usage

`MultiIndex.memory_usage(deep=False)`

Memory usage of my values

Parameters **deep** : bool

Introspect the data deeply, interrogate *object* dtypes for system-level memory consumption

Returns bytes used

See also:

`numpy.ndarray.nbytes`

Notes

Memory usage does not include memory consumed by elements that are not components of the array if deep=False or if used on PyPy

34.10.1.94 pandas.MultiIndex.min

`MultiIndex.min()`

The minimum value of the object

34.10.1.95 pandas.MultiIndex.notna

`MultiIndex.notna()`

Inverse of isna

New in version 0.20.0.

Returns a boolean array of whether my values are not NA

See also:

notnull alias of notna

pandas.notna top-level notna

34.10.1.96 pandas.MultiIndex.notnull

`MultiIndex.notnull()`

Inverse of isna

New in version 0.20.0.

Returns a boolean array of whether my values are not NA

See also:

notnull alias of notna

pandas.notna top-level notna

34.10.1.97 pandas.MultiIndex.nunique

`MultiIndex.nunique(dropna=True)`

Return number of unique elements in the object.

Excludes NA values by default.

Parameters **dropna** : boolean, default True

Don't include NaN in the count.

Returns **nunique** : int

34.10.1.98 pandas.MultiIndex.putmask

`MultiIndex.putmask(mask, value)`

return a new Index of the values set with the mask

See also:

`numpy.ndarray.putmask`

34.10.1.99 pandas.MultiIndex.ravel

`MultiIndex.ravel(order='C')`

return an ndarray of the flattened values of the underlying data

See also:

`numpy.ndarray.ravel`

34.10.1.100 pandas.MultiIndex.reindex

`MultiIndex.reindex(target, method=None, level=None, limit=None, tolerance=None)`

Create index with target's values (move/add/delete values as necessary)

Returns **new_index** : pd.MultiIndex

Resulting index

indexer : np.ndarray or None

Indices of output values in original index

34.10.1.101 pandas.MultiIndex.remove_unused_levels

`MultiIndex.remove_unused_levels()`

create a new MultiIndex from the current that removing unused levels, meaning that they are not expressed in the labels

The resulting MultiIndex will have the same outward appearance, meaning the same .values and ordering. It will also be .equals() to the original.

New in version 0.20.0.

Returns MultiIndex

Examples

```
>>> i = pd.MultiIndex.from_product([range(2), list('ab')])
MultiIndex(levels=[[0, 1], ['a', 'b']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]])
```

```
>>> i[2:]
MultiIndex(levels=[[0, 1], ['a', 'b']],
           labels=[[1, 1], [0, 1]])
```

The 0 from the first level is not represented and can be removed

```
>>> i[2:].remove_unused_levels()
MultiIndex(levels=[[1], ['a', 'b']],
           labels=[[0, 0], [0, 1]])
```

34.10.1.102 pandas.MultiIndex.rename

`MultiIndex.rename(names, level=None, inplace=False)`

Set new names on index. Defaults to returning new index.

Parameters **names** : str or sequence

name(s) to set

level : int, level name, or sequence of int/level names (default None)

If the index is a MultiIndex (hierarchical), level(s) to set (None for all levels). Otherwise level must be None

inplace : bool

if True, mutates in place

Returns new index (of same type and class...etc) [if inplace, returns None]

Examples

```
>>> Index([1, 2, 3, 4]).set_names('foo')
Int64Index([1, 2, 3, 4], dtype='int64')
>>> Index([1, 2, 3, 4]).set_names(['foo'])
Int64Index([1, 2, 3, 4], dtype='int64')
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                  (2, u'one'), (2, u'two')],
                                  names=['foo', 'bar'])
>>> idx.set_names(['baz', 'quz'])
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'baz', u'quz'])
>>> idx.set_names('baz', level=0)
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'baz', u'bar'])
```

34.10.1.103 pandas.MultiIndex.reorder_levels

`MultiIndex.reorder_levels(order)`

Rearrange levels using input order. May not drop or duplicate levels

34.10.1.104 pandas.MultiIndex.repeat

`MultiIndex.repeat(repeats, *args, **kwargs)`

34.10.1.105 pandas.MultiIndex.reshape

`MultiIndex.reshape(*args, **kwargs)`

NOT IMPLEMENTED: do not call this method, as reshaping is not supported for Index objects and will raise an error.

Reshape an Index.

34.10.1.106 pandas.MultiIndex.searchsorted

`MultiIndex.searchsorted(value, side='left', sorter=None)`

Find indices where elements should be inserted to maintain order.

Find the indices into a sorted IndexOpsMixin *self* such that, if the corresponding elements in *value* were inserted before the indices, the order of *self* would be preserved.

Parameters **value** : array_like

Values to insert into *self*.

side : {'left', 'right'}, optional

If 'left', the index of the first suitable location found is given. If 'right', return the last such index. If there is no suitable index, return either 0 or N (where N is the length of *self*).

sorter : 1-D array_like, optional

Optional array of integer indices that sort *self* into ascending order. They are typically the result of `np.argsort`.

Returns **indices** : array of ints

Array of insertion points with the same shape as *value*.

See also:

`numpy.searchsorted`

Notes

Binary search is used to find the required insertion points.

Examples

```
>>> x = pd.Series([1, 2, 3])
>>> x
0    1
1    2
2    3
dtype: int64
```

```
>>> x.searchsorted(4)
array([3])
```

```
>>> x.searchsorted([0, 4])
array([0, 3])
```

```
>>> x.searchsorted([1, 3], side='left')
array([0, 2])
```

```
>>> x.searchsorted([1, 3], side='right')
array([1, 3])
```

```
>>> x = pd.Categorical(['apple', 'bread', 'bread', 'cheese', 'milk' ])
[apple, bread, bread, cheese, milk]
Categories (4, object): [apple < bread < cheese < milk]
```

```
>>> x.searchsorted('bread')
array([1])     # Note: an array, not a scalar
```

```
>>> x.searchsorted(['bread'])
array([1])
```

```
>>> x.searchsorted(['bread', 'eggs'])
array([1, 4])
```

```
>>> x.searchsorted(['bread', 'eggs'], side='right')
array([3, 4])    # eggs before milk
```

34.10.1.107 pandas.MultiIndex.set_labels

`MultiIndex.set_labels`(*labels*, *level=None*, *inplace=False*, *verify_integrity=True*)

Set new labels on MultiIndex. Defaults to returning new index.

Parameters **labels** : sequence or list of sequence

new labels to apply

level : int, level name, or sequence of int/level names (default None)

level(s) to set (None for all levels)

inplace : bool

if True, mutates in place

verify_integrity : bool (default True)

if True, checks that levels and labels are compatible

Returns new index (of same type and class...etc)

Examples

```
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                  (2, u'one'), (2, u'two')],
                                  names=['foo', 'bar'])
>>> idx.set_labels([[1,0,1,0], [0,0,1,1]])
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[1, 0, 1, 0], [0, 0, 1, 1]],
           names=[u'foo', u'bar'])
>>> idx.set_labels([1,0,1,0], level=0)
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[1, 0, 1, 0], [0, 1, 0, 1]],
           names=[u'foo', u'bar'])
>>> idx.set_labels([0,0,1,1], level='bar')
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 0, 1, 1]],
           names=[u'foo', u'bar'])
>>> idx.set_labels([[1,0,1,0], [0,0,1,1]], level=[0,1])
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[1, 0, 1, 0], [0, 0, 1, 1]],
           names=[u'foo', u'bar'])
```

34.10.1.108 pandas.MultiIndex.set_levels

`MultiIndex.set_levels`(*levels*, *level=None*, *inplace=False*, *verify_integrity=True*)

Set new levels on MultiIndex. Defaults to returning new index.

Parameters **levels** : sequence or list of sequence

new level(s) to apply

level : int, level name, or sequence of int/level names (default None)

level(s) to set (None for all levels)

inplace : bool

if True, mutates in place

verify_integrity : bool (default True)

if True, checks that levels and labels are compatible

Returns new index (of same type and class...etc)

Examples

```
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                  (2, u'one'), (2, u'two')],
                                  names=['foo', 'bar'])
>>> idx.set_levels([['a','b'], [1,2]])
MultiIndex(levels=[[u'a', u'b'], [1, 2]],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'foo', u'bar'])
>>> idx.set_levels(['a','b'], level=0)
MultiIndex(levels=[[u'a', u'b'], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'foo', u'bar'])
>>> idx.set_levels(['a','b'], level='bar')
MultiIndex(levels=[[1, 2], [u'a', u'b']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'foo', u'bar'])
>>> idx.set_levels([['a','b'], [1,2]], level=[0,1])
MultiIndex(levels=[[u'a', u'b'], [1, 2]],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'foo', u'bar'])
```

34.10.1.109 pandas.MultiIndex.set_names

`MultiIndex.set_names`(*names*, *level=None*, *inplace=False*)

Set new names on index. Defaults to returning new index.

Parameters **names** : str or sequence

name(s) to set

level : int, level name, or sequence of int/level names (default None)

If the index is a MultiIndex (hierarchical), level(s) to set (None for all levels). Otherwise level must be None

inplace : bool

if True, mutates in place

Returns new index (of same type and class...etc) [if inplace, returns None]

Examples

```
>>> Index([1, 2, 3, 4]).set_names('foo')
Int64Index([1, 2, 3, 4], dtype='int64')
>>> Index([1, 2, 3, 4]).set_names(['foo'])
Int64Index([1, 2, 3, 4], dtype='int64')
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
```

```
                                  (2, u'one'), (2, u'two')],
                                  names=['foo', 'bar'])
>>> idx.set_names(['baz', 'quz'])
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'baz', u'quz'])
>>> idx.set_names('baz', level=0)
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'baz', u'bar'])
```

34.10.1.110 pandas.MultiIndex.set_value

`MultiIndex.set_value`(*arr*, *key*, *value*)

Fast lookup of value from 1-dimensional ndarray. Only use this if you know what you're doing

34.10.1.111 pandas.MultiIndex.shift

`MultiIndex.shift`(*periods=1*, *freq=None*)

Shift Index containing datetime objects by input number of periods and DateOffset

Returns **shifted** : Index

34.10.1.112 pandas.MultiIndex.slice_indexer

`MultiIndex.slice_indexer`(*start=None*, *end=None*, *step=None*, *kind=None*)

For an ordered Index, compute the slice indexer for input labels and step

Parameters **start** : label, default None

If None, defaults to the beginning

end : label, default None

If None, defaults to the end

step : int, default None

kind : string, default None

Returns **indexer** : ndarray or slice

Notes

This function assumes that the data is sorted, so use at your own peril

34.10.1.113 pandas.MultiIndex.slice_locs

`MultiIndex.slice_locs`(*start=None*, *end=None*, *step=None*, *kind=None*)

For an ordered MultiIndex, compute the slice locations for input labels.

The input labels can be tuples representing partial levels, e.g. for a MultiIndex with 3 levels, you can pass a single value (corresponding to the first level), or a 1-, 2-, or 3-tuple.

Parameters **start** : label or tuple, default None

If None, defaults to the beginning

end : label or tuple

If None, defaults to the end

step : int or None

Slice step

kind : string, optional, defaults None

Returns (start, end) : (int, int)

See also:

MultiIndex.get_loc Get location for a label or a tuple of labels.

MultiIndex.get_locs Get location for a label/slice/list/mask or a sequence of such.

Notes

This method only works if the MultiIndex is properly lex-sorted. So, if only the first 2 levels of a 3-level MultiIndex are lexsorted, you can only pass two levels to `.slice_locs`.

Examples

```
>>> mi = pd.MultiIndex.from_arrays([list('abbd'), list('deff')],
...                                names=['A', 'B'])
```

Get the slice locations from the beginning of 'b' in the first level until the end of the multiindex:

```
>>> mi.slice_locs(start='b')
(1, 4)
```

Like above, but stop at the end of 'b' in the first level and 'f' in the second level:

```
>>> mi.slice_locs(start='b', end=('b', 'f'))
(1, 3)
```

34.10.1.114 pandas.MultiIndex.sort

`MultiIndex.`**`sort`**(**args*, ***kwargs*)

34.10.1.115 pandas.MultiIndex.sort_values

`MultiIndex.`**`sort_values`**(*return_indexer=False*, *ascending=True*)

Return sorted copy of Index

34.10.1.116 pandas.MultiIndex.sortlevel

`MultiIndex.`**`sortlevel`**(*level=0*, *ascending=True*, *sort_remaining=True*)

Sort MultiIndex at the requested level. The result will respect the original ordering of the associated factor at that level.

Parameters **level** : list-like, int or str, default 0

If a string is given, must be a name of the level If list-like must be names or ints of levels.

ascending : boolean, default True

False to sort in descending order Can also be a list to specify a directed ordering

sort_remaining : sort by the remaining levels after level.

Returns **sorted_index** : pd.MultiIndex

Resulting index

indexer : np.ndarray

Indices of output values in original index

34.10.1.117 pandas.MultiIndex.str

`MultiIndex.str()`

Vectorized string functions for Series and Index. NAs stay NA unless handled otherwise by a particular method. Patterned after Python's string methods, with some inspiration from R's stringr package.

Examples

```
>>> s.str.split('_')
>>> s.str.replace('_', '')
```

34.10.1.118 pandas.MultiIndex.summary

`MultiIndex.summary(name=None)`

34.10.1.119 pandas.MultiIndex.swaplevel

`MultiIndex.swaplevel(i=-2, j=-1)`

Swap level i with level j. Do not change the ordering of anything

Parameters **i, j** : int, string (can be mixed)

Level of index to be swapped. Can pass level name as string.

Returns **swapped** : MultiIndex

Changed in version 0.18.1: The indexes `i` and `j` are now optional, and default to the two innermost levels of the index.

34.10.1.120 pandas.MultiIndex.symmetric_difference

`MultiIndex.symmetric_difference(other, result_name=None)`

Compute the symmetric difference of two Index objects. It's sorted if sorting is possible.

Parameters **other** : Index or array-like

result_name : str

Returns symmetric_difference : Index

Notes

`symmetric_difference` contains elements that appear in either `idx1` or `idx2` but not both. Equivalent to the Index created by `idx1.difference(idx2) | idx2.difference(idx1)` with duplicates dropped.

Examples

```
>>> idx1 = Index([1, 2, 3, 4])
>>> idx2 = Index([2, 3, 4, 5])
>>> idx1.symmetric_difference(idx2)
Int64Index([1, 5], dtype='int64')
```

You can also use the ^ operator:

```
>>> idx1 ^ idx2
Int64Index([1, 5], dtype='int64')
```

34.10.1.121 pandas.MultiIndex.take

`MultiIndex.take`(*indices*, *axis=0*, *allow_fill=True*, *fill_value=None*, ***kwargs*)

return a new MultiIndex of the values selected by the indices

For internal compatibility with numpy arrays.

Parameters indices : list

Indices to be taken

axis : int, optional

The axis over which to select values, always 0.

allow_fill : bool, default True

fill_value : bool, default None

If allow_fill=True and fill_value is not None, indices specified by -1 is regarded as NA. If Index doesn't hold NA, raise ValueError

See also:

`numpy.ndarray.take`

34.10.1.122 pandas.MultiIndex.to_datetime

`MultiIndex.to_datetime`(*dayfirst=False*)

DEPRECATED: use `pandas.to_datetime()` instead.

For an Index containing strings or datetime.datetime objects, attempt conversion to DatetimeIndex

34.10.1.123 pandas.MultiIndex.to_frame

`MultiIndex.to_frame(index=True)`

Create a DataFrame with the levels of the MultiIndex as columns.

New in version 0.20.0.

Parameters **index** : boolean, default True

Set the index of the returned DataFrame as the original MultiIndex.

Returns **DataFrame** : a DataFrame containing the original MultiIndex data.

34.10.1.124 pandas.MultiIndex.to_hierarchical

`MultiIndex.to_hierarchical(n_repeat, n_shuffle=1)`

Return a MultiIndex reshaped to conform to the shapes given by n_repeat and n_shuffle.

Useful to replicate and rearrange a MultiIndex for combination with another Index with n_repeat items.

Parameters **n_repeat** : int

Number of times to repeat the labels on self

n_shuffle : int

Controls the reordering of the labels. If the result is going to be an inner level in a MultiIndex, n_shuffle will need to be greater than one. The size of each label must divisible by n_shuffle.

Returns MultiIndex

Examples

```
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                  (2, u'one'), (2, u'two')])
>>> idx.to_hierarchical(3)
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1],
                   [0, 0, 0, 1, 1, 1, 0, 0, 0, 1, 1, 1]])
```

34.10.1.125 pandas.MultiIndex.to_native_types

`MultiIndex.to_native_types(slicer=None, **kwargs)`

Format specified values of *self* and return them.

Parameters **slicer** : int, array-like

An indexer into *self* that specifies which values are used in the formatting process.

kwargs : dict

Options for specifying how the values should be formatted. These options include the following:

1. **na_rep** [str] The value that serves as a placeholder for NULL values
2. **quoting** [bool or None] Whether or not there are quoted values in *self*
3. **date_format** [str] The format used to represent date-like values

34.10.1.126 pandas.MultiIndex.to_series

`MultiIndex.to_series(**kwargs)`

Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index

Returns **Series** : dtype will be based on the type of the Index values.

34.10.1.127 pandas.MultiIndex.tolist

`MultiIndex.tolist()`

Return a list of the values.

These are each a scalar type, which is a Python scalar (for str, int, float) or a pandas scalar (for Timestamp/Timedelta/Interval/Period)

See also:

`numpy.ndarray.tolist`

34.10.1.128 pandas.MultiIndex.transpose

`MultiIndex.transpose(*args, **kwargs)`

return the transpose, which is by definition self

34.10.1.129 pandas.MultiIndex.truncate

`MultiIndex.truncate(before=None, after=None)`

Slice index between two labels / tuples, return new MultiIndex

Parameters **before** : label or tuple, can be partial. Default None

None defaults to start

after : label or tuple, can be partial. Default None

None defaults to end

Returns **truncated** : MultiIndex

34.10.1.130 pandas.MultiIndex.union

`MultiIndex.union(other)`

Form the union of two MultiIndex objects, sorting if possible

Parameters **other** : MultiIndex or array / Index of tuples

Returns Index

```
>>> index.union(index2)
```

34.10.1.131 pandas.MultiIndex.unique

`MultiIndex.unique()`

Return unique values in the object. Uniques are returned in order of appearance, this does NOT sort. Hash table-based unique.

Parameters **values** : 1d array-like

Returns unique values.

- If the input is an Index, the return is an Index
- If the input is a Categorical dtype, the return is a Categorical
- If the input is a Series/ndarray, the return will be an ndarray

See also:

unique, *Index.unique*, *Series.unique*

34.10.1.132 pandas.MultiIndex.value_counts

`MultiIndex.value_counts(normalize=False, sort=True, ascending=False, bins=None, dropna=True)`

Returns object containing counts of unique values.

The resulting object will be in descending order so that the first element is the most frequently-occurring element. Excludes NA values by default.

Parameters **normalize** : boolean, default False

If True then the object returned will contain the relative frequencies of the unique values.

sort : boolean, default True

Sort by values

ascending : boolean, default False

Sort in ascending order

bins : integer, optional

Rather than count values, group them into half-open bins, a convenience for pd.cut, only works with numeric data

dropna : boolean, default True

Don't include counts of NaN.

Returns **counts** : Series

34.10.1.133 pandas.MultiIndex.view

`MultiIndex.view(cls=None)`

this is defined as a copy with the same identity

34.10.1.134 pandas.MultiIndex.where

`MultiIndex.where(cond, other=None)`

34.10.2 pandas.IndexSlice

pandas.**IndexSlice = <pandas.core.indexing._IndexSlice object>**

Create an object to more easily perform multi-index slicing

Examples

```
>>> midx = pd.MultiIndex.from_product([['A0','A1'], ['B0','B1','B2','B3']])
>>> columns = ['foo', 'bar']
>>> dfmi = pd.DataFrame(np.arange(16).reshape((len(midx), len(columns))),
                        index=midx, columns=columns)
```

Using the default slice command:

```
>>> dfmi.loc[(slice(None), slice('B0', 'B1')), :]
           foo  bar
    A0 B0    0    1
       B1    2    3
    A1 B0    8    9
       B1   10   11
```

Using the IndexSlice class for a more intuitive command:

```
>>> idx = pd.IndexSlice
>>> dfmi.loc[idx[:, 'B0':'B1'], :]
           foo  bar
    A0 B0    0    1
       B1    2    3
    A1 B0    8    9
       B1   10   11
```

34.10.3 MultiIndex Components

MultiIndex.from_arrays(arrays[, sortorder, ...])	Convert arrays to MultiIndex
MultiIndex.from_tuples(tuples[, sortorder, ...])	Convert list of tuples to MultiIndex
MultiIndex.from_product(iterables[, ...])	Make a MultiIndex from the cartesian product of multiple iterables
MultiIndex.set_levels(levels[, level, ...])	Set new levels on MultiIndex.
MultiIndex.set_labels(labels[, level, ...])	Set new labels on MultiIndex.
MultiIndex.to_hierarchical(n_repeat[, n_shuffle])	Return a MultiIndex reshaped to conform to the shapes given by n_repeat and n_shuffle.
MultiIndex.to_frame([index])	Create a DataFrame with the levels of the MultiIndex as columns.
MultiIndex.is_lexsorted()	Return True if the labels are lexicographically sorted
MultiIndex.droplevel([level])	Return Index with requested level removed.
MultiIndex.swaplevel([i, j])	Swap level i with level j.
MultiIndex.reorder_levels(order)	Rearrange levels using input order.
MultiIndex.remove_unused_levels()	create a new MultiIndex from the current that removing

34.11 DatetimeIndex

DatetimeIndex	Immutable ndarray of datetime64 data, represented internally as int64, and which can be boxed to Timestamp objects that are subclasses of datetime and carry metadata such as frequency information.

34.11.1 pandas.DatetimeIndex

class pandas.**DatetimeIndex**

Immutable ndarray of datetime64 data, represented internally as int64, and which can be boxed to Timestamp objects that are subclasses of datetime and carry metadata such as frequency information.

Parameters **data** : array-like (1-dimensional), optional

Optional datetime-like data to construct index with

copy : bool

Make a copy of input ndarray

freq : string or pandas offset object, optional

One of pandas date offset strings or corresponding objects

start : starting value, datetime-like, optional

If data is None, start is used as the start point in generating regular timestamp data.

periods : int, optional, > 0

Number of periods to generate, if generating index. Takes precedence over end argument

end : end time, datetime-like, optional

If periods is none, generated index will extend to first conforming time on or just past end argument

closed : string or None, default None

Make the interval closed with respect to the given frequency to the 'left', 'right', or both sides (None)

tz : pytz.timezone or dateutil.tz.tzfile

ambiguous : 'infer', bool-ndarray, 'NaT', default 'raise'

- 'infer' will attempt to infer fall dst-transition hours based on order
- bool-ndarray where True signifies a DST time, False signifies a non-DST time (note that this flag is only applicable for ambiguous times)
- 'NaT' will return NaT where there are ambiguous times
- 'raise' will raise an AmbiguousTimeError if there are ambiguous times

infer_dst : boolean, default False

Deprecated since version 0.15.0: Attempt to infer fall dst-transition hours based on order

name : object

Name to be stored in the index

See also:

Index The base pandas Index type

TimedeltaIndex Index of timedelta64 data

PeriodIndex Index of Period data

Notes

To learn more about the frequency strings, please see this link.

Attributes

T	return the transpose, which is by definition self
asi8	
asobject	return object Index which contains boxed values
base	return the base object if the memory of the underlying data is
data	return the data pointer of the underlying data
date	Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without timezone information).
day	The days of the datetime
dayofweek	The day of the week with Monday=0, Sunday=6
dayofyear	The ordinal day of the year
days_in_month	The number of days in the month
daysinmonth	The number of days in the month
dtype	
dtype_str	
empty	
flags	
freq	get/set the frequency of the Index
freqstr	Return the frequency object as a string if its set, otherwise None
has_duplicates	
hasnans	
hour	The hours of the datetime
inferred_freq	
inferred_type	
is_all_dates	
is_leap_year	Logical indicating if the date belongs to a leap year
is_monotonic	alias for is_monotonic_increasing (deprecated)
is_monotonic_decreasing	return if the index is monotonic decreasing (only equal or
is_monotonic_increasing	return if the index is monotonic increasing (only equal or
is_month_end	Logical indicating if last day of month (defined by frequency)
is_month_start	Logical indicating if first day of month (defined by frequency)
is_normalized	

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is_quarter_end	Logical indicating if last day of quarter (defined by frequency)
is_quarter_start	Logical indicating if first day of quarter (defined by frequency)
is_unique	
is_year_end	Logical indicating if last day of year (defined by frequency)
is_year_start	Logical indicating if first day of year (defined by frequency)
itemsize	return the size of the dtype of the item of the underlying data
microsecond	The microseconds of the datetime
minute	The minutes of the datetime
month	The month as January=1, December=12
name	
names	
nanosecond	The nanoseconds of the datetime
nbytes	return the number of bytes in the underlying data
ndim	return the number of dimensions of the underlying data,
nlevels	
offset	
quarter	The quarter of the date
resolution	
second	The seconds of the datetime
shape	return a tuple of the shape of the underlying data
size	return the number of elements in the underlying data
strides	return the strides of the underlying data
time	Returns numpy array of datetime.time.
tz	
tzinfo	Alias for tz attribute
values	return the underlying data as an ndarray
week	The week ordinal of the year
weekday	The day of the week with Monday=0, Sunday=6
weekday_name	The name of day in a week (ex: Friday)
weekofyear	The week ordinal of the year
year	The year of the datetime

34.11.1.1 pandas.DatetimeIndex.T

`DatetimeIndex.`**`T`**

return the transpose, which is by definition self

34.11.1.2 pandas.DatetimeIndex.asi8

`DatetimeIndex.`**`asi8`**

34.11.1.3 pandas.DatetimeIndex.asobject

`DatetimeIndex.`**`asobject`**

return object Index which contains boxed values

this is an internal non-public method

34.11.1.4 pandas.DatetimeIndex.base

`DatetimeIndex.base`

return the base object if the memory of the underlying data is shared

34.11.1.5 pandas.DatetimeIndex.data

`DatetimeIndex.data`

return the data pointer of the underlying data

34.11.1.6 pandas.DatetimeIndex.date

`DatetimeIndex.date`

Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without timezone information).

34.11.1.7 pandas.DatetimeIndex.day

`DatetimeIndex.day`

The days of the datetime

34.11.1.8 pandas.DatetimeIndex.dayofweek

`DatetimeIndex.dayofweek`

The day of the week with Monday=0, Sunday=6

34.11.1.9 pandas.DatetimeIndex.dayofyear

`DatetimeIndex.dayofyear`

The ordinal day of the year

34.11.1.10 pandas.DatetimeIndex.days_in_month

`DatetimeIndex.days_in_month`

The number of days in the month

34.11.1.11 pandas.DatetimeIndex.daysinmonth

`DatetimeIndex.daysinmonth`

The number of days in the month

34.11.1.12 pandas.DatetimeIndex.dtype

`DatetimeIndex.dtype` = **None**

34.11.1.13 pandas.DatetimeIndex.dtype_str

`DatetimeIndex.dtype_str` = None

34.11.1.14 pandas.DatetimeIndex.empty

`DatetimeIndex.empty`

34.11.1.15 pandas.DatetimeIndex.flags

`DatetimeIndex.flags`

34.11.1.16 pandas.DatetimeIndex.freq

`DatetimeIndex.freq`

get/set the frequency of the Index

34.11.1.17 pandas.DatetimeIndex.freqstr

`DatetimeIndex.freqstr`

Return the frequency object as a string if its set, otherwise None

34.11.1.18 pandas.DatetimeIndex.has_duplicates

`DatetimeIndex.has_duplicates`

34.11.1.19 pandas.DatetimeIndex.hasnans

`DatetimeIndex.hasnans` = None

34.11.1.20 pandas.DatetimeIndex.hour

`DatetimeIndex.hour`

The hours of the datetime

34.11.1.21 pandas.DatetimeIndex.inferred_freq

`DatetimeIndex.inferred_freq` = None

34.11.1.22 pandas.DatetimeIndex.inferred_type

`DatetimeIndex.inferred_type`

34.11.1.23 pandas.DatetimeIndex.is_all_dates

`DatetimeIndex.is_all_dates`

34.11.1.24 pandas.DatetimeIndex.is_leap_year

`DatetimeIndex.is_leap_year`

Logical indicating if the date belongs to a leap year

34.11.1.25 pandas.DatetimeIndex.is_monotonic

`DatetimeIndex.is_monotonic`

alias for is_monotonic_increasing (deprecated)

34.11.1.26 pandas.DatetimeIndex.is_monotonic_decreasing

`DatetimeIndex.is_monotonic_decreasing`

return if the index is monotonic decreasing (only equal or decreasing) values.

Examples

```
>>> Index([3, 2, 1]).is_monotonic_decreasing
True
>>> Index([3, 2, 2]).is_monotonic_decreasing
True
>>> Index([3, 1, 2]).is_monotonic_decreasing
False
```

34.11.1.27 pandas.DatetimeIndex.is_monotonic_increasing

`DatetimeIndex.is_monotonic_increasing`

return if the index is monotonic increasing (only equal or increasing) values.

Examples

```
>>> Index([1, 2, 3]).is_monotonic_increasing
True
>>> Index([1, 2, 2]).is_monotonic_increasing
True
>>> Index([1, 3, 2]).is_monotonic_increasing
False
```

34.11.1.28 pandas.DatetimeIndex.is_month_end

`DatetimeIndex.is_month_end`

Logical indicating if last day of month (defined by frequency)

34.11.1.29 pandas.DatetimeIndex.is_month_start

`DatetimeIndex.is_month_start`

Logical indicating if first day of month (defined by frequency)

34.11.1.30 pandas.DatetimeIndex.is_normalized

`DatetimeIndex.`**`is_normalized`** = **None**

34.11.1.31 pandas.DatetimeIndex.is_quarter_end

`DatetimeIndex.`**`is_quarter_end`**

Logical indicating if last day of quarter (defined by frequency)

34.11.1.32 pandas.DatetimeIndex.is_quarter_start

`DatetimeIndex.`**`is_quarter_start`**

Logical indicating if first day of quarter (defined by frequency)

34.11.1.33 pandas.DatetimeIndex.is_unique

`DatetimeIndex.`**`is_unique`** = **None**

34.11.1.34 pandas.DatetimeIndex.is_year_end

`DatetimeIndex.`**`is_year_end`**

Logical indicating if last day of year (defined by frequency)

34.11.1.35 pandas.DatetimeIndex.is_year_start

`DatetimeIndex.`**`is_year_start`**

Logical indicating if first day of year (defined by frequency)

34.11.1.36 pandas.DatetimeIndex.itemsize

`DatetimeIndex.`**`itemsize`**

return the size of the dtype of the item of the underlying data

34.11.1.37 pandas.DatetimeIndex.microsecond

`DatetimeIndex.`**`microsecond`**

The microseconds of the datetime

34.11.1.38 pandas.DatetimeIndex.minute

`DatetimeIndex.`**`minute`**

The minutes of the datetime

34.11.1.39 pandas.DatetimeIndex.month

`DatetimeIndex.`**`month`**

The month as January=1, December=12

34.11.1.40 pandas.DatetimeIndex.name

`DatetimeIndex.name` = None

34.11.1.41 pandas.DatetimeIndex.names

`DatetimeIndex.names`

34.11.1.42 pandas.DatetimeIndex.nanosecond

`DatetimeIndex.nanosecond`

The nanoseconds of the datetime

34.11.1.43 pandas.DatetimeIndex.nbytes

`DatetimeIndex.nbytes`

return the number of bytes in the underlying data

34.11.1.44 pandas.DatetimeIndex.ndim

`DatetimeIndex.ndim`

return the number of dimensions of the underlying data, by definition 1

34.11.1.45 pandas.DatetimeIndex.nlevels

`DatetimeIndex.nlevels`

34.11.1.46 pandas.DatetimeIndex.offset

`DatetimeIndex.offset` = None

34.11.1.47 pandas.DatetimeIndex.quarter

`DatetimeIndex.quarter`

The quarter of the date

34.11.1.48 pandas.DatetimeIndex.resolution

`DatetimeIndex.resolution` = None

34.11.1.49 pandas.DatetimeIndex.second

`DatetimeIndex.second`

The seconds of the datetime

34.11.1.50 pandas.DatetimeIndex.shape

`DatetimeIndex.shape`

return a tuple of the shape of the underlying data

34.11.1.51 pandas.DatetimeIndex.size

`DatetimeIndex.size`

return the number of elements in the underlying data

34.11.1.52 pandas.DatetimeIndex.strides

`DatetimeIndex.strides`

return the strides of the underlying data

34.11.1.53 pandas.DatetimeIndex.time

`DatetimeIndex.time`

Returns numpy array of datetime.time. The time part of the Timestamps.

34.11.1.54 pandas.DatetimeIndex.tz

`DatetimeIndex.tz` = **None**

34.11.1.55 pandas.DatetimeIndex.tzinfo

`DatetimeIndex.tzinfo`

Alias for tz attribute

34.11.1.56 pandas.DatetimeIndex.values

`DatetimeIndex.values`

return the underlying data as an ndarray

34.11.1.57 pandas.DatetimeIndex.week

`DatetimeIndex.week`

The week ordinal of the year

34.11.1.58 pandas.DatetimeIndex.weekday

`DatetimeIndex.weekday`

The day of the week with Monday=0, Sunday=6

34.11.1.59 pandas.DatetimeIndex.weekday_name

`DatetimeIndex.weekday_name`

The name of day in a week (ex: Friday)

New in version 0.18.1.

34.11.1.60 pandas.DatetimeIndex.weekofyear

`DatetimeIndex.weekofyear`

The week ordinal of the year

34.11.1.61 pandas.DatetimeIndex.year

`DatetimeIndex.year`

The year of the datetime

Methods

all([other])	
any([other])	
append(other)	Append a collection of Index options together
argmax([axis])	Returns the indices of the maximum values along an axis.
argmin([axis])	Returns the indices of the minimum values along an axis.
argsort(*args, **kwargs)	Returns the indices that would sort the index and its underlying data.
asof(label)	For a sorted index, return the most recent label up to and including the passed label.
asof_locs(where, mask)	where : array of timestamps
astype(dtype[, copy])	Create an Index with values cast to dtypes.
ceil(freq)	ceil the index to the specified freq
contains(key)	return a boolean if this key is IN the index
copy([name, deep, dtype])	Make a copy of this object.
delete(loc)	Make a new DatetimeIndex with passed location(s) deleted.
difference(other)	Return a new Index with elements from the index that are not in *other*.
drop(labels[, errors])	Make new Index with passed list of labels deleted
drop_duplicates([keep])	Return Index with duplicate values removed
dropna([how])	Return Index without NA/NaN values
duplicated([keep])	Return boolean np.ndarray denoting duplicate values
equals(other)	Determines if two Index objects contain the same elements.
factorize([sort, na_sentinel])	Encode the object as an enumerated type or categorical variable
fillna([value, downcast])	Fill NA/NaN values with the specified value
floor(freq)	floor the index to the specified freq

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Table 34.110 – continued from previous page

format([name, formatter])	Render a string representation of the Index
get_duplicates()	
get_indexer(target[, method, limit, tolerance])	Compute indexer and mask for new index given the current index.
get_indexer_for(target, **kwargs)	guaranteed return of an indexer even when non-unique
get_indexer_non_unique(target)	Compute indexer and mask for new index given the current index.
get_level_values(level)	Return an Index of values for requested level, equal to the length of the index.
get_loc(key[, method, tolerance])	Get integer location for requested label
get_slice_bound(label, side, kind)	Calculate slice bound that corresponds to given label.
get_value(series, key)	Fast lookup of value from 1-dimensional ndarray.
get_value_maybe_box(series, key)	
get_values()	return the underlying data as an ndarray
groupby(values)	Group the index labels by a given array of values.
holds_integer()	
identical(other)	Similar to equals, but check that other comparable attributes are
indexer_at_time(time[, asof])	Select values at particular time of day (e.g.
indexer_between_time(start_time, end_time[, ...])	Select values between particular times of day (e.g., 9:00-9:30AM).
insert(loc, item)	Make new Index inserting new item at location
intersection(other)	Specialized intersection for DatetimeIndex objects.
is_(other)	More flexible, faster check like `is` but that works through views
is_boolean()	
is_categorical()	
is_floating()	
is_integer()	
is_interval()	
is_lexsorted_for_tuple(tup)	
is_mixed()	
is_numeric()	
is_object()	
is_type_compatible(typ)	
isin(values)	Compute boolean array of whether each index value is found in the
isna()	Detect missing values
isnull()	Detect missing values
item()	return the first element of the underlying data as a python
join(other[, how, level, return_indexers, sort])	See Index.join
map(f)	
max([axis])	Return the maximum value of the Index or maximum along an axis.
memory_usage([deep])	Memory usage of my values
min([axis])	Return the minimum value of the Index or minimum along an axis.
normalize()	Return DatetimeIndex with times to midnight.
notna()	Inverse of isna

Continued on next page

Table 34.110 – continued from previous page

notnull()	Inverse of isna
nunique([dropna])	Return number of unique elements in the object.
putmask(mask, value)	return a new Index of the values set with the mask
ravel([order])	return an ndarray of the flattened values of the underlying data
reindex(target[, method, level, limit, ...])	Create index with target's values (move/add/delete values as necessary)
rename(name[, inplace])	Set new names on index.
repeat(repeats, *args, **kwargs)	Analogous to ndarray.repeat
reshape(*args, **kwargs)	NOT IMPLEMENTED: do not call this method, as reshaping is not supported for Index objects and will raise an error.
round(freq, *args, **kwargs)	round the index to the specified freq
searchsorted(value[, side, sorter])	Find indices where elements should be inserted to maintain order.
set_names(names[, level, inplace])	Set new names on index.
set_value(arr, key, value)	Fast lookup of value from 1-dimensional ndarray.
shift(n[, freq])	Specialized shift which produces a DatetimeIndex
slice_indexer([start, end, step, kind])	Return indexer for specified label slice.
slice_locs([start, end, step, kind])	Compute slice locations for input labels.
snap([freq])	Snap time stamps to nearest occurring frequency
sort(*args, **kwargs)	
sort_values([return_indexer, ascending])	Return sorted copy of Index
sortlevel([level, ascending, sort_remaining])	For internal compatibility with with the Index API
str	alias of `StringMethods`
strftime(date_format)	Return an array of formatted strings specified by date_format, which supports the same string format as the python standard library.
summary([name])	return a summarized representation
symmetric_difference(other[, result_name])	Compute the symmetric difference of two Index objects.
take(indices[, axis, allow_fill, fill_value])	return a new Index of the values selected by the indices
to_datetime([dayfirst])	
to_frame([index])	Create a DataFrame with a column containing the Index.
to_julian_date()	Convert DatetimeIndex to Float64Index of Julian Dates.
to_native_types([slicer])	Format specified values of *self* and return them.
to_period([freq])	Cast to PeriodIndex at a particular frequency
to_perioddelta(freq)	Calcuates TimedeltaIndex of difference between index values and index converted to PeriodIndex at specified freq.
to_pydatetime()	Return DatetimeIndex as object ndarray of datetime.datetime objects
to_series([keep_tz])	Create a Series with both index and values equal to the index keys
tolist()	return a list of the underlying data
transpose(*args, **kwargs)	return the transpose, which is by definition self
tz_convert(tz)	Convert tz-aware DatetimeIndex from one time zone to another (using
tz_localize(tz[, ambiguous, errors])	Localize tz-naive DatetimeIndex to given time zone (using
union(other)	Specialized union for DatetimeIndex objects.

Continued on next page

Table 34.110 – continued from previous page

union_many(others)	A bit of a hack to accelerate unioning a collection of indexes
unique()	Return unique values in the object.
value_counts([normalize, sort, ascending, ...])	Returns object containing counts of unique values.
view([cls])	
where(cond[, other])	New in version 0.19.0.

34.11.1.62 pandas.DatetimeIndex.all

DatetimeIndex.**all**(*other=None*)

34.11.1.63 pandas.DatetimeIndex.any

DatetimeIndex.**any**(*other=None*)

34.11.1.64 pandas.DatetimeIndex.append

DatetimeIndex.**append**(*other*)

Append a collection of Index options together

Parameters **other** : Index or list/tuple of indices

Returns **appended** : Index

34.11.1.65 pandas.DatetimeIndex.argmax

DatetimeIndex.**argmax**(*axis=None*, **args*, ***kwargs*)

Returns the indices of the maximum values along an axis. See *numpy.ndarray.argmax* for more information on the *axis* parameter.

See also:

numpy.ndarray.argmax

34.11.1.66 pandas.DatetimeIndex.argmin

DatetimeIndex.**argmin**(*axis=None*, **args*, ***kwargs*)

Returns the indices of the minimum values along an axis. See *numpy.ndarray.argmin* for more information on the *axis* parameter.

See also:

numpy.ndarray.argmin

34.11.1.67 pandas.DatetimeIndex.argsort

DatetimeIndex.**argsort**(**args*, ***kwargs*)

Returns the indices that would sort the index and its underlying data.

Returns **argsorted** : numpy array

See also:

numpy.ndarray.argsort

34.11.1.68 pandas.DatetimeIndex.asof

DatetimeIndex.**asof**(*label*)

For a sorted index, return the most recent label up to and including the passed label. Return NaN if not found.

See also:

get_loc asof is a thin wrapper around get_loc with method='pad'

34.11.1.69 pandas.DatetimeIndex.asof_locs

DatetimeIndex.**asof_locs**(*where*, *mask*)

where : array of timestamps mask : array of booleans where data is not NA

34.11.1.70 pandas.DatetimeIndex.astype

DatetimeIndex.**astype**(*dtype*, *copy=True*)

Create an Index with values cast to dtypes. The class of a new Index is determined by dtype. When conversion is impossible, a ValueError exception is raised.

Parameters **dtype** : numpy dtype or pandas type

copy : bool, default True

By default, astype always returns a newly allocated object. If copy is set to False and internal requirements on dtype are satisfied, the original data is used to create a new Index or the original Index is returned.

New in version 0.19.0.

34.11.1.71 pandas.DatetimeIndex.ceil

DatetimeIndex.**ceil**(*freq*)

ceil the index to the specified freq

Parameters **freq** : freq string/object

Returns index of same type

Raises **ValueError if the freq cannot be converted**

34.11.1.72 pandas.DatetimeIndex.contains

DatetimeIndex.**contains**(*key*)

return a boolean if this key is IN the index

Parameters **key** : object

Returns boolean

34.11.1.73 pandas.DatetimeIndex.copy

`DatetimeIndex.copy`(*name=None*, *deep=False*, *dtype=None*, ***kwargs*)

Make a copy of this object. Name and dtype sets those attributes on the new object.

Parameters **name** : string, optional

deep : boolean, default False

dtype : numpy dtype or pandas type

Returns **copy** : Index

Notes

In most cases, there should be no functional difference from using `deep`, but if `deep` is passed it will attempt to deepcopy.

34.11.1.74 pandas.DatetimeIndex.delete

`DatetimeIndex.delete`(*loc*)

Make a new DatetimeIndex with passed location(s) deleted.

Parameters **loc: int, slice or array of ints**

Indicate which sub-arrays to remove.

Returns **new_index** : DatetimeIndex

34.11.1.75 pandas.DatetimeIndex.difference

`DatetimeIndex.difference`(*other*)

Return a new Index with elements from the index that are not in *other*.

This is the set difference of two Index objects. It's sorted if sorting is possible.

Parameters **other** : Index or array-like

Returns **difference** : Index

Examples

```
>>> idx1 = pd.Index([1, 2, 3, 4])
>>> idx2 = pd.Index([3, 4, 5, 6])
>>> idx1.difference(idx2)
Int64Index([1, 2], dtype='int64')
```

34.11.1.76 pandas.DatetimeIndex.drop

`DatetimeIndex.drop`(*labels*, *errors='raise'*)

Make new Index with passed list of labels deleted

Parameters **labels** : array-like

errors : {'ignore', 'raise'}, default 'raise'

If 'ignore', suppress error and existing labels are dropped.

Returns **dropped** : Index

34.11.1.77 pandas.DatetimeIndex.drop_duplicates

`DatetimeIndex.drop_duplicates(keep='first')`

Return Index with duplicate values removed

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Drop duplicates except for the first occurrence.
- `last` : Drop duplicates except for the last occurrence.
- False : Drop all duplicates.

Returns **deduplicated** : Index

34.11.1.78 pandas.DatetimeIndex.dropna

`DatetimeIndex.dropna(how='any')`

Return Index without NA/NaN values

Parameters **how** : {'any', 'all'}, default 'any'

If the Index is a MultiIndex, drop the value when any or all levels are NaN.

Returns **valid** : Index

34.11.1.79 pandas.DatetimeIndex.duplicated

`DatetimeIndex.duplicated(keep='first')`

Return boolean np.ndarray denoting duplicate values

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Mark duplicates as `True` except for the first occurrence.
- `last` : Mark duplicates as `True` except for the last occurrence.
- False : Mark all duplicates as `True`.

Returns **duplicated** : np.ndarray

34.11.1.80 pandas.DatetimeIndex.equals

`DatetimeIndex.equals(other)`

Determines if two Index objects contain the same elements.

34.11.1.81 pandas.DatetimeIndex.factorize

`DatetimeIndex.factorize(sort=False, na_sentinel=-1)`

Encode the object as an enumerated type or categorical variable

Parameters **sort** : boolean, default False

Sort by values

na_sentinel: int, default -1

Value to mark "not found"

Returns **labels** : the indexer to the original array

uniques : the unique Index

34.11.1.82 pandas.DatetimeIndex.fillna

`DatetimeIndex.fillna(value=None, downcast=None)`

Fill NA/NaN values with the specified value

Parameters **value** : scalar

Scalar value to use to fill holes (e.g. 0). This value cannot be a list-likes.

downcast : dict, default is None

a dict of item->dtype of what to downcast if possible, or the string 'infer' which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns **filled** : %(klass)s

34.11.1.83 pandas.DatetimeIndex.floor

`DatetimeIndex.floor(freq)`

floor the index to the specified freq

Parameters **freq** : freq string/object

Returns index of same type

Raises **ValueError if the freq cannot be converted**

34.11.1.84 pandas.DatetimeIndex.format

`DatetimeIndex.format(name=False, formatter=None, **kwargs)`

Render a string representation of the Index

34.11.1.85 pandas.DatetimeIndex.get_duplicates

`DatetimeIndex.get_duplicates()`

34.11.1.86 pandas.DatetimeIndex.get_indexer

`DatetimeIndex.get_indexer(target, method=None, limit=None, tolerance=None)`

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

Parameters **target** : Index

method : {None, 'pad'/'ffill', 'backfill'/'bfill', 'nearest'}, optional

- default: exact matches only.
- pad / ffill: find the PREVIOUS index value if no exact match.

- backfill / bfill: use NEXT index value if no exact match
- nearest: use the NEAREST index value if no exact match. Tied distances are broken by preferring the larger index value.

limit : int, optional

Maximum number of consecutive labels in `target` to match for inexact matches.

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **indexer** : ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

Examples

```
>>> indexer = index.get_indexer(new_index)
>>> new_values = cur_values.take(indexer)
```

34.11.1.87 pandas.DatetimeIndex.get_indexer_for

`DatetimeIndex.`**`get_indexer_for`**(*target*, ***kwargs*)

guaranteed return of an indexer even when non-unique This dispatches to get_indexer or get_indexer_nonunique as appropriate

34.11.1.88 pandas.DatetimeIndex.get_indexer_non_unique

`DatetimeIndex.`**`get_indexer_non_unique`**(*target*)

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

Parameters **target** : Index

Returns **indexer** : ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

missing : ndarray of int

An indexer into the target of the values not found. These correspond to the -1 in the indexer array

34.11.1.89 pandas.DatetimeIndex.get_level_values

`DatetimeIndex.get_level_values(level)`

Return an Index of values for requested level, equal to the length of the index.

Parameters **level** : int or str

`level` is either the integer position of the level in the MultiIndex, or the name of the level.

Returns **values** : Index

`self`, as there is only one level in the Index.

See also:

`pandas.MultiIndex.get_level_values` get values for a level of a MultiIndex

34.11.1.90 pandas.DatetimeIndex.get_loc

`DatetimeIndex.get_loc(key, method=None, tolerance=None)`

Get integer location for requested label

Returns **loc** : int

34.11.1.91 pandas.DatetimeIndex.get_slice_bound

`DatetimeIndex.get_slice_bound(label, side, kind)`

Calculate slice bound that corresponds to given label.

Returns leftmost (one-past-the-rightmost if `side=='right'`) position of given label.

Parameters **label** : object

side : {'left', 'right'}

kind : {'ix', 'loc', 'getitem'}

34.11.1.92 pandas.DatetimeIndex.get_value

`DatetimeIndex.get_value(series, key)`

Fast lookup of value from 1-dimensional ndarray. Only use this if you know what you're doing

34.11.1.93 pandas.DatetimeIndex.get_value_maybe_box

`DatetimeIndex.get_value_maybe_box(series, key)`

34.11.1.94 pandas.DatetimeIndex.get_values

`DatetimeIndex.get_values()`

return the underlying data as an ndarray

34.11.1.95 pandas.DatetimeIndex.groupby

`DatetimeIndex.groupby(values)`

Group the index labels by a given array of values.

Parameters **values** : array

Values used to determine the groups.

Returns **groups** : dict

{group name -> group labels}

34.11.1.96 pandas.DatetimeIndex.holds_integer

`DatetimeIndex.holds_integer()`

34.11.1.97 pandas.DatetimeIndex.identical

`DatetimeIndex.identical(other)`

Similar to equals, but check that other comparable attributes are also equal

34.11.1.98 pandas.DatetimeIndex.indexer_at_time

`DatetimeIndex.indexer_at_time(time, asof=False)`

Select values at particular time of day (e.g. 9:30AM)

Parameters **time** : datetime.time or string

Returns **values_at_time** : TimeSeries

34.11.1.99 pandas.DatetimeIndex.indexer_between_time

`DatetimeIndex.indexer_between_time(start_time, end_time, include_start=True, include_end=True)`

Select values between particular times of day (e.g., 9:00-9:30AM).

Return values of the index between two times. If start_time or end_time are strings then tseries.tools.to_time is used to convert to a time object.

Parameters **start_time, end_time** : datetime.time, str

datetime.time or string in appropriate format ("%H:%M", "%H%M", "%I:%M%p", "%I%M%p", "%H:%M:%S", "%H%M%S", "%I:%M:%S%p", "%I%M%S%p")

include_start : boolean, default True

include_end : boolean, default True

Returns **values_between_time** : TimeSeries

34.11.1.100 pandas.DatetimeIndex.insert

`DatetimeIndex.insert(loc, item)`

Make new Index inserting new item at location

Parameters **loc** : int

item : object

if not either a Python datetime or a numpy integer-like, returned Index dtype will be object rather than datetime.

Returns **new_index** : Index

34.11.1.101 pandas.DatetimeIndex.intersection

`DatetimeIndex.intersection(other)`

Specialized intersection for DatetimeIndex objects. May be much faster than Index.intersection

Parameters **other** : DatetimeIndex or array-like

Returns **y** : Index or DatetimeIndex

34.11.1.102 pandas.DatetimeIndex.is_

`DatetimeIndex.is_(other)`

More flexible, faster check like `is` but that works through views

Note: this is *not* the same as `Index.identical()`, which checks that metadata is also the same.

Parameters **other** : object

other object to compare against.

Returns **True if both have same underlying data, False otherwise** : bool

34.11.1.103 pandas.DatetimeIndex.is_boolean

`DatetimeIndex.is_boolean()`

34.11.1.104 pandas.DatetimeIndex.is_categorical

`DatetimeIndex.is_categorical()`

34.11.1.105 pandas.DatetimeIndex.is_floating

`DatetimeIndex.is_floating()`

34.11.1.106 pandas.DatetimeIndex.is_integer

`DatetimeIndex.is_integer()`

34.11.1.107 pandas.DatetimeIndex.is_interval

`DatetimeIndex.is_interval()`

34.11.1.108 pandas.DatetimeIndex.is_lexsorted_for_tuple

`DatetimeIndex.is_lexsorted_for_tuple(tup)`

34.11.1.109 pandas.DatetimeIndex.is_mixed

`DatetimeIndex.is_mixed()`

34.11.1.110 pandas.DatetimeIndex.is_numeric

`DatetimeIndex.is_numeric()`

34.11.1.111 pandas.DatetimeIndex.is_object

`DatetimeIndex.is_object()`

34.11.1.112 pandas.DatetimeIndex.is_type_compatible

`DatetimeIndex.is_type_compatible(typ)`

34.11.1.113 pandas.DatetimeIndex.isin

`DatetimeIndex.isin(values)`

Compute boolean array of whether each index value is found in the passed set of values

Parameters **values** : set or sequence of values

Returns **is_contained** : ndarray (boolean dtype)

34.11.1.114 pandas.DatetimeIndex.isna

`DatetimeIndex.isna()`

Detect missing values

New in version 0.20.0.

Returns a boolean array of whether my values are NA

See also:

isnull alias of isna

pandas.isna top-level isna

34.11.1.115 pandas.DatetimeIndex.isnull

`DatetimeIndex.isnull()`

Detect missing values

New in version 0.20.0.

Returns a boolean array of whether my values are NA

See also:

isnull alias of isna

pandas.isna top-level isna

34.11.1.116 pandas.DatetimeIndex.item

`DatetimeIndex.item()`

return the first element of the underlying data as a python scalar

34.11.1.117 pandas.DatetimeIndex.join

`DatetimeIndex.join(other, how='left', level=None, return_indexers=False, sort=False)`

See Index.join

34.11.1.118 pandas.DatetimeIndex.map

`DatetimeIndex.map(f)`

34.11.1.119 pandas.DatetimeIndex.max

`DatetimeIndex.max(axis=None, *args, **kwargs)`

Return the maximum value of the Index or maximum along an axis.

See also:

`numpy.ndarray.max`

34.11.1.120 pandas.DatetimeIndex.memory_usage

`DatetimeIndex.memory_usage(deep=False)`

Memory usage of my values

Parameters **deep** : bool

Introspect the data deeply, interrogate *object* dtypes for system-level memory consumption

Returns bytes used

See also:

`numpy.ndarray.nbytes`

Notes

Memory usage does not include memory consumed by elements that are not components of the array if deep=False or if used on PyPy

34.11.1.121 pandas.DatetimeIndex.min

`DatetimeIndex.min(axis=None, *args, **kwargs)`

Return the minimum value of the Index or minimum along an axis.

See also:

`numpy.ndarray.min`

34.11.1.122 pandas.DatetimeIndex.normalize

`DatetimeIndex.normalize()`

Return DatetimeIndex with times to midnight. Length is unaltered

Returns **normalized** : DatetimeIndex

34.11.1.123 pandas.DatetimeIndex.notna

`DatetimeIndex.notna()`

Inverse of isna

New in version 0.20.0.

Returns a boolean array of whether my values are not NA

See also:

notnull alias of notna

pandas.notna top-level notna

34.11.1.124 pandas.DatetimeIndex.notnull

`DatetimeIndex.notnull()`

Inverse of isna

New in version 0.20.0.

Returns a boolean array of whether my values are not NA

See also:

notnull alias of notna

pandas.notna top-level notna

34.11.1.125 pandas.DatetimeIndex.nunique

`DatetimeIndex.nunique(dropna=True)`

Return number of unique elements in the object.

Excludes NA values by default.

Parameters **dropna** : boolean, default True

Don't include NaN in the count.

Returns **nunique** : int

34.11.1.126 pandas.DatetimeIndex.putmask

`DatetimeIndex.putmask(mask, value)`

return a new Index of the values set with the mask

See also:

`numpy.ndarray.putmask`

34.11.1.127 pandas.DatetimeIndex.ravel

`DatetimeIndex.ravel(order='C')`

return an ndarray of the flattened values of the underlying data

See also:

`numpy.ndarray.ravel`

34.11.1.128 pandas.DatetimeIndex.reindex

`DatetimeIndex.reindex(target, method=None, level=None, limit=None, tolerance=None)`

Create index with target's values (move/add/delete values as necessary)

Parameters **target** : an iterable

Returns **new_index** : pd.Index

Resulting index

indexer : np.ndarray or None

Indices of output values in original index

34.11.1.129 pandas.DatetimeIndex.rename

`DatetimeIndex.rename(name, inplace=False)`

Set new names on index. Defaults to returning new index.

Parameters **name** : str or list

name to set

inplace : bool

if True, mutates in place

Returns new index (of same type and class...etc) [if inplace, returns None]

34.11.1.130 pandas.DatetimeIndex.repeat

`DatetimeIndex.repeat`(*repeats*, **args*, ***kwargs*)

Analogous to ndarray.repeat

34.11.1.131 pandas.DatetimeIndex.reshape

`DatetimeIndex.reshape`(**args*, ***kwargs*)

NOT IMPLEMENTED: do not call this method, as reshaping is not supported for Index objects and will raise an error.

Reshape an Index.

34.11.1.132 pandas.DatetimeIndex.round

`DatetimeIndex.round`(*freq*, **args*, ***kwargs*)

round the index to the specified freq

Parameters **freq** : freq string/object

Returns index of same type

Raises **ValueError if the freq cannot be converted**

34.11.1.133 pandas.DatetimeIndex.searchsorted

`DatetimeIndex.searchsorted`(*value*, *side='left'*, *sorter=None*)

Find indices where elements should be inserted to maintain order.

Find the indices into a sorted DatetimeIndex *self* such that, if the corresponding elements in *value* were inserted before the indices, the order of *self* would be preserved.

Parameters **value** : array_like

Values to insert into *self*.

side : {'left', 'right'}, optional

If 'left', the index of the first suitable location found is given. If 'right', return the last such index. If there is no suitable index, return either 0 or N (where N is the length of *self*).

sorter : 1-D array_like, optional

Optional array of integer indices that sort *self* into ascending order. They are typically the result of `np.argsort`.

Returns **indices** : array of ints

Array of insertion points with the same shape as *value*.

See also:

`numpy.searchsorted`

Notes

Binary search is used to find the required insertion points.

Examples

```
>>> x = pd.Series([1, 2, 3])
>>> x
0    1
1    2
2    3
dtype: int64
```

```
>>> x.searchsorted(4)
array([3])
```

```
>>> x.searchsorted([0, 4])
array([0, 3])
```

```
>>> x.searchsorted([1, 3], side='left')
array([0, 2])
```

```
>>> x.searchsorted([1, 3], side='right')
array([1, 3])
```

```
>>> x = pd.Categorical(['apple', 'bread', 'bread', 'cheese', 'milk' ])
[apple, bread, bread, cheese, milk]
Categories (4, object): [apple < bread < cheese < milk]
```

```
>>> x.searchsorted('bread')
array([1])     # Note: an array, not a scalar
```

```
>>> x.searchsorted(['bread'])
array([1])
```

```
>>> x.searchsorted(['bread', 'eggs'])
array([1, 4])
```

```
>>> x.searchsorted(['bread', 'eggs'], side='right')
array([3, 4])    # eggs before milk
```

34.11.1.134 pandas.DatetimeIndex.set_names

`DatetimeIndex.set_names`(*names*, *level=None*, *inplace=False*)

Set new names on index. Defaults to returning new index.

Parameters **names** : str or sequence

name(s) to set

level : int, level name, or sequence of int/level names (default None)

If the index is a MultiIndex (hierarchical), level(s) to set (None for all levels). Otherwise level must be None

inplace : bool

if True, mutates in place

Returns new index (of same type and class...etc) [if inplace, returns None]

Examples

```
>>> Index([1, 2, 3, 4]).set_names('foo')
Int64Index([1, 2, 3, 4], dtype='int64')
>>> Index([1, 2, 3, 4]).set_names(['foo'])
Int64Index([1, 2, 3, 4], dtype='int64')
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                  (2, u'one'), (2, u'two')],
                                  names=['foo', 'bar'])
>>> idx.set_names(['baz', 'quz'])
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'baz', u'quz'])
>>> idx.set_names('baz', level=0)
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'baz', u'bar'])
```

34.11.1.135 pandas.DatetimeIndex.set_value

`DatetimeIndex.set_value(arr, key, value)`

Fast lookup of value from 1-dimensional ndarray. Only use this if you know what you're doing

34.11.1.136 pandas.DatetimeIndex.shift

`DatetimeIndex.shift(n, freq=None)`

Specialized shift which produces a DatetimeIndex

Parameters **n** : int

Periods to shift by

freq : DateOffset or timedelta-like, optional

Returns **shifted** : DatetimeIndex

34.11.1.137 pandas.DatetimeIndex.slice_indexer

`DatetimeIndex.slice_indexer(start=None, end=None, step=None, kind=None)`

Return indexer for specified label slice. Index.slice_indexer, customized to handle time slicing.

In addition to functionality provided by Index.slice_indexer, does the following:

- if both *start* and *end* are instances of *datetime.time*, it invokes *indexer_between_time*
- if *start* and *end* are both either string or None perform value-based selection in non-monotonic cases.

34.11.1.138 pandas.DatetimeIndex.slice_locs

`DatetimeIndex.slice_locs(start=None, end=None, step=None, kind=None)`

Compute slice locations for input labels.

Parameters **start** : label, default None

If None, defaults to the beginning

end : label, default None

If None, defaults to the end

step : int, defaults None

If None, defaults to 1

kind : {'ix', 'loc', 'getitem'} or None

Returns **start, end** : int

See also:

Index.get_loc Get location for a single label

Notes

This method only works if the index is monotonic or unique.

Examples

```
>>> idx = pd.Index(list('abcd'))
>>> idx.slice_locs(start='b', end='c')
(1, 3)
```

34.11.1.139 pandas.DatetimeIndex.snap

`DatetimeIndex.snap`(*freq='S'*)

Snap time stamps to nearest occurring frequency

34.11.1.140 pandas.DatetimeIndex.sort

`DatetimeIndex.sort`(**args*, ***kwargs*)

34.11.1.141 pandas.DatetimeIndex.sort_values

`DatetimeIndex.sort_values`(*return_indexer=False*, *ascending=True*)

Return sorted copy of Index

34.11.1.142 pandas.DatetimeIndex.sortlevel

`DatetimeIndex.sortlevel`(*level=None*, *ascending=True*, *sort_remaining=None*)

For internal compatibility with with the Index API

Sort the Index. This is for compat with MultiIndex

Parameters **ascending** : boolean, default True

False to sort in descending order

level, sort_remaining are compat parameters

Returns **sorted_index** : Index

34.11.1.143 pandas.DatetimeIndex.str

`DatetimeIndex.str()`

Vectorized string functions for Series and Index. NAs stay NA unless handled otherwise by a particular method. Patterned after Python's string methods, with some inspiration from R's stringr package.

Examples

```
>>> s.str.split('_')
>>> s.str.replace('_', '')
```

34.11.1.144 pandas.DatetimeIndex.strftime

`DatetimeIndex.strftime(date_format)`

Return an array of formatted strings specified by date_format, which supports the same string format as the python standard library. Details of the string format can be found in python string format doc

New in version 0.17.0.

Parameters **date_format** : str

date format string (e.g. "%Y-%m-%d")

Returns ndarray of formatted strings

34.11.1.145 pandas.DatetimeIndex.summary

`DatetimeIndex.summary(name=None)`

return a summarized representation

34.11.1.146 pandas.DatetimeIndex.symmetric_difference

`DatetimeIndex.symmetric_difference(other, result_name=None)`

Compute the symmetric difference of two Index objects. It's sorted if sorting is possible.

Parameters **other** : Index or array-like

result_name : str

Returns **symmetric_difference** : Index

Notes

`symmetric_difference` contains elements that appear in either `idx1` or `idx2` but not both. Equivalent to the Index created by `idx1.difference(idx2) | idx2.difference(idx1)` with duplicates dropped.

Examples

```
>>> idx1 = Index([1, 2, 3, 4])
>>> idx2 = Index([2, 3, 4, 5])
>>> idx1.symmetric_difference(idx2)
Int64Index([1, 5], dtype='int64')
```

You can also use the ^ operator:

```
>>> idx1 ^ idx2
Int64Index([1, 5], dtype='int64')
```

34.11.1.147 pandas.DatetimeIndex.take

`DatetimeIndex.take`(*indices*, *axis=0*, *allow_fill=True*, *fill_value=None*, ***kwargs*)

return a new Index of the values selected by the indices

For internal compatibility with numpy arrays.

Parameters **indices** : list

Indices to be taken

axis : int, optional

The axis over which to select values, always 0.

allow_fill : bool, default True

fill_value : bool, default None

If allow_fill=True and fill_value is not None, indices specified by -1 is regarded as NA. If Index doesn't hold NA, raise ValueError

See also:

`numpy.ndarray.take`

34.11.1.148 pandas.DatetimeIndex.to_datetime

`DatetimeIndex.to_datetime`(*dayfirst=False*)

34.11.1.149 pandas.DatetimeIndex.to_frame

`DatetimeIndex.to_frame`(*index=True*)

Create a DataFrame with a column containing the Index.

New in version 0.21.0.

Parameters **index** : boolean, default True

Set the index of the returned DataFrame as the original Index.

Returns **DataFrame** : a DataFrame containing the original Index data.

34.11.1.150 pandas.DatetimeIndex.to_julian_date

`DatetimeIndex.to_julian_date()`

Convert DatetimeIndex to Float64Index of Julian Dates. 0 Julian date is noon January 1, 4713 BC. http://en.wikipedia.org/wiki/Julian_day

34.11.1.151 pandas.DatetimeIndex.to_native_types

`DatetimeIndex.to_native_types(slicer=None, **kwargs)`

Format specified values of *self* and return them.

Parameters **slicer** : int, array-like

An indexer into *self* that specifies which values are used in the formatting process.

kwargs : dict

Options for specifying how the values should be formatted. These options include the following:

1. **na_rep** [str] The value that serves as a placeholder for NULL values
2. **quoting** [bool or None] Whether or not there are quoted values in *self*
3. **date_format** [str] The format used to represent date-like values

34.11.1.152 pandas.DatetimeIndex.to_period

`DatetimeIndex.to_period(freq=None)`

Cast to PeriodIndex at a particular frequency

34.11.1.153 pandas.DatetimeIndex.to_perioddelta

`DatetimeIndex.to_perioddelta(freq)`

Calcuates TimedeltaIndex of difference between index values and index converted to PeriodIndex at specified freq. Used for vectorized offsets

New in version 0.17.0.

Parameters **freq** : Period frequency

Returns **y** : TimedeltaIndex

34.11.1.154 pandas.DatetimeIndex.to_pydatetime

`DatetimeIndex.to_pydatetime()`

Return DatetimeIndex as object ndarray of datetime.datetime objects

Returns **datetimes** : ndarray

34.11.1.155 pandas.DatetimeIndex.to_series

`DatetimeIndex.to_series(keep_tz=False)`

Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index

Parameters **keep_tz** : optional, defaults False.

return the data keeping the timezone.

If keep_tz is True:

If the timezone is not set, the resulting Series will have a datetime64[ns] dtype.

Otherwise the Series will have an datetime64[ns, tz] dtype; the tz will be preserved.

If keep_tz is False:

Series will have a datetime64[ns] dtype. TZ aware objects will have the tz removed.

Returns Series

34.11.1.156 pandas.DatetimeIndex.tolist

`DatetimeIndex.tolist()`

return a list of the underlying data

34.11.1.157 pandas.DatetimeIndex.transpose

`DatetimeIndex.transpose(*args, **kwargs)`

return the transpose, which is by definition self

34.11.1.158 pandas.DatetimeIndex.tz_convert

`DatetimeIndex.tz_convert(tz)`

Convert tz-aware DatetimeIndex from one time zone to another (using pytz/dateutil)

Parameters **tz** : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time. Corresponding timestamps would be converted to time zone of the TimeSeries. None will remove timezone holding UTC time.

Returns **normalized** : DatetimeIndex

Raises **TypeError**

If DatetimeIndex is tz-naive.

34.11.1.159 pandas.DatetimeIndex.tz_localize

`DatetimeIndex.tz_localize(tz, ambiguous='raise', errors='raise')`

Localize tz-naive DatetimeIndex to given time zone (using pytz/dateutil), or remove timezone from tz-aware DatetimeIndex

Parameters **tz** : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time. Corresponding timestamps would be converted to time zone of the TimeSeries. None will remove timezone holding local time.

ambiguous : 'infer', bool-ndarray, 'NaT', default 'raise'

- 'infer' will attempt to infer fall dst-transition hours based on order

- bool-ndarray where True signifies a DST time, False signifies a non-DST time (note that this flag is only applicable for ambiguous times)
- 'NaT' will return NaT where there are ambiguous times
- 'raise' will raise an AmbiguousTimeError if there are ambiguous times

errors : 'raise', 'coerce', default 'raise'

- **'raise' will raise a NonExistentTimeError if a timestamp is not** valid in the specified timezone (e.g. due to a transition from or to DST time)
- 'coerce' will return NaT if the timestamp can not be converted into the specified timezone

New in version 0.19.0.

infer_dst : boolean, default False

Deprecated since version 0.15.0: Attempt to infer fall dst-transition hours based on order

Returns **localized** : DatetimeIndex

Raises **TypeError**

If the DatetimeIndex is tz-aware and tz is not None.

34.11.1.160 pandas.DatetimeIndex.union

`DatetimeIndex.union(other)`

Specialized union for DatetimeIndex objects. If combine overlapping ranges with the same DateOffset, will be much faster than Index.union

Parameters **other** : DatetimeIndex or array-like

Returns **y** : Index or DatetimeIndex

34.11.1.161 pandas.DatetimeIndex.union_many

`DatetimeIndex.union_many(others)`

A bit of a hack to accelerate unioning a collection of indexes

34.11.1.162 pandas.DatetimeIndex.unique

`DatetimeIndex.unique()`

Return unique values in the object. Uniques are returned in order of appearance, this does NOT sort. Hash table-based unique.

Parameters **values** : 1d array-like

Returns unique values.

- If the input is an Index, the return is an Index
- If the input is a Categorical dtype, the return is a Categorical
- If the input is a Series/ndarray, the return will be an ndarray

See also:

unique, *Index.unique*, *Series.unique*

34.11.1.163 pandas.DatetimeIndex.value_counts

`DatetimeIndex.value_counts(normalize=False, sort=True, ascending=False, bins=None, dropna=True)`

Returns object containing counts of unique values.

The resulting object will be in descending order so that the first element is the most frequently-occurring element. Excludes NA values by default.

Parameters **normalize** : boolean, default False

If True then the object returned will contain the relative frequencies of the unique values.

sort : boolean, default True

Sort by values

ascending : boolean, default False

Sort in ascending order

bins : integer, optional

Rather than count values, group them into half-open bins, a convenience for pd.cut, only works with numeric data

dropna : boolean, default True

Don't include counts of NaN.

Returns **counts** : Series

34.11.1.164 pandas.DatetimeIndex.view

`DatetimeIndex.view(cls=None)`

34.11.1.165 pandas.DatetimeIndex.where

`DatetimeIndex.where(cond, other=None)`

New in version 0.19.0.

Return an Index of same shape as self and whose corresponding entries are from self where cond is True and otherwise are from other.

Parameters **cond** : boolean array-like with the same length as self

other : scalar, or array-like

34.11.2 Time/Date Components

`DatetimeIndex.year`	The year of the datetime
`DatetimeIndex.month`	The month as January=1, December=12
`DatetimeIndex.day`	The days of the datetime
`DatetimeIndex.hour`	The hours of the datetime
`DatetimeIndex.minute`	The minutes of the datetime
`DatetimeIndex.second`	The seconds of the datetime

Continued on next page

Table 34.111 – continued from previous page

DatetimeIndex.microsecond	The microseconds of the datetime
DatetimeIndex.nanosecond	The nanoseconds of the datetime
DatetimeIndex.date	Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without timezone information).
DatetimeIndex.time	Returns numpy array of datetime.time.
DatetimeIndex.dayofyear	The ordinal day of the year
DatetimeIndex.weekofyear	The week ordinal of the year
DatetimeIndex.week	The week ordinal of the year
DatetimeIndex.dayofweek	The day of the week with Monday=0, Sunday=6
DatetimeIndex.weekday	The day of the week with Monday=0, Sunday=6
DatetimeIndex.weekday_name	The name of day in a week (ex: Friday)
DatetimeIndex.quarter	The quarter of the date
DatetimeIndex.tz	
DatetimeIndex.freq	get/set the frequency of the Index
DatetimeIndex.freqstr	Return the frequency object as a string if its set, otherwise None
DatetimeIndex.is_month_start	Logical indicating if first day of month (defined by frequency)
DatetimeIndex.is_month_end	Logical indicating if last day of month (defined by frequency)
DatetimeIndex.is_quarter_start	Logical indicating if first day of quarter (defined by frequency)
DatetimeIndex.is_quarter_end	Logical indicating if last day of quarter (defined by frequency)
DatetimeIndex.is_year_start	Logical indicating if first day of year (defined by frequency)
DatetimeIndex.is_year_end	Logical indicating if last day of year (defined by frequency)
DatetimeIndex.is_leap_year	Logical indicating if the date belongs to a leap year
DatetimeIndex.inferred_freq	

34.11.3 Selecting

DatetimeIndex.indexer_at_time(time[, asof])	Select values at particular time of day (e.g.
DatetimeIndex.indexer_between_time(...[, ...])	Select values between particular times of day (e.g., 9:00-9:30AM).

34.11.4 Time-specific operations

DatetimeIndex.normalize()	Return DatetimeIndex with times to midnight.
DatetimeIndex.strftime(date_format)	Return an array of formatted strings specified by date_format, which supports the same string format as the python standard library.
DatetimeIndex.snap([freq])	Snap time stamps to nearest occurring frequency
DatetimeIndex.tz_convert(tz)	Convert tz-aware DatetimeIndex from one time zone to another (using
DatetimeIndex.tz_localize(tz[, ambiguous, ...])	Localize tz-naive DatetimeIndex to given time zone (using
DatetimeIndex.round(freq, *args, **kwargs)	round the index to the specified freq

Continued on next page

Table 34.113 – continued from previous page

`DatetimeIndex.floor`(freq)	floor the index to the specified freq
`DatetimeIndex.ceil`(freq)	ceil the index to the specified freq

34.11.5 Conversion

`DatetimeIndex.to_datetime`([dayfirst])	
`DatetimeIndex.to_period`([freq])	Cast to PeriodIndex at a particular frequency
`DatetimeIndex.to_perioddelta`(freq)	Calcuates TimedeltaIndex of difference between index values and index converted to PeriodIndex at specified freq.
`DatetimeIndex.to_pydatetime`()	Return DatetimeIndex as object ndarray of datetime.datetime objects
`DatetimeIndex.to_series`([keep_tz])	Create a Series with both index and values equal to the index keys
`DatetimeIndex.to_frame`([index])	Create a DataFrame with a column containing the Index.

34.12 TimedeltaIndex

`TimedeltaIndex`	Immutable ndarray of timedelta64 data, represented internally as int64, and

34.12.1 pandas.TimedeltaIndex

class `pandas.`**`TimedeltaIndex`**

Immutable ndarray of timedelta64 data, represented internally as int64, and which can be boxed to timedelta objects

Parameters **data** : array-like (1-dimensional), optional

Optional timedelta-like data to construct index with

unit: unit of the arg (D,h,m,s,ms,us,ns) denote the unit, optional

which is an integer/float number

freq: a frequency for the index, optional

copy : bool

Make a copy of input ndarray

start : starting value, timedelta-like, optional

If data is None, start is used as the start point in generating regular timedelta data.

periods : int, optional, > 0

Number of periods to generate, if generating index. Takes precedence over end argument

end : end time, timedelta-like, optional

If periods is none, generated index will extend to first conforming time on or just past end argument

closed : string or None, default None

Make the interval closed with respect to the given frequency to the 'left', 'right', or both sides (None)

name : object

Name to be stored in the index

See also:

Index The base pandas Index type

Timedelta Represents a duration between two dates or times.

DatetimeIndex Index of datetime64 data

PeriodIndex Index of Period data

Notes

To learn more about the frequency strings, please see this link.

Attributes

T	return the transpose, which is by definition self
asi8	
asobject	return object Index which contains boxed values
base	return the base object if the memory of the underlying data is
components	Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.
data	return the data pointer of the underlying data
days	Number of days for each element.
dtype	
dtype_str	
empty	
flags	
freq	
freqstr	Return the frequency object as a string if its set, otherwise None
has_duplicates	
hasnans	
inferred_freq	
inferred_type	
is_all_dates	
is_monotonic	alias for is_monotonic_increasing (deprecated)
is_monotonic_decreasing	return if the index is monotonic decreasing (only equal or
is_monotonic_increasing	return if the index is monotonic increasing (only equal or
is_unique	

Continued on next page

Table 34.116 – continued from previous page

itemsize	return the size of the dtype of the item of the underlying data
microseconds	Number of microseconds (>= 0 and less than 1 second) for each element.
name	
names	
nanoseconds	Number of nanoseconds (>= 0 and less than 1 microsecond) for each element.
nbytes	return the number of bytes in the underlying data
ndim	return the number of dimensions of the underlying data,
nlevels	
resolution	
seconds	Number of seconds (>= 0 and less than 1 day) for each element.
shape	return a tuple of the shape of the underlying data
size	return the number of elements in the underlying data
strides	return the strides of the underlying data
values	return the underlying data as an ndarray

34.12.1.1 pandas.TimedeltaIndex.T

`TimedeltaIndex.T`

return the transpose, which is by definition self

34.12.1.2 pandas.TimedeltaIndex.asi8

`TimedeltaIndex.asi8`

34.12.1.3 pandas.TimedeltaIndex.asobject

`TimedeltaIndex.asobject`

return object Index which contains boxed values

this is an internal non-public method

34.12.1.4 pandas.TimedeltaIndex.base

`TimedeltaIndex.base`

return the base object if the memory of the underlying data is shared

34.12.1.5 pandas.TimedeltaIndex.components

`TimedeltaIndex.components`

Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.

Returns a DataFrame

34.12.1.6 pandas.TimedeltaIndex.data

`TimedeltaIndex.data`
return the data pointer of the underlying data

34.12.1.7 pandas.TimedeltaIndex.days

`TimedeltaIndex.days`
Number of days for each element.

34.12.1.8 pandas.TimedeltaIndex.dtype

`TimedeltaIndex.dtype`

34.12.1.9 pandas.TimedeltaIndex.dtype_str

`TimedeltaIndex.dtype_str` = None

34.12.1.10 pandas.TimedeltaIndex.empty

`TimedeltaIndex.empty`

34.12.1.11 pandas.TimedeltaIndex.flags

`TimedeltaIndex.flags`

34.12.1.12 pandas.TimedeltaIndex.freq

`TimedeltaIndex.freq` = None

34.12.1.13 pandas.TimedeltaIndex.freqstr

`TimedeltaIndex.freqstr`
Return the frequency object as a string if its set, otherwise None

34.12.1.14 pandas.TimedeltaIndex.has_duplicates

`TimedeltaIndex.has_duplicates`

34.12.1.15 pandas.TimedeltaIndex.hasnans

`TimedeltaIndex.hasnans` = None

34.12.1.16 pandas.TimedeltaIndex.inferred_freq

`TimedeltaIndex.inferred_freq` = None

34.12.1.17 pandas.TimedeltaIndex.inferred_type

`TimedeltaIndex.inferred_type`

34.12.1.18 pandas.TimedeltaIndex.is_all_dates

`TimedeltaIndex.is_all_dates`

34.12.1.19 pandas.TimedeltaIndex.is_monotonic

`TimedeltaIndex.is_monotonic`

alias for is_monotonic_increasing (deprecated)

34.12.1.20 pandas.TimedeltaIndex.is_monotonic_decreasing

`TimedeltaIndex.is_monotonic_decreasing`

return if the index is monotonic decreasing (only equal or decreasing) values.

Examples

```
>>> Index([3, 2, 1]).is_monotonic_decreasing
True
>>> Index([3, 2, 2]).is_monotonic_decreasing
True
>>> Index([3, 1, 2]).is_monotonic_decreasing
False
```

34.12.1.21 pandas.TimedeltaIndex.is_monotonic_increasing

`TimedeltaIndex.is_monotonic_increasing`

return if the index is monotonic increasing (only equal or increasing) values.

Examples

```
>>> Index([1, 2, 3]).is_monotonic_increasing
True
>>> Index([1, 2, 2]).is_monotonic_increasing
True
>>> Index([1, 3, 2]).is_monotonic_increasing
False
```

34.12.1.22 pandas.TimedeltaIndex.is_unique

`TimedeltaIndex.is_unique` = None

34.12.1.23 pandas.TimedeltaIndex.itemsize

`TimedeltaIndex.itemsize`

return the size of the dtype of the item of the underlying data

34.12.1.24 pandas.TimedeltaIndex.microseconds

`TimedeltaIndex.microseconds`

Number of microseconds (>= 0 and less than 1 second) for each element.

34.12.1.25 pandas.TimedeltaIndex.name

`TimedeltaIndex.name` = **None**

34.12.1.26 pandas.TimedeltaIndex.names

`TimedeltaIndex.names`

34.12.1.27 pandas.TimedeltaIndex.nanoseconds

`TimedeltaIndex.nanoseconds`

Number of nanoseconds (>= 0 and less than 1 microsecond) for each element.

34.12.1.28 pandas.TimedeltaIndex.nbytes

`TimedeltaIndex.nbytes`

return the number of bytes in the underlying data

34.12.1.29 pandas.TimedeltaIndex.ndim

`TimedeltaIndex.ndim`

return the number of dimensions of the underlying data, by definition 1

34.12.1.30 pandas.TimedeltaIndex.nlevels

`TimedeltaIndex.nlevels`

34.12.1.31 pandas.TimedeltaIndex.resolution

`TimedeltaIndex.resolution` = **None**

34.12.1.32 pandas.TimedeltaIndex.seconds

`TimedeltaIndex.seconds`

Number of seconds (>= 0 and less than 1 day) for each element.

34.12.1.33 pandas.TimedeltaIndex.shape

`TimedeltaIndex.shape`

return a tuple of the shape of the underlying data

34.12.1.34 pandas.TimedeltaIndex.size

`TimedeltaIndex.size`

return the number of elements in the underlying data

34.12.1.35 pandas.TimedeltaIndex.strides

`TimedeltaIndex.strides`

return the strides of the underlying data

34.12.1.36 pandas.TimedeltaIndex.values

`TimedeltaIndex.values`

return the underlying data as an ndarray

Methods

all([other])	
any([other])	
append(other)	Append a collection of Index options together
argmax([axis])	Returns the indices of the maximum values along an axis.
argmin([axis])	Returns the indices of the minimum values along an axis.
argsort(*args, **kwargs)	Returns the indices that would sort the index and its underlying data.
asof(label)	For a sorted index, return the most recent label up to and including the passed label.
asof_locs(where, mask)	where : array of timestamps
astype(dtype[, copy])	Create an Index with values cast to dtypes.
ceil(freq)	ceil the index to the specified freq
contains(key)	return a boolean if this key is IN the index
copy([name, deep, dtype])	Make a copy of this object.
delete(loc)	Make a new DatetimeIndex with passed location(s) deleted.
difference(other)	Return a new Index with elements from the index that are not in *other*.
drop(labels[, errors])	Make new Index with passed list of labels deleted
drop_duplicates([keep])	Return Index with duplicate values removed
dropna([how])	Return Index without NA/NaN values
duplicated([keep])	Return boolean np.ndarray denoting duplicate values
equals(other)	Determines if two Index objects contain the same elements.

Continued on next page

Table 34.117 – continued from previous page

factorize([sort, na_sentinel])	Encode the object as an enumerated type or categorical variable
fillna([value, downcast])	Fill NA/NaN values with the specified value
floor(freq)	floor the index to the specified freq
format([name, formatter])	Render a string representation of the Index
get_duplicates()	
get_indexer(target[, method, limit, tolerance])	Compute indexer and mask for new index given the current index.
get_indexer_for(target, **kwargs)	guaranteed return of an indexer even when non-unique
get_indexer_non_unique(target)	Compute indexer and mask for new index given the current index.
get_level_values(level)	Return an Index of values for requested level, equal to the length of the index.
get_loc(key[, method, tolerance])	Get integer location for requested label
get_slice_bound(label, side, kind)	Calculate slice bound that corresponds to given label.
get_value(series, key)	Fast lookup of value from 1-dimensional ndarray.
get_value_maybe_box(series, key)	
get_values()	return the underlying data as an ndarray
groupby(values)	Group the index labels by a given array of values.
holds_integer()	
identical(other)	Similar to equals, but check that other comparable attributes are
insert(loc, item)	Make new Index inserting new item at location
intersection(other)	Specialized intersection for TimedeltaIndex objects.
is_(other)	More flexible, faster check like `is` but that works through views
is_boolean()	
is_categorical()	
is_floating()	
is_integer()	
is_interval()	
is_lexsorted_for_tuple(tup)	
is_mixed()	
is_numeric()	
is_object()	
is_type_compatible(typ)	
isin(values)	Compute boolean array of whether each index value is found in the
isna()	Detect missing values
isnull()	Detect missing values
item()	return the first element of the underlying data as a python
join(other[, how, level, return_indexers, sort])	See Index.join
map(f)	
max([axis])	Return the maximum value of the Index or maximum along an axis.
memory_usage([deep])	Memory usage of my values
min([axis])	Return the minimum value of the Index or minimum along an axis.
notna()	Inverse of isna

Continued on next page

Table 34.117 – continued from previous page

notnull()	Inverse of isna
nunique([dropna])	Return number of unique elements in the object.
putmask(mask, value)	return a new Index of the values set with the mask
ravel([order])	return an ndarray of the flattened values of the underlying data
reindex(target[, method, level, limit, ...])	Create index with target's values (move/add/delete values as necessary)
rename(name[, inplace])	Set new names on index.
repeat(repeats, *args, **kwargs)	Analogous to ndarray.repeat
reshape(*args, **kwargs)	NOT IMPLEMENTED: do not call this method, as reshaping is not supported for Index objects and will raise an error.
round(freq, *args, **kwargs)	round the index to the specified freq
searchsorted(value[, side, sorter])	Find indices where elements should be inserted to maintain order.
set_names(names[, level, inplace])	Set new names on index.
set_value(arr, key, value)	Fast lookup of value from 1-dimensional ndarray.
shift(n[, freq])	Specialized shift which produces a DatetimeIndex
slice_indexer([start, end, step, kind])	For an ordered Index, compute the slice indexer for input labels and
slice_locs([start, end, step, kind])	Compute slice locations for input labels.
sort(*args, **kwargs)	
sort_values([return_indexer, ascending])	Return sorted copy of Index
sortlevel([level, ascending, sort_remaining])	For internal compatibility with with the Index API
str	alias of `StringMethods`
summary([name])	return a summarized representation
symmetric_difference(other[, result_name])	Compute the symmetric difference of two Index objects.
take(indices[, axis, allow_fill, fill_value])	return a new Index of the values selected by the indices
to_datetime([dayfirst])	DEPRECATED: use `pandas.to_datetime()` instead.
to_frame([index])	Create a DataFrame with a column containing the Index.
to_native_types([slicer])	Format specified values of *self* and return them.
to_pytimedelta()	Return TimedeltaIndex as object ndarray of datetime.timedelta objects
to_series(**kwargs)	Create a Series with both index and values equal to the index keys
tolist()	return a list of the underlying data
total_seconds()	Total duration of each element expressed in seconds.
transpose(*args, **kwargs)	return the transpose, which is by definition self
union(other)	Specialized union for TimedeltaIndex objects.
unique()	Return unique values in the object.
value_counts([normalize, sort, ascending, ...])	Returns object containing counts of unique values.
view([cls])	
where(cond[, other])	New in version 0.19.0.

34.12.1.37 pandas.TimedeltaIndex.all

`TimedeltaIndex.all(other=None)`

34.12.1.38 pandas.TimedeltaIndex.any

`TimedeltaIndex.any(other=None)`

34.12.1.39 pandas.TimedeltaIndex.append

`TimedeltaIndex.append(other)`

Append a collection of Index options together

Parameters **other** : Index or list/tuple of indices

Returns **appended** : Index

34.12.1.40 pandas.TimedeltaIndex.argmax

`TimedeltaIndex.argmax(axis=None, *args, **kwargs)`

Returns the indices of the maximum values along an axis. See *numpy.ndarray.argmax* for more information on the *axis* parameter.

See also:

`numpy.ndarray.argmax`

34.12.1.41 pandas.TimedeltaIndex.argmin

`TimedeltaIndex.argmin(axis=None, *args, **kwargs)`

Returns the indices of the minimum values along an axis. See *numpy.ndarray.argmin* for more information on the *axis* parameter.

See also:

`numpy.ndarray.argmin`

34.12.1.42 pandas.TimedeltaIndex.argsort

`TimedeltaIndex.argsort(*args, **kwargs)`

Returns the indices that would sort the index and its underlying data.

Returns **argsorted** : numpy array

See also:

`numpy.ndarray.argsort`

34.12.1.43 pandas.TimedeltaIndex.asof

`TimedeltaIndex.asof(label)`

For a sorted index, return the most recent label up to and including the passed label. Return NaN if not found.

See also:

get_loc asof is a thin wrapper around get_loc with method='pad'

34.12.1.44 pandas.TimedeltaIndex.asof_locs

`TimedeltaIndex.asof_locs(where, mask)`

where : array of timestamps mask : array of booleans where data is not NA

34.12.1.45 pandas.TimedeltaIndex.astype

`TimedeltaIndex.astype(dtype, copy=True)`

Create an Index with values cast to dtypes. The class of a new Index is determined by dtype. When conversion is impossible, a ValueError exception is raised.

Parameters **dtype** : numpy dtype or pandas type

copy : bool, default True

By default, astype always returns a newly allocated object. If copy is set to False and internal requirements on dtype are satisfied, the original data is used to create a new Index or the original Index is returned.

New in version 0.19.0.

34.12.1.46 pandas.TimedeltaIndex.ceil

`TimedeltaIndex.ceil(freq)`

ceil the index to the specified freq

Parameters **freq** : freq string/object

Returns index of same type

Raises **ValueError if the freq cannot be converted**

34.12.1.47 pandas.TimedeltaIndex.contains

`TimedeltaIndex.contains(key)`

return a boolean if this key is IN the index

Parameters **key** : object

Returns boolean

34.12.1.48 pandas.TimedeltaIndex.copy

`TimedeltaIndex.copy(name=None, deep=False, dtype=None, **kwargs)`

Make a copy of this object. Name and dtype sets those attributes on the new object.

Parameters **name** : string, optional

deep : boolean, default False

dtype : numpy dtype or pandas type

Returns **copy** : Index

Notes

In most cases, there should be no functional difference from using `deep`, but if `deep` is passed it will attempt to deepcopy.

34.12.1.49 pandas.TimedeltaIndex.delete

`TimedeltaIndex.delete(loc)`

Make a new DatetimeIndex with passed location(s) deleted.

Parameters **loc: int, slice or array of ints**

Indicate which sub-arrays to remove.

Returns **new_index** : TimedeltaIndex

34.12.1.50 pandas.TimedeltaIndex.difference

`TimedeltaIndex.difference(other)`

Return a new Index with elements from the index that are not in *other*.

This is the set difference of two Index objects. It's sorted if sorting is possible.

Parameters **other** : Index or array-like

Returns **difference** : Index

Examples

```
>>> idx1 = pd.Index([1, 2, 3, 4])
>>> idx2 = pd.Index([3, 4, 5, 6])
>>> idx1.difference(idx2)
Int64Index([1, 2], dtype='int64')
```

34.12.1.51 pandas.TimedeltaIndex.drop

`TimedeltaIndex.drop(labels, errors='raise')`

Make new Index with passed list of labels deleted

Parameters **labels** : array-like

errors : {'ignore', 'raise'}, default 'raise'

If 'ignore', suppress error and existing labels are dropped.

Returns **dropped** : Index

34.12.1.52 pandas.TimedeltaIndex.drop_duplicates

`TimedeltaIndex.drop_duplicates(keep='first')`

Return Index with duplicate values removed

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Drop duplicates except for the first occurrence.

- `last` : Drop duplicates except for the last occurrence.
- False : Drop all duplicates.

Returns **deduplicated** : Index

34.12.1.53 pandas.TimedeltaIndex.dropna

`TimedeltaIndex.`**`dropna`**(*how='any'*)

Return Index without NA/NaN values

Parameters **how** : {'any', 'all'}, default 'any'

If the Index is a MultiIndex, drop the value when any or all levels are NaN.

Returns **valid** : Index

34.12.1.54 pandas.TimedeltaIndex.duplicated

`TimedeltaIndex.`**`duplicated`**(*keep='first'*)

Return boolean np.ndarray denoting duplicate values

Parameters **keep** : {'first', 'last', False}, default 'first'

- `first` : Mark duplicates as `True` except for the first occurrence.
- `last` : Mark duplicates as `True` except for the last occurrence.
- False : Mark all duplicates as `True`.

Returns **duplicated** : np.ndarray

34.12.1.55 pandas.TimedeltaIndex.equals

`TimedeltaIndex.`**`equals`**(*other*)

Determines if two Index objects contain the same elements.

34.12.1.56 pandas.TimedeltaIndex.factorize

`TimedeltaIndex.`**`factorize`**(*sort=False*, *na_sentinel=-1*)

Encode the object as an enumerated type or categorical variable

Parameters **sort** : boolean, default False

Sort by values

na_sentinel: int, default -1

Value to mark "not found"

Returns **labels** : the indexer to the original array

uniques : the unique Index

34.12.1.57 pandas.TimedeltaIndex.fillna

`TimedeltaIndex.fillna(value=None, downcast=None)`

Fill NA/NaN values with the specified value

Parameters **value** : scalar

Scalar value to use to fill holes (e.g. 0). This value cannot be a list-likes.

downcast : dict, default is None

a dict of item->dtype of what to downcast if possible, or the string 'infer' which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns **filled** : %(klass)s

34.12.1.58 pandas.TimedeltaIndex.floor

`TimedeltaIndex.floor(freq)`

floor the index to the specified freq

Parameters **freq** : freq string/object

Returns index of same type

Raises **ValueError if the freq cannot be converted**

34.12.1.59 pandas.TimedeltaIndex.format

`TimedeltaIndex.format(name=False, formatter=None, **kwargs)`

Render a string representation of the Index

34.12.1.60 pandas.TimedeltaIndex.get_duplicates

`TimedeltaIndex.get_duplicates()`

34.12.1.61 pandas.TimedeltaIndex.get_indexer

`TimedeltaIndex.get_indexer(target, method=None, limit=None, tolerance=None)`

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

Parameters **target** : Index

method : {None, 'pad'/'ffill', 'backfill'/'bfill', 'nearest'}, optional

- default: exact matches only.
- pad / ffill: find the PREVIOUS index value if no exact match.
- backfill / bfill: use NEXT index value if no exact match
- nearest: use the NEAREST index value if no exact match. Tied distances are broken by preferring the larger index value.

limit : int, optional

Maximum number of consecutive labels in `target` to match for inexact matches.

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index's type.

New in version 0.17.0.

New in version 0.21.0: (list-like tolerance)

Returns **indexer** : ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

Examples

```
>>> indexer = index.get_indexer(new_index)
>>> new_values = cur_values.take(indexer)
```

34.12.1.62 pandas.TimedeltaIndex.get_indexer_for

`TimedeltaIndex.`**`get_indexer_for`**(*target*, ***kwargs*)

guaranteed return of an indexer even when non-unique This dispatches to get_indexer or get_indexer_nonunique as appropriate

34.12.1.63 pandas.TimedeltaIndex.get_indexer_non_unique

`TimedeltaIndex.`**`get_indexer_non_unique`**(*target*)

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

Parameters **target** : Index

Returns **indexer** : ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

missing : ndarray of int

An indexer into the target of the values not found. These correspond to the -1 in the indexer array

34.12.1.64 pandas.TimedeltaIndex.get_level_values

`TimedeltaIndex.`**`get_level_values`**(*level*)

Return an Index of values for requested level, equal to the length of the index.

Parameters **level** : int or str

`level` is either the integer position of the level in the MultiIndex, or the name of the level.

Returns **values** : Index

`self`, as there is only one level in the Index.

See also:

pandas.MultiIndex.get_level_values get values for a level of a MultiIndex

34.12.1.65 pandas.TimedeltaIndex.get_loc

`TimedeltaIndex.`**`get_loc`**(*key*, *method=None*, *tolerance=None*)

Get integer location for requested label

Returns **loc** : int

34.12.1.66 pandas.TimedeltaIndex.get_slice_bound

`TimedeltaIndex.`**`get_slice_bound`**(*label*, *side*, *kind*)

Calculate slice bound that corresponds to given label.

Returns leftmost (one-past-the-rightmost if `side=='right'`) position of given label.

Parameters **label** : object

side : {'left', 'right'}

kind : {'ix', 'loc', 'getitem'}

34.12.1.67 pandas.TimedeltaIndex.get_value

`TimedeltaIndex.`**`get_value`**(*series*, *key*)

Fast lookup of value from 1-dimensional ndarray. Only use this if you know what you're doing

34.12.1.68 pandas.TimedeltaIndex.get_value_maybe_box

`TimedeltaIndex.`**`get_value_maybe_box`**(*series*, *key*)

34.12.1.69 pandas.TimedeltaIndex.get_values

`TimedeltaIndex.`**`get_values`**()

return the underlying data as an ndarray

34.12.1.70 pandas.TimedeltaIndex.groupby

`TimedeltaIndex.`**`groupby`**(*values*)

Group the index labels by a given array of values.

Parameters **values** : array

Values used to determine the groups.

Returns **groups** : dict

{group name -> group labels}

34.12.1.71 pandas.TimedeltaIndex.holds_integer

`TimedeltaIndex.holds_integer()`

34.12.1.72 pandas.TimedeltaIndex.identical

`TimedeltaIndex.identical(other)`

Similar to equals, but check that other comparable attributes are also equal

34.12.1.73 pandas.TimedeltaIndex.insert

`TimedeltaIndex.insert(loc, item)`

Make new Index inserting new item at location

Parameters **loc** : int

item : object

if not either a Python datetime or a numpy integer-like, returned Index dtype will be object rather than datetime.

Returns **new_index** : Index

34.12.1.74 pandas.TimedeltaIndex.intersection

`TimedeltaIndex.intersection(other)`

Specialized intersection for TimedeltaIndex objects. May be much faster than Index.intersection

Parameters **other** : TimedeltaIndex or array-like

Returns **y** : Index or TimedeltaIndex

34.12.1.75 pandas.TimedeltaIndex.is_

`TimedeltaIndex.is_(other)`

More flexible, faster check like `is` but that works through views

Note: this is *not* the same as `Index.identical()`, which checks that metadata is also the same.

Parameters **other** : object

other object to compare against.

Returns **True if both have same underlying data, False otherwise** : bool

34.12.1.76 pandas.TimedeltaIndex.is_boolean

`TimedeltaIndex.is_boolean()`

34.12.1.77 pandas.TimedeltaIndex.is_categorical

`TimedeltaIndex.is_categorical()`

34.12.1.78 pandas.TimedeltaIndex.is_floating

`TimedeltaIndex.is_floating()`

34.12.1.79 pandas.TimedeltaIndex.is_integer

`TimedeltaIndex.is_integer()`

34.12.1.80 pandas.TimedeltaIndex.is_interval

`TimedeltaIndex.is_interval()`

34.12.1.81 pandas.TimedeltaIndex.is_lexsorted_for_tuple

`TimedeltaIndex.is_lexsorted_for_tuple(tup)`

34.12.1.82 pandas.TimedeltaIndex.is_mixed

`TimedeltaIndex.is_mixed()`

34.12.1.83 pandas.TimedeltaIndex.is_numeric

`TimedeltaIndex.is_numeric()`

34.12.1.84 pandas.TimedeltaIndex.is_object

`TimedeltaIndex.is_object()`

34.12.1.85 pandas.TimedeltaIndex.is_type_compatible

`TimedeltaIndex.is_type_compatible(typ)`

34.12.1.86 pandas.TimedeltaIndex.isin

`TimedeltaIndex.isin(values)`

Compute boolean array of whether each index value is found in the passed set of values

Parameters **values** : set or sequence of values

Returns **is_contained** : ndarray (boolean dtype)

34.12.1.87 pandas.TimedeltaIndex.isna

`TimedeltaIndex.isna()`

Detect missing values

New in version 0.20.0.

Returns a boolean array of whether my values are NA

See also:

isnull alias of isna

pandas.isna top-level isna

34.12.1.88 pandas.TimedeltaIndex.isnull

`TimedeltaIndex.isnull()`

Detect missing values

New in version 0.20.0.

Returns a boolean array of whether my values are NA

See also:

isnull alias of isna

pandas.isna top-level isna

34.12.1.89 pandas.TimedeltaIndex.item

`TimedeltaIndex.item()`

return the first element of the underlying data as a python scalar

34.12.1.90 pandas.TimedeltaIndex.join

`TimedeltaIndex.join(other, how='left', level=None, return_indexers=False, sort=False)`

See Index.join

34.12.1.91 pandas.TimedeltaIndex.map

`TimedeltaIndex.map(f)`

34.12.1.92 pandas.TimedeltaIndex.max

`TimedeltaIndex.max(axis=None, *args, **kwargs)`

Return the maximum value of the Index or maximum along an axis.

See also:

`numpy.ndarray.max`

34.12.1.93 pandas.TimedeltaIndex.memory_usage

`TimedeltaIndex.memory_usage(deep=False)`

Memory usage of my values

Parameters **deep** : bool

Introspect the data deeply, interrogate *object* dtypes for system-level memory consumption

Returns bytes used

See also:

`numpy.ndarray.nbytes`

Notes

Memory usage does not include memory consumed by elements that are not components of the array if deep=False or if used on PyPy

34.12.1.94 pandas.TimedeltaIndex.min

`TimedeltaIndex.min(axis=None, *args, **kwargs)`

Return the minimum value of the Index or minimum along an axis.

See also:

`numpy.ndarray.min`

34.12.1.95 pandas.TimedeltaIndex.notna

`TimedeltaIndex.notna()`

Inverse of isna

New in version 0.20.0.

Returns a boolean array of whether my values are not NA

See also:

notnull alias of notna

pandas.notna top-level notna

34.12.1.96 pandas.TimedeltaIndex.notnull

`TimedeltaIndex.notnull()`

Inverse of isna

New in version 0.20.0.

Returns a boolean array of whether my values are not NA

See also:

notnull alias of notna

pandas.notna top-level notna

34.12.1.97 pandas.TimedeltaIndex.nunique

`TimedeltaIndex.nunique(dropna=True)`

Return number of unique elements in the object.

Excludes NA values by default.

Parameters **dropna** : boolean, default True

Don't include NaN in the count.

Returns **nunique** : int

34.12.1.98 pandas.TimedeltaIndex.putmask

`TimedeltaIndex.putmask(mask, value)`

return a new Index of the values set with the mask

See also:

`numpy.ndarray.putmask`

34.12.1.99 pandas.TimedeltaIndex.ravel

`TimedeltaIndex.ravel(order='C')`

return an ndarray of the flattened values of the underlying data

See also:

`numpy.ndarray.ravel`

34.12.1.100 pandas.TimedeltaIndex.reindex

`TimedeltaIndex.reindex(target, method=None, level=None, limit=None, tolerance=None)`

Create index with target's values (move/add/delete values as necessary)

Parameters **target** : an iterable

Returns **new_index** : pd.Index

Resulting index

indexer : np.ndarray or None

Indices of output values in original index

34.12.1.101 pandas.TimedeltaIndex.rename

`TimedeltaIndex.rename(name, inplace=False)`

Set new names on index. Defaults to returning new index.

Parameters **name** : str or list

name to set

inplace : bool

if True, mutates in place

Returns new index (of same type and class...etc) [if inplace, returns None]

34.12.1.102 pandas.TimedeltaIndex.repeat

`TimedeltaIndex.repeat(repeats, *args, **kwargs)`

Analogous to ndarray.repeat

34.12.1.103 pandas.TimedeltaIndex.reshape

`TimedeltaIndex.reshape(*args, **kwargs)`

NOT IMPLEMENTED: do not call this method, as reshaping is not supported for Index objects and will raise an error.

Reshape an Index.

34.12.1.104 pandas.TimedeltaIndex.round

`TimedeltaIndex.round(freq, *args, **kwargs)`

round the index to the specified freq

Parameters **freq** : freq string/object

Returns index of same type

Raises **ValueError if the freq cannot be converted**

34.12.1.105 pandas.TimedeltaIndex.searchsorted

`TimedeltaIndex.searchsorted(value, side='left', sorter=None)`

Find indices where elements should be inserted to maintain order.

Find the indices into a sorted TimedeltaIndex *self* such that, if the corresponding elements in *value* were inserted before the indices, the order of *self* would be preserved.

Parameters **value** : array_like

Values to insert into *self*.

side : {'left', 'right'}, optional

If 'left', the index of the first suitable location found is given. If 'right', return the last such index. If there is no suitable index, return either 0 or N (where N is the length of *self*).

sorter : 1-D array_like, optional

Optional array of integer indices that sort *self* into ascending order. They are typically the result of `np.argsort`.

Returns **indices** : array of ints

Array of insertion points with the same shape as *value*.

See also:

`numpy.searchsorted`

Notes

Binary search is used to find the required insertion points.

Examples

```
>>> x = pd.Series([1, 2, 3])
>>> x
0    1
1    2
2    3
dtype: int64
```

```
>>> x.searchsorted(4)
array([3])
```

```
>>> x.searchsorted([0, 4])
array([0, 3])
```

```
>>> x.searchsorted([1, 3], side='left')
array([0, 2])
```

```
>>> x.searchsorted([1, 3], side='right')
array([1, 3])
```

```
>>> x = pd.Categorical(['apple', 'bread', 'bread', 'cheese', 'milk' ])
[apple, bread, bread, cheese, milk]
Categories (4, object): [apple < bread < cheese < milk]
```

```
>>> x.searchsorted('bread')
array([1])     # Note: an array, not a scalar
```

```
>>> x.searchsorted(['bread'])
array([1])
```

```
>>> x.searchsorted(['bread', 'eggs'])
array([1, 4])
```

```
>>> x.searchsorted(['bread', 'eggs'], side='right')
array([3, 4])    # eggs before milk
```

34.12.1.106 pandas.TimedeltaIndex.set_names

`TimedeltaIndex.`**`set_names`**(*names*, *level=None*, *inplace=False*)

Set new names on index. Defaults to returning new index.

Parameters **names** : str or sequence

name(s) to set

level : int, level name, or sequence of int/level names (default None)

If the index is a MultiIndex (hierarchical), level(s) to set (None for all levels). Otherwise level must be None

inplace : bool

if True, mutates in place

Returns new index (of same type and class...etc) [if inplace, returns None]

Examples

```
>>> Index([1, 2, 3, 4]).set_names('foo')
Int64Index([1, 2, 3, 4], dtype='int64')
>>> Index([1, 2, 3, 4]).set_names(['foo'])
Int64Index([1, 2, 3, 4], dtype='int64')
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                  (2, u'one'), (2, u'two')],
                                  names=['foo', 'bar'])
>>> idx.set_names(['baz', 'quz'])
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'baz', u'quz'])
>>> idx.set_names('baz', level=0)
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=[u'baz', u'bar'])
```

34.12.1.107 pandas.TimedeltaIndex.set_value

`TimedeltaIndex.set_value(arr, key, value)`

Fast lookup of value from 1-dimensional ndarray. Only use this if you know what you're doing

34.12.1.108 pandas.TimedeltaIndex.shift

`TimedeltaIndex.shift(n, freq=None)`

Specialized shift which produces a DatetimeIndex

Parameters **n** : int

Periods to shift by

freq : DateOffset or timedelta-like, optional

Returns **shifted** : DatetimeIndex

34.12.1.109 pandas.TimedeltaIndex.slice_indexer

`TimedeltaIndex.slice_indexer(start=None, end=None, step=None, kind=None)`

For an ordered Index, compute the slice indexer for input labels and step

Parameters **start** : label, default None

If None, defaults to the beginning

end : label, default None

If None, defaults to the end

step : int, default None

kind : string, default None

Returns **indexer** : ndarray or slice

Notes

This function assumes that the data is sorted, so use at your own peril

34.12.1.110 pandas.TimedeltaIndex.slice_locs

`TimedeltaIndex.slice_locs(start=None, end=None, step=None, kind=None)`

Compute slice locations for input labels.

Parameters **start** : label, default None

If None, defaults to the beginning

end : label, default None

If None, defaults to the end

step : int, defaults None

If None, defaults to 1

kind : {'ix', 'loc', 'getitem'} or None

Returns **start, end** : int

See also:

Index.get_loc Get location for a single label

Notes

This method only works if the index is monotonic or unique.

Examples

```
>>> idx = pd.Index(list('abcd'))
>>> idx.slice_locs(start='b', end='c')
(1, 3)
```

34.12.1.111 pandas.TimedeltaIndex.sort

`TimedeltaIndex.sort(*args, **kwargs)`

34.12.1.112 pandas.TimedeltaIndex.sort_values

`TimedeltaIndex.sort_values(return_indexer=False, ascending=True)`

Return sorted copy of Index

34.12.1.113 pandas.TimedeltaIndex.sortlevel

`TimedeltaIndex.sortlevel`(*level=None*, *ascending=True*, *sort_remaining=None*)

For internal compatibility with with the Index API

Sort the Index. This is for compat with MultiIndex

Parameters **ascending** : boolean, default True

False to sort in descending order

level, sort_remaining are compat parameters

Returns **sorted_index** : Index

34.12.1.114 pandas.TimedeltaIndex.str

`TimedeltaIndex.str`()

Vectorized string functions for Series and Index. NAs stay NA unless handled otherwise by a particular method. Patterned after Python's string methods, with some inspiration from R's stringr package.

Examples

```
>>> s.str.split('_')
>>> s.str.replace('_', '')
```

34.12.1.115 pandas.TimedeltaIndex.summary

`TimedeltaIndex.summary`(*name=None*)

return a summarized representation

34.12.1.116 pandas.TimedeltaIndex.symmetric_difference

`TimedeltaIndex.symmetric_difference`(*other*, *result_name=None*)

Compute the symmetric difference of two Index objects. It's sorted if sorting is possible.

Parameters **other** : Index or array-like

result_name : str

Returns **symmetric_difference** : Index

Notes

`symmetric_difference` contains elements that appear in either `idx1` or `idx2` but not both. Equivalent to the Index created by `idx1.difference(idx2) | idx2.difference(idx1)` with duplicates dropped.

Examples

```
>>> idx1 = Index([1, 2, 3, 4])
>>> idx2 = Index([2, 3, 4, 5])
>>> idx1.symmetric_difference(idx2)
Int64Index([1, 5], dtype='int64')
```

You can also use the ^ operator:

```
>>> idx1 ^ idx2
Int64Index([1, 5], dtype='int64')
```

34.12.1.117 pandas.TimedeltaIndex.take

`TimedeltaIndex.take`(*indices*, *axis=0*, *allow_fill=True*, *fill_value=None*, ***kwargs*)

return a new Index of the values selected by the indices

For internal compatibility with numpy arrays.

Parameters **indices** : list

Indices to be taken

axis : int, optional

The axis over which to select values, always 0.

allow_fill : bool, default True

fill_value : bool, default None

If allow_fill=True and fill_value is not None, indices specified by -1 is regarded as NA. If Index doesn't hold NA, raise ValueError

See also:

`numpy.ndarray.take`

34.12.1.118 pandas.TimedeltaIndex.to_datetime

`TimedeltaIndex.to_datetime`(*dayfirst=False*)

DEPRECATED: use `pandas.to_datetime()` instead.

For an Index containing strings or datetime.datetime objects, attempt conversion to DatetimeIndex

34.12.1.119 pandas.TimedeltaIndex.to_frame

`TimedeltaIndex.to_frame`(*index=True*)

Create a DataFrame with a column containing the Index.

New in version 0.21.0.

Parameters **index** : boolean, default True

Set the index of the returned DataFrame as the original Index.

Returns **DataFrame** : a DataFrame containing the original Index data.

34.12.1.120 pandas.TimedeltaIndex.to_native_types

`TimedeltaIndex.to_native_types(slicer=None, **kwargs)`

Format specified values of *self* and return them.

Parameters **slicer** : int, array-like

An indexer into *self* that specifies which values are used in the formatting process.

kwargs : dict

Options for specifying how the values should be formatted. These options include the following:

1. **na_rep** [str] The value that serves as a placeholder for NULL values
2. **quoting** [bool or None] Whether or not there are quoted values in *self*
3. **date_format** [str] The format used to represent date-like values

34.12.1.121 pandas.TimedeltaIndex.to_pytimedelta

`TimedeltaIndex.to_pytimedelta()`

Return TimedeltaIndex as object ndarray of datetime.timedelta objects

Returns **datetimes** : ndarray

34.12.1.122 pandas.TimedeltaIndex.to_series

`TimedeltaIndex.to_series(**kwargs)`

Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index

Returns **Series** : dtype will be based on the type of the Index values.

34.12.1.123 pandas.TimedeltaIndex.tolist

`TimedeltaIndex.tolist()`

return a list of the underlying data

34.12.1.124 pandas.TimedeltaIndex.total_seconds

`TimedeltaIndex.total_seconds()`

Total duration of each element expressed in seconds.

New in version 0.17.0.

34.12.1.125 pandas.TimedeltaIndex.transpose

`TimedeltaIndex.transpose(*args, **kwargs)`

return the transpose, which is by definition self

34.12.1.126 pandas.TimedeltaIndex.union

`TimedeltaIndex.union(other)`

Specialized union for TimedeltaIndex objects. If combine overlapping ranges with the same DateOffset, will be much faster than Index.union

Parameters **other** : TimedeltaIndex or array-like

Returns **y** : Index or TimedeltaIndex

34.12.1.127 pandas.TimedeltaIndex.unique

`TimedeltaIndex.unique()`

Return unique values in the object. Uniques are returned in order of appearance, this does NOT sort. Hash table-based unique.

Parameters **values** : 1d array-like

Returns unique values.

- If the input is an Index, the return is an Index
- If the input is a Categorical dtype, the return is a Categorical
- If the input is a Series/ndarray, the return will be an ndarray

See also:

unique, *Index.unique*, *Series.unique*

34.12.1.128 pandas.TimedeltaIndex.value_counts

`TimedeltaIndex.value_counts(normalize=False, sort=True, ascending=False, bins=None, dropna=True)`

Returns object containing counts of unique values.

The resulting object will be in descending order so that the first element is the most frequently-occurring element. Excludes NA values by default.

Parameters **normalize** : boolean, default False

If True then the object returned will contain the relative frequencies of the unique values.

sort : boolean, default True

Sort by values

ascending : boolean, default False

Sort in ascending order

bins : integer, optional

Rather than count values, group them into half-open bins, a convenience for pd.cut, only works with numeric data

dropna : boolean, default True

Don't include counts of NaN.

Returns **counts** : Series

34.12.1.129 pandas.TimedeltaIndex.view

`TimedeltaIndex.view(cls=None)`

34.12.1.130 pandas.TimedeltaIndex.where

`TimedeltaIndex.where(cond, other=None)`

New in version 0.19.0.

Return an Index of same shape as self and whose corresponding entries are from self where cond is True and otherwise are from other.

Parameters **cond** : boolean array-like with the same length as self

other : scalar, or array-like

34.12.2 Components

`TimedeltaIndex.days`	Number of days for each element.
`TimedeltaIndex.seconds`	Number of seconds (>= 0 and less than 1 day) for each element.
`TimedeltaIndex.microseconds`	Number of microseconds (>= 0 and less than 1 second) for each element.
`TimedeltaIndex.nanoseconds`	Number of nanoseconds (>= 0 and less than 1 microsecond) for each element.
`TimedeltaIndex.components`	Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.
`TimedeltaIndex.inferred_freq`	

34.12.3 Conversion

`TimedeltaIndex.to_pytimedelta`()	Return TimedeltaIndex as object ndarray of datetime.timedelta objects
`TimedeltaIndex.to_series`(**kwargs)	Create a Series with both index and values equal to the index keys
`TimedeltaIndex.round`(freq, *args, **kwargs)	round the index to the specified freq
`TimedeltaIndex.floor`(freq)	floor the index to the specified freq
`TimedeltaIndex.ceil`(freq)	ceil the index to the specified freq
`TimedeltaIndex.to_frame`([index])	Create a DataFrame with a column containing the Index.

34.13 PeriodIndex

`PeriodIndex`	Immutable ndarray holding ordinal values indicating regular periods in time such as particular years, quarters, months, etc.

34.13.1 pandas.PeriodIndex

class `pandas.PeriodIndex`

Immutable ndarray holding ordinal values indicating regular periods in time such as particular years, quarters, months, etc.

Index keys are boxed to Period objects which carries the metadata (eg, frequency information).

Parameters **data** : array-like (1-dimensional), optional

Optional period-like data to construct index with

copy : bool

Make a copy of input ndarray

freq : string or period object, optional

One of pandas period strings or corresponding objects

start : starting value, period-like, optional

If data is None, used as the start point in generating regular period data.

periods : int, optional, > 0

Number of periods to generate, if generating index. Takes precedence over end argument

end : end value, period-like, optional

If periods is none, generated index will extend to first conforming period on or just past end argument

year : int, array, or Series, default None

month : int, array, or Series, default None

quarter : int, array, or Series, default None

day : int, array, or Series, default None

hour : int, array, or Series, default None

minute : int, array, or Series, default None

second : int, array, or Series, default None

tz : object, default None

Timezone for converting datetime64 data to Periods

dtype : str or PeriodDtype, default None

See also:

Index The base pandas Index type

Period Represents a period of time

DatetimeIndex Index with datetime64 data

TimedeltaIndex Index of timedelta64 data

Examples

```
>>> idx = PeriodIndex(year=year_arr, quarter=q_arr)
```

```
>>> idx2 = PeriodIndex(start='2000', end='2010', freq='A')
```

34.13.2 Attributes

PeriodIndex.day	The days of the period
PeriodIndex.dayofweek	The day of the week with Monday=0, Sunday=6
PeriodIndex.dayofyear	The ordinal day of the year
PeriodIndex.days_in_month	The number of days in the month
PeriodIndex.daysinmonth	The number of days in the month
PeriodIndex.end_time	
PeriodIndex.freq	
PeriodIndex.freqstr	Return the frequency object as a string if its set, otherwise None
PeriodIndex.hour	The hour of the period
PeriodIndex.is_leap_year	Logical indicating if the date belongs to a leap year
PeriodIndex.minute	The minute of the period
PeriodIndex.month	The month as January=1, December=12
PeriodIndex.quarter	The quarter of the date
PeriodIndex.qyear	
PeriodIndex.second	The second of the period
PeriodIndex.start_time	
PeriodIndex.week	The week ordinal of the year
PeriodIndex.weekday	The day of the week with Monday=0, Sunday=6
PeriodIndex.weekofyear	The week ordinal of the year
PeriodIndex.year	The year of the period

34.13.2.1 pandas.PeriodIndex.day

PeriodIndex.**day**

The days of the period

34.13.2.2 pandas.PeriodIndex.dayofweek

PeriodIndex.**dayofweek**

The day of the week with Monday=0, Sunday=6

34.13.2.3 pandas.PeriodIndex.dayofyear

PeriodIndex.**dayofyear**

The ordinal day of the year

34.13.2.4 pandas.PeriodIndex.days_in_month

`PeriodIndex.days_in_month`
The number of days in the month

34.13.2.5 pandas.PeriodIndex.daysinmonth

`PeriodIndex.daysinmonth`
The number of days in the month

34.13.2.6 pandas.PeriodIndex.end_time

`PeriodIndex.end_time`

34.13.2.7 pandas.PeriodIndex.freq

`PeriodIndex.freq = None`

34.13.2.8 pandas.PeriodIndex.freqstr

`PeriodIndex.freqstr`
Return the frequency object as a string if its set, otherwise None

34.13.2.9 pandas.PeriodIndex.hour

`PeriodIndex.hour`
The hour of the period

34.13.2.10 pandas.PeriodIndex.is_leap_year

`PeriodIndex.is_leap_year`
Logical indicating if the date belongs to a leap year

34.13.2.11 pandas.PeriodIndex.minute

`PeriodIndex.minute`
The minute of the period

34.13.2.12 pandas.PeriodIndex.month

`PeriodIndex.month`
The month as January=1, December=12

34.13.2.13 pandas.PeriodIndex.quarter

`PeriodIndex.quarter`
The quarter of the date

34.13.2.14 pandas.PeriodIndex.qyear

`PeriodIndex.qyear`

34.13.2.15 pandas.PeriodIndex.second

`PeriodIndex.second`

The second of the period

34.13.2.16 pandas.PeriodIndex.start_time

`PeriodIndex.start_time`

34.13.2.17 pandas.PeriodIndex.week

`PeriodIndex.week`

The week ordinal of the year

34.13.2.18 pandas.PeriodIndex.weekday

`PeriodIndex.weekday`

The day of the week with Monday=0, Sunday=6

34.13.2.19 pandas.PeriodIndex.weekofyear

`PeriodIndex.weekofyear`

The week ordinal of the year

34.13.2.20 pandas.PeriodIndex.year

`PeriodIndex.year`

The year of the period

34.13.3 Methods

PeriodIndex.asfreq([freq, how])	Convert the PeriodIndex to the specified frequency *freq*.
PeriodIndex.strftime(date_format)	Return an array of formatted strings specified by date_format, which supports the same string format as the python standard library.
PeriodIndex.to_timestamp([freq, how])	Cast to DatetimeIndex
PeriodIndex.tz_convert(tz)	Convert tz-aware DatetimeIndex from one time zone to another (using
PeriodIndex.tz_localize(tz[, infer_dst])	Localize tz-naive DatetimeIndex to given time zone (using

34.13.3.1 pandas.PeriodIndex.asfreq

`PeriodIndex.asfreq(freq=None, how='E')`

Convert the PeriodIndex to the specified frequency *freq*.

Parameters **freq** : str

a frequency

how : str {'E', 'S'}

'E', 'END', or 'FINISH' for end, 'S', 'START', or 'BEGIN' for start. Whether the elements should be aligned to the end or start within pa period. January 31st ('END') vs. Janury 1st ('START') for example.

Returns **new** : PeriodIndex with the new frequency

Examples

```
>>> pidx = pd.period_range('2010-01-01', '2015-01-01', freq='A')
>>> pidx
<class 'pandas.core.indexes.period.PeriodIndex'>
[2010, ..., 2015]
Length: 6, Freq: A-DEC
```

```
>>> pidx.asfreq('M')
<class 'pandas.core.indexes.period.PeriodIndex'>
[2010-12, ..., 2015-12]
Length: 6, Freq: M
```

```
>>> pidx.asfreq('M', how='S')
<class 'pandas.core.indexes.period.PeriodIndex'>
[2010-01, ..., 2015-01]
Length: 6, Freq: M
```

34.13.3.2 pandas.PeriodIndex.strftime

`PeriodIndex.strftime(date_format)`

Return an array of formatted strings specified by date_format, which supports the same string format as the python standard library. Details of the string format can be found in python string format doc

New in version 0.17.0.

Parameters **date_format** : str

date format string (e.g. "%Y-%m-%d")

Returns ndarray of formatted strings

34.13.3.3 pandas.PeriodIndex.to_timestamp

`PeriodIndex.to_timestamp(freq=None, how='start')`

Cast to DatetimeIndex

Parameters **freq** : string or DateOffset, default 'D' for week or longer, 'S'

otherwise

Target frequency

how : {'s', 'e', 'start', 'end'}

Returns DatetimeIndex

34.13.3.4 pandas.PeriodIndex.tz_convert

`PeriodIndex.tz_convert(tz)`

Convert tz-aware DatetimeIndex from one time zone to another (using pytz/dateutil)

Parameters **tz** : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time. Corresponding timestamps would be converted to time zone of the TimeSeries. None will remove timezone holding UTC time.

Returns **normalized** : DatetimeIndex

34.13.3.5 pandas.PeriodIndex.tz_localize

`PeriodIndex.tz_localize(tz, infer_dst=False)`

Localize tz-naive DatetimeIndex to given time zone (using pytz/dateutil), or remove timezone from tz-aware DatetimeIndex

Parameters **tz** : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time. Corresponding timestamps would be converted to time zone of the TimeSeries. None will remove timezone holding local time.

infer_dst : boolean, default False

Attempt to infer fall dst-transition hours based on order

Returns **localized** : DatetimeIndex

34.14 Scalars

34.14.1 Period

Period	Represents a period of time

34.14.1.1 pandas.Period

class `pandas.Period`

Represents a period of time

Parameters **value** : Period or compat.string_types, default None

The time period represented (e.g., '4Q2005')

freq : str, default None

One of pandas period strings or corresponding objects

year : int, default None

month : int, default 1

quarter : int, default None

day : int, default 1

hour : int, default 0

minute : int, default 0

second : int, default 0

Attributes

day
dayofweek
dayofyear
days_in_month
daysinmonth
end_time
freq
freqstr
hour
is_leap_year
minute
month
ordinal
quarter
qyear
second
start_time
week
weekday
weekofyear
year

pandas.Period.day

`Period.`**`day`**

pandas.Period.dayofweek

`Period.`**`dayofweek`**

pandas.Period.dayofyear

`Period.`**`dayofyear`**

pandas.Period.days_in_month

Period.**days_in_month**

pandas.Period.daysinmonth

Period.**daysinmonth**

pandas.Period.end_time

Period.**end_time**

pandas.Period.freq

Period.**freq**

pandas.Period.freqstr

Period.**freqstr**

pandas.Period.hour

Period.**hour**

pandas.Period.is_leap_year

Period.**is_leap_year**

pandas.Period.minute

Period.**minute**

pandas.Period.month

Period.**month**

pandas.Period.ordinal

Period.**ordinal**

pandas.Period.quarter

Period.**quarter**

pandas.Period.qyear

`Period.qyear`

pandas.Period.second

`Period.second`

pandas.Period.start_time

`Period.start_time`

pandas.Period.week

`Period.week`

pandas.Period.weekday

`Period.weekday`

pandas.Period.weekofyear

`Period.weekofyear`

pandas.Period.year

`Period.year`

Methods

asfreq	Convert Period to desired frequency, either at the start or end of the
now	
strftime	Returns the string representation of the *Period*, depending on the selected `format`.
to_timestamp	Return the Timestamp representation of the Period at the target

pandas.Period.asfreq

`Period.asfreq()`

Convert Period to desired frequency, either at the start or end of the interval

Parameters **freq** : string

how : {'E', 'S', 'end', 'start'}, default 'end'

Start or end of the timespan

Returns **resampled** : Period

pandas.Period.now

`Period.now()`

pandas.Period.strftime

`Period.strftime()`

Returns the string representation of the *Period*, depending on the selected `format`. `format` must be a string containing one or several directives. The method recognizes the same directives as the `time.strftime()` function of the standard Python distribution, as well as the specific additional directives `%f`, `%F`, `%q`. (formatting & docs originally from scikits.timeries)

Directive	Meaning	Notes
`%a`	Locale's abbreviated weekday name.	
`%A`	Locale's full weekday name.	
`%b`	Locale's abbreviated month name.	
`%B`	Locale's full month name.	
`%c`	Locale's appropriate date and time representation.	
`%d`	Day of the month as a decimal number [01,31].	
`%f`	'Fiscal' year without a century as a decimal number [00,99]	(1)
`%F`	'Fiscal' year with a century as a decimal number	(2)
`%H`	Hour (24-hour clock) as a decimal number [00,23].	
`%I`	Hour (12-hour clock) as a decimal number [01,12].	
`%j`	Day of the year as a decimal number [001,366].	
`%m`	Month as a decimal number [01,12].	
`%M`	Minute as a decimal number [00,59].	
`%p`	Locale's equivalent of either AM or PM.	(3)
`%q`	Quarter as a decimal number [01,04]	
`%S`	Second as a decimal number [00,61].	(4)
`%U`	Week number of the year (Sunday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Sunday are considered to be in week 0.	(5)
`%w`	Weekday as a decimal number [0(Sunday),6].	
`%W`	Week number of the year (Monday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Monday are considered to be in week 0.	(5)
`%x`	Locale's appropriate date representation.	
`%X`	Locale's appropriate time representation.	
`%y`	Year without century as a decimal number [00,99].	
`%Y`	Year with century as a decimal number.	
`%Z`	Time zone name (no characters if no time zone exists).	
`%%`	A literal `'%'` character.	

Notes

1. The `%f` directive is the same as `%y` if the frequency is not quarterly. Otherwise, it corresponds to the 'fiscal' year, as defined by the *qyear* attribute.
2. The `%F` directive is the same as `%Y` if the frequency is not quarterly. Otherwise, it corresponds to the 'fiscal' year, as defined by the *qyear* attribute.
3. The `%p` directive only affects the output hour field if the `%I` directive is used to parse the hour.
4. The range really is `0` to `61`; this accounts for leap seconds and the (very rare) double leap seconds.
5. The `%U` and `%W` directives are only used in calculations when the day of the week and the year are specified.

Examples

```
>>> a = Period(freq='Q@JUL', year=2006, quarter=1)
>>> a.strftime('%F-Q%q')
'2006-Q1'
>>> # Output the last month in the quarter of this date
>>> a.strftime('%b-%Y')
'Oct-2005'
>>>
>>> a = Period(freq='D', year=2001, month=1, day=1)
>>> a.strftime('%d-%b-%Y')
'01-Jan-2006'
>>> a.strftime('%b. %d, %Y was a %A')
'Jan. 01, 2001 was a Monday'
```

pandas.Period.to_timestamp

`Period.`**`to_timestamp`**`()`

Return the Timestamp representation of the Period at the target frequency at the specified end (how) of the Period

Parameters **freq** : string or DateOffset

Target frequency. Default is 'D' if self.freq is week or longer and 'S' otherwise

how: str, default 'S' (start)

'S', 'E'. Can be aliased as case insensitive 'Start', 'Finish', 'Begin', 'End'

Returns Timestamp

34.14.2 Attributes

Period.day
Period.dayofweek
Period.dayofyear
Period.days_in_month
Period.daysinmonth

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Period.end_time
Period.freq
Period.freqstr
Period.hour
Period.is_leap_year
Period.minute
Period.month
Period.ordinal
Period.quarter
Period.qyear
Period.second
Period.start_time
Period.week
Period.weekday
Period.weekofyear
Period.year

34.14.3 Methods

Period.asfreq	Convert Period to desired frequency, either at the start or end of the
Period.now	
Period.strftime	Returns the string representation of the *Period*, depending on the selected `format`.
Period.to_timestamp	Return the Timestamp representation of the Period at the target

34.14.4 Timestamp

Timestamp	TimeStamp is the pandas equivalent of python's Datetime and is interchangable with it in most cases.

34.14.4.1 pandas.Timestamp

class `pandas.`**`Timestamp`**

TimeStamp is the pandas equivalent of python's Datetime and is interchangable with it in most cases. It's the type used for the entries that make up a DatetimeIndex, and other timeseries oriented data structures in pandas.

There are essentially three calling conventions for the constructor. The primary form accepts four parameters. They can be passed by position or keyword.

Parameters **ts_input** : datetime-like, str, int, float

Value to be converted to Timestamp

freq : str, DateOffset

Offset which Timestamp will have

tz : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time which Timestamp will have.

unit : string

numpy unit used for conversion, if ts_input is int or float

offset : str, DateOffset

Deprecated, use freq

The other two forms mimic the parameters from ‘‘datetime.datetime‘‘. They can be passed by either position or keyword, but not both mixed together.

Attributes

asm8	
day	
dayofweek	
dayofyear	
days_in_month	
daysinmonth	
fold	
freq	
freqstr	
hour	
is_leap_year	
is_month_end	
is_month_start	
is_quarter_end	
is_quarter_start	
is_year_end	
is_year_start	
microsecond	
minute	
month	
nanosecond	
offset	
quarter	
second	
tz	Alias for tzinfo
tzinfo	
value	
week	
weekday_name	
weekofyear	
year	

pandas.Timestamp.asm8

`Timestamp.`**`asm8`**

pandas.Timestamp.day

`Timestamp.day`

pandas.Timestamp.dayofweek

`Timestamp.dayofweek`

pandas.Timestamp.dayofyear

`Timestamp.dayofyear`

pandas.Timestamp.days_in_month

`Timestamp.days_in_month`

pandas.Timestamp.daysinmonth

`Timestamp.daysinmonth`

pandas.Timestamp.fold

`Timestamp.fold`

pandas.Timestamp.freq

`Timestamp.freq`

pandas.Timestamp.freqstr

`Timestamp.freqstr`

pandas.Timestamp.hour

`Timestamp.hour`

pandas.Timestamp.is_leap_year

`Timestamp.is_leap_year`

pandas.Timestamp.is_month_end

`Timestamp.is_month_end`

pandas.Timestamp.is_month_start

`Timestamp.is_month_start`

pandas.Timestamp.is_quarter_end

`Timestamp.is_quarter_end`

pandas.Timestamp.is_quarter_start

`Timestamp.is_quarter_start`

pandas.Timestamp.is_year_end

`Timestamp.is_year_end`

pandas.Timestamp.is_year_start

`Timestamp.is_year_start`

pandas.Timestamp.microsecond

`Timestamp.microsecond`

pandas.Timestamp.minute

`Timestamp.minute`

pandas.Timestamp.month

`Timestamp.month`

pandas.Timestamp.nanosecond

`Timestamp.nanosecond`

pandas.Timestamp.offset

`Timestamp.offset`

pandas.Timestamp.quarter

`Timestamp.quarter`

pandas.Timestamp.second

`Timestamp.`**`second`**

pandas.Timestamp.tz

`Timestamp.`**`tz`**

Alias for tzinfo

pandas.Timestamp.tzinfo

`Timestamp.`**`tzinfo`**

pandas.Timestamp.value

`Timestamp.`**`value`**

pandas.Timestamp.week

`Timestamp.`**`week`**

pandas.Timestamp.weekday_name

`Timestamp.`**`weekday_name`**

pandas.Timestamp.weekofyear

`Timestamp.`**`weekofyear`**

pandas.Timestamp.year

`Timestamp.`**`year`**

Methods

astimezone	Convert tz-aware Timestamp to another time zone.
ceil	return a new Timestamp ceiled to this resolution
combine	
ctime	Return ctime() style string.
date	Return date object with same year, month and day.
dst	Return self.tzinfo.dst(self).
floor	return a new Timestamp floored to this resolution
fromordinal	passed an ordinal, translate and convert to a ts
fromtimestamp	

Continued on next page

Table 34.130 – continued from previous page

isocalendar	Return a 3-tuple containing ISO year, week number, and weekday.
isoformat	
isoweekday	Return the day of the week represented by the date.
normalize	Normalize Timestamp to midnight, preserving tz information.
now	Return the current time in the local timezone.
replace	implements datetime.replace, handles nanoseconds
round	Round the Timestamp to the specified resolution
strftime	format -> strftime() style string.
strptime	string, format -> new datetime parsed from a string (like time.strptime()).
time	Return time object with same time but with tzinfo=None.
timestamp	Return POSIX timestamp as float.
timetuple	Return time tuple, compatible with time.localtime().
timetz	Return time object with same time and tzinfo.
to_datetime	DEPRECATED: use *to_pydatetime()* instead.
to_datetime64	Returns a numpy.datetime64 object with 'ns' precision
to_julian_date	Convert TimeStamp to a Julian Date.
to_period	Return an period of which this timestamp is an observation.
to_pydatetime	Convert a Timestamp object to a native Python datetime object.
today	Return the current time in the local timezone.
toordinal	Return proleptic Gregorian ordinal.
tz_convert	Convert tz-aware Timestamp to another time zone.
tz_localize	Convert naive Timestamp to local time zone, or remove timezone from tz-aware Timestamp.
tzname	Return self.tzinfo.tzname(self).
utcfromtimestamp	
utcnow	
utcoffset	Return self.tzinfo.utcoffset(self).
utctimetuple	Return UTC time tuple, compatible with time.localtime().
weekday	Return the day of the week represented by the date.

pandas.Timestamp.astimezone

`Timestamp.astimezone()`

Convert tz-aware Timestamp to another time zone.

Parameters **tz** : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time which Timestamp will be converted to. None will remove timezone holding UTC time.

Returns **converted** : Timestamp

Raises **TypeError**

If Timestamp is tz-naive.

pandas.Timestamp.ceil

`Timestamp.ceil()`

return a new Timestamp ceiled to this resolution

Parameters **freq** : a freq string indicating the ceiling resolution

pandas.Timestamp.combine

classmethod `Timestamp.combine()`

pandas.Timestamp.ctime

`Timestamp.ctime()`

Return ctime() style string.

pandas.Timestamp.date

`Timestamp.date()`

Return date object with same year, month and day.

pandas.Timestamp.dst

`Timestamp.dst()`

Return self.tzinfo.dst(self).

pandas.Timestamp.floor

`Timestamp.floor()`

return a new Timestamp floored to this resolution

Parameters **freq** : a freq string indicating the flooring resolution

pandas.Timestamp.fromordinal

classmethod `Timestamp.fromordinal()`

passed an ordinal, translate and convert to a ts note: by definition there cannot be any tz info on the ordinal itself

Parameters **ordinal** : int

date corresponding to a proleptic Gregorian ordinal

freq : str, DateOffset

Offset which Timestamp will have

tz : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time which Timestamp will have.

offset : str, DateOffset

Deprecated, use freq

pandas.Timestamp.fromtimestamp

classmethod `Timestamp.fromtimestamp()`

pandas.Timestamp.isocalendar

`Timestamp.isocalendar()`

Return a 3-tuple containing ISO year, week number, and weekday.

pandas.Timestamp.isoformat

`Timestamp.isoformat()`

pandas.Timestamp.isoweekday

`Timestamp.isoweekday()`

Return the day of the week represented by the date. Monday == 1 ... Sunday == 7

pandas.Timestamp.normalize

`Timestamp.normalize()`

Normalize Timestamp to midnight, preserving tz information.

pandas.Timestamp.now

classmethod `Timestamp.now()`

Return the current time in the local timezone. Equivalent to datetime.now([tz])

Parameters **tz** : string / timezone object, default None

Timezone to localize to

pandas.Timestamp.replace

`Timestamp.replace()`

implements datetime.replace, handles nanoseconds

Parameters **year** : int, optional

month : int, optional

day : int, optional

hour : int, optional

minute : int, optional

second : int, optional

microsecond : int, optional

nanosecond: int, optional

tzinfo : tz-convertible, optional

fold : int, optional, default is 0

added in 3.6, NotImplemented

Returns Timestamp with fields replaced

pandas.Timestamp.round

`Timestamp.round()`

Round the Timestamp to the specified resolution

Parameters **freq** : a freq string indicating the rounding resolution

Returns a new Timestamp rounded to the given resolution of *freq*

Raises **ValueError if the freq cannot be converted**

pandas.Timestamp.strftime

`Timestamp.strftime()`

format -> strftime() style string.

pandas.Timestamp.strptime

`Timestamp.strptime()`

string, format -> new datetime parsed from a string (like time.strptime()).

pandas.Timestamp.time

`Timestamp.time()`

Return time object with same time but with tzinfo=None.

pandas.Timestamp.timestamp

`Timestamp.timestamp()`

Return POSIX timestamp as float.

pandas.Timestamp.timetuple

`Timestamp.timetuple()`

Return time tuple, compatible with time.localtime().

pandas.Timestamp.timetz

`Timestamp.timetz()`

Return time object with same time and tzinfo.

pandas.Timestamp.to_datetime

`Timestamp.to_datetime()`

DEPRECATED: use `to_pydatetime()` instead.

Convert a Timestamp object to a native Python datetime object.

pandas.Timestamp.to_datetime64

`Timestamp.to_datetime64()`

Returns a numpy.datetime64 object with 'ns' precision

pandas.Timestamp.to_julian_date

`Timestamp.to_julian_date()`

Convert TimeStamp to a Julian Date. 0 Julian date is noon January 1, 4713 BC.

pandas.Timestamp.to_period

`Timestamp.to_period()`

Return an period of which this timestamp is an observation.

pandas.Timestamp.to_pydatetime

`Timestamp.to_pydatetime()`

Convert a Timestamp object to a native Python datetime object.

If warn=True, issue a warning if nanoseconds is nonzero.

pandas.Timestamp.today

classmethod `Timestamp.today()`

Return the current time in the local timezone. This differs from datetime.today() in that it can be localized to a passed timezone.

Parameters **tz** : string / timezone object, default None

Timezone to localize to

pandas.Timestamp.toordinal

`Timestamp.toordinal()`

Return proleptic Gregorian ordinal. January 1 of year 1 is day 1.

pandas.Timestamp.tz_convert

`Timestamp.tz_convert()`

Convert tz-aware Timestamp to another time zone.

Parameters **tz** : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time which Timestamp will be converted to. None will remove timezone holding UTC time.

Returns **converted** : Timestamp

Raises **TypeError**

If Timestamp is tz-naive.

pandas.Timestamp.tz_localize

`Timestamp.tz_localize()`

Convert naive Timestamp to local time zone, or remove timezone from tz-aware Timestamp.

Parameters **tz** : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time which Timestamp will be converted to. None will remove timezone holding local time.

ambiguous : bool, 'NaT', default 'raise'

- bool contains flags to determine if time is dst or not (note

that this flag is only applicable for ambiguous fall dst dates) - 'NaT' will return NaT for an ambiguous time - 'raise' will raise an AmbiguousTimeError for an ambiguous time

errors : 'raise', 'coerce', default 'raise'

- **'raise' will raise a NonExistentTimeError if a timestamp is not** valid in the specified timezone (e.g. due to a transition from or to DST time)
- 'coerce' will return NaT if the timestamp can not be converted into the specified timezone

New in version 0.19.0.

Returns **localized** : Timestamp

Raises **TypeError**

If the Timestamp is tz-aware and tz is not None.

pandas.Timestamp.tzname

`Timestamp.tzname()`

Return self.tzinfo.tzname(self).

pandas.Timestamp.utcfromtimestamp

classmethod `Timestamp.utcfromtimestamp()`

pandas.Timestamp.utcnow

classmethod `Timestamp.utcnow()`

pandas.Timestamp.utcoffset

`Timestamp.utcoffset()`
Return self.tzinfo.utcoffset(self).

pandas.Timestamp.utctimetuple

`Timestamp.utctimetuple()`
Return UTC time tuple, compatible with time.localtime().

pandas.Timestamp.weekday

`Timestamp.weekday()`
Return the day of the week represented by the date. Monday == 0 ... Sunday == 6

34.14.5 Properties

Timestamp.asm8	
Timestamp.day	
Timestamp.dayofweek	
Timestamp.dayofyear	
Timestamp.days_in_month	
Timestamp.daysinmonth	
Timestamp.hour	
Timestamp.is_leap_year	
Timestamp.is_month_end	
Timestamp.is_month_start	
Timestamp.is_quarter_end	
Timestamp.is_quarter_start	
Timestamp.is_year_end	
Timestamp.is_year_start	
Timestamp.max	
Timestamp.microsecond	
Timestamp.min	
Timestamp.month	
Timestamp.nanosecond	
Timestamp.quarter	
Timestamp.resolution	
Timestamp.second	
Timestamp.tz	Alias for tzinfo
Timestamp.tzinfo	
Timestamp.value	
Timestamp.weekday_name	
Timestamp.weekofyear	
Timestamp.year	

34.14.5.1 pandas.Timestamp.max

`Timestamp.max` = Timestamp('2262-04-11 23:47:16.854775807')

34.14.5.2 pandas.Timestamp.min

`Timestamp.min` = Timestamp('1677-09-21 00:12:43.145225')

34.14.5.3 pandas.Timestamp.resolution

`Timestamp.resolution` = datetime.timedelta(0, 0, 1)

34.14.6 Methods

Timestamp.astimezone	Convert tz-aware Timestamp to another time zone.
Timestamp.ceil	return a new Timestamp ceiled to this resolution
Timestamp.combine	
Timestamp.ctime	Return ctime() style string.
Timestamp.date	Return date object with same year, month and day.
Timestamp.dst	Return self.tzinfo.dst(self).
Timestamp.floor	return a new Timestamp floored to this resolution
Timestamp.freq	
Timestamp.freqstr	
Timestamp.fromordinal	passed an ordinal, translate and convert to a ts
Timestamp.fromtimestamp	
Timestamp.isocalendar	Return a 3-tuple containing ISO year, week number, and weekday.
Timestamp.isoformat	
Timestamp.isoweekday	Return the day of the week represented by the date.
Timestamp.normalize	Normalize Timestamp to midnight, preserving tz information.
Timestamp.now	Return the current time in the local timezone.
Timestamp.replace	implements datetime.replace, handles nanoseconds
Timestamp.round	Round the Timestamp to the specified resolution
Timestamp.strftime	format -> strftime() style string.
Timestamp.strptime	string, format -> new datetime parsed from a string (like time.strptime()).
Timestamp.time	Return time object with same time but with tzinfo=None.
Timestamp.timetuple	Return time tuple, compatible with time.localtime().
Timestamp.timetz	Return time object with same time and tzinfo.
Timestamp.to_datetime64	Returns a numpy.datetime64 object with 'ns' precision
Timestamp.to_julian_date	Convert TimeStamp to a Julian Date.
Timestamp.to_period	Return an period of which this timestamp is an observation.
Timestamp.to_pydatetime	Convert a Timestamp object to a native Python datetime object.
Timestamp.today	Return the current time in the local timezone.
Timestamp.toordinal	Return proleptic Gregorian ordinal.
Timestamp.tz_convert	Convert tz-aware Timestamp to another time zone.

Continued on next page

Table 34.132 – continued from previous page

Timestamp.tz_localize	Convert naive Timestamp to local time zone, or remove timezone from tz-aware Timestamp.
Timestamp.tzname	Return self.tzinfo.tzname(self).
Timestamp.utcfromtimestamp	
Timestamp.utcnow	
Timestamp.utcoffset	Return self.tzinfo.utcoffset(self).
Timestamp.utctimetuple	Return UTC time tuple, compatible with time.localtime().
Timestamp.weekday	Return the day of the week represented by the date.

34.14.7 Interval

Interval	Immutable object implementing an Interval, a bounded slice-like interval.

34.14.7.1 pandas.Interval

class pandas.**Interval**

Immutable object implementing an Interval, a bounded slice-like interval.

New in version 0.20.0.

Parameters **left** : value

Left bound for interval.

right : value

Right bound for interval.

closed : {'left', 'right', 'both', 'neither'}

Whether the interval is closed on the left-side, right-side, both or neither. Defaults to 'right'.

See also:

IntervalIndex an Index of `interval` s that are all closed on the same side.

cut, *qcut*

Examples

```
>>> iv = pd.Interval(left=0, right=5)
>>> iv
Interval(0, 5, closed='right')
>>> 2.5 in iv
True
```

```
>>> year_2017 = pd.Interval(pd.Timestamp('2017-01-01'),
...                         pd.Timestamp('2017-12-31'), closed='both')
>>> pd.Timestamp('2017-01-01 00:00') in year_2017
True
```

Attributes

closed
closed_left
closed_right
left
mid
open_left
open_right
right

pandas.Interval.closed

`Interval.`**`closed`**

pandas.Interval.closed_left

`Interval.`**`closed_left`**

pandas.Interval.closed_right

`Interval.`**`closed_right`**

pandas.Interval.left

`Interval.`**`left`**

pandas.Interval.mid

`Interval.`**`mid`**

pandas.Interval.open_left

`Interval.`**`open_left`**

pandas.Interval.open_right

`Interval.`**`open_right`**

pandas.Interval.right

`Interval.`**`right`**

34.14.8 Properties

Interval.closed	
Interval.closed_left	
Interval.closed_right	
Interval.left	
Interval.mid	
Interval.open_left	
Interval.open_right	
Interval.right	

34.14.9 Timedelta

Timedelta	Represents a duration, the difference between two dates or times.

34.14.9.1 pandas.Timedelta

class pandas.**Timedelta**

Represents a duration, the difference between two dates or times.

Timedelta is the pandas equivalent of python's `datetime.timedelta` and is interchangable with it in most cases.

Parameters **value** : Timedelta, timedelta, np.timedelta64, string, or integer

unit : string, [D,h,m,s,ms,us,ns]

Denote the unit of the input, if input is an integer. Default 'ns'.

days, seconds, microseconds,

milliseconds, minutes, hours, weeks : numeric, optional

Values for construction in compat with datetime.timedelta. np ints and floats will be coereced to python ints and floats.

Notes

The `.value` attribute is always in ns.

Attributes

asm8	return a numpy timedelta64 array view of myself
components	Return a Components NamedTuple-like
days	Number of Days
delta	return out delta in ns (for internal compat)
freq	
is_populated	
microseconds	Number of microseconds (>= 0 and less than 1 second).
nanoseconds	Number of nanoseconds (>= 0 and less than 1 microsecond).

Continued on next page

Table 34.137 – continued from previous page

resolution	return a string representing the lowest resolution that we have
seconds	Number of seconds (>= 0 and less than 1 day).
value	

pandas.Timedelta.asm8

`Timedelta.`**`asm8`**

return a numpy timedelta64 array view of myself

pandas.Timedelta.components

`Timedelta.`**`components`**

Return a Components NamedTuple-like

pandas.Timedelta.days

`Timedelta.`**`days`**

Number of Days

.components will return the shown components

pandas.Timedelta.delta

`Timedelta.`**`delta`**

return out delta in ns (for internal compat)

pandas.Timedelta.freq

`Timedelta.`**`freq`**

pandas.Timedelta.is_populated

`Timedelta.`**`is_populated`**

pandas.Timedelta.microseconds

`Timedelta.`**`microseconds`**

Number of microseconds (>= 0 and less than 1 second).

.components will return the shown components

pandas.Timedelta.nanoseconds

`Timedelta.nanoseconds`

Number of nanoseconds (>= 0 and less than 1 microsecond).

.components will return the shown components

pandas.Timedelta.resolution

`Timedelta.resolution`

return a string representing the lowest resolution that we have

pandas.Timedelta.seconds

`Timedelta.seconds`

Number of seconds (>= 0 and less than 1 day).

.components will return the shown components

pandas.Timedelta.value

`Timedelta.value`

Methods

ceil	return a new Timedelta ceiled to this resolution
floor	return a new Timedelta floored to this resolution
isoformat	Format Timedelta as ISO 8601 Duration like *P[n]Y[n]M[n]DT[n]H[n]M[n]S*, where the '[n]'s are replaced by the values.
round	Round the Timedelta to the specified resolution
to_pytimedelta	return an actual datetime.timedelta object
to_timedelta64	Returns a numpy.timedelta64 object with 'ns' precision
total_seconds	Total duration of timedelta in seconds (to ns precision)
view	array view compat

pandas.Timedelta.ceil

`Timedelta.ceil()`

return a new Timedelta ceiled to this resolution

Parameters **freq** : a freq string indicating the ceiling resolution

pandas.Timedelta.floor

`Timedelta.floor()`

return a new Timedelta floored to this resolution

Parameters **freq** : a freq string indicating the flooring resolution

pandas.Timedelta.isoformat

`Timedelta.isoformat()`

Format Timedelta as ISO 8601 Duration like *P[n]Y[n]M[n]DT[n]H[n]M[n]S*, where the '[n]'s are replaced by the values. See https://en.wikipedia.org/wiki/ISO_8601#Durations

New in version 0.20.0.

Returns **formatted** : str

See also:

Timestamp.isoformat

Notes

The longest component is days, whose value may be larger than 365. Every component is always included, even if its value is 0. Pandas uses nanosecond precision, so up to 9 decimal places may be included in the seconds component. Trailing 0's are removed from the seconds component after the decimal. We do not 0 pad components, so it's *...T5H...*, not *...T05H...*

Examples

```
>>> td = pd.Timedelta(days=6, minutes=50, seconds=3,
...                   milliseconds=10, microseconds=10, nanoseconds=12)
>>> td.isoformat()
'P6DT0H50M3.010010012S'
>>> pd.Timedelta(hours=1, seconds=10).isoformat()
'P0DT0H0M10S'
>>> pd.Timedelta(hours=1, seconds=10).isoformat()
'P0DT0H0M10S'
>>> pd.Timedelta(days=500.5).isoformat()
'P500DT12H0MS'
```

pandas.Timedelta.round

`Timedelta.round()`

Round the Timedelta to the specified resolution

Parameters **freq** : a freq string indicating the rounding resolution

Returns a new Timedelta rounded to the given resolution of *freq*

Raises **ValueError if the freq cannot be converted**

pandas.Timedelta.to_pytimedelta

`Timedelta.to_pytimedelta()`

return an actual datetime.timedelta object note: we lose nanosecond resolution if any

pandas.Timedelta.to_timedelta64

`Timedelta.to_timedelta64()`
Returns a numpy.timedelta64 object with 'ns' precision

pandas.Timedelta.total_seconds

`Timedelta.total_seconds()`
Total duration of timedelta in seconds (to ns precision)

pandas.Timedelta.view

`Timedelta.view()`
array view compat

34.14.10 Properties

Timedelta.asm8	return a numpy timedelta64 array view of myself
Timedelta.components	Return a Components NamedTuple-like
Timedelta.days	Number of Days
Timedelta.freq	
Timedelta.max	
Timedelta.microseconds	Number of microseconds (>= 0 and less than 1 second).
Timedelta.min	
Timedelta.nanoseconds	Number of nanoseconds (>= 0 and less than 1 microsecond).
Timedelta.resolution	return a string representing the lowest resolution that we have
Timedelta.seconds	Number of seconds (>= 0 and less than 1 day).
Timedelta.value	

34.14.11 Methods

Timedelta.ceil	return a new Timedelta ceiled to this resolution
Timedelta.floor	return a new Timedelta floored to this resolution
Timedelta.isoformat	Format Timedelta as ISO 8601 Duration like *P[n]Y[n]M[n]DT[n]H[n]M[n]S*, where the '[n]'s are replaced by the values.
Timedelta.round	Round the Timedelta to the specified resolution
Timedelta.to_pytimedelta	return an actual datetime.timedelta object
Timedelta.to_timedelta64	Returns a numpy.timedelta64 object with 'ns' precision
Timedelta.total_seconds	Total duration of timedelta in seconds (to ns precision)

34.15 Window

Rolling objects are returned by `.rolling` calls: *pandas.DataFrame.rolling()*, *pandas.Series.rolling()*, etc. Expanding objects are returned by `.expanding` calls: *pandas.DataFrame.expanding()*, *pandas.Series.expanding()*, etc. EWM objects are returned by `.ewm` calls: *pandas.DataFrame.ewm()*, *pandas.Series.ewm()*, etc.

34.15.1 Standard moving window functions

Rolling.count()	rolling count of number of non-NaN
Rolling.sum(*args, **kwargs)	rolling sum
Rolling.mean(*args, **kwargs)	rolling mean
Rolling.median(**kwargs)	rolling median
Rolling.var([ddof])	rolling variance
Rolling.std([ddof])	rolling standard deviation
Rolling.min(*args, **kwargs)	rolling minimum
Rolling.max(*args, **kwargs)	rolling maximum
Rolling.corr([other, pairwise])	rolling sample correlation
Rolling.cov([other, pairwise, ddof])	rolling sample covariance
Rolling.skew(**kwargs)	Unbiased rolling skewness
Rolling.kurt(**kwargs)	Unbiased rolling kurtosis
Rolling.apply(func[, args, kwargs])	rolling function apply
Rolling.quantile(quantile, **kwargs)	rolling quantile
Window.mean(*args, **kwargs)	window mean
Window.sum(*args, **kwargs)	window sum

34.15.1.1 pandas.core.window.Rolling.count

`Rolling.`**`count`**`()`

rolling count of number of non-NaN observations inside provided window.

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.2 pandas.core.window.Rolling.sum

`Rolling.`**`sum`**`(`**args*, ***kwargs*`)`

rolling sum

Parameters **how** : string, default None

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.3 pandas.core.window.Rolling.mean

`Rolling.mean(*args, **kwargs)`

rolling mean

Parameters **how** : string, default None

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.4 pandas.core.window.Rolling.median

`Rolling.median(**kwargs)`

rolling median

Parameters **how** : string, default 'median'

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.5 pandas.core.window.Rolling.var

`Rolling.var(ddof=1, *args, **kwargs)`

rolling variance

Parameters **ddof** : int, default 1

Delta Degrees of Freedom. The divisor used in calculations is `N - ddof`, where `N` represents the number of elements.

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.6 pandas.core.window.Rolling.std

`Rolling.std(ddof=1, *args, **kwargs)`

rolling standard deviation

Parameters **ddof** : int, default 1

Delta Degrees of Freedom. The divisor used in calculations is `N - ddof`, where `N` represents the number of elements.

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.7 pandas.core.window.Rolling.min

`Rolling.min(*args, **kwargs)`

rolling minimum

Parameters **how** : string, default 'min'

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.8 pandas.core.window.Rolling.max

`Rolling.max(*args, **kwargs)`

rolling maximum

Parameters **how** : string, default 'max'

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.9 pandas.core.window.Rolling.corr

`Rolling.corr(other=None, pairwise=None, **kwargs)`

rolling sample correlation

Parameters **other** : Series, DataFrame, or ndarray, optional

if not supplied then will default to self and produce pairwise output

pairwise : bool, default None

If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndex DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.10 pandas.core.window.Rolling.cov

`Rolling.cov(other=None, pairwise=None, ddof=1, **kwargs)`

rolling sample covariance

Parameters **other** : Series, DataFrame, or ndarray, optional

if not supplied then will default to self and produce pairwise output

pairwise : bool, default None

If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndexed DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

ddof : int, default 1

Delta Degrees of Freedom. The divisor used in calculations is `N - ddof`, where `N` represents the number of elements.

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.11 pandas.core.window.Rolling.skew

`Rolling.`**`skew`**(***kwargs*)

Unbiased rolling skewness

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.12 pandas.core.window.Rolling.kurt

`Rolling.`**`kurt`**(***kwargs*)

Unbiased rolling kurtosis

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.13 pandas.core.window.Rolling.apply

`Rolling.`**`apply`**(*func*, *args=()*, *kwargs={}*)

rolling function apply

Parameters **func** : function

Must produce a single value from an ndarray input *args and **kwargs are passed to the function

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.14 pandas.core.window.Rolling.quantile

`Rolling.`**`quantile`**(*quantile*, ***kwargs*)

rolling quantile

Parameters **quantile** : float

0 <= quantile <= 1

Returns same type as input

See also:

pandas.Series.rolling, *pandas.DataFrame.rolling*

34.15.1.15 pandas.core.window.Window.mean

`Window.mean(*args, **kwargs)`

window mean

Parameters **how** : string, default None

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

`pandas.Series.window`, `pandas.DataFrame.window`

34.15.1.16 pandas.core.window.Window.sum

`Window.sum(*args, **kwargs)`

window sum

Parameters **how** : string, default None

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

`pandas.Series.window`, `pandas.DataFrame.window`

34.15.2 Standard expanding window functions

Expanding.count(**kwargs)	expanding count of number of non-NaN
Expanding.sum(*args, **kwargs)	expanding sum
Expanding.mean(*args, **kwargs)	expanding mean
Expanding.median(**kwargs)	expanding median
Expanding.var([ddof])	expanding variance
Expanding.std([ddof])	expanding standard deviation
Expanding.min(*args, **kwargs)	expanding minimum
Expanding.max(*args, **kwargs)	expanding maximum
Expanding.corr([other, pairwise])	expanding sample correlation
Expanding.cov([other, pairwise, ddof])	expanding sample covariance
Expanding.skew(**kwargs)	Unbiased expanding skewness
Expanding.kurt(**kwargs)	Unbiased expanding kurtosis
Expanding.apply(func[, args, kwargs])	expanding function apply
Expanding.quantile(quantile, **kwargs)	expanding quantile

34.15.2.1 pandas.core.window.Expanding.count

`Expanding.count(**kwargs)`

expanding count of number of non-NaN observations inside provided window.

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.2 pandas.core.window.Expanding.sum

`Expanding.sum(*args, **kwargs)`

expanding sum

Parameters **how** : string, default None

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.3 pandas.core.window.Expanding.mean

`Expanding.mean(*args, **kwargs)`

expanding mean

Parameters **how** : string, default None

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.4 pandas.core.window.Expanding.median

`Expanding.median(**kwargs)`

expanding median

Parameters **how** : string, default 'median'

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.5 pandas.core.window.Expanding.var

`Expanding.var(ddof=1, *args, **kwargs)`

expanding variance

Parameters **ddof** : int, default 1

Delta Degrees of Freedom. The divisor used in calculations is `N - ddof`, where `N` represents the number of elements.

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.6 pandas.core.window.Expanding.std

`Expanding.std(ddof=1, *args, **kwargs)`

expanding standard deviation

Parameters **ddof** : int, default 1

Delta Degrees of Freedom. The divisor used in calculations is `N - ddof`, where `N` represents the number of elements.

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.7 pandas.core.window.Expanding.min

`Expanding.min(*args, **kwargs)`

expanding minimum

Parameters **how** : string, default 'min'

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.8 pandas.core.window.Expanding.max

`Expanding.max(*args, **kwargs)`

expanding maximum

Parameters **how** : string, default 'max'

Deprecated since version 0.18.0: Method for down- or re-sampling

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.9 pandas.core.window.Expanding.corr

`Expanding.corr`(*other=None*, *pairwise=None*, ***kwargs*)

expanding sample correlation

Parameters **other** : Series, DataFrame, or ndarray, optional

if not supplied then will default to self and produce pairwise output

pairwise : bool, default None

If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndex DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.10 pandas.core.window.Expanding.cov

`Expanding.cov`(*other=None*, *pairwise=None*, *ddof=1*, ***kwargs*)

expanding sample covariance

Parameters **other** : Series, DataFrame, or ndarray, optional

if not supplied then will default to self and produce pairwise output

pairwise : bool, default None

If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndexed DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

ddof : int, default 1

Delta Degrees of Freedom. The divisor used in calculations is `N - ddof`, where `N` represents the number of elements.

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.11 pandas.core.window.Expanding.skew

`Expanding.skew`(***kwargs*)

Unbiased expanding skewness

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.12 pandas.core.window.Expanding.kurt

`Expanding.kurt(**kwargs)`

Unbiased expanding kurtosis

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.13 pandas.core.window.Expanding.apply

`Expanding.apply(func, args=(), kwargs={})`

expanding function apply

Parameters **func** : function

Must produce a single value from an ndarray input *args and **kwargs are passed to the function

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.2.14 pandas.core.window.Expanding.quantile

`Expanding.quantile(quantile, **kwargs)`

expanding quantile

Parameters **quantile** : float

0 <= quantile <= 1

Returns same type as input

See also:

pandas.Series.expanding, *pandas.DataFrame.expanding*

34.15.3 Exponentially-weighted moving window functions

EWM.mean(*args, **kwargs)	exponential weighted moving average
EWM.std([bias])	exponential weighted moving stddev
EWM.var([bias])	exponential weighted moving variance
EWM.corr([other, pairwise])	exponential weighted sample correlation
EWM.cov([other, pairwise, bias])	exponential weighted sample covariance

34.15.3.1 pandas.core.window.EWM.mean

`EWM.mean(*args, **kwargs)`

exponential weighted moving average

Returns same type as input

See also:

pandas.Series.ewm, *pandas.DataFrame.ewm*

34.15.3.2 pandas.core.window.EWM.std

EWM.**std**(*bias=False*, **args*, ***kwargs*)

exponential weighted moving stddev

Parameters **bias** : boolean, default False

Use a standard estimation bias correction

Returns same type as input

See also:

pandas.Series.ewm, *pandas.DataFrame.ewm*

34.15.3.3 pandas.core.window.EWM.var

EWM.**var**(*bias=False*, **args*, ***kwargs*)

exponential weighted moving variance

Parameters **bias** : boolean, default False

Use a standard estimation bias correction

Returns same type as input

See also:

pandas.Series.ewm, *pandas.DataFrame.ewm*

34.15.3.4 pandas.core.window.EWM.corr

EWM.**corr**(*other=None*, *pairwise=None*, ***kwargs*)

exponential weighted sample correlation

Parameters **other** : Series, DataFrame, or ndarray, optional

if not supplied then will default to self and produce pairwise output

pairwise : bool, default None

If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndex DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

bias : boolean, default False

Use a standard estimation bias correction

Returns same type as input

See also:

pandas.Series.ewm, *pandas.DataFrame.ewm*

34.15.3.5 pandas.core.window.EWM.cov

`EWM.cov(other=None, pairwise=None, bias=False, **kwargs)`

exponential weighted sample covariance

Parameters **other** : Series, DataFrame, or ndarray, optional

if not supplied then will default to self and produce pairwise output

pairwise : bool, default None

If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndex DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

bias : boolean, default False

Use a standard estimation bias correction

Returns same type as input

See also:

pandas.Series.ewm, *pandas.DataFrame.ewm*

34.16 GroupBy

GroupBy objects are returned by groupby calls: *pandas.DataFrame.groupby()*, *pandas.Series.groupby()*, etc.

34.16.1 Indexing, iteration

GroupBy.__iter__()	Groupby iterator
GroupBy.groups	dict {group name -> group labels}
GroupBy.indices	dict {group name -> group indices}
GroupBy.get_group(name[, obj])	Constructs NDFrame from group with provided name

34.16.1.1 pandas.core.groupby.GroupBy.__iter__

`GroupBy.__iter__()`

Groupby iterator

Returns Generator yielding sequence of (name, subsetted object)

for each group

34.16.1.2 pandas.core.groupby.GroupBy.groups

`GroupBy.groups`

dict {group name -> group labels}

34.16.1.3 pandas.core.groupby.GroupBy.indices

`GroupBy.indices`

dict {group name -> group indices}

34.16.1.4 pandas.core.groupby.GroupBy.get_group

`GroupBy.get_group(name, obj=None)`

Constructs NDFrame from group with provided name

Parameters **name** : object

the name of the group to get as a DataFrame

obj : NDFrame, default None

the NDFrame to take the DataFrame out of. If it is None, the object groupby was called on will be used

Returns **group** : type of obj

`Grouper`([key, level, freq, axis, sort])	A Grouper allows the user to specify a groupby instruction for a target

34.16.1.5 pandas.Grouper

class `pandas.Grouper(key=None, level=None, freq=None, axis=0, sort=False)`

A Grouper allows the user to specify a groupby instruction for a target object

This specification will select a column via the key parameter, or if the level and/or axis parameters are given, a level of the index of the target object.

These are local specifications and will override 'global' settings, that is the parameters axis and level which are passed to the groupby itself.

Parameters **key** : string, defaults to None

groupby key, which selects the grouping column of the target

level : name/number, defaults to None

the level for the target index

freq : string / frequency object, defaults to None

This will groupby the specified frequency if the target selection (via key or level) is a datetime-like object. For full specification of available frequencies, please see here.

axis : number/name of the axis, defaults to 0

sort : boolean, default to False

whether to sort the resulting labels

additional kwargs to control time-like groupers (when freq is passed)

closed : closed end of interval; left or right

label : interval boundary to use for labeling; left or right

convention : {'start', 'end', 'e', 's'}

If grouper is PeriodIndex

Returns A specification for a groupby instruction

Examples

Syntactic sugar for `df.groupby('A')`

```
>>> df.groupby(Grouper(key='A'))
```

Specify a resample operation on the column 'date'

```
>>> df.groupby(Grouper(key='date', freq='60s'))
```

Specify a resample operation on the level 'date' on the columns axis with a frequency of 60s

```
>>> df.groupby(Grouper(level='date', freq='60s', axis=1))
```

Attributes

ax	
groups	

pandas.Grouper.ax

`Grouper.`**`ax`**

pandas.Grouper.groups

`Grouper.`**`groups`**

34.16.2 Function application

GroupBy.apply(func, *args, **kwargs)	Apply function and combine results together in an intelligent way.
GroupBy.aggregate(func, *args, **kwargs)	
GroupBy.transform(func, *args, **kwargs)	
GroupBy.pipe(func, *args, **kwargs)	Apply a function with arguments to this GroupBy object,

34.16.2.1 pandas.core.groupby.GroupBy.apply

`GroupBy.`**`apply`**(*func*, **args*, ***kwargs*)

Apply function and combine results together in an intelligent way.

The split-apply-combine combination rules attempt to be as common sense based as possible. For example:

case 1: group DataFrame apply aggregation function (f(chunk) -> Series) yield DataFrame, with group axis having group labels

case 2: group DataFrame apply transform function ((f(chunk) -> DataFrame with same indexes) yield DataFrame with resulting chunks glued together

case 3: group Series apply function with f(chunk) -> DataFrame yield DataFrame with result of chunks glued together

Parameters **func** : function

See also:

pipe Apply function to the full GroupBy object instead of to each group.

aggregate, *transform*

Notes

See online documentation for full exposition on how to use apply.

In the current implementation apply calls func twice on the first group to decide whether it can take a fast or slow code path. This can lead to unexpected behavior if func has side-effects, as they will take effect twice for the first group.

34.16.2.2 pandas.core.groupby.GroupBy.aggregate

`GroupBy.aggregate`(*func*, **args*, ***kwargs*)

34.16.2.3 pandas.core.groupby.GroupBy.transform

`GroupBy.transform`(*func*, **args*, ***kwargs*)

34.16.2.4 pandas.core.groupby.GroupBy.pipe

`GroupBy.pipe`(*func*, **args*, ***kwargs*)

Apply a function with arguments to this GroupBy object,

New in version 0.21.0.

Parameters **func** : callable or tuple of (callable, string)

Function to apply to this GroupBy object or, alternatively, a `(callable, data_keyword)` tuple where `data_keyword` is a string indicating the keyword of `callable` that expects the GroupBy object.

args : iterable, optional

positional arguments passed into `func`.

kwargs : dict, optional

a dictionary of keyword arguments passed into `func`.

Returns **object** : the return type of `func`.

See also:

pandas.Series.pipe Apply a function with arguments to a series

pandas.DataFrame.pipe Apply a function with arguments to a dataframe

apply Apply function to each group instead of to the full GroupBy object.

Notes

Use `.pipe` when chaining together functions that expect Series, DataFrames or GroupBy objects. Instead of writing

```
>>> f(g(h(df.groupby('group')), arg1=a), arg2=b, arg3=c)
```

You can write

```
>>> (df
...    .groupby('group')
...    .pipe(f, arg1)
...    .pipe(g, arg2)
...    .pipe(h, arg3))
```

See more here

34.16.3 Computations / Descriptive Stats

`GroupBy.count`()	Compute count of group, excluding missing values
`GroupBy.cumcount`([ascending])	Number each item in each group from 0 to the length of that group - 1.
`GroupBy.first`(**kwargs)	Compute first of group values
`GroupBy.head`([n])	Returns first n rows of each group.
`GroupBy.last`(**kwargs)	Compute last of group values
`GroupBy.max`(**kwargs)	Compute max of group values
`GroupBy.mean`(*args, **kwargs)	Compute mean of groups, excluding missing values
`GroupBy.median`(**kwargs)	Compute median of groups, excluding missing values
`GroupBy.min`(**kwargs)	Compute min of group values
`GroupBy.ngroup`([ascending])	Number each group from 0 to the number of groups - 1.
`GroupBy.nth`(n[, dropna])	Take the nth row from each group if n is an int, or a subset of rows if n is a list of ints.
`GroupBy.ohlc`()	Compute sum of values, excluding missing values
`GroupBy.prod`(**kwargs)	Compute prod of group values
`GroupBy.size`()	Compute group sizes
`GroupBy.sem`([ddof])	Compute standard error of the mean of groups, excluding missing values
`GroupBy.std`([ddof])	Compute standard deviation of groups, excluding missing values
`GroupBy.sum`(**kwargs)	Compute sum of group values
`GroupBy.var`([ddof])	Compute variance of groups, excluding missing values
`GroupBy.tail`([n])	Returns last n rows of each group

34.16.3.1 pandas.core.groupby.GroupBy.count

`GroupBy.count()`

Compute count of group, excluding missing values

See also:

`pandas.Series.groupby`, `pandas.DataFrame.groupby`, `pandas.Panel.groupby`

34.16.3.2 pandas.core.groupby.GroupBy.cumcount

`GroupBy.cumcount(ascending=True)`

Number each item in each group from 0 to the length of that group - 1.

Essentially this is equivalent to

```
>>> self.apply(lambda x: Series(np.arange(len(x)), x.index))
```

Parameters **ascending** : bool, default True

If False, number in reverse, from length of group - 1 to 0.

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

Examples

```
>>> df = pd.DataFrame([['a'], ['a'], ['a'], ['b'], ['b'], ['a']],
...                   columns=['A'])
>>> df
   A
0  a
1  a
2  a
3  b
4  b
5  a
>>> df.groupby('A').cumcount()
0    0
1    1
2    2
3    0
4    1
5    3
dtype: int64
>>> df.groupby('A').cumcount(ascending=False)
0    3
1    2
2    1
3    1
4    0
5    0
dtype: int64
```

34.16.3.3 pandas.core.groupby.GroupBy.first

`GroupBy.first(**kwargs)`

Compute first of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.4 pandas.core.groupby.GroupBy.head

`GroupBy.head(n=5)`

Returns first n rows of each group.

Essentially equivalent to `.apply(lambda x: x.head(n))`, except ignores as_index flag.

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

Examples

```
>>> df = DataFrame([[1, 2], [1, 4], [5, 6]],
                   columns=['A', 'B'])
>>> df.groupby('A', as_index=False).head(1)
   A  B
0  1  2
2  5  6
>>> df.groupby('A').head(1)
   A  B
0  1  2
2  5  6
```

34.16.3.5 pandas.core.groupby.GroupBy.last

`GroupBy.last(**kwargs)`

Compute last of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.6 pandas.core.groupby.GroupBy.max

`GroupBy.max(**kwargs)`

Compute max of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.7 pandas.core.groupby.GroupBy.mean

`GroupBy.mean(*args, **kwargs)`

Compute mean of groups, excluding missing values

For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.8 pandas.core.groupby.GroupBy.median

`GroupBy.median(**kwargs)`

Compute median of groups, excluding missing values

For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.9 pandas.core.groupby.GroupBy.min

`GroupBy.min(**kwargs)`

Compute min of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.10 pandas.core.groupby.GroupBy.ngroup

`GroupBy.ngroup(ascending=True)`

Number each group from 0 to the number of groups - 1.

This is the enumerative complement of cumcount. Note that the numbers given to the groups match the order in which the groups would be seen when iterating over the groupby object, not the order they are first observed.

New in version 0.20.2.

Parameters **ascending** : bool, default True

If False, number in reverse, from number of group - 1 to 0.

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

Examples

```
>>> df = pd.DataFrame({"A": list("aaabba")})
>>> df
   A
0  a
1  a
2  a
3  b
4  b
5  a
>>> df.groupby('A').ngroup()
0    0
1    0
2    0
3    1
4    1
5    0
dtype: int64
>>> df.groupby('A').ngroup(ascending=False)
```

```
0    1
1    1
2    1
3    0
4    0
5    1
dtype: int64
>>> df.groupby(["A", [1,1,2,3,2,1]]).ngroup()
0    0
1    0
2    1
3    3
4    2
5    0
dtype: int64
```

34.16.3.11 pandas.core.groupby.GroupBy.nth

`GroupBy.nth`(*n*, *dropna=None*)

Take the nth row from each group if n is an int, or a subset of rows if n is a list of ints.

If dropna, will take the nth non-null row, dropna is either Truthy (if a Series) or 'all', 'any' (if a DataFrame); this is equivalent to calling dropna(how=dropna) before the groupby.

Parameters **n** : int or list of ints

a single nth value for the row or a list of nth values

dropna : None or str, optional

apply the specified dropna operation before counting which row is the nth row. Needs to be None, 'any' or 'all'

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

Examples

```
>>> df = pd.DataFrame({'A': [1, 1, 2, 1, 2],
...                    'B': [np.nan, 2, 3, 4, 5]}, columns=['A', 'B'])
>>> g = df.groupby('A')
>>> g.nth(0)
     B
A
1  NaN
2  3.0
>>> g.nth(1)
     B
A
1  2.0
2  5.0
>>> g.nth(-1)
     B
A
1  4.0
2  5.0
```

```
>>> g.nth([0, 1])
     B
A
1  NaN
1  2.0
2  3.0
2  5.0
```

Specifying `dropna` allows count ignoring NaN

```
>>> g.nth(0, dropna='any')
     B
A
1  2.0
2  3.0
```

NaNs denote group exhausted when using dropna

```
>>> g.nth(3, dropna='any')
    B
A
1 NaN
2 NaN
```

Specifying `as_index=False` in `groupby` keeps the original index.

```
>>> df.groupby('A', as_index=False).nth(1)
   A    B
1  1  2.0
4  2  5.0
```

34.16.3.12 pandas.core.groupby.GroupBy.ohlc

`GroupBy.ohlc()`

Compute sum of values, excluding missing values For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.13 pandas.core.groupby.GroupBy.prod

`GroupBy.prod(**kwargs)`

Compute prod of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.14 pandas.core.groupby.GroupBy.size

`GroupBy.size()`

Compute group sizes

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.15 pandas.core.groupby.GroupBy.sem

`GroupBy.sem(ddof=1)`

Compute standard error of the mean of groups, excluding missing values

For multiple groupings, the result index will be a MultiIndex

Parameters **ddof** : integer, default 1

degrees of freedom

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.16 pandas.core.groupby.GroupBy.std

`GroupBy.std(ddof=1, *args, **kwargs)`

Compute standard deviation of groups, excluding missing values

For multiple groupings, the result index will be a MultiIndex

Parameters **ddof** : integer, default 1

degrees of freedom

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.17 pandas.core.groupby.GroupBy.sum

`GroupBy.sum(**kwargs)`

Compute sum of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.18 pandas.core.groupby.GroupBy.var

`GroupBy.var(ddof=1, *args, **kwargs)`

Compute variance of groups, excluding missing values

For multiple groupings, the result index will be a MultiIndex

Parameters **ddof** : integer, default 1

degrees of freedom

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.19 pandas.core.groupby.GroupBy.tail

`GroupBy.tail(n=5)`

Returns last n rows of each group

Essentially equivalent to `.apply(lambda x: x.tail(n))`, except ignores as_index flag.

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

Examples

```
>>> df = DataFrame([['a', 1], ['a', 2], ['b', 1], ['b', 2]],
                   columns=['A', 'B'])
>>> df.groupby('A').tail(1)
   A  B
1  a  2
3  b  2
>>> df.groupby('A').head(1)
   A  B
0  a  1
2  b  1
```

The following methods are available in both `SeriesGroupBy` and `DataFrameGroupBy` objects, but may differ slightly, usually in that the `DataFrameGroupBy` version usually permits the specification of an axis argument, and often an argument indicating whether to restrict application to columns of a specific data type.

DataFrameGroupBy.agg(arg, *args, **kwargs)	Aggregate using callable, string, dict, or list of string/callables
DataFrameGroupBy.all	Return whether all elements are True over requested axis
DataFrameGroupBy.any	Return whether any element is True over requested axis
DataFrameGroupBy.bfill([limit])	Backward fill the values
DataFrameGroupBy.corr	Compute pairwise correlation of columns, excluding NA/null values
DataFrameGroupBy.count()	Compute count of group, excluding missing values
DataFrameGroupBy.cov	Compute pairwise covariance of columns, excluding NA/null values
DataFrameGroupBy.cummax([axis])	Cumulative max for each group
DataFrameGroupBy.cummin([axis])	Cumulative min for each group
DataFrameGroupBy.cumprod([axis])	Cumulative product for each group
DataFrameGroupBy.cumsum([axis])	Cumulative sum for each group
DataFrameGroupBy.describe(**kwargs)	Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding `NaN` values.
DataFrameGroupBy.diff	1st discrete difference of object
DataFrameGroupBy.ffill([limit])	Forward fill the values
DataFrameGroupBy.fillna	Fill NA/NaN values using the specified method
DataFrameGroupBy.filter(func[, dropna])	Return a copy of a DataFrame excluding elements from groups that do not satisfy the boolean criterion specified by func.
DataFrameGroupBy.hist	Draw histogram of the DataFrame's series using matplotlib / pylab.

Continued on next page

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DataFrameGroupBy.idxmax	Return index of first occurrence of maximum over requested axis.
DataFrameGroupBy.idxmin	Return index of first occurrence of minimum over requested axis.
DataFrameGroupBy.mad	Return the mean absolute deviation of the values for the requested axis
DataFrameGroupBy.pct_change	Percent change over given number of periods.
DataFrameGroupBy.plot	Class implementing the .plot attribute for groupby objects
DataFrameGroupBy.quantile	Return values at the given quantile over requested axis, a la numpy.percentile.
DataFrameGroupBy.rank	Compute numerical data ranks (1 through n) along axis.
DataFrameGroupBy.resample(rule, *args, **kwargs)	Provide resampling when using a TimeGrouper
DataFrameGroupBy.shift([periods, freq, axis])	Shift each group by periods observations
DataFrameGroupBy.size()	Compute group sizes
DataFrameGroupBy.skew	Return unbiased skew over requested axis
DataFrameGroupBy.take	Return the elements in the given *positional* indices along an axis.
DataFrameGroupBy.tshift	Shift the time index, using the index's frequency if available.

34.16.3.20 pandas.core.groupby.DataFrameGroupBy.agg

DataFrameGroupBy.**agg**(*arg*, **args*, ***kwargs*)

Aggregate using callable, string, dict, or list of string/callables

Parameters **func** : callable, string, dictionary, or list of string/callables

Function to use for aggregating the data. If a function, must either work when passed a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted Combinations are:

- string function name
- function
- list of functions
- dict of column names -> functions (or list of functions)

Returns **aggregated** : DataFrame

See also:

pandas.DataFrame.groupby.apply, pandas.DataFrame.groupby.transform, *pandas.DataFrame.aggregate*

Notes

Numpy functions mean/median/prod/sum/std/var are special cased so the default behavior is applying the function along axis=0 (e.g., np.mean(arr_2d, axis=0)) as opposed to mimicking the default Numpy behavior (e.g., np.mean(arr_2d)).

agg is an alias for *aggregate*. Use the alias.

Examples

```
>>> df = pd.DataFrame({'A': [1, 1, 2, 2],
...                    'B': [1, 2, 3, 4],
...                    'C': np.random.randn(4)})
```

```
>>> df
   A  B         C
0  1  1  0.362838
1  1  2  0.227877
2  2  3  1.267767
3  2  4 -0.562860
```

The aggregation is for each column.

```
>>> df.groupby('A').agg('min')
   B         C
A
1  1  0.227877
2  3 -0.562860
```

Multiple aggregations

```
>>> df.groupby('A').agg(['min', 'max'])
    B             C
  min max       min       max
A
1   1   2  0.227877  0.362838
2   3   4 -0.562860  1.267767
```

Select a column for aggregation

```
>>> df.groupby('A').B.agg(['min', 'max'])
   min  max
A
1    1    2
2    3    4
```

Different aggregations per column

```
>>> df.groupby('A').agg({'B': ['min', 'max'], 'C': 'sum'})
    B             C
  min max       sum
A
1   1   2  0.590716
2   3   4  0.704907
```

34.16.3.21 pandas.core.groupby.DataFrameGroupBy.all

`DataFrameGroupBy.`**`all`**

Return whether all elements are True over requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

bool_only : boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

Returns **all** : Series or DataFrame (if level specified)

34.16.3.22 pandas.core.groupby.DataFrameGroupBy.any

`DataFrameGroupBy.`**`any`**

Return whether any element is True over requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

bool_only : boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

Returns **any** : Series or DataFrame (if level specified)

34.16.3.23 pandas.core.groupby.DataFrameGroupBy.bfill

`DataFrameGroupBy.`**`bfill`**(*limit=None*)

Backward fill the values

Parameters **limit** : integer, optional

limit of how many values to fill

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.24 pandas.core.groupby.DataFrameGroupBy.corr

`DataFrameGroupBy.`**`corr`**

Compute pairwise correlation of columns, excluding NA/null values

Parameters **method** : {'pearson', 'kendall', 'spearman'}

- pearson : standard correlation coefficient
- kendall : Kendall Tau correlation coefficient
- spearman : Spearman rank correlation

min_periods : int, optional

Minimum number of observations required per pair of columns to have a valid result. Currently only available for pearson and spearman correlation

Returns **y** : DataFrame

34.16.3.25 pandas.core.groupby.DataFrameGroupBy.count

`DataFrameGroupBy.count()`

Compute count of group, excluding missing values

34.16.3.26 pandas.core.groupby.DataFrameGroupBy.cov

`DataFrameGroupBy.cov`

Compute pairwise covariance of columns, excluding NA/null values

Parameters **min_periods** : int, optional

Minimum number of observations required per pair of columns to have a valid result.

Returns **y** : DataFrame

Notes

y contains the covariance matrix of the DataFrame's time series. The covariance is normalized by N-1 (unbiased estimator).

34.16.3.27 pandas.core.groupby.DataFrameGroupBy.cummax

`DataFrameGroupBy.cummax(axis=0, **kwargs)`

Cumulative max for each group

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.28 pandas.core.groupby.DataFrameGroupBy.cummin

`DataFrameGroupBy.cummin(axis=0, **kwargs)`

Cumulative min for each group

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.29 pandas.core.groupby.DataFrameGroupBy.cumprod

`DataFrameGroupBy.cumprod(axis=0, *args, **kwargs)`

Cumulative product for each group

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.30 pandas.core.groupby.DataFrameGroupBy.cumsum

`DataFrameGroupBy.cumsum(axis=0, *args, **kwargs)`

Cumulative sum for each group

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.31 pandas.core.groupby.DataFrameGroupBy.describe

`DataFrameGroupBy.describe(**kwargs)`

Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding `NaN` values.

Analyzes both numeric and object series, as well as `DataFrame` column sets of mixed data types. The output will vary depending on what is provided. Refer to the notes below for more detail.

Parameters **percentiles** : list-like of numbers, optional

The percentiles to include in the output. All should fall between 0 and 1. The default is `[.25, .5, .75]`, which returns the 25th, 50th, and 75th percentiles.

include : 'all', list-like of dtypes or None (default), optional

A white list of data types to include in the result. Ignored for `Series`. Here are the options:

- 'all' : All columns of the input will be included in the output.
- A list-like of dtypes : Limits the results to the provided data types. To limit the result to numeric types submit `numpy.number`. To limit it instead to object columns submit the `numpy.object` data type. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To select pandas categorical columns, use `'category'`
- None (default) : The result will include all numeric columns.

exclude : list-like of dtypes or None (default), optional,

A black list of data types to omit from the result. Ignored for `Series`. Here are the options:

- A list-like of dtypes : Excludes the provided data types from the result. To exclude numeric types submit `numpy.number`. To exclude object columns submit the data type `numpy.object`. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To exclude pandas categorical columns, use `'category'`
- None (default) : The result will exclude nothing.

Returns summary: Series/DataFrame of summary statistics

See also:

`DataFrame.count`, `DataFrame.max`, `DataFrame.min`, `DataFrame.mean`, `DataFrame.std`, `DataFrame.select_dtypes`

Notes

For numeric data, the result's index will include `count`, `mean`, `std`, `min`, `max` as well as lower, `50` and upper percentiles. By default the lower percentile is `25` and the upper percentile is `75`. The `50` percentile is the same as the median.

For object data (e.g. strings or timestamps), the result's index will include `count`, `unique`, `top`, and `freq`. The `top` is the most common value. The `freq` is the most common value's frequency. Timestamps also include the `first` and `last` items.

If multiple object values have the highest count, then the `count` and `top` results will be arbitrarily chosen from among those with the highest count.

For mixed data types provided via a `DataFrame`, the default is to return only an analysis of numeric columns. If the dataframe consists only of object and categorical data without any numeric columns, the default is to return an analysis of both the object and categorical columns. If `include='all'` is provided as an option, the result will include a union of attributes of each type.

The *include* and *exclude* parameters can be used to limit which columns in a `DataFrame` are analyzed for the output. The parameters are ignored when analyzing a `Series`.

Examples

Describing a numeric `Series`.

```
>>> s = pd.Series([1, 2, 3])
>>> s.describe()
count    3.0
mean     2.0
std      1.0
min      1.0
25%      1.5
50%      2.0
75%      2.5
max      3.0
```

Describing a categorical `Series`.

```
>>> s = pd.Series(['a', 'a', 'b', 'c'])
>>> s.describe()
count     4
unique    3
top       a
freq      2
dtype: object
```

Describing a timestamp `Series`.

```
>>> s = pd.Series([
...   np.datetime64("2000-01-01"),
...   np.datetime64("2010-01-01"),
...   np.datetime64("2010-01-01")
... ])
>>> s.describe()
count                       3
unique                      2
top       2010-01-01 00:00:00
```

```
freq                          2
first     2000-01-01 00:00:00
last      2010-01-01 00:00:00
dtype: object
```

Describing a `DataFrame`. By default only numeric fields are returned.

```
>>> df = pd.DataFrame({ 'object': ['a', 'b', 'c'],
...                     'numeric': [1, 2, 3],
...                     'categorical': pd.Categorical(['d','e','f'])
...                   })
>>> df.describe()
       numeric
count      3.0
mean       2.0
std        1.0
min        1.0
25%        1.5
50%        2.0
75%        2.5
max        3.0
```

Describing all columns of a `DataFrame` regardless of data type.

```
>>> df.describe(include='all')
        categorical  numeric object
count             3      3.0      3
unique            3      NaN      3
top               f      NaN      c
freq              1      NaN      1
mean            NaN      2.0    NaN
std             NaN      1.0    NaN
min             NaN      1.0    NaN
25%             NaN      1.5    NaN
50%             NaN      2.0    NaN
75%             NaN      2.5    NaN
max             NaN      3.0    NaN
```

Describing a column from a `DataFrame` by accessing it as an attribute.

```
>>> df.numeric.describe()
count    3.0
mean     2.0
std      1.0
min      1.0
25%      1.5
50%      2.0
75%      2.5
max      3.0
Name: numeric, dtype: float64
```

Including only numeric columns in a `DataFrame` description.

```
>>> df.describe(include=[np.number])
       numeric
count      3.0
mean       2.0
std        1.0
```

```
min        1.0
25%        1.5
50%        2.0
75%        2.5
max        3.0
```

Including only string columns in a `DataFrame` description.

```
>>> df.describe(include=[np.object])
       object
count       3
unique      3
top         c
freq        1
```

Including only categorical columns from a `DataFrame` description.

```
>>> df.describe(include=['category'])
       categorical
count            3
unique           3
top              f
freq             1
```

Excluding numeric columns from a `DataFrame` description.

```
>>> df.describe(exclude=[np.number])
       categorical object
count            3      3
unique           3      3
top              f      c
freq             1      1
```

Excluding object columns from a `DataFrame` description.

```
>>> df.describe(exclude=[np.object])
        categorical  numeric
count            3      3.0
unique           3      NaN
top              f      NaN
freq             1      NaN
mean           NaN      2.0
std            NaN      1.0
min            NaN      1.0
25%            NaN      1.5
50%            NaN      2.0
75%            NaN      2.5
max            NaN      3.0
```

34.16.3.32 pandas.core.groupby.DataFrameGroupBy.diff

`DataFrameGroupBy.`**`diff`**

1st discrete difference of object

Parameters **periods** : int, default 1

Periods to shift for forming difference

axis : {0 or 'index', 1 or 'columns'}, default 0

Take difference over rows (0) or columns (1).

Returns **diffed** : DataFrame

34.16.3.33 pandas.core.groupby.DataFrameGroupBy.ffill

`DataFrameGroupBy.ffill(limit=None)`

Forward fill the values

Parameters **limit** : integer, optional

limit of how many values to fill

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.34 pandas.core.groupby.DataFrameGroupBy.fillna

`DataFrameGroupBy.fillna`

Fill NA/NaN values using the specified method

Parameters **value** : scalar, dict, Series, or DataFrame

Value to use to fill holes (e.g. 0), alternately a dict/Series/DataFrame of values specifying which value to use for each index (for a Series) or column (for a DataFrame). (values not in the dict/Series/DataFrame will not be filled). This value cannot be a list.

method : {'backfill', 'bfill', 'pad', 'ffill', None}, default None

Method to use for filling holes in reindexed Series pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation to fill gap

axis : {0 or 'index', 1 or 'columns'}

inplace : boolean, default False

If True, fill in place. Note: this will modify any other views on this object, (e.g. a no-copy slice for a column in a DataFrame).

limit : int, default None

If method is specified, this is the maximum number of consecutive NaN values to forward/backward fill. In other words, if there is a gap with more than this number of consecutive NaNs, it will only be partially filled. If method is not specified, this is the maximum number of entries along the entire axis where NaNs will be filled. Must be greater than 0 if not None.

downcast : dict, default is None

a dict of item->dtype of what to downcast if possible, or the string 'infer' which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns **filled** : DataFrame

See also:

`reindex`, `asfreq`

Examples

```
>>> df = pd.DataFrame([[np.nan, 2, np.nan, 0],
...                    [3, 4, np.nan, 1],
...                    [np.nan, np.nan, np.nan, 5],
...                    [np.nan, 3, np.nan, 4]],
...                    columns=list('ABCD'))
>>> df
     A    B   C  D
0  NaN  2.0 NaN  0
1  3.0  4.0 NaN  1
2  NaN  NaN NaN  5
3  NaN  3.0 NaN  4
```

Replace all NaN elements with 0s.

```
>>> df.fillna(0)
    A   B   C   D
0   0.0 2.0 0.0 0
1   3.0 4.0 0.0 1
2   0.0 0.0 0.0 5
3   0.0 3.0 0.0 4
```

We can also propagate non-null values forward or backward.

```
>>> df.fillna(method='ffill')
    A   B   C   D
0   NaN 2.0 NaN 0
1   3.0 4.0 NaN 1
2   3.0 4.0 NaN 5
3   3.0 3.0 NaN 4
```

Replace all NaN elements in column 'A', 'B', 'C', and 'D', with 0, 1, 2, and 3 respectively.

```
>>> values = {'A': 0, 'B': 1, 'C': 2, 'D': 3}
>>> df.fillna(value=values)
    A   B   C   D
0   0.0 2.0 2.0 0
1   3.0 4.0 2.0 1
2   0.0 1.0 2.0 5
3   0.0 3.0 2.0 4
```

Only replace the first NaN element.

```
>>> df.fillna(value=values, limit=1)
    A   B   C   D
0   0.0 2.0 2.0 0
1   3.0 4.0 NaN 1
2   NaN 1.0 NaN 5
3   NaN 3.0 NaN 4
```

34.16.3.35 pandas.core.groupby.DataFrameGroupBy.filter

`DataFrameGroupBy.filter`(*func*, *dropna=True*, **args*, ***kwargs*)

Return a copy of a DataFrame excluding elements from groups that do not satisfy the boolean criterion specified by func.

Parameters **f** : function

Function to apply to each subframe. Should return True or False.

dropna : Drop groups that do not pass the filter. True by default;

if False, groups that evaluate False are filled with NaNs.

Returns **filtered** : DataFrame

Notes

Each subframe is endowed the attribute 'name' in case you need to know which group you are working on.

Examples

```
>>> import pandas as pd
>>> df = pd.DataFrame({'A' : ['foo', 'bar', 'foo', 'bar',
...                           'foo', 'bar'],
...                    'B' : [1, 2, 3, 4, 5, 6],
...                    'C' : [2.0, 5., 8., 1., 2., 9.]})
>>> grouped = df.groupby('A')
>>> grouped.filter(lambda x: x['B'].mean() > 3.)
     A  B    C
1  bar  2  5.0
3  bar  4  1.0
5  bar  6  9.0
```

34.16.3.36 pandas.core.groupby.DataFrameGroupBy.hist

`DataFrameGroupBy.hist`

Draw histogram of the DataFrame's series using matplotlib / pylab.

Parameters **data** : DataFrame

column : string or sequence

If passed, will be used to limit data to a subset of columns

by : object, optional

If passed, then used to form histograms for separate groups

grid : boolean, default True

Whether to show axis grid lines

xlabelsize : int, default None

If specified changes the x-axis label size

xrot : float, default None

rotation of x axis labels

ylabelsize : int, default None

If specified changes the y-axis label size

yrot : float, default None

rotation of y axis labels

ax : matplotlib axes object, default None

sharex : boolean, default True if ax is None else False

In case subplots=True, share x axis and set some x axis labels to invisible; defaults to True if ax is None otherwise False if an ax is passed in; Be aware, that passing in both an ax and sharex=True will alter all x axis labels for all subplots in a figure!

sharey : boolean, default False

In case subplots=True, share y axis and set some y axis labels to invisible

figsize : tuple

The size of the figure to create in inches by default

layout : tuple, optional

Tuple of (rows, columns) for the layout of the histograms

bins : integer, default 10

Number of histogram bins to be used

kwds : other plotting keyword arguments

To be passed to hist function

34.16.3.37 pandas.core.groupby.DataFrameGroupBy.idxmax

`DataFrameGroupBy.`**`idxmax`**

Return index of first occurrence of maximum over requested axis. NA/null values are excluded.

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

0 or 'index' for row-wise, 1 or 'columns' for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be first index.

Returns **idxmax** : Series

See also:

`Series.idxmax`

Notes

This method is the DataFrame version of `ndarray.argmax`.

34.16.3.38 pandas.core.groupby.DataFrameGroupBy.idxmin

`DataFrameGroupBy.`**`idxmin`**

Return index of first occurrence of minimum over requested axis. NA/null values are excluded.

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

0 or 'index' for row-wise, 1 or 'columns' for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **idxmin** : Series

See also:

`Series.idxmin`

Notes

This method is the DataFrame version of `ndarray.argmin`.

34.16.3.39 pandas.core.groupby.DataFrameGroupBy.mad

`DataFrameGroupBy.`**`mad`**

Return the mean absolute deviation of the values for the requested axis

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **mad** : Series or DataFrame (if level specified)

34.16.3.40 pandas.core.groupby.DataFrameGroupBy.pct_change

`DataFrameGroupBy.`**`pct_change`**

Percent change over given number of periods.

Parameters **periods** : int, default 1

Periods to shift for forming percent change

fill_method : str, default 'pad'

How to handle NAs before computing percent changes

limit : int, default None

The number of consecutive NAs to fill before stopping

freq : DateOffset, timedelta, or offset alias string, optional

Increment to use from time series API (e.g. 'M' or BDay())

Returns **chg** : NDFrame

Notes

By default, the percentage change is calculated along the stat axis: 0, or `Index`, for `DataFrame` and 1, or `minor` for `Panel`. You can change this with the `axis` keyword argument.

34.16.3.41 pandas.core.groupby.DataFrameGroupBy.plot

`DataFrameGroupBy.plot`

Class implementing the .plot attribute for groupby objects

34.16.3.42 pandas.core.groupby.DataFrameGroupBy.quantile

`DataFrameGroupBy.quantile`

Return values at the given quantile over requested axis, a la numpy.percentile.

Parameters **q** : float or array-like, default 0.5 (50% quantile)

0 <= q <= 1, the quantile(s) to compute

axis : {0, 1, 'index', 'columns'} (default 0)

0 or 'index' for row-wise, 1 or 'columns' for column-wise

interpolation : {'linear', 'lower', 'higher', 'midpoint', 'nearest'}

New in version 0.18.0.

This optional parameter specifies the interpolation method to use, when the desired quantile lies between two data points *i* and *j*:

- linear: *i + (j - i) * fraction*, where *fraction* is the fractional part of the index surrounded by *i* and *j*.
- lower: *i*.
- higher: *j*.
- nearest: *i* or *j* whichever is nearest.
- midpoint: $(i + j) / 2$.

Returns **quantiles** : Series or DataFrame

- If `q` is an array, a DataFrame will be returned where the index is `q`, the columns are the columns of self, and the values are the quantiles.
- If `q` is a float, a Series will be returned where the index is the columns of self and the values are the quantiles.

Examples

```
>>> df = DataFrame(np.array([[1, 1], [2, 10], [3, 100], [4, 100]]),
                   columns=['a', 'b'])
>>> df.quantile(.1)
a    1.3
b    3.7
dtype: float64
>>> df.quantile([.1, .5])
       a     b
```

```
0.1  1.3   3.7
0.5  2.5  55.0
```

34.16.3.43 pandas.core.groupby.DataFrameGroupBy.rank

`DataFrameGroupBy.rank`

Compute numerical data ranks (1 through n) along axis. Equal values are assigned a rank that is the average of the ranks of those values

Parameters **axis** : {0 or 'index', 1 or 'columns'}, default 0

index to direct ranking

method : {'average', 'min', 'max', 'first', 'dense'}

- average: average rank of group
- min: lowest rank in group
- max: highest rank in group
- first: ranks assigned in order they appear in the array
- dense: like 'min', but rank always increases by 1 between groups

numeric_only : boolean, default None

Include only float, int, boolean data. Valid only for DataFrame or Panel objects

na_option : {'keep', 'top', 'bottom'}

- keep: leave NA values where they are
- top: smallest rank if ascending
- bottom: smallest rank if descending

ascending : boolean, default True

False for ranks by high (1) to low (N)

pct : boolean, default False

Computes percentage rank of data

Returns **ranks** : same type as caller

34.16.3.44 pandas.core.groupby.DataFrameGroupBy.resample

`DataFrameGroupBy.resample`(*rule*, **args*, ***kwargs*)

Provide resampling when using a TimeGrouper Return a new grouper with our resampler appended

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.45 pandas.core.groupby.DataFrameGroupBy.shift

`DataFrameGroupBy.shift`(*periods=1*, *freq=None*, *axis=0*)

Shift each group by periods observations

Parameters **periods** : integer, default 1

number of periods to shift

freq : frequency string

axis : axis to shift, default 0

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.46 pandas.core.groupby.DataFrameGroupBy.size

`DataFrameGroupBy.size()`

Compute group sizes

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.16.3.47 pandas.core.groupby.DataFrameGroupBy.skew

`DataFrameGroupBy.skew`

Return unbiased skew over requested axis Normalized by N-1

Parameters **axis** : {index (0), columns (1)}

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA or empty, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns **skew** : Series or DataFrame (if level specified)

34.16.3.48 pandas.core.groupby.DataFrameGroupBy.take

`DataFrameGroupBy.take`

Return the elements in the given *positional* indices along an axis.

This means that we are not indexing according to actual values in the index attribute of the object. We are indexing according to the actual position of the element in the object.

Parameters **indices** : array-like

An array of ints indicating which positions to take.

axis : int, default 0

The axis on which to select elements. "0" means that we are selecting rows, "1" means that we are selecting columns, etc.

convert : bool, default True

Deprecated since version 0.21.0: In the future, negative indices will always be converted.

Whether to convert negative indices into positive ones. For example, `-1` would map to the `len(axis) - 1`. The conversions are similar to the behavior of indexing a regular Python list.

is_copy : bool, default True

Whether to return a copy of the original object or not.

Returns **taken** : type of caller

An array-like containing the elements taken from the object.

See also:

`numpy.ndarray.take`, `numpy.take`

Examples

```
>>> df = pd.DataFrame([('falcon', 'bird',    389.0),
                       ('parrot', 'bird',     24.0),
                       ('lion',   'mammal',   80.5),
                       ('monkey', 'mammal', np.nan)],
                      columns=('name', 'class', 'max_speed'),
                      index=[0, 2, 3, 1])
>>> df
     name   class  max_speed
0  falcon    bird      389.0
2  parrot    bird       24.0
3    lion  mammal       80.5
1  monkey  mammal        NaN
```

Take elements at positions 0 and 3 along the axis 0 (default).

Note how the actual indices selected (0 and 1) do not correspond to our selected indices 0 and 3. That's because we are selecting the 0th and 3rd rows, not rows whose indices equal 0 and 3.

```
>>> df.take([0, 3])
0  falcon    bird      389.0
1  monkey  mammal        NaN
```

Take elements at indices 1 and 2 along the axis 1 (column selection).

```
>>> df.take([1, 2], axis=1)
    class  max_speed
0    bird      389.0
2    bird       24.0
3  mammal       80.5
1  mammal        NaN
```

We may take elements using negative integers for positive indices, starting from the end of the object, just like with Python lists.

```
>>> df.take([-1, -2])
     name   class  max_speed
1  monkey  mammal        NaN
3    lion  mammal       80.5
```

34.16.3.49 pandas.core.groupby.DataFrameGroupBy.tshift

`DataFrameGroupBy.tshift`

Shift the time index, using the index's frequency if available.

Parameters **periods** : int

Number of periods to move, can be positive or negative

freq : DateOffset, timedelta, or time rule string, default None

Increment to use from the tseries module or time rule (e.g. 'EOM')

axis : int or basestring

Corresponds to the axis that contains the Index

Returns **shifted** : NDFrame

Notes

If freq is not specified then tries to use the freq or inferred_freq attributes of the index. If neither of those attributes exist, a ValueError is thrown

The following methods are available only for `SeriesGroupBy` objects.

`SeriesGroupBy.nlargest`	Return the largest *n* elements.
`SeriesGroupBy.nsmallest`	Return the smallest *n* elements.
`SeriesGroupBy.nunique`([dropna])	Returns number of unique elements in the group
`SeriesGroupBy.unique`	Return unique values in the object.
`SeriesGroupBy.value_counts`([normalize, ...])	

34.16.3.50 pandas.core.groupby.SeriesGroupBy.nlargest

`SeriesGroupBy.nlargest`

Return the largest *n* elements.

Parameters **n** : int

Return this many descending sorted values

keep : {'first', 'last', False}, default 'first'

Where there are duplicate values: - `first` : take the first occurrence. - `last` : take the last occurrence.

Returns **top_n** : Series

The n largest values in the Series, in sorted order

See also:

`Series.nsmallest`

Notes

Faster than `.sort_values(ascending=False).head(n)` for small *n* relative to the size of the `Series` object.

Examples

```
>>> import pandas as pd
>>> import numpy as np
>>> s = pd.Series(np.random.randn(10**6))
>>> s.nlargest(10)  # only sorts up to the N requested
219921    4.644710
82124     4.608745
421689    4.564644
425277    4.447014
718691    4.414137
43154     4.403520
283187    4.313922
595519    4.273635
503969    4.250236
121637    4.240952
dtype: float64
```

34.16.3.51 pandas.core.groupby.SeriesGroupBy.nsmallest

`SeriesGroupBy.nsmallest`

Return the smallest *n* elements.

Parameters **n** : int

Return this many ascending sorted values

keep : {'first', 'last', False}, default 'first'

Where there are duplicate values: - `first` : take the first occurrence. - `last` : take the last occurrence.

Returns **bottom_n** : Series

The n smallest values in the Series, in sorted order

See also:

`Series.nlargest`

Notes

Faster than `.sort_values().head(n)` for small *n* relative to the size of the `Series` object.

Examples

```
>>> import pandas as pd
>>> import numpy as np
>>> s = pd.Series(np.random.randn(10**6))
>>> s.nsmallest(10)  # only sorts up to the N requested
288532   -4.954580
732345   -4.835960
64803    -4.812550
446457   -4.609998
501225   -4.483945
669476   -4.472935
```

```
973615   -4.401699
621279   -4.355126
773916   -4.347355
359919   -4.331927
dtype: float64
```

34.16.3.52 pandas.core.groupby.SeriesGroupBy.nunique

`SeriesGroupBy.nunique(dropna=True)`

Returns number of unique elements in the group

34.16.3.53 pandas.core.groupby.SeriesGroupBy.unique

`SeriesGroupBy.unique`

Return unique values in the object. Uniques are returned in order of appearance, this does NOT sort. Hash table-based unique.

Parameters **values** : 1d array-like

Returns unique values.

- If the input is an Index, the return is an Index
- If the input is a Categorical dtype, the return is a Categorical
- If the input is a Series/ndarray, the return will be an ndarray

See also:

unique, `Index.unique`, `Series.unique`

34.16.3.54 pandas.core.groupby.SeriesGroupBy.value_counts

`SeriesGroupBy.value_counts(normalize=False, sort=True, ascending=False, bins=None, dropna=True)`

The following methods are available only for `DataFrameGroupBy` objects.

DataFrameGroupBy.corrwith	Compute pairwise correlation between rows or columns of two DataFrame objects.
DataFrameGroupBy.boxplot(grouped[, ...])	Make box plots from DataFrameGroupBy data.

34.16.3.55 pandas.core.groupby.DataFrameGroupBy.corrwith

`DataFrameGroupBy.corrwith`

Compute pairwise correlation between rows or columns of two DataFrame objects.

Parameters **other** : DataFrame

axis : {0 or 'index', 1 or 'columns'}, default 0

0 or 'index' to compute column-wise, 1 or 'columns' for row-wise

drop : boolean, default False

Drop missing indices from result, default returns union of all

Returns **correls** : Series

34.16.3.56 pandas.core.groupby.DataFrameGroupBy.boxplot

`DataFrameGroupBy.boxplot`(*grouped*, *subplots=True*, *column=None*, *fontsize=None*, *rot=0*, *grid=True*, *ax=None*, *figsize=None*, *layout=None*, ***kwds*)

Make box plots from DataFrameGroupBy data.

Parameters **grouped** : Grouped DataFrame

subplots :

- `False` - no subplots will be used
- `True` - create a subplot for each group

column : column name or list of names, or vector

Can be any valid input to groupby

fontsize : int or string

rot : label rotation angle

grid : Setting this to True will show the grid

ax : Matplotlib axis object, default None

figsize : A tuple (width, height) in inches

layout : tuple (optional)

(rows, columns) for the layout of the plot

kwds : other plotting keyword arguments to be passed to matplotlib boxplot

function

Returns dict of key/value = group key/DataFrame.boxplot return value

or DataFrame.boxplot return value in case subplots=figures=False

Examples

```
>>> import pandas
>>> import numpy as np
>>> import itertools
>>>
>>> tuples = [t for t in itertools.product(range(1000), range(4))]
>>> index = pandas.MultiIndex.from_tuples(tuples, names=['lvl0', 'lvl1'])
>>> data = np.random.randn(len(index),4)
>>> df = pandas.DataFrame(data, columns=list('ABCD'), index=index)
>>>
>>> grouped = df.groupby(level='lvl1')
>>> boxplot_frame_groupby(grouped)
>>>
>>> grouped = df.unstack(level='lvl1').groupby(level=0, axis=1)
>>> boxplot_frame_groupby(grouped, subplots=False)
```

34.17 Resampling

Resampler objects are returned by resample calls: *pandas.DataFrame.resample()*, *pandas.Series.resample()*.

34.17.1 Indexing, iteration

Resampler.__iter__()	Groupby iterator
Resampler.groups	dict {group name -> group labels}
Resampler.indices	dict {group name -> group indices}
Resampler.get_group(name[, obj])	Constructs NDFrame from group with provided name

34.17.1.1 pandas.core.resample.Resampler.__iter__

`Resampler.__iter__()`

Groupby iterator

Returns Generator yielding sequence of (name, subsetted object)

for each group

34.17.1.2 pandas.core.resample.Resampler.groups

`Resampler.groups`

dict {group name -> group labels}

34.17.1.3 pandas.core.resample.Resampler.indices

`Resampler.indices`

dict {group name -> group indices}

34.17.1.4 pandas.core.resample.Resampler.get_group

`Resampler.get_group(name, obj=None)`

Constructs NDFrame from group with provided name

Parameters **name** : object

the name of the group to get as a DataFrame

obj : NDFrame, default None

the NDFrame to take the DataFrame out of. If it is None, the object groupby was called on will be used

Returns **group** : type of obj

34.17.2 Function application

`Resampler.apply`(arg, *args, **kwargs)	Aggregate using callable, string, dict, or list of string/callables
`Resampler.aggregate`(arg, *args, **kwargs)	Aggregate using callable, string, dict, or list of string/callables
`Resampler.transform`(arg, *args, **kwargs)	Call function producing a like-indexed Series on each group and return

34.17.2.1 pandas.core.resample.Resampler.apply

`Resampler.`**`apply`**(*arg*, **args*, ***kwargs*)

Aggregate using callable, string, dict, or list of string/callables

Parameters **func** : callable, string, dictionary, or list of string/callables

Function to use for aggregating the data. If a function, must either work when passed a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted Combinations are:

- string function name
- function
- list of functions
- dict of column names -> functions (or list of functions)

Returns **aggregated** : DataFrame

See also:

`pandas.DataFrame.groupby.aggregate`, `pandas.DataFrame.resample.transform`, `pandas.DataFrame.aggregate`

Notes

Numpy functions mean/median/prod/sum/std/var are special cased so the default behavior is applying the function along axis=0 (e.g., np.mean(arr_2d, axis=0)) as opposed to mimicking the default Numpy behavior (e.g., np.mean(arr_2d)).

agg is an alias for *aggregate*. Use the alias.

Examples

```
>>> s = Series([1,2,3,4,5],
               index=pd.date_range('20130101',
                                   periods=5,freq='s'))
2013-01-01 00:00:00    1
2013-01-01 00:00:01    2
2013-01-01 00:00:02    3
2013-01-01 00:00:03    4
2013-01-01 00:00:04    5
Freq: S, dtype: int64
```

```
>>> r = s.resample('2s')
DatetimeIndexResampler [freq=<2 * Seconds>, axis=0, closed=left,
                        label=left, convention=start, base=0]
```

```
>>> r.agg(np.sum)
2013-01-01 00:00:00    3
2013-01-01 00:00:02    7
2013-01-01 00:00:04    5
Freq: 2S, dtype: int64
```

```
>>> r.agg(['sum','mean','max'])
                     sum  mean  max
2013-01-01 00:00:00    3   1.5    2
2013-01-01 00:00:02    7   3.5    4
2013-01-01 00:00:04    5   5.0    5
```

```
>>> r.agg({'result' : lambda x: x.mean() / x.std(),
           'total' : np.sum})
                     total    result
2013-01-01 00:00:00      3  2.121320
2013-01-01 00:00:02      7  4.949747
2013-01-01 00:00:04      5       NaN
```

34.17.2.2 pandas.core.resample.Resampler.aggregate

`Resampler.`**`aggregate`**(*arg*, **args*, ***kwargs*)

Aggregate using callable, string, dict, or list of string/callables

Parameters **func** : callable, string, dictionary, or list of string/callables

Function to use for aggregating the data. If a function, must either work when passed a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted Combinations are:

- string function name
- function
- list of functions
- dict of column names -> functions (or list of functions)

Returns **aggregated** : DataFrame

See also:

`pandas.DataFrame.groupby.aggregate`, `pandas.DataFrame.resample.transform`, *`pandas.DataFrame.aggregate`*

Notes

Numpy functions mean/median/prod/sum/std/var are special cased so the default behavior is applying the function along axis=0 (e.g., np.mean(arr_2d, axis=0)) as opposed to mimicking the default Numpy behavior (e.g., np.mean(arr_2d)).

agg is an alias for *aggregate*. Use the alias.

Examples

```
>>> s = Series([1,2,3,4,5],
               index=pd.date_range('20130101',
                                   periods=5,freq='s'))
2013-01-01 00:00:00    1
2013-01-01 00:00:01    2
2013-01-01 00:00:02    3
2013-01-01 00:00:03    4
2013-01-01 00:00:04    5
Freq: S, dtype: int64
```

```
>>> r = s.resample('2s')
DatetimeIndexResampler [freq=<2 * Seconds>, axis=0, closed=left,
                        label=left, convention=start, base=0]
```

```
>>> r.agg(np.sum)
2013-01-01 00:00:00    3
2013-01-01 00:00:02    7
2013-01-01 00:00:04    5
Freq: 2S, dtype: int64
```

```
>>> r.agg(['sum','mean','max'])
                     sum  mean  max
2013-01-01 00:00:00    3   1.5    2
2013-01-01 00:00:02    7   3.5    4
2013-01-01 00:00:04    5   5.0    5
```

```
>>> r.agg({'result' : lambda x: x.mean() / x.std(),
           'total' : np.sum})
                     total    result
2013-01-01 00:00:00      3  2.121320
2013-01-01 00:00:02      7  4.949747
2013-01-01 00:00:04      5       NaN
```

34.17.2.3 pandas.core.resample.Resampler.transform

`Resampler.`**`transform`**(*arg*, **args*, ***kwargs*)

Call function producing a like-indexed Series on each group and return a Series with the transformed values

Parameters **func** : function

To apply to each group. Should return a Series with the same index

Returns **transformed** : Series

Examples

```
>>> resampled.transform(lambda x: (x - x.mean()) / x.std())
```

34.17.3 Upsampling

`Resampler.ffill`([limit])	Forward fill the values
`Resampler.backfill`([limit])	Backward fill the values
`Resampler.bfill`([limit])	Backward fill the values
`Resampler.pad`([limit])	Forward fill the values
`Resampler.nearest`([limit])	Fill values with nearest neighbor starting from center
`Resampler.fillna`(method[, limit])	Fill missing values
`Resampler.asfreq`([fill_value])	return the values at the new freq,
`Resampler.interpolate`([method, axis, limit, ...])	Interpolate values according to different methods.

34.17.3.1 pandas.core.resample.Resampler.ffill

`Resampler.`**`ffill`**(*limit=None*)

Forward fill the values

Parameters **limit** : integer, optional

limit of how many values to fill

Returns an upsampled Series

See also:

`Series.fillna`, `DataFrame.fillna`

34.17.3.2 pandas.core.resample.Resampler.backfill

`Resampler.`**`backfill`**(*limit=None*)

Backward fill the values

Parameters **limit** : integer, optional

limit of how many values to fill

Returns an upsampled Series

See also:

`Series.fillna`, `DataFrame.fillna`

34.17.3.3 pandas.core.resample.Resampler.bfill

`Resampler.`**`bfill`**(*limit=None*)

Backward fill the values

Parameters **limit** : integer, optional

limit of how many values to fill

Returns an upsampled Series

See also:

`Series.fillna`, `DataFrame.fillna`

34.17.3.4 pandas.core.resample.Resampler.pad

`Resampler.pad(limit=None)`

Forward fill the values

Parameters **limit** : integer, optional

limit of how many values to fill

Returns an upsampled Series

See also:

`Series.fillna`, `DataFrame.fillna`

34.17.3.5 pandas.core.resample.Resampler.nearest

`Resampler.nearest(limit=None)`

Fill values with nearest neighbor starting from center

Parameters **limit** : integer, optional

limit of how many values to fill

New in version 0.21.0.

Returns an upsampled Series

See also:

`Series.fillna`, `DataFrame.fillna`

34.17.3.6 pandas.core.resample.Resampler.fillna

`Resampler.fillna(method, limit=None)`

Fill missing values

Parameters **method** : str, method of resampling ('ffill', 'bfill')

limit : integer, optional

limit of how many values to fill

See also:

`Series.fillna`, `DataFrame.fillna`

34.17.3.7 pandas.core.resample.Resampler.asfreq

`Resampler.asfreq(fill_value=None)`

return the values at the new freq, essentially a reindex

Parameters **fill_value: scalar, optional**

Value to use for missing values, applied during upsampling (note this does not fill NaNs that already were present).

New in version 0.20.0.

See also:

`Series.asfreq`, `DataFrame.asfreq`

34.17.3.8 pandas.core.resample.Resampler.interpolate

`Resampler.interpolate`(*method='linear'*, *axis=0*, *limit=None*, *inplace=False*, *limit_direction='forward'*, *downcast=None*, ***kwargs*)

Interpolate values according to different methods.

New in version 0.18.1.

Please note that only `method='linear'` is supported for DataFrames/Series with a MultiIndex.

Parameters **method** : {'linear', 'time', 'index', 'values', 'nearest', 'zero',

'slinear', 'quadratic', 'cubic', 'barycentric', 'krogh', 'polynomial', 'spline', 'piecewise_polynomial', 'from_derivatives', 'pchip', 'akima'}

- 'linear': ignore the index and treat the values as equally spaced. This is the only method supported on MultiIndexes. default
- 'time': interpolation works on daily and higher resolution data to interpolate given length of interval
- 'index', 'values': use the actual numerical values of the index
- 'nearest', 'zero', 'slinear', 'quadratic', 'cubic', 'barycentric', 'polynomial' is passed to `scipy.interpolate.interp1d`. Both 'polynomial' and 'spline' require that you also specify an *order* (int), e.g. df.interpolate(method='polynomial', order=4). These use the actual numerical values of the index.
- 'krogh', 'piecewise_polynomial', 'spline', 'pchip' and 'akima' are all wrappers around the scipy interpolation methods of similar names. These use the actual numerical values of the index. For more information on their behavior, see the scipy documentation and tutorial documentation
- 'from_derivatives' refers to BPoly.from_derivatives which replaces 'piecewise_polynomial' interpolation method in scipy 0.18

New in version 0.18.1: Added support for the 'akima' method Added interpolate method 'from_derivatives' which replaces 'piecewise_polynomial' in scipy 0.18; backwards-compatible with scipy < 0.18

axis : {0, 1}, default 0

- 0: fill column-by-column
- 1: fill row-by-row

limit : int, default None.

Maximum number of consecutive NaNs to fill. Must be greater than 0.

limit_direction : {'forward', 'backward', 'both'}, default 'forward'

If limit is specified, consecutive NaNs will be filled in this direction.

New in version 0.17.0.

inplace : bool, default False

Update the NDFrame in place if possible.

downcast : optional, 'infer' or None, defaults to None

Downcast dtypes if possible.

kwargs : keyword arguments to pass on to the interpolating function.

Returns Series or DataFrame of same shape interpolated at the NaNs

See also:

`reindex`, `replace`, *`fillna`*

Examples

Filling in NaNs

```
>>> s = pd.Series([0, 1, np.nan, 3])
>>> s.interpolate()
0    0
1    1
2    2
3    3
dtype: float64
```

34.17.4 Computations / Descriptive Stats

`Resampler.count`([_method])	Compute count of group, excluding missing values
`Resampler.nunique`([_method])	Returns number of unique elements in the group
`Resampler.first`([_method])	Compute first of group values
`Resampler.last`([_method])	Compute last of group values
`Resampler.max`([_method])	Compute max of group values
`Resampler.mean`([_method])	Compute mean of groups, excluding missing values
`Resampler.median`([_method])	Compute median of groups, excluding missing values
`Resampler.min`([_method])	Compute min of group values
`Resampler.ohlc`([_method])	Compute sum of values, excluding missing values
`Resampler.prod`([_method])	Compute prod of group values
`Resampler.size`()	Compute group sizes
`Resampler.sem`([_method])	Compute standard error of the mean of groups, excluding missing values
`Resampler.std`([ddof])	Compute standard deviation of groups, excluding missing values
`Resampler.sum`([_method])	Compute sum of group values
`Resampler.var`([ddof])	Compute variance of groups, excluding missing values

34.17.4.1 pandas.core.resample.Resampler.count

`Resampler.`**`count`**(*_method='count'*)

Compute count of group, excluding missing values

See also:

`pandas.Series.groupby`, *`pandas.DataFrame.groupby`*, *`pandas.Panel.groupby`*

34.17.4.2 pandas.core.resample.Resampler.nunique

`Resampler.nunique(_method='nunique')`

Returns number of unique elements in the group

34.17.4.3 pandas.core.resample.Resampler.first

`Resampler.first(_method='first', *args, **kwargs)`

Compute first of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.4 pandas.core.resample.Resampler.last

`Resampler.last(_method='last', *args, **kwargs)`

Compute last of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.5 pandas.core.resample.Resampler.max

`Resampler.max(_method='max', *args, **kwargs)`

Compute max of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.6 pandas.core.resample.Resampler.mean

`Resampler.mean(_method='mean', *args, **kwargs)`

Compute mean of groups, excluding missing values

For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.7 pandas.core.resample.Resampler.median

`Resampler.median(_method='median', *args, **kwargs)`

Compute median of groups, excluding missing values

For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.8 pandas.core.resample.Resampler.min

`Resampler.min(_method='min', *args, **kwargs)`

Compute min of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.9 pandas.core.resample.Resampler.ohlc

`Resampler.ohlc(_method='ohlc', *args, **kwargs)`

Compute sum of values, excluding missing values For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.10 pandas.core.resample.Resampler.prod

`Resampler.prod(_method='prod', *args, **kwargs)`

Compute prod of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.11 pandas.core.resample.Resampler.size

`Resampler.size()`

Compute group sizes

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.12 pandas.core.resample.Resampler.sem

`Resampler.sem(_method='sem', *args, **kwargs)`

Compute standard error of the mean of groups, excluding missing values

For multiple groupings, the result index will be a MultiIndex

Parameters **ddof** : integer, default 1

degrees of freedom

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.13 pandas.core.resample.Resampler.std

`Resampler.std(ddof=1, *args, **kwargs)`

Compute standard deviation of groups, excluding missing values

Parameters **ddof** : integer, default 1

degrees of freedom

34.17.4.14 pandas.core.resample.Resampler.sum

`Resampler.sum(_method='sum', *args, **kwargs)`

Compute sum of group values

See also:

pandas.Series.groupby, *pandas.DataFrame.groupby*, *pandas.Panel.groupby*

34.17.4.15 pandas.core.resample.Resampler.var

`Resampler.var(ddof=1, *args, **kwargs)`

Compute variance of groups, excluding missing values

Parameters **ddof** : integer, default 1

degrees of freedom

34.18 Style

`Styler` objects are returned by *pandas.DataFrame.style*.

34.18.1 Constructor

Styler(data[, precision, table_styles, ...])	Helps style a DataFrame or Series according to the data with HTML and CSS.

34.18.1.1 pandas.io.formats.style.Styler

class `pandas.io.formats.style.Styler(data, precision=None, table_styles=None, uuid=None, caption=None, table_attributes=None)`

Helps style a DataFrame or Series according to the data with HTML and CSS.

New in version 0.17.1.

> **Warning:** This is a new feature and is under active development. We'll be adding features and possibly making breaking changes in future releases.

Parameters **data: Series or DataFrame**

precision: int

precision to round floats to, defaults to pd.options.display.precision

table_styles: list-like, default None

list of {selector: (attr, value)} dicts; see Notes

uuid: str, default None

a unique identifier to avoid CSS collisons; generated automatically

caption: str, default None

caption to attach to the table

See also:

pandas.DataFrame.style

Notes

Most styling will be done by passing style functions into `Styler.apply` or `Styler.applymap`. Style functions should return values with strings containing CSS `'attr: value'` that will be applied to the indicated cells.

If using in the Jupyter notebook, Styler has defined a `_repr_html_` to automatically render itself. Otherwise call Styler.render to get the genterated HTML.

CSS classes are attached to the generated HTML

- Index and Column names include `index_name` and `level<k>` where *k* is its level in a MultiIndex
- Index label cells include
  - `row_heading`
  - `row<n>` where *n* is the numeric position of the row
  - `level<k>` where *k* is the level in a MultiIndex
- Column label cells include * `col_heading` * `col<n>` where *n* is the numeric position of the column * `evel<k>` where *k* is the level in a MultiIndex
- Blank cells include `blank`
- Data cells include `data`

Attributes

env
template
loader

pandas.io.formats.style.Styler.env

`Styler.`**`env`** **= <jinja2.environment.Environment object>**

pandas.io.formats.style.Styler.template

`Styler.`**`template`** **= <Template 'html.tpl'>**

pandas.io.formats.style.Styler.loader

`Styler.`**`loader`** **= <jinja2.loaders.PackageLoader object>**

Methods

apply(func[, axis, subset])	Apply a function column-wise, row-wise, or table-wase, updating the HTML representation with the result.
applymap(func[, subset])	Apply a function elementwise, updating the HTML representation with the result.
background_gradient([cmap, low, high, axis, ...])	Color the background in a gradient according to the data in each column (optionally row).
bar([subset, axis, color, width, align])	Color the background `color` proptional to the values in each column.
clear()	"Reset" the styler, removing any previously applied styles.
export()	Export the styles to applied to the current Styler.
format(formatter[, subset])	Format the text display value of cells.
from_custom_template(searchpath, name)	Factory function for creating a subclass of `Styler` with a custom template and Jinja environment.
highlight_max([subset, color, axis])	Highlight the maximum by shading the background
highlight_min([subset, color, axis])	Highlight the minimum by shading the background
highlight_null([null_color])	Shade the background `null_color` for missing values.
render(**kwargs)	Render the built up styles to HTML
set_caption(caption)	Se the caption on a Styler
set_precision(precision)	Set the precision used to render.
set_properties([subset])	Convience method for setting one or more non-data dependent properties or each cell.
set_table_attributes(attributes)	Set the table attributes.
set_table_styles(table_styles)	Set the table styles on a Styler.
set_uuid(uuid)	Set the uuid for a Styler.
to_excel(excel_writer[, sheet_name, na_rep, ...])	Write Styler to an excel sheet
use(styles)	Set the styles on the current Styler, possibly using styles from `Styler.export`.
where(cond, value[, other, subset])	Apply a function elementwise, updating the HTML representation with a style which is selected in accordance with the return value of a function.

pandas.io.formats.style.Styler.apply

`Styler.`**`apply`**(*func*, *axis=0*, *subset=None*, ***kwargs*)

Apply a function column-wise, row-wise, or table-wase, updating the HTML representation with the result.

New in version 0.17.1.

Parameters **func** : function

`func` should take a Series or DataFrame (depending on `axis`), and return an object with the same shape. Must return a DataFrame with identical index and column labels when `axis=None`

axis : int, str or None

apply to each column (`axis=0` or `'index'`) or to each row (`axis=1` or `'columns'`) or to the entire DataFrame at once with `axis=None`

subset : IndexSlice

a valid indexer to limit `data` to *before* applying the function. Consider using a pandas.IndexSlice

kwargs : dict

pass along to `func`

Returns **self** : Styler

Notes

The output shape of `func` should match the input, i.e. if `x` is the input row, column, or table (depending on `axis`), then `func(x.shape) == x.shape` should be true.

This is similar to `DataFrame.apply`, except that `axis=None` applies the function to the entire DataFrame at once, rather than column-wise or row-wise.

Examples

```
>>> def highlight_max(x):
...     return ['background-color: yellow' if v == x.max() else ''
                for v in x]
...
>>> df = pd.DataFrame(np.random.randn(5, 2))
>>> df.style.apply(highlight_max)
```

pandas.io.formats.style.Styler.applymap

`Styler.`**`applymap`**(*func*, *subset=None*, ***kwargs*)

Apply a function elementwise, updating the HTML representation with the result.

New in version 0.17.1.

Parameters **func** : function

`func` should take a scalar and return a scalar

subset : IndexSlice

a valid indexer to limit `data` to *before* applying the function. Consider using a pandas.IndexSlice

kwargs : dict

pass along to `func`

Returns **self** : Styler

See also:

`Styler.where`

pandas.io.formats.style.Styler.background_gradient

`Styler.background_gradient`(*cmap='PuBu', low=0, high=0, axis=0, subset=None*)

Color the background in a gradient according to the data in each column (optionally row). Requires matplotlib.

New in version 0.17.1.

Parameters **cmap: str or colormap**

matplotlib colormap

low, high: float

compress the range by these values.

axis: int or str

1 or 'columns' for columnwise, 0 or 'index' for rowwise

subset: IndexSlice

a valid slice for `data` to limit the style application to

Returns **self** : Styler

Notes

Tune `low` and `high` to keep the text legible by not using the entire range of the color map. These extend the range of the data by `low * (x.max() - x.min())` and `high * (x.max() - x.min())` before normalizing.

pandas.io.formats.style.Styler.bar

`Styler.bar`(*subset=None, axis=0, color='#d65f5f', width=100, align='left'*)

Color the background `color` proptional to the values in each column. Excludes non-numeric data by default.

New in version 0.17.1.

Parameters **subset: IndexSlice, default None**

a valid slice for `data` to limit the style application to

axis: int

color: str or 2-tuple/list

If a str is passed, the color is the same for both negative and positive numbers. If 2-tuple/list is used, the first element is the color_negative and the second is the color_positive (eg: ['#d65f5f', '#5fba7d'])

width: float

A number between 0 or 100. The largest value will cover `width` percent of the cell's width

align : {'left', 'zero',' mid'}, default 'left'

- 'left' : the min value starts at the left of the cell
- 'zero' : a value of zero is located at the center of the cell

- 'mid' : the center of the cell is at (max-min)/2, or if values are all negative (positive) the zero is aligned at the right (left) of the cell

  New in version 0.20.0.

Returns **self** : Styler

pandas.io.formats.style.Styler.clear

`Styler.clear()`

"Reset" the styler, removing any previously applied styles. Returns None.

pandas.io.formats.style.Styler.export

`Styler.export()`

Export the styles to applied to the current Styler. Can be applied to a second style with `Styler.use`.

New in version 0.17.1.

Returns styles: list

See also:

`Styler.use`

pandas.io.formats.style.Styler.format

`Styler.format` (*formatter*, *subset=None*)

Format the text display value of cells.

New in version 0.18.0.

Parameters **formatter: str, callable, or dict**

subset: IndexSlice

An argument to `DataFrame.loc` that restricts which elements `formatter` is applied to.

Returns **self** : Styler

Notes

`formatter` is either an `a` or a dict `{column name: a}` where `a` is one of

- str: this will be wrapped in: `a.format(x)`
- callable: called with the value of an individual cell

The default display value for numeric values is the "general" (`g`) format with `pd.options.display.precision` precision.

Examples

```
>>> df = pd.DataFrame(np.random.randn(4, 2), columns=['a', 'b'])
>>> df.style.format("{:.2%}")
>>> df['c'] = ['a', 'b', 'c', 'd']
>>> df.style.format({'C': str.upper})
```

pandas.io.formats.style.Styler.from_custom_template

classmethod `Styler.`**`from_custom_template`**(*searchpath*, *name*)

Factory function for creating a subclass of `Styler` with a custom template and Jinja environment.

Parameters **searchpath** : str or list

Path or paths of directories containing the templates

name : str

Name of your custom template to use for rendering

Returns **MyStyler** : subclass of Styler

has the correct `env` and `template` class attributes set.

pandas.io.formats.style.Styler.highlight_max

`Styler.`**`highlight_max`**(*subset=None*, *color='yellow'*, *axis=0*)

Highlight the maximum by shading the background

New in version 0.17.1.

Parameters **subset: IndexSlice, default None**

a valid slice for `data` to limit the style application to

color: str, default 'yellow'

axis: int, str, or None; default 0

0 or 'index' for columnwise (default), 1 or 'columns' for rowwise, or `None` for tablewise

Returns **self** : Styler

pandas.io.formats.style.Styler.highlight_min

`Styler.`**`highlight_min`**(*subset=None*, *color='yellow'*, *axis=0*)

Highlight the minimum by shading the background

New in version 0.17.1.

Parameters **subset: IndexSlice, default None**

a valid slice for `data` to limit the style application to

color: str, default 'yellow'

axis: int, str, or None; default 0

0 or 'index' for columnwise (default), 1 or 'columns' for rowwise, or `None` for tablewise

Returns **self** : Styler

pandas.io.formats.style.Styler.highlight_null

`Styler.highlight_null(null_color='red')`

Shade the background `null_color` for missing values.

New in version 0.17.1.

Parameters **null_color: str**

Returns **self** : Styler

pandas.io.formats.style.Styler.render

`Styler.render(**kwargs)`

Render the built up styles to HTML

New in version 0.17.1.

Parameters ****kwargs:**

Any additional keyword arguments are passed through to `self.template.render`. This is useful when you need to provide additional variables for a custom template.

New in version 0.20.

Returns rendered: str

the rendered HTML

Notes

`Styler` objects have defined the `_repr_html_` method which automatically calls `self.render()` when it's the last item in a Notebook cell. When calling `Styler.render()` directly, wrap the result in `IPython.display.HTML` to view the rendered HTML in the notebook.

Pandas uses the following keys in render. Arguments passed in `**kwargs` take precedence, so think carefuly if you want to override them:

- head
- cellstyle
- body
- uuid
- precision
- table_styles
- caption
- table_attributes

pandas.io.formats.style.Styler.set_caption

`Styler.set_caption(caption)`

Se the caption on a Styler

New in version 0.17.1.

Parameters **caption: str**

Returns **self** : Styler

pandas.io.formats.style.Styler.set_precision

`Styler.set_precision(precision)`

Set the precision used to render.

New in version 0.17.1.

Parameters **precision: int**

Returns **self** : Styler

pandas.io.formats.style.Styler.set_properties

`Styler.set_properties(subset=None, **kwargs)`

Convience method for setting one or more non-data dependent properties or each cell.

New in version 0.17.1.

Parameters **subset: IndexSlice**

a valid slice for `data` to limit the style application to

kwargs: dict

property: value pairs to be set for each cell

Returns **self** : Styler

Examples

```
>>> df = pd.DataFrame(np.random.randn(10, 4))
>>> df.style.set_properties(color="white", align="right")
>>> df.style.set_properties(**{'background-color': 'yellow'})
```

pandas.io.formats.style.Styler.set_table_attributes

`Styler.set_table_attributes(attributes)`

Set the table attributes. These are the items that show up in the opening `<table>` tag in addition to to automatic (by default) id.

New in version 0.17.1.

Parameters **attributes** : string

Returns **self** : Styler

Examples

```
>>> df = pd.DataFrame(np.random.randn(10, 4))
>>> df.style.set_table_attributes('class="pure-table"')
# ... <table class="pure-table"> ...
```

pandas.io.formats.style.Styler.set_table_styles

`Styler.set_table_styles(table_styles)`

Set the table styles on a Styler. These are placed in a `<style>` tag before the generated HTML table.

New in version 0.17.1.

Parameters table_styles: list

Each individual table_style should be a dictionary with `selector` and `props` keys. `selector` should be a CSS selector that the style will be applied to (automatically prefixed by the table's UUID) and `props` should be a list of tuples with `(attribute, value)`.

Returns self : Styler

Examples

```
>>> df = pd.DataFrame(np.random.randn(10, 4))
>>> df.style.set_table_styles(
...     [{'selector': 'tr:hover',
...       'props': [('background-color', 'yellow')]}]
... )
```

pandas.io.formats.style.Styler.set_uuid

`Styler.set_uuid(uuid)`

Set the uuid for a Styler.

New in version 0.17.1.

Parameters uuid: str

Returns self : Styler

pandas.io.formats.style.Styler.to_excel

`Styler.to_excel(excel_writer, sheet_name='Sheet1', na_rep='', float_format=None, columns=None, header=True, index=True, index_label=None, startrow=0, startcol=0, engine=None, merge_cells=True, encoding=None, inf_rep='inf', verbose=True, freeze_panes=None)`

Write Styler to an excel sheet

New in version 0.20.

Parameters excel_writer : string or ExcelWriter object

File path or existing ExcelWriter

sheet_name : string, default 'Sheet1'

Name of sheet which will contain DataFrame

na_rep : string, default ''

Missing data representation

float_format : string, default None

Format string for floating point numbers

columns : sequence, optional

Columns to write

header : boolean or list of string, default True

Write out the column names. If a list of strings is given it is assumed to be aliases for the column names

index : boolean, default True

Write row names (index)

index_label : string or sequence, default None

Column label for index column(s) if desired. If None is given, and *header* and *index* are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

startrow :

upper left cell row to dump data frame

startcol :

upper left cell column to dump data frame

engine : string, default None

write engine to use - you can also set this via the options `io.excel.xlsx.writer`, `io.excel.xls.writer`, and `io.excel.xlsm.writer`.

merge_cells : boolean, default True

Write MultiIndex and Hierarchical Rows as merged cells.

encoding: string, default None

encoding of the resulting excel file. Only necessary for xlwt, other writers support unicode natively.

inf_rep : string, default 'inf'

Representation for infinity (there is no native representation for infinity in Excel)

freeze_panes : tuple of integer (length 2), default None

Specifies the one-based bottommost row and rightmost column that is to be frozen

New in version 0.20.0.

Notes

If passing an existing ExcelWriter object, then the sheet will be added to the existing workbook. This can be used to save different DataFrames to one workbook:

```
>>> writer = pd.ExcelWriter('output.xlsx')
>>> df1.to_excel(writer,'Sheet1')
>>> df2.to_excel(writer,'Sheet2')
>>> writer.save()
```

For compatibility with to_csv, to_excel serializes lists and dicts to strings before writing.

pandas.io.formats.style.Styler.use

`Styler.use`(*styles*)

Set the styles on the current Styler, possibly using styles from `Styler.export`.

New in version 0.17.1.

Parameters **styles: list**

list of style functions

Returns **self** : Styler

See also:

`Styler.export`

pandas.io.formats.style.Styler.where

`Styler.where`(*cond*, *value*, *other=None*, *subset=None*, ***kwargs*)

Apply a function elementwise, updating the HTML representation with a style which is selected in accordance with the return value of a function.

New in version 0.21.0.

Parameters **cond** : callable

`cond` should take a scalar and return a boolean

value : str

applied when `cond` returns true

other : str

applied when `cond` returns false

subset : IndexSlice

a valid indexer to limit `data` to *before* applying the function. Consider using a pandas.IndexSlice

kwargs : dict

pass along to `cond`

Returns **self** : Styler

See also:

`Styler.applymap`

34.18.2 Style Application

`Styler.apply`(func[, axis, subset])	Apply a function column-wise, row-wise, or table-wase, updating the HTML representation with the result.
`Styler.applymap`(func[, subset])	Apply a function elementwise, updating the HTML representation with the result.
`Styler.where`(cond, value[, other, subset])	Apply a function elementwise, updating the HTML representation with a style which is selected in accordance with the return value of a function.
`Styler.format`(formatter[, subset])	Format the text display value of cells.
`Styler.set_precision`(precision)	Set the precision used to render.
`Styler.set_table_styles`(table_styles)	Set the table styles on a Styler.
`Styler.set_caption`(caption)	Se the caption on a Styler
`Styler.set_properties`([subset])	Convience method for setting one or more non-data dependent properties or each cell.
`Styler.set_uuid`(uuid)	Set the uuid for a Styler.
`Styler.clear`()	"Reset" the styler, removing any previously applied styles.

34.18.3 Builtin Styles

`Styler.highlight_max`([subset, color, axis])	Highlight the maximum by shading the background
`Styler.highlight_min`([subset, color, axis])	Highlight the minimum by shading the background
`Styler.highlight_null`([null_color])	Shade the background `null_color` for missing values.
`Styler.background_gradient`([cmap, low, ...])	Color the background in a gradient according to the data in each column (optionally row).
`Styler.bar`([subset, axis, color, width, align])	Color the background `color` proptional to the values in each column.

34.18.4 Style Export and Import

`Styler.render`(**kwargs)	Render the built up styles to HTML
`Styler.export`()	Export the styles to applied to the current Styler.
`Styler.use`(styles)	Set the styles on the current Styler, possibly using styles from `Styler.export`.

34.19 General utility functions

34.19.1 Working with options

`describe_option`(pat[, _print_desc])	Prints the description for one or more registered options.
`reset_option`(pat)	Reset one or more options to their default value.
`get_option`(pat)	Retrieves the value of the specified option.
`set_option`(pat, value)	Sets the value of the specified option.
`option_context`(*args)	Context manager to temporarily set options in the *with* statement context.

34.19.1.1 pandas.describe_option

`pandas.describe_option`(*pat*, *_print_desc=False*) = **<pandas.core.config.CallableDynamicDoc object>**

Prints the description for one or more registered options.

Call with not arguments to get a listing for all registered options.

Available options:

- compute.[use_bottleneck, use_numexpr]
- display.[chop_threshold, colheader_justify, column_space, date_dayfirst, date_yearfirst, encoding, expand_frame_repr, float_format, height]
- display.html.[border, table_schema]
- display.[large_repr]
- display.latex.[escape, longtable, multicolumn, multicolumn_format, multirow, repr]
- display.[line_width, max_categories, max_columns, max_colwidth, max_info_columns, max_info_rows, max_rows, max_seq_items, memory_usage, multi_sparse, notebook_repr_html, pprint_nest_depth, precision, show_dimensions]
- display.unicode.[ambiguous_as_wide, east_asian_width]
- display.[width]
- html.[border]
- io.excel.xls.[writer]
- io.excel.xlsm.[writer]
- io.excel.xlsx.[writer]
- io.hdf.[default_format, dropna_table]
- io.parquet.[engine]
- mode.[chained_assignment, sim_interactive, use_inf_as_na, use_inf_as_null]

Parameters **pat** : str

Regexp pattern. All matching keys will have their description displayed.

_print_desc : bool, default True

If True (default) the description(s) will be printed to stdout. Otherwise, the description(s) will be returned as a unicode string (for testing).

Returns None by default, the description(s) as a unicode string if _print_desc

is False

Notes

The available options with its descriptions:

compute.use_bottleneck [bool] Use the bottleneck library to accelerate if it is installed, the default is True Valid values: False,True [default: True] [currently: True]

compute.use_numexpr [bool] Use the numexpr library to accelerate computation if it is installed, the default is True Valid values: False,True [default: True] [currently: True]

display.chop_threshold [float or None] if set to a float value, all float values smaller then the given threshold will be displayed as exactly 0 by repr and friends. [default: None] [currently: None]

display.colheader_justify ['left'/'right'] Controls the justification of column headers. used by DataFrameFormatter. [default: right] [currently: right]

display.column_space No description available. [default: 12] [currently: 12]

display.date_dayfirst [boolean] When True, prints and parses dates with the day first, eg 20/01/2005 [default: False] [currently: False]

display.date_yearfirst [boolean] When True, prints and parses dates with the year first, eg 2005/01/20 [default: False] [currently: False]

display.encoding [str/unicode] Defaults to the detected encoding of the console. Specifies the encoding to be used for strings returned by to_string, these are generally strings meant to be displayed on the console. [default: UTF-8] [currently: UTF-8]

display.expand_frame_repr [boolean] Whether to print out the full DataFrame repr for wide DataFrames across multiple lines, *max_columns* is still respected, but the output will wrap-around across multiple "pages" if its width exceeds *display.width*. [default: True] [currently: True]

display.float_format [callable] The callable should accept a floating point number and return a string with the desired format of the number. This is used in some places like SeriesFormatter. See formats.format.EngFormatter for an example. [default: None] [currently: None]

display.height [int] Deprecated. [default: 60] [currently: 60]

display.html.border [int] A `border=value` attribute is inserted in the `<table>` tag for the DataFrame HTML repr. [default: 1] [currently: 1]

display.html.table_schema [boolean] Whether to publish a Table Schema representation for frontends that support it. (default: False) [default: False] [currently: False]

display.large_repr ['truncate'/'info'] For DataFrames exceeding max_rows/max_cols, the repr (and HTML repr) can show a truncated table (the default from 0.13), or switch to the view from df.info() (the behaviour in earlier versions of pandas). [default: truncate] [currently: truncate]

display.latex.escape [bool] This specifies if the to_latex method of a Dataframe uses escapes special characters. Valid values: False,True [default: True] [currently: True]

display.latex.longtable :bool This specifies if the to_latex method of a Dataframe uses the longtable format. Valid values: False,True [default: False] [currently: False]

display.latex.multicolumn [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: True] [currently: True]

display.latex.multicolumn_format [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: l] [currently: l]

display.latex.multirow [bool] This specifies if the to_latex method of a Dataframe uses multirows to pretty-print MultiIndex rows. Valid values: False,True [default: False] [currently: False]

display.latex.repr [boolean] Whether to produce a latex DataFrame representation for jupyter environments that support it. (default: False) [default: False] [currently: False]

display.line_width [int] Deprecated. [default: 80] [currently: 80]

display.max_categories [int] This sets the maximum number of categories pandas should output when printing out a *Categorical* or a Series of dtype "category". [default: 8] [currently: 8]

display.max_columns [int] If max_cols is exceeded, switch to truncate view. Depending on *large_repr*, objects are either centrally truncated or printed as a summary view. 'None' value means unlimited.

In case python/IPython is running in a terminal and *large_repr* equals 'truncate' this can be set to 0 and pandas will auto-detect the width of the terminal and print a truncated object which fits the screen width. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 20] [currently: 20]

display.max_colwidth [int] The maximum width in characters of a column in the repr of a pandas data structure. When the column overflows, a "..." placeholder is embedded in the output. [default: 50] [currently: 50]

display.max_info_columns [int] max_info_columns is used in DataFrame.info method to decide if per column information will be printed. [default: 100] [currently: 100]

display.max_info_rows [int or None] df.info() will usually show null-counts for each column. For large frames this can be quite slow. max_info_rows and max_info_cols limit this null check only to frames with smaller dimensions than specified. [default: 1690785] [currently: 1690785]

display.max_rows [int] If max_rows is exceeded, switch to truncate view. Depending on *large_repr*, objects are either centrally truncated or printed as a summary view. 'None' value means unlimited.

In case python/IPython is running in a terminal and *large_repr* equals 'truncate' this can be set to 0 and pandas will auto-detect the height of the terminal and print a truncated object which fits the screen height. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 60] [currently: 15]

display.max_seq_items [int or None] when pretty-printing a long sequence, no more then *max_seq_items* will be printed. If items are omitted, they will be denoted by the addition of "..." to the resulting string.

If set to None, the number of items to be printed is unlimited. [default: 100] [currently: 100]

display.memory_usage [bool, string or None] This specifies if the memory usage of a DataFrame should be displayed when df.info() is called. Valid values True,False,'deep' [default: True] [currently: True]

display.multi_sparse [boolean] "sparsify" MultiIndex display (don't display repeated elements in outer levels within groups) [default: True] [currently: True]

display.notebook_repr_html [boolean] When True, IPython notebook will use html representation for pandas objects (if it is available). [default: True] [currently: True]

display.pprint_nest_depth [int] Controls the number of nested levels to process when pretty-printing [default: 3] [currently: 3]

display.precision [int] Floating point output precision (number of significant digits). This is only a suggestion [default: 6] [currently: 6]

display.show_dimensions [boolean or 'truncate'] Whether to print out dimensions at the end of DataFrame repr. If 'truncate' is specified, only print out the dimensions if the frame is truncated (e.g. not display all rows and/or columns) [default: truncate] [currently: truncate]

display.unicode.ambiguous_as_wide [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.unicode.east_asian_width [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.width [int] Width of the display in characters. In case python/IPython is running in a terminal this can be set to None and pandas will correctly auto-detect the width. Note that the IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to correctly detect the width. [default: 80] [currently: 80]

html.border [int] A `border=value` attribute is inserted in the `<table>` tag for the DataFrame HTML repr. [default: 1] [currently: 1] (Deprecated, use *display.html.border* instead.)

io.excel.xls.writer [string] The default Excel writer engine for 'xls' files. Available options: auto, xlwt. [default: auto] [currently: auto]

io.excel.xlsm.writer [string] The default Excel writer engine for 'xlsm' files. Available options: auto, openpyxl. [default: auto] [currently: auto]

io.excel.xlsx.writer [string] The default Excel writer engine for 'xlsx' files. Available options: auto, openpyxl, xlsxwriter. [default: auto] [currently: auto]

io.hdf.default_format [format] default format writing format, if None, then put will default to 'fixed' and append will default to 'table' [default: None] [currently: None]

io.hdf.dropna_table [boolean] drop ALL nan rows when appending to a table [default: False] [currently: False]

io.parquet.engine [string] The default parquet reader/writer engine. Available options: 'auto', 'pyarrow', 'fastparquet', the default is 'auto' [default: auto] [currently: auto]

mode.chained_assignment [string] Raise an exception, warn, or no action if trying to use chained assignment, The default is warn [default: warn] [currently: warn]

mode.sim_interactive [boolean] Whether to simulate interactive mode for purposes of testing [default: False] [currently: False]

mode.use_inf_as_na [boolean] True means treat None, NaN, INF, -INF as NA (old way), False means None and NaN are null, but INF, -INF are not NA (new way). [default: False] [currently: False]

mode.use_inf_as_null use_inf_as_null had been deprecated and will be removed in a future version. Use *use_inf_as_na* instead.

[default: False] [currently: False] (Deprecated, use *mode.use_inf_as_na* instead.)

34.19.1.2 pandas.reset_option

`pandas.`**`reset_option`**(*pat*) = **<pandas.core.config.CallableDynamicDoc object>**

Reset one or more options to their default value.

Pass "all" as argument to reset all options.

Available options:

- compute.[use_bottleneck, use_numexpr]
- display.[chop_threshold, colheader_justify, column_space, date_dayfirst, date_yearfirst, encoding, expand_frame_repr, float_format, height]
- display.html.[border, table_schema]
- display.[large_repr]
- display.latex.[escape, longtable, multicolumn, multicolumn_format, multirow, repr]
- display.[line_width, max_categories, max_columns, max_colwidth, max_info_columns, max_info_rows, max_rows, max_seq_items, memory_usage, multi_sparse, notebook_repr_html, pprint_nest_depth, precision, show_dimensions]
- display.unicode.[ambiguous_as_wide, east_asian_width]
- display.[width]
- html.[border]

- io.excel.xls.[writer]
- io.excel.xlsm.[writer]
- io.excel.xlsx.[writer]
- io.hdf.[default_format, dropna_table]
- io.parquet.[engine]
- mode.[chained_assignment, sim_interactive, use_inf_as_na, use_inf_as_null]

Parameters **pat** : str/regex

If specified only options matching *prefix** will be reset. Note: partial matches are supported for convenience, but unless you use the full option name (e.g. x.y.z.option_name), your code may break in future versions if new options with similar names are introduced.

Returns None

Notes

The available options with its descriptions:

compute.use_bottleneck [bool] Use the bottleneck library to accelerate if it is installed, the default is True Valid values: False,True [default: True] [currently: True]

compute.use_numexpr [bool] Use the numexpr library to accelerate computation if it is installed, the default is True Valid values: False,True [default: True] [currently: True]

display.chop_threshold [float or None] if set to a float value, all float values smaller then the given threshold will be displayed as exactly 0 by repr and friends. [default: None] [currently: None]

display.colheader_justify ['left'/'right'] Controls the justification of column headers. used by DataFrameFormatter. [default: right] [currently: right]

display.column_space No description available. [default: 12] [currently: 12]

display.date_dayfirst [boolean] When True, prints and parses dates with the day first, eg 20/01/2005 [default: False] [currently: False]

display.date_yearfirst [boolean] When True, prints and parses dates with the year first, eg 2005/01/20 [default: False] [currently: False]

display.encoding [str/unicode] Defaults to the detected encoding of the console. Specifies the encoding to be used for strings returned by to_string, these are generally strings meant to be displayed on the console. [default: UTF-8] [currently: UTF-8]

display.expand_frame_repr [boolean] Whether to print out the full DataFrame repr for wide DataFrames across multiple lines, *max_columns* is still respected, but the output will wrap-around across multiple "pages" if its width exceeds *display.width*. [default: True] [currently: True]

display.float_format [callable] The callable should accept a floating point number and return a string with the desired format of the number. This is used in some places like SeriesFormatter. See formats.format.EngFormatter for an example. [default: None] [currently: None]

display.height [int] Deprecated. [default: 60] [currently: 60]

display.html.border [int] A `border=value` attribute is inserted in the `<table>` tag for the DataFrame HTML repr. [default: 1] [currently: 1]

display.html.table_schema [boolean] Whether to publish a Table Schema representation for frontends that support it. (default: False) [default: False] [currently: False]

display.large_repr ['truncate'/'info'] For DataFrames exceeding max_rows/max_cols, the repr (and HTML repr) can show a truncated table (the default from 0.13), or switch to the view from df.info() (the behaviour in earlier versions of pandas). [default: truncate] [currently: truncate]

display.latex.escape [bool] This specifies if the to_latex method of a Dataframe uses escapes special characters. Valid values: False,True [default: True] [currently: True]

display.latex.longtable :bool This specifies if the to_latex method of a Dataframe uses the longtable format. Valid values: False,True [default: False] [currently: False]

display.latex.multicolumn [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: True] [currently: True]

display.latex.multicolumn_format [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: l] [currently: l]

display.latex.multirow [bool] This specifies if the to_latex method of a Dataframe uses multirows to pretty-print MultiIndex rows. Valid values: False,True [default: False] [currently: False]

display.latex.repr [boolean] Whether to produce a latex DataFrame representation for jupyter environments that support it. (default: False) [default: False] [currently: False]

display.line_width [int] Deprecated. [default: 80] [currently: 80]

display.max_categories [int] This sets the maximum number of categories pandas should output when printing out a *Categorical* or a Series of dtype "category". [default: 8] [currently: 8]

display.max_columns [int] If max_cols is exceeded, switch to truncate view. Depending on *large_repr*, objects are either centrally truncated or printed as a summary view. 'None' value means unlimited.

In case python/IPython is running in a terminal and *large_repr* equals 'truncate' this can be set to 0 and pandas will auto-detect the width of the terminal and print a truncated object which fits the screen width. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 20] [currently: 20]

display.max_colwidth [int] The maximum width in characters of a column in the repr of a pandas data structure. When the column overflows, a "..." placeholder is embedded in the output. [default: 50] [currently: 50]

display.max_info_columns [int] max_info_columns is used in DataFrame.info method to decide if per column information will be printed. [default: 100] [currently: 100]

display.max_info_rows [int or None] df.info() will usually show null-counts for each column. For large frames this can be quite slow. max_info_rows and max_info_cols limit this null check only to frames with smaller dimensions than specified. [default: 1690785] [currently: 1690785]

display.max_rows [int] If max_rows is exceeded, switch to truncate view. Depending on *large_repr*, objects are either centrally truncated or printed as a summary view. 'None' value means unlimited.

In case python/IPython is running in a terminal and *large_repr* equals 'truncate' this can be set to 0 and pandas will auto-detect the height of the terminal and print a truncated object which fits the screen height. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 60] [currently: 15]

display.max_seq_items [int or None] when pretty-printing a long sequence, no more then *max_seq_items* will be printed. If items are omitted, they will be denoted by the addition of "..." to the resulting string.

If set to None, the number of items to be printed is unlimited. [default: 100] [currently: 100]

display.memory_usage [bool, string or None] This specifies if the memory usage of a DataFrame should be displayed when df.info() is called. Valid values True,False,'deep' [default: True] [currently: True]

display.multi_sparse [boolean] "sparsify" MultiIndex display (don't display repeated elements in outer levels within groups) [default: True] [currently: True]

display.notebook_repr_html [boolean] When True, IPython notebook will use html representation for pandas objects (if it is available). [default: True] [currently: True]

display.pprint_nest_depth [int] Controls the number of nested levels to process when pretty-printing [default: 3] [currently: 3]

display.precision [int] Floating point output precision (number of significant digits). This is only a suggestion [default: 6] [currently: 6]

display.show_dimensions [boolean or 'truncate'] Whether to print out dimensions at the end of DataFrame repr. If 'truncate' is specified, only print out the dimensions if the frame is truncated (e.g. not display all rows and/or columns) [default: truncate] [currently: truncate]

display.unicode.ambiguous_as_wide [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.unicode.east_asian_width [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.width [int] Width of the display in characters. In case python/IPython is running in a terminal this can be set to None and pandas will correctly auto-detect the width. Note that the IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to correctly detect the width. [default: 80] [currently: 80]

html.border [int] A `border=value` attribute is inserted in the `<table>` tag for the DataFrame HTML repr. [default: 1] [currently: 1] (Deprecated, use *display.html.border* instead.)

io.excel.xls.writer [string] The default Excel writer engine for 'xls' files. Available options: auto, xlwt. [default: auto] [currently: auto]

io.excel.xlsm.writer [string] The default Excel writer engine for 'xlsm' files. Available options: auto, openpyxl. [default: auto] [currently: auto]

io.excel.xlsx.writer [string] The default Excel writer engine for 'xlsx' files. Available options: auto, openpyxl, xlsxwriter. [default: auto] [currently: auto]

io.hdf.default_format [format] default format writing format, if None, then put will default to 'fixed' and append will default to 'table' [default: None] [currently: None]

io.hdf.dropna_table [boolean] drop ALL nan rows when appending to a table [default: False] [currently: False]

io.parquet.engine [string] The default parquet reader/writer engine. Available options: 'auto', 'pyarrow', 'fastparquet', the default is 'auto' [default: auto] [currently: auto]

mode.chained_assignment [string] Raise an exception, warn, or no action if trying to use chained assignment, The default is warn [default: warn] [currently: warn]

mode.sim_interactive [boolean] Whether to simulate interactive mode for purposes of testing [default: False] [currently: False]

mode.use_inf_as_na [boolean] True means treat None, NaN, INF, -INF as NA (old way), False means None and NaN are null, but INF, -INF are not NA (new way). [default: False] [currently: False]

mode.use_inf_as_null use_inf_as_null had been deprecated and will be removed in a future version. Use *use_inf_as_na* instead.

[default: False] [currently: False] (Deprecated, use *mode.use_inf_as_na* instead.)

34.19.1.3 pandas.get_option

`pandas.get_option(pat)` = **<pandas.core.config.CallableDynamicDoc object>**

Retrieves the value of the specified option.

Available options:

- compute.[use_bottleneck, use_numexpr]
- display.[chop_threshold, colheader_justify, column_space, date_dayfirst, date_yearfirst, encoding, expand_frame_repr, float_format, height]
- display.html.[border, table_schema]
- display.[large_repr]
- display.latex.[escape, longtable, multicolumn, multicolumn_format, multirow, repr]
- display.[line_width, max_categories, max_columns, max_colwidth, max_info_columns, max_info_rows, max_rows, max_seq_items, memory_usage, multi_sparse, notebook_repr_html, pprint_nest_depth, precision, show_dimensions]
- display.unicode.[ambiguous_as_wide, east_asian_width]
- display.[width]
- html.[border]
- io.excel.xls.[writer]
- io.excel.xlsm.[writer]
- io.excel.xlsx.[writer]
- io.hdf.[default_format, dropna_table]
- io.parquet.[engine]
- mode.[chained_assignment, sim_interactive, use_inf_as_na, use_inf_as_null]

Parameters **pat** : str

Regexp which should match a single option. Note: partial matches are supported for convenience, but unless you use the full option name (e.g. x.y.z.option_name), your code may break in future versions if new options with similar names are introduced.

Returns **result** : the value of the option

Raises **OptionError** : if no such option exists

Notes

The available options with its descriptions:

compute.use_bottleneck [bool] Use the bottleneck library to accelerate if it is installed, the default is True Valid values: False,True [default: True] [currently: True]

compute.use_numexpr [bool] Use the numexpr library to accelerate computation if it is installed, the default is True Valid values: False,True [default: True] [currently: True]

display.chop_threshold [float or None] if set to a float value, all float values smaller then the given threshold will be displayed as exactly 0 by repr and friends. [default: None] [currently: None]

display.colheader_justify ['left'/'right'] Controls the justification of column headers. used by DataFrameFormatter. [default: right] [currently: right]

display.column_space No description available. [default: 12] [currently: 12]

display.date_dayfirst [boolean] When True, prints and parses dates with the day first, eg 20/01/2005 [default: False] [currently: False]

display.date_yearfirst [boolean] When True, prints and parses dates with the year first, eg 2005/01/20 [default: False] [currently: False]

display.encoding [str/unicode] Defaults to the detected encoding of the console. Specifies the encoding to be used for strings returned by to_string, these are generally strings meant to be displayed on the console. [default: UTF-8] [currently: UTF-8]

display.expand_frame_repr [boolean] Whether to print out the full DataFrame repr for wide DataFrames across multiple lines, *max_columns* is still respected, but the output will wrap-around across multiple "pages" if its width exceeds *display.width*. [default: True] [currently: True]

display.float_format [callable] The callable should accept a floating point number and return a string with the desired format of the number. This is used in some places like SeriesFormatter. See formats.format.EngFormatter for an example. [default: None] [currently: None]

display.height [int] Deprecated. [default: 60] [currently: 60]

display.html.border [int] A `border=value` attribute is inserted in the `<table>` tag for the DataFrame HTML repr. [default: 1] [currently: 1]

display.html.table_schema [boolean] Whether to publish a Table Schema representation for frontends that support it. (default: False) [default: False] [currently: False]

display.large_repr ['truncate'/'info'] For DataFrames exceeding max_rows/max_cols, the repr (and HTML repr) can show a truncated table (the default from 0.13), or switch to the view from df.info() (the behaviour in earlier versions of pandas). [default: truncate] [currently: truncate]

display.latex.escape [bool] This specifies if the to_latex method of a Dataframe uses escapes special characters. Valid values: False,True [default: True] [currently: True]

display.latex.longtable :bool This specifies if the to_latex method of a Dataframe uses the longtable format. Valid values: False,True [default: False] [currently: False]

display.latex.multicolumn [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: True] [currently: True]

display.latex.multicolumn_format [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: l] [currently: l]

display.latex.multirow [bool] This specifies if the to_latex method of a Dataframe uses multirows to pretty-print MultiIndex rows. Valid values: False,True [default: False] [currently: False]

display.latex.repr [boolean] Whether to produce a latex DataFrame representation for jupyter environments that support it. (default: False) [default: False] [currently: False]

display.line_width [int] Deprecated. [default: 80] [currently: 80]

display.max_categories [int] This sets the maximum number of categories pandas should output when printing out a *Categorical* or a Series of dtype "category". [default: 8] [currently: 8]

display.max_columns [int] If max_cols is exceeded, switch to truncate view. Depending on *large_repr*, objects are either centrally truncated or printed as a summary view. 'None' value means unlimited.

In case python/IPython is running in a terminal and *large_repr* equals 'truncate' this can be set to 0 and pandas will auto-detect the width of the terminal and print a truncated object which fits the screen width. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 20] [currently: 20]

display.max_colwidth [int] The maximum width in characters of a column in the repr of a pandas data structure. When the column overflows, a "..." placeholder is embedded in the output. [default: 50] [currently: 50]

display.max_info_columns [int] max_info_columns is used in DataFrame.info method to decide if per column information will be printed. [default: 100] [currently: 100]

display.max_info_rows [int or None] df.info() will usually show null-counts for each column. For large frames this can be quite slow. max_info_rows and max_info_cols limit this null check only to frames with smaller dimensions than specified. [default: 1690785] [currently: 1690785]

display.max_rows [int] If max_rows is exceeded, switch to truncate view. Depending on *large_repr*, objects are either centrally truncated or printed as a summary view. 'None' value means unlimited.

In case python/IPython is running in a terminal and *large_repr* equals 'truncate' this can be set to 0 and pandas will auto-detect the height of the terminal and print a truncated object which fits the screen height. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 60] [currently: 15]

display.max_seq_items [int or None] when pretty-printing a long sequence, no more then *max_seq_items* will be printed. If items are omitted, they will be denoted by the addition of "..." to the resulting string.

If set to None, the number of items to be printed is unlimited. [default: 100] [currently: 100]

display.memory_usage [bool, string or None] This specifies if the memory usage of a DataFrame should be displayed when df.info() is called. Valid values True,False,'deep' [default: True] [currently: True]

display.multi_sparse [boolean] "sparsify" MultiIndex display (don't display repeated elements in outer levels within groups) [default: True] [currently: True]

display.notebook_repr_html [boolean] When True, IPython notebook will use html representation for pandas objects (if it is available). [default: True] [currently: True]

display.pprint_nest_depth [int] Controls the number of nested levels to process when pretty-printing [default: 3] [currently: 3]

display.precision [int] Floating point output precision (number of significant digits). This is only a suggestion [default: 6] [currently: 6]

display.show_dimensions [boolean or 'truncate'] Whether to print out dimensions at the end of DataFrame repr. If 'truncate' is specified, only print out the dimensions if the frame is truncated (e.g. not display all rows and/or columns) [default: truncate] [currently: truncate]

display.unicode.ambiguous_as_wide [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.unicode.east_asian_width [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.width [int] Width of the display in characters. In case python/IPython is running in a terminal this can be set to None and pandas will correctly auto-detect the width. Note that the IPython notebook, IPython

qtconsole, or IDLE do not run in a terminal and hence it is not possible to correctly detect the width. [default: 80] [currently: 80]

html.border [int] A `border=value` attribute is inserted in the `<table>` tag for the DataFrame HTML repr. [default: 1] [currently: 1] (Deprecated, use *display.html.border* instead.)

io.excel.xls.writer [string] The default Excel writer engine for 'xls' files. Available options: auto, xlwt. [default: auto] [currently: auto]

io.excel.xlsm.writer [string] The default Excel writer engine for 'xlsm' files. Available options: auto, openpyxl. [default: auto] [currently: auto]

io.excel.xlsx.writer [string] The default Excel writer engine for 'xlsx' files. Available options: auto, openpyxl, xlsxwriter. [default: auto] [currently: auto]

io.hdf.default_format [format] default format writing format, if None, then put will default to 'fixed' and append will default to 'table' [default: None] [currently: None]

io.hdf.dropna_table [boolean] drop ALL nan rows when appending to a table [default: False] [currently: False]

io.parquet.engine [string] The default parquet reader/writer engine. Available options: 'auto', 'pyarrow', 'fastparquet', the default is 'auto' [default: auto] [currently: auto]

mode.chained_assignment [string] Raise an exception, warn, or no action if trying to use chained assignment, The default is warn [default: warn] [currently: warn]

mode.sim_interactive [boolean] Whether to simulate interactive mode for purposes of testing [default: False] [currently: False]

mode.use_inf_as_na [boolean] True means treat None, NaN, INF, -INF as NA (old way), False means None and NaN are null, but INF, -INF are not NA (new way). [default: False] [currently: False]

mode.use_inf_as_null use_inf_as_null had been deprecated and will be removed in a future version. Use *use_inf_as_na* instead.

[default: False] [currently: False] (Deprecated, use *mode.use_inf_as_na* instead.)

34.19.1.4 pandas.set_option

`pandas.`**`set_option`**(*pat*, *value*) **= <pandas.core.config.CallableDynamicDoc object>**

Sets the value of the specified option.

Available options:

- compute.[use_bottleneck, use_numexpr]
- display.[chop_threshold, colheader_justify, column_space, date_dayfirst, date_yearfirst, encoding, expand_frame_repr, float_format, height]
- display.html.[border, table_schema]
- display.[large_repr]
- display.latex.[escape, longtable, multicolumn, multicolumn_format, multirow, repr]
- display.[line_width, max_categories, max_columns, max_colwidth, max_info_columns, max_info_rows, max_rows, max_seq_items, memory_usage, multi_sparse, notebook_repr_html, pprint_nest_depth, precision, show_dimensions]
- display.unicode.[ambiguous_as_wide, east_asian_width]
- display.[width]

- html.[border]
- io.excel.xls.[writer]
- io.excel.xlsm.[writer]
- io.excel.xlsx.[writer]
- io.hdf.[default_format, dropna_table]
- io.parquet.[engine]
- mode.[chained_assignment, sim_interactive, use_inf_as_na, use_inf_as_null]

Parameters **pat** : str

Regexp which should match a single option. Note: partial matches are supported for convenience, but unless you use the full option name (e.g. x.y.z.option_name), your code may break in future versions if new options with similar names are introduced.

value :

new value of option.

Returns None

Raises **OptionError if no such option exists**

Notes

The available options with its descriptions:

compute.use_bottleneck [bool] Use the bottleneck library to accelerate if it is installed, the default is True Valid values: False,True [default: True] [currently: True]

compute.use_numexpr [bool] Use the numexpr library to accelerate computation if it is installed, the default is True Valid values: False,True [default: True] [currently: True]

display.chop_threshold [float or None] if set to a float value, all float values smaller then the given threshold will be displayed as exactly 0 by repr and friends. [default: None] [currently: None]

display.colheader_justify ['left'/'right'] Controls the justification of column headers. used by DataFrameFormatter. [default: right] [currently: right]

display.column_space No description available. [default: 12] [currently: 12]

display.date_dayfirst [boolean] When True, prints and parses dates with the day first, eg 20/01/2005 [default: False] [currently: False]

display.date_yearfirst [boolean] When True, prints and parses dates with the year first, eg 2005/01/20 [default: False] [currently: False]

display.encoding [str/unicode] Defaults to the detected encoding of the console. Specifies the encoding to be used for strings returned by to_string, these are generally strings meant to be displayed on the console. [default: UTF-8] [currently: UTF-8]

display.expand_frame_repr [boolean] Whether to print out the full DataFrame repr for wide DataFrames across multiple lines, *max_columns* is still respected, but the output will wrap-around across multiple "pages" if its width exceeds *display.width*. [default: True] [currently: True]

display.float_format [callable] The callable should accept a floating point number and return a string with the desired format of the number. This is used in some places like SeriesFormatter. See formats.format.EngFormatter for an example. [default: None] [currently: None]

display.height [int] Deprecated. [default: 60] [currently: 60]

display.html.border [int] A `border=value` attribute is inserted in the `<table>` tag for the DataFrame HTML repr. [default: 1] [currently: 1]

display.html.table_schema [boolean] Whether to publish a Table Schema representation for frontends that support it. (default: False) [default: False] [currently: False]

display.large_repr ['truncate'/'info'] For DataFrames exceeding max_rows/max_cols, the repr (and HTML repr) can show a truncated table (the default from 0.13), or switch to the view from df.info() (the behaviour in earlier versions of pandas). [default: truncate] [currently: truncate]

display.latex.escape [bool] This specifies if the to_latex method of a Dataframe uses escapes special characters. Valid values: False,True [default: True] [currently: True]

display.latex.longtable :bool This specifies if the to_latex method of a Dataframe uses the longtable format. Valid values: False,True [default: False] [currently: False]

display.latex.multicolumn [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: True] [currently: True]

display.latex.multicolumn_format [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: l] [currently: l]

display.latex.multirow [bool] This specifies if the to_latex method of a Dataframe uses multirows to pretty-print MultiIndex rows. Valid values: False,True [default: False] [currently: False]

display.latex.repr [boolean] Whether to produce a latex DataFrame representation for jupyter environments that support it. (default: False) [default: False] [currently: False]

display.line_width [int] Deprecated. [default: 80] [currently: 80]

display.max_categories [int] This sets the maximum number of categories pandas should output when printing out a *Categorical* or a Series of dtype "category". [default: 8] [currently: 8]

display.max_columns [int] If max_cols is exceeded, switch to truncate view. Depending on *large_repr*, objects are either centrally truncated or printed as a summary view. 'None' value means unlimited.

In case python/IPython is running in a terminal and *large_repr* equals 'truncate' this can be set to 0 and pandas will auto-detect the width of the terminal and print a truncated object which fits the screen width. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 20] [currently: 20]

display.max_colwidth [int] The maximum width in characters of a column in the repr of a pandas data structure. When the column overflows, a "..." placeholder is embedded in the output. [default: 50] [currently: 50]

display.max_info_columns [int] max_info_columns is used in DataFrame.info method to decide if per column information will be printed. [default: 100] [currently: 100]

display.max_info_rows [int or None] df.info() will usually show null-counts for each column. For large frames this can be quite slow. max_info_rows and max_info_cols limit this null check only to frames with smaller dimensions than specified. [default: 1690785] [currently: 1690785]

display.max_rows [int] If max_rows is exceeded, switch to truncate view. Depending on *large_repr*, objects are either centrally truncated or printed as a summary view. 'None' value means unlimited.

In case python/IPython is running in a terminal and *large_repr* equals 'truncate' this can be set to 0 and pandas will auto-detect the height of the terminal and print a truncated object which fits the screen height. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 60] [currently: 15]

display.max_seq_items [int or None] when pretty-printing a long sequence, no more then *max_seq_items* will be printed. If items are omitted, they will be denoted by the addition of "..." to the resulting string.

If set to None, the number of items to be printed is unlimited. [default: 100] [currently: 100]

display.memory_usage [bool, string or None] This specifies if the memory usage of a DataFrame should be displayed when df.info() is called. Valid values True,False,'deep' [default: True] [currently: True]

display.multi_sparse [boolean] "sparsify" MultiIndex display (don't display repeated elements in outer levels within groups) [default: True] [currently: True]

display.notebook_repr_html [boolean] When True, IPython notebook will use html representation for pandas objects (if it is available). [default: True] [currently: True]

display.pprint_nest_depth [int] Controls the number of nested levels to process when pretty-printing [default: 3] [currently: 3]

display.precision [int] Floating point output precision (number of significant digits). This is only a suggestion [default: 6] [currently: 6]

display.show_dimensions [boolean or 'truncate'] Whether to print out dimensions at the end of DataFrame repr. If 'truncate' is specified, only print out the dimensions if the frame is truncated (e.g. not display all rows and/or columns) [default: truncate] [currently: truncate]

display.unicode.ambiguous_as_wide [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.unicode.east_asian_width [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.width [int] Width of the display in characters. In case python/IPython is running in a terminal this can be set to None and pandas will correctly auto-detect the width. Note that the IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to correctly detect the width. [default: 80] [currently: 80]

html.border [int] A `border=value` attribute is inserted in the `<table>` tag for the DataFrame HTML repr. [default: 1] [currently: 1] (Deprecated, use *display.html.border* instead.)

io.excel.xls.writer [string] The default Excel writer engine for 'xls' files. Available options: auto, xlwt. [default: auto] [currently: auto]

io.excel.xlsm.writer [string] The default Excel writer engine for 'xlsm' files. Available options: auto, openpyxl. [default: auto] [currently: auto]

io.excel.xlsx.writer [string] The default Excel writer engine for 'xlsx' files. Available options: auto, openpyxl, xlsxwriter. [default: auto] [currently: auto]

io.hdf.default_format [format] default format writing format, if None, then put will default to 'fixed' and append will default to 'table' [default: None] [currently: None]

io.hdf.dropna_table [boolean] drop ALL nan rows when appending to a table [default: False] [currently: False]

io.parquet.engine [string] The default parquet reader/writer engine. Available options: 'auto', 'pyarrow', 'fastparquet', the default is 'auto' [default: auto] [currently: auto]

mode.chained_assignment [string] Raise an exception, warn, or no action if trying to use chained assignment, The default is warn [default: warn] [currently: warn]

mode.sim_interactive [boolean] Whether to simulate interactive mode for purposes of testing [default: False] [currently: False]

mode.use_inf_as_na [boolean] True means treat None, NaN, INF, -INF as NA (old way), False means None and NaN are null, but INF, -INF are not NA (new way). [default: False] [currently: False]

mode.use_inf_as_null use_inf_as_null had been deprecated and will be removed in a future version. Use *use_inf_as_na* instead.

[default: False] [currently: False] (Deprecated, use *mode.use_inf_as_na* instead.)

34.19.1.5 pandas.option_context

class `pandas.`**`option_context`**`(`**args*`)`

Context manager to temporarily set options in the *with* statement context.

You need to invoke as `option_context(pat, val, [(pat, val), ...])`.

Examples

```
>>> with option_context('display.max_rows', 10, 'display.max_columns', 5):
        ...
```

34.19.2 Testing functions

`testing.assert_frame_equal`(left, right[, ...])	Check that left and right DataFrame are equal.
`testing.assert_series_equal`(left, right[, ...])	Check that left and right Series are equal.
`testing.assert_index_equal`(left, right[, ...])	Check that left and right Index are equal.

34.19.2.1 pandas.testing.assert_frame_equal

`pandas.testing.`**`assert_frame_equal`**`(`*left, right, check_dtype=True, check_index_type='equiv', check_column_type='equiv', check_frame_type=True, check_less_precise=False, check_names=True, by_blocks=False, check_exact=False, check_datetimelike_compat=False, check_categorical=True, check_like=False, obj='DataFrame'*`)`

Check that left and right DataFrame are equal.

Parameters **left** : DataFrame

right : DataFrame

check_dtype : bool, default True

Whether to check the DataFrame dtype is identical.

check_index_type : bool / string {'equiv'}, default False

Whether to check the Index class, dtype and inferred_type are identical.

check_column_type : bool / string {'equiv'}, default False

Whether to check the columns class, dtype and inferred_type are identical.

check_frame_type : bool, default False

Whether to check the DataFrame class is identical.

check_less_precise : bool or int, default False

Specify comparison precision. Only used when check_exact is False. 5 digits (False) or 3 digits (True) after decimal points are compared. If int, then specify the digits to compare

check_names : bool, default True

Whether to check the Index names attribute.

by_blocks : bool, default False

Specify how to compare internal data. If False, compare by columns. If True, compare by blocks.

check_exact : bool, default False

Whether to compare number exactly.

check_datetimelike_compat : bool, default False

Compare datetime-like which is comparable ignoring dtype.

check_categorical : bool, default True

Whether to compare internal Categorical exactly.

check_like : bool, default False

If true, ignore the order of rows & columns

obj : str, default 'DataFrame'

Specify object name being compared, internally used to show appropriate assertion message

34.19.2.2 pandas.testing.assert_series_equal

`pandas.testing.`**`assert_series_equal`**(*left*, *right*, *check_dtype=True*, *check_index_type='equiv'*, *check_series_type=True*, *check_less_precise=False*, *check_names=True*, *check_exact=False*, *check_datetimelike_compat=False*, *check_categorical=True*, *obj='Series'*)

Check that left and right Series are equal.

Parameters **left** : Series

right : Series

check_dtype : bool, default True

Whether to check the Series dtype is identical.

check_index_type : bool / string {'equiv'}, default 'equiv'

Whether to check the Index class, dtype and inferred_type are identical.

check_series_type : bool, default True

Whether to check the Series class is identical.

check_less_precise : bool or int, default False

Specify comparison precision. Only used when check_exact is False. 5 digits (False) or 3 digits (True) after decimal points are compared. If int, then specify the digits to compare

check_exact : bool, default False

Whether to compare number exactly.

check_names : bool, default True

Whether to check the Series and Index names attribute.

check_datetimelike_compat : bool, default False

Compare datetime-like which is comparable ignoring dtype.

check_categorical : bool, default True

Whether to compare internal Categorical exactly.

obj : str, default 'Series'

Specify object name being compared, internally used to show appropriate assertion message

34.19.2.3 pandas.testing.assert_index_equal

`pandas.testing.`**`assert_index_equal`**(*left*, *right*, *exact='equiv'*, *check_names=True*, *check_less_precise=False*, *check_exact=True*, *check_categorical=True*, *obj='Index'*)

Check that left and right Index are equal.

Parameters **left** : Index

right : Index

exact : bool / string {'equiv'}, default False

Whether to check the Index class, dtype and inferred_type are identical. If 'equiv', then RangeIndex can be substituted for Int64Index as well.

check_names : bool, default True

Whether to check the names attribute.

check_less_precise : bool or int, default False

Specify comparison precision. Only used when check_exact is False. 5 digits (False) or 3 digits (True) after decimal points are compared. If int, then specify the digits to compare

check_exact : bool, default True

Whether to compare number exactly.

check_categorical : bool, default True

Whether to compare internal Categorical exactly.

obj : str, default 'Index'

Specify object name being compared, internally used to show appropriate assertion message

Continued on next page

Table 34.164 – continued from previous page

34.19.3 Exceptions and warnings

errors.DtypeWarning	Warning that is raised for a dtype incompatiblity.
errors.EmptyDataError	Exception that is thrown in *pd.read_csv* (by both the C and Python engines) when empty data or header is encountered.
errors.OutOfBoundsDatetime	
errors.ParserError	Exception that is raised by an error encountered in *pd.read_csv*.
errors.ParserWarning	Warning that is raised in *pd.read_csv* whenever it is necessary to change parsers (generally from 'c' to 'python') contrary to the one specified by the user due to lack of support or functionality for parsing particular attributes of a CSV file with the requsted engine.
errors.PerformanceWarning	Warning raised when there is a possible performance impact.
errors.UnsortedIndexError	Error raised when attempting to get a slice of a MultiIndex, and the index has not been lexsorted.
errors.UnsupportedFunctionCall	Exception raised when attempting to call a numpy function on a pandas object, but that function is not supported by the object e.g.

34.19.3.1 pandas.errors.DtypeWarning

exception pandas.errors.**DtypeWarning**

Warning that is raised for a dtype incompatiblity. This can happen whenever *pd.read_csv* encounters non-uniform dtypes in a column(s) of a given CSV file.

34.19.3.2 pandas.errors.EmptyDataError

exception pandas.errors.**EmptyDataError**

Exception that is thrown in *pd.read_csv* (by both the C and Python engines) when empty data or header is encountered.

34.19.3.3 pandas.errors.OutOfBoundsDatetime

exception pandas.errors.**OutOfBoundsDatetime**

34.19.3.4 pandas.errors.ParserError

exception pandas.errors.**ParserError**

Exception that is raised by an error encountered in *pd.read_csv*.

34.19.3.5 pandas.errors.ParserWarning

exception pandas.errors.**ParserWarning**

Warning that is raised in *pd.read_csv* whenever it is necessary to change parsers (generally from 'c' to 'python')

contrary to the one specified by the user due to lack of support or functionality for parsing particular attributes of a CSV file with the requsted engine.

34.19.3.6 pandas.errors.PerformanceWarning

exception `pandas.errors.`**`PerformanceWarning`**

Warning raised when there is a possible performance impact.

34.19.3.7 pandas.errors.UnsortedIndexError

exception `pandas.errors.`**`UnsortedIndexError`**

Error raised when attempting to get a slice of a MultiIndex, and the index has not been lexsorted. Subclass of *KeyError*.

New in version 0.20.0.

34.19.3.8 pandas.errors.UnsupportedFunctionCall

exception `pandas.errors.`**`UnsupportedFunctionCall`**

Exception raised when attempting to call a numpy function on a pandas object, but that function is not supported by the object e.g. `np.cumsum(groupby_object)`.

34.19.4 Data types related functionality

`api.types.union_categoricals`(to_union[, ...])	Combine list-like of Categorical-like, unioning categories.
`api.types.infer_dtype`	Efficiently infer the type of a passed val, or list-like array of values.
`api.types.pandas_dtype`(dtype)	Converts input into a pandas only dtype object or a numpy dtype object.

34.19.4.1 pandas.api.types.union_categoricals

`pandas.api.types.`**`union_categoricals`**(*to_union*, *sort_categories=False*, *ignore_order=False*)

Combine list-like of Categorical-like, unioning categories. All categories must have the same dtype.

New in version 0.19.0.

Parameters **to_union** : list-like of Categorical, CategoricalIndex,

or Series with dtype='category'

sort_categories : boolean, default False

If true, resulting categories will be lexsorted, otherwise they will be ordered as they appear in the data.

ignore_order: boolean, default False

If true, the ordered attribute of the Categoricals will be ignored. Results in an unordered categorical.

New in version 0.20.0.

Returns **result** : Categorical

Raises **TypeError**

- all inputs do not have the same dtype
- all inputs do not have the same ordered property
- all inputs are ordered and their categories are not identical
- sort_categories=True and Categoricals are ordered

ValueError

Empty list of categoricals passed

Notes

To learn more about categories, see link

Examples

```
>>> from pandas.api.types import union_categoricals
```

If you want to combine categoricals that do not necessarily have the same categories, *union_categoricals* will combine a list-like of categoricals. The new categories will be the union of the categories being combined.

```
>>> a = pd.Categorical(["b", "c"])
>>> b = pd.Categorical(["a", "b"])
>>> union_categoricals([a, b])
[b, c, a, b]
Categories (3, object): [b, c, a]
```

By default, the resulting categories will be ordered as they appear in the *categories* of the data. If you want the categories to be lexsorted, use *sort_categories=True* argument.

```
>>> union_categoricals([a, b], sort_categories=True)
[b, c, a, b]
Categories (3, object): [a, b, c]
```

union_categoricals also works with the case of combining two categoricals of the same categories and order information (e.g. what you could also *append* for).

```
>>> a = pd.Categorical(["a", "b"], ordered=True)
>>> b = pd.Categorical(["a", "b", "a"], ordered=True)
>>> union_categoricals([a, b])
[a, b, a, b, a]
Categories (2, object): [a < b]
```

Raises *TypeError* because the categories are ordered and not identical.

```
>>> a = pd.Categorical(["a", "b"], ordered=True)
>>> b = pd.Categorical(["a", "b", "c"], ordered=True)
>>> union_categoricals([a, b])
TypeError: to union ordered Categoricals, all categories must be the same
```

New in version 0.20.0

Ordered categoricals with different categories or orderings can be combined by using the *ignore_ordered=True* argument.

```
>>> a = pd.Categorical(["a", "b", "c"], ordered=True)
>>> b = pd.Categorical(["c", "b", "a"], ordered=True)
>>> union_categoricals([a, b], ignore_order=True)
[a, b, c, c, b, a]
Categories (3, object): [a, b, c]
```

union_categoricals also works with a *CategoricalIndex*, or *Series* containing categorical data, but note that the resulting array will always be a plain *Categorical*

```
>>> a = pd.Series(["b", "c"], dtype='category')
>>> b = pd.Series(["a", "b"], dtype='category')
>>> union_categoricals([a, b])
[b, c, a, b]
Categories (3, object): [b, c, a]
```

34.19.4.2 pandas.api.types.infer_dtype

`pandas.api.types.`**`infer_dtype`**`()`

Efficiently infer the type of a passed val, or list-like array of values. Return a string describing the type.

Parameters **value** : scalar, list, ndarray, or pandas type

skipna : bool, default False

Ignore NaN values when inferring the type. The default of `False` will be deprecated in a later version of pandas.

New in version 0.21.0.

Returns string describing the common type of the input data.

Results can include:

- string
- unicode
- bytes
- floating
- integer
- mixed-integer
- mixed-integer-float
- decimal
- complex
- categorical
- boolean
- datetime64
- datetime
- date
- timedelta64
- timedelta

- time
- period
- mixed

Raises **TypeError if ndarray-like but cannot infer the dtype**

Notes

- 'mixed' is the catchall for anything that is not otherwise specialized
- 'mixed-integer-float' are floats and integers
- 'mixed-integer' are integers mixed with non-integers

Examples

```
>>> infer_dtype(['foo', 'bar'])
'string'
```

```
>>> infer_dtype(['a', np.nan, 'b'], skipna=True)
'string'
```

```
>>> infer_dtype(['a', np.nan, 'b'], skipna=False)
'mixed'
```

```
>>> infer_dtype([b'foo', b'bar'])
'bytes'
```

```
>>> infer_dtype([1, 2, 3])
'integer'
```

```
>>> infer_dtype([1, 2, 3.5])
'mixed-integer-float'
```

```
>>> infer_dtype([1.0, 2.0, 3.5])
'floating'
```

```
>>> infer_dtype(['a', 1])
'mixed-integer'
```

```
>>> infer_dtype([Decimal(1), Decimal(2.0)])
'decimal'
```

```
>>> infer_dtype([True, False])
'boolean'
```

```
>>> infer_dtype([True, False, np.nan])
'mixed'
```

```
>>> infer_dtype([pd.Timestamp('20130101')])
'datetime'
```

```
>>> infer_dtype([datetime.date(2013, 1, 1)])
'date'
```

```
>>> infer_dtype([np.datetime64('2013-01-01')])
'datetime64'
```

```
>>> infer_dtype([datetime.timedelta(0, 1, 1)])
'timedelta'
```

```
>>> infer_dtype(pd.Series(list('aabc')).astype('category'))
'categorical'
```

34.19.4.3 pandas.api.types.pandas_dtype

`pandas.api.types.`**`pandas_dtype`**(*dtype*)

Converts input into a pandas only dtype object or a numpy dtype object.

Parameters **dtype** : object to be converted

Returns np.dtype or a pandas dtype

Dtype introspection

api.types.is_bool_dtype(arr_or_dtype)	Check whether the provided array or dtype is of a boolean dtype.
api.types.is_categorical_dtype(arr_or_dtype)	Check whether an array-like or dtype is of the Categorical dtype.
api.types.is_complex_dtype(arr_or_dtype)	Check whether the provided array or dtype is of a complex dtype.
api.types.is_datetime64_any_dtype(arr_or_dtype)	Check whether the provided array or dtype is of the datetime64 dtype.
api.types.is_datetime64_dtype(arr_or_dtype)	Check whether an array-like or dtype is of the datetime64 dtype.
api.types.is_datetime64_ns_dtype(arr_or_dtype)	Check whether the provided array or dtype is of the datetime64[ns] dtype.
api.types.is_datetime64tz_dtype(arr_or_dtype)	Check whether an array-like or dtype is of a DatetimeTZDtype dtype.
api.types.is_extension_type(arr)	Check whether an array-like is of a pandas extension class instance.
api.types.is_float_dtype(arr_or_dtype)	Check whether the provided array or dtype is of a float dtype.
api.types.is_int64_dtype(arr_or_dtype)	Check whether the provided array or dtype is of the int64 dtype.
api.types.is_integer_dtype(arr_or_dtype)	Check whether the provided array or dtype is of an integer dtype.
api.types.is_interval_dtype(arr_or_dtype)	Check whether an array-like or dtype is of the Interval dtype.
api.types.is_numeric_dtype(arr_or_dtype)	Check whether the provided array or dtype is of a numeric dtype.

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api.types.is_object_dtype(arr_or_dtype)	Check whether an array-like or dtype is of the object dtype.
api.types.is_period_dtype(arr_or_dtype)	Check whether an array-like or dtype is of the Period dtype.
api.types.is_signed_integer_dtype(arr_or_dtype)	Check whether the provided array or dtype is of a signed integer dtype.
api.types.is_string_dtype(arr_or_dtype)	Check whether the provided array or dtype is of the string dtype.
api.types.is_timedelta64_dtype(arr_or_dtype)	Check whether an array-like or dtype is of the timedelta64 dtype.
api.types.is_timedelta64_ns_dtype(arr_or_dtype)	Check whether the provided array or dtype is of the timedelta64[ns] dtype.
api.types.is_unsigned_integer_dtype(arr_or_dtype)	Check whether the provided array or dtype is of an unsigned integer dtype.
api.types.is_sparse(arr)	Check whether an array-like is a pandas sparse array.

34.19.4.4 pandas.api.types.is_bool_dtype

`pandas.api.types.`**`is_bool_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of a boolean dtype.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of a boolean dtype.

Examples

```
>>> is_bool_dtype(str)
False
>>> is_bool_dtype(int)
False
>>> is_bool_dtype(bool)
True
>>> is_bool_dtype(np.bool)
True
>>> is_bool_dtype(np.array(['a', 'b']))
False
>>> is_bool_dtype(pd.Series([1, 2]))
False
>>> is_bool_dtype(np.array([True, False]))
True
```

34.19.4.5 pandas.api.types.is_categorical_dtype

`pandas.api.types.`**`is_categorical_dtype`**(*arr_or_dtype*)

Check whether an array-like or dtype is of the Categorical dtype.

Parameters **arr_or_dtype** : array-like

The array-like or dtype to check.

Returns **boolean** : Whether or not the array-like or dtype is

of the Categorical dtype.

Examples

```
>>> is_categorical_dtype(object)
False
>>> is_categorical_dtype(CategoricalDtype())
True
>>> is_categorical_dtype([1, 2, 3])
False
>>> is_categorical_dtype(pd.Categorical([1, 2, 3]))
True
>>> is_categorical_dtype(pd.CategoricalIndex([1, 2, 3]))
True
```

34.19.4.6 pandas.api.types.is_complex_dtype

`pandas.api.types.`**`is_complex_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of a complex dtype.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of a compex dtype.

Examples

```
>>> is_complex_dtype(str)
False
>>> is_complex_dtype(int)
False
>>> is_complex_dtype(np.complex)
True
>>> is_complex_dtype(np.array(['a', 'b']))
False
>>> is_complex_dtype(pd.Series([1, 2]))
False
>>> is_complex_dtype(np.array([1 + 1j, 5]))
True
```

34.19.4.7 pandas.api.types.is_datetime64_any_dtype

`pandas.api.types.`**`is_datetime64_any_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of the datetime64 dtype.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of the datetime64 dtype.

Examples

```
>>> is_datetime64_any_dtype(str)
False
>>> is_datetime64_any_dtype(int)
False
>>> is_datetime64_any_dtype(np.datetime64)  # can be tz-naive
True
>>> is_datetime64_any_dtype(DatetimeTZDtype("ns", "US/Eastern"))
True
>>> is_datetime64_any_dtype(np.array(['a', 'b']))
False
>>> is_datetime64_any_dtype(np.array([1, 2]))
False
>>> is_datetime64_any_dtype(np.array([], dtype=np.datetime64))
True
>>> is_datetime64_any_dtype(pd.DatetimeIndex([1, 2, 3],
                            dtype=np.datetime64))
True
```

34.19.4.8 pandas.api.types.is_datetime64_dtype

`pandas.api.types.`**`is_datetime64_dtype`**(*arr_or_dtype*)

Check whether an array-like or dtype is of the datetime64 dtype.

Parameters **arr_or_dtype** : array-like

The array-like or dtype to check.

Returns **boolean** : Whether or not the array-like or dtype is of

the datetime64 dtype.

Examples

```
>>> is_datetime64_dtype(object)
False
>>> is_datetime64_dtype(np.datetime64)
True
>>> is_datetime64_dtype(np.array([], dtype=int))
False
>>> is_datetime64_dtype(np.array([], dtype=np.datetime64))
True
>>> is_datetime64_dtype([1, 2, 3])
False
```

34.19.4.9 pandas.api.types.is_datetime64_ns_dtype

`pandas.api.types.`**`is_datetime64_ns_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of the datetime64[ns] dtype.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of the datetime64[ns] dtype.

Examples

```
>>> is_datetime64_ns_dtype(str)
False
>>> is_datetime64_ns_dtype(int)
False
>>> is_datetime64_ns_dtype(np.datetime64)  # no unit
False
>>> is_datetime64_ns_dtype(DatetimeTZDtype("ns", "US/Eastern"))
True
>>> is_datetime64_ns_dtype(np.array(['a', 'b']))
False
>>> is_datetime64_ns_dtype(np.array([1, 2]))
False
>>> is_datetime64_ns_dtype(np.array([], dtype=np.datetime64))  # no unit
False
>>> is_datetime64_ns_dtype(np.array([],
                           dtype="datetime64[ps]"))  # wrong unit
False
>>> is_datetime64_ns_dtype(pd.DatetimeIndex([1, 2, 3],
                           dtype=np.datetime64))  # has 'ns' unit
True
```

34.19.4.10 pandas.api.types.is_datetime64tz_dtype

`pandas.api.types.`**`is_datetime64tz_dtype`**(*arr_or_dtype*)

Check whether an array-like or dtype is of a DatetimeTZDtype dtype.

Parameters **arr_or_dtype** : array-like

The array-like or dtype to check.

Returns **boolean** : Whether or not the array-like or dtype is of

a DatetimeTZDtype dtype.

Examples

```
>>> is_datetime64tz_dtype(object)
False
>>> is_datetime64tz_dtype([1, 2, 3])
False
>>> is_datetime64tz_dtype(pd.DatetimeIndex([1, 2, 3]))  # tz-naive
False
>>> is_datetime64tz_dtype(pd.DatetimeIndex([1, 2, 3], tz="US/Eastern"))
True
```

```
>>> dtype = DatetimeTZDtype("ns", tz="US/Eastern")
>>> s = pd.Series([], dtype=dtype)
>>> is_datetime64tz_dtype(dtype)
True
>>> is_datetime64tz_dtype(s)
True
```

34.19.4.11 pandas.api.types.is_extension_type

`pandas.api.types.is_extension_type(arr)`

Check whether an array-like is of a pandas extension class instance.

Extension classes include categoricals, pandas sparse objects (i.e. classes represented within the pandas library and not ones external to it like scipy sparse matrices), and datetime-like arrays.

Parameters **arr** : array-like

The array-like to check.

Returns **boolean** : Whether or not the array-like is of a pandas

extension class instance.

Examples

```
>>> is_extension_type([1, 2, 3])
False
>>> is_extension_type(np.array([1, 2, 3]))
False
>>>
>>> cat = pd.Categorical([1, 2, 3])
>>>
>>> is_extension_type(cat)
True
>>> is_extension_type(pd.Series(cat))
True
>>> is_extension_type(pd.SparseArray([1, 2, 3]))
True
>>> is_extension_type(pd.SparseSeries([1, 2, 3]))
True
>>>
>>> from scipy.sparse import bsr_matrix
>>> is_extension_type(bsr_matrix([1, 2, 3]))
False
>>> is_extension_type(pd.DatetimeIndex([1, 2, 3]))
False
>>> is_extension_type(pd.DatetimeIndex([1, 2, 3], tz="US/Eastern"))
True
>>>
>>> dtype = DatetimeTZDtype("ns", tz="US/Eastern")
>>> s = pd.Series([], dtype=dtype)
>>> is_extension_type(s)
True
```

34.19.4.12 pandas.api.types.is_float_dtype

`pandas.api.types.is_float_dtype(arr_or_dtype)`

Check whether the provided array or dtype is of a float dtype.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of a float dtype.

Examples

```
>>> is_float_dtype(str)
False
>>> is_float_dtype(int)
False
>>> is_float_dtype(float)
True
>>> is_float_dtype(np.array(['a', 'b']))
False
>>> is_float_dtype(pd.Series([1, 2]))
False
>>> is_float_dtype(pd.Index([1, 2.]))
True
```

34.19.4.13 pandas.api.types.is_int64_dtype

`pandas.api.types.`**`is_int64_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of the int64 dtype.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of the int64 dtype.

Notes

Depending on system architecture, the return value of *is_int64_dtype(int)* will be True if the OS uses 64-bit integers and False if the OS uses 32-bit integers.

Examples

```
>>> is_int64_dtype(str)
False
>>> is_int64_dtype(np.int32)
False
>>> is_int64_dtype(np.int64)
True
>>> is_int64_dtype(float)
False
>>> is_int64_dtype(np.uint64)  # unsigned
False
>>> is_int64_dtype(np.array(['a', 'b']))
False
>>> is_int64_dtype(np.array([1, 2], dtype=np.int64))
True
>>> is_int64_dtype(pd.Index([1, 2.]))  # float
False
>>> is_int64_dtype(np.array([1, 2], dtype=np.uint32))  # unsigned
False
```

34.19.4.14 pandas.api.types.is_integer_dtype

`pandas.api.types.`**`is_integer_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of an integer dtype.

Unlike in *in_any_int_dtype*, timedelta64 instances will return False.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of an integer dtype

and not an instance of timedelta64.

Examples

```
>>> is_integer_dtype(str)
False
>>> is_integer_dtype(int)
True
>>> is_integer_dtype(float)
False
>>> is_integer_dtype(np.uint64)
True
>>> is_integer_dtype(np.datetime64)
False
>>> is_integer_dtype(np.timedelta64)
False
>>> is_integer_dtype(np.array(['a', 'b']))
False
>>> is_integer_dtype(pd.Series([1, 2]))
True
>>> is_integer_dtype(np.array([], dtype=np.timedelta64))
False
>>> is_integer_dtype(pd.Index([1, 2.]))  # float
False
```

34.19.4.15 pandas.api.types.is_interval_dtype

`pandas.api.types.`**`is_interval_dtype`**(*arr_or_dtype*)

Check whether an array-like or dtype is of the Interval dtype.

Parameters **arr_or_dtype** : array-like

The array-like or dtype to check.

Returns **boolean** : Whether or not the array-like or dtype is

of the Interval dtype.

Examples

```
>>> is_interval_dtype(object)
False
>>> is_interval_dtype(IntervalDtype())
```

```
True
>>> is_interval_dtype([1, 2, 3])
False
>>>
>>> interval = pd.Interval(1, 2, closed="right")
>>> is_interval_dtype(interval)
False
>>> is_interval_dtype(pd.IntervalIndex([interval]))
True
```

34.19.4.16 pandas.api.types.is_numeric_dtype

`pandas.api.types.`**`is_numeric_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of a numeric dtype.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of a numeric dtype.

Examples

```
>>> is_numeric_dtype(str)
False
>>> is_numeric_dtype(int)
True
>>> is_numeric_dtype(float)
True
>>> is_numeric_dtype(np.uint64)
True
>>> is_numeric_dtype(np.datetime64)
False
>>> is_numeric_dtype(np.timedelta64)
False
>>> is_numeric_dtype(np.array(['a', 'b']))
False
>>> is_numeric_dtype(pd.Series([1, 2]))
True
>>> is_numeric_dtype(pd.Index([1, 2.]))
True
>>> is_numeric_dtype(np.array([], dtype=np.timedelta64))
False
```

34.19.4.17 pandas.api.types.is_object_dtype

`pandas.api.types.`**`is_object_dtype`**(*arr_or_dtype*)

Check whether an array-like or dtype is of the object dtype.

Parameters **arr_or_dtype** : array-like

The array-like or dtype to check.

Returns **boolean** : Whether or not the array-like or dtype is of the object dtype.

Examples

```
>>> is_object_dtype(object)
True
>>> is_object_dtype(int)
False
>>> is_object_dtype(np.array([], dtype=object))
True
>>> is_object_dtype(np.array([], dtype=int))
False
>>> is_object_dtype([1, 2, 3])
False
```

34.19.4.18 pandas.api.types.is_period_dtype

`pandas.api.types.`**`is_period_dtype`**(*arr_or_dtype*)

Check whether an array-like or dtype is of the Period dtype.

Parameters **arr_or_dtype** : array-like

The array-like or dtype to check.

Returns **boolean** : Whether or not the array-like or dtype is of the Period dtype.

Examples

```
>>> is_period_dtype(object)
False
>>> is_period_dtype(PeriodDtype(freq="D"))
True
>>> is_period_dtype([1, 2, 3])
False
>>> is_period_dtype(pd.Period("2017-01-01"))
False
>>> is_period_dtype(pd.PeriodIndex([], freq="A"))
True
```

34.19.4.19 pandas.api.types.is_signed_integer_dtype

`pandas.api.types.`**`is_signed_integer_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of a signed integer dtype.

Unlike in *in_any_int_dtype*, timedelta64 instances will return False.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of a signed integer dtype

and not an instance of timedelta64.

Examples

```
>>> is_signed_integer_dtype(str)
False
>>> is_signed_integer_dtype(int)
True
>>> is_signed_integer_dtype(float)
False
>>> is_signed_integer_dtype(np.uint64)  # unsigned
False
>>> is_signed_integer_dtype(np.datetime64)
False
>>> is_signed_integer_dtype(np.timedelta64)
False
>>> is_signed_integer_dtype(np.array(['a', 'b']))
False
>>> is_signed_integer_dtype(pd.Series([1, 2]))
True
>>> is_signed_integer_dtype(np.array([], dtype=np.timedelta64))
False
>>> is_signed_integer_dtype(pd.Index([1, 2.]))  # float
False
>>> is_signed_integer_dtype(np.array([1, 2], dtype=np.uint32))  # unsigned
False
```

34.19.4.20 pandas.api.types.is_string_dtype

`pandas.api.types.`**`is_string_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of the string dtype.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of the string dtype.

Examples

```
>>> is_string_dtype(str)
True
>>> is_string_dtype(object)
True
>>> is_string_dtype(int)
False
>>>
>>> is_string_dtype(np.array(['a', 'b']))
True
>>> is_string_dtype(pd.Series([1, 2]))
False
```

34.19.4.21 pandas.api.types.is_timedelta64_dtype

`pandas.api.types.`**`is_timedelta64_dtype`**(*arr_or_dtype*)

Check whether an array-like or dtype is of the timedelta64 dtype.

Parameters **arr_or_dtype** : array-like

The array-like or dtype to check.

Returns **boolean** : Whether or not the array-like or dtype is

of the timedelta64 dtype.

Examples

```
>>> is_timedelta64_dtype(object)
False
>>> is_timedelta64_dtype(np.timedelta64)
True
>>> is_timedelta64_dtype([1, 2, 3])
False
>>> is_timedelta64_dtype(pd.Series([], dtype="timedelta64[ns]"))
True
>>> is_timedelta64_dtype('0 days')
False
```

34.19.4.22 pandas.api.types.is_timedelta64_ns_dtype

`pandas.api.types.`**`is_timedelta64_ns_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of the timedelta64[ns] dtype.

This is a very specific dtype, so generic ones like *np.timedelta64* will return False if passed into this function.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of the

timedelta64[ns] dtype.

Examples

```
>>> is_timedelta64_ns_dtype(np.dtype('m8[ns]'))
True
>>> is_timedelta64_ns_dtype(np.dtype('m8[ps]'))  # Wrong frequency
False
>>> is_timedelta64_ns_dtype(np.array([1, 2], dtype='m8[ns]'))
True
>>> is_timedelta64_ns_dtype(np.array([1, 2], dtype=np.timedelta64))
False
```

34.19.4.23 pandas.api.types.is_unsigned_integer_dtype

`pandas.api.types.`**`is_unsigned_integer_dtype`**(*arr_or_dtype*)

Check whether the provided array or dtype is of an unsigned integer dtype.

Parameters **arr_or_dtype** : array-like

The array or dtype to check.

Returns **boolean** : Whether or not the array or dtype is of an unsigned integer dtype.

Examples

```
>>> is_unsigned_integer_dtype(str)
False
>>> is_unsigned_integer_dtype(int)  # signed
False
>>> is_unsigned_integer_dtype(float)
False
>>> is_unsigned_integer_dtype(np.uint64)
True
>>> is_unsigned_integer_dtype(np.array(['a', 'b']))
False
>>> is_unsigned_integer_dtype(pd.Series([1, 2]))  # signed
False
>>> is_unsigned_integer_dtype(pd.Index([1, 2.]))  # float
False
>>> is_unsigned_integer_dtype(np.array([1, 2], dtype=np.uint32))
True
```

34.19.4.24 pandas.api.types.is_sparse

`pandas.api.types.`**`is_sparse`**(*arr*)

Check whether an array-like is a pandas sparse array.

Parameters **arr** : array-like

The array-like to check.

Returns **boolean** : Whether or not the array-like is a pandas sparse array.

Examples

```
>>> is_sparse(np.array([1, 2, 3]))
False
>>> is_sparse(pd.SparseArray([1, 2, 3]))
True
>>> is_sparse(pd.SparseSeries([1, 2, 3]))
True
```

This function checks only for pandas sparse array instances, so sparse arrays from other libraries will return False.

```
>>> from scipy.sparse import bsr_matrix
>>> is_sparse(bsr_matrix([1, 2, 3]))
False
```

Iterable introspection

api.types.is_dict_like(obj)	Check if the object is dict-like.

Continued on next page

Table 34.167 – continued from previous page

api.types.is_file_like(obj)	Check if the object is a file-like object.
api.types.is_list_like(obj)	Check if the object is list-like.
api.types.is_named_tuple(obj)	Check if the object is a named tuple.
api.types.is_iterator(obj)	Check if the object is an iterator.

34.19.4.25 pandas.api.types.is_dict_like

`pandas.api.types.`**`is_dict_like`**(*obj*)

Check if the object is dict-like.

Parameters **obj** : The object to check.

Returns **is_dict_like** : bool

Whether *obj* has dict-like properties.

Examples

```
>>> is_dict_like({1: 2})
True
>>> is_dict_like([1, 2, 3])
False
```

34.19.4.26 pandas.api.types.is_file_like

`pandas.api.types.`**`is_file_like`**(*obj*)

Check if the object is a file-like object.

For objects to be considered file-like, they must be an iterator AND have either a *read* and/or *write* method as an attribute.

Note: file-like objects must be iterable, but iterable objects need not be file-like.

New in version 0.20.0.

Parameters **obj** : The object to check.

Returns **is_file_like** : bool

Whether *obj* has file-like properties.

Examples

```
>>> buffer(StringIO("data"))
>>> is_file_like(buffer)
True
>>> is_file_like([1, 2, 3])
False
```

34.19.4.27 pandas.api.types.is_list_like

`pandas.api.types.is_list_like(obj)`

Check if the object is list-like.

Objects that are considered list-like are for example Python lists, tuples, sets, NumPy arrays, and Pandas Series.

Strings and datetime objects, however, are not considered list-like.

Parameters **obj** : The object to check.

Returns **is_list_like** : bool

Whether *obj* has list-like properties.

Examples

```
>>> is_list_like([1, 2, 3])
True
>>> is_list_like({1, 2, 3})
True
>>> is_list_like(datetime(2017, 1, 1))
False
>>> is_list_like("foo")
False
>>> is_list_like(1)
False
```

34.19.4.28 pandas.api.types.is_named_tuple

`pandas.api.types.is_named_tuple(obj)`

Check if the object is a named tuple.

Parameters **obj** : The object to check.

Returns **is_named_tuple** : bool

Whether *obj* is a named tuple.

Examples

```
>>> Point = namedtuple("Point", ["x", "y"])
>>> p = Point(1, 2)
>>>
>>> is_named_tuple(p)
True
>>> is_named_tuple((1, 2))
False
```

34.19.4.29 pandas.api.types.is_iterator

`pandas.api.types.is_iterator(obj)`

Check if the object is an iterator.

For example, lists are considered iterators but not strings or datetime objects.

Parameters **obj** : The object to check.

Returns **is_iter** : bool

Whether *obj* is an iterator.

Examples

```
>>> is_iterator([1, 2, 3])
True
>>> is_iterator(datetime(2017, 1, 1))
False
>>> is_iterator("foo")
False
>>> is_iterator(1)
False
```

Scalar introspection

api.types.is_bool	
api.types.is_categorical(arr)	Check whether an array-like is a Categorical instance.
api.types.is_complex	
api.types.is_datetimetz(arr)	Check whether an array-like is a datetime array-like with a timezone component in its dtype.
api.types.is_float	
api.types.is_hashable(obj)	Return True if hash(obj) will succeed, False otherwise.
api.types.is_integer	
api.types.is_interval	
api.types.is_number(obj)	Check if the object is a number.
api.types.is_period(arr)	Check whether an array-like is a periodical index.
api.types.is_re(obj)	Check if the object is a regex pattern instance.
api.types.is_re_compilable(obj)	Check if the object can be compiled into a regex pattern instance.
api.types.is_scalar	Return True if given value is scalar.

34.19.4.30 pandas.api.types.is_bool

`pandas.api.types.`**`is_bool`**`()`

34.19.4.31 pandas.api.types.is_categorical

`pandas.api.types.`**`is_categorical`**`(`*arr*`)`

Check whether an array-like is a Categorical instance.

Parameters **arr** : array-like

The array-like to check.

Returns **boolean** : Whether or not the array-like is of a Categorical instance.

Examples

```
>>> is_categorical([1, 2, 3])
False
```

Categoricals, Series Categoricals, and CategoricalIndex will return True.

```
>>> cat = pd.Categorical([1, 2, 3])
>>> is_categorical(cat)
True
>>> is_categorical(pd.Series(cat))
True
>>> is_categorical(pd.CategoricalIndex([1, 2, 3]))
True
```

34.19.4.32 pandas.api.types.is_complex

`pandas.api.types.`**`is_complex`**`()`

34.19.4.33 pandas.api.types.is_datetimetz

`pandas.api.types.`**`is_datetimetz`**`(`*arr*`)`

Check whether an array-like is a datetime array-like with a timezone component in its dtype.

Parameters **arr** : array-like

The array-like to check.

Returns **boolean** : Whether or not the array-like is a datetime array-like with

a timezone component in its dtype.

Examples

```
>>> is_datetimetz([1, 2, 3])
False
```

Although the following examples are both DatetimeIndex objects, the first one returns False because it has no timezone component unlike the second one, which returns True.

```
>>> is_datetimetz(pd.DatetimeIndex([1, 2, 3]))
False
>>> is_datetimetz(pd.DatetimeIndex([1, 2, 3], tz="US/Eastern"))
True
```

The object need not be a DatetimeIndex object. It just needs to have a dtype which has a timezone component.

```
>>> dtype = DatetimeTZDtype("ns", tz="US/Eastern")
>>> s = pd.Series([], dtype=dtype)
>>> is_datetimetz(s)
True
```

34.19.4.34 pandas.api.types.is_float

`pandas.api.types.is_float()`

34.19.4.35 pandas.api.types.is_hashable

`pandas.api.types.is_hashable(obj)`

Return True if hash(obj) will succeed, False otherwise.

Some types will pass a test against collections.Hashable but fail when they are actually hashed with hash().

Distinguish between these and other types by trying the call to hash() and seeing if they raise TypeError.

Examples

```
>>> a = ([],)
>>> isinstance(a, collections.Hashable)
True
>>> is_hashable(a)
False
```

34.19.4.36 pandas.api.types.is_integer

`pandas.api.types.is_integer()`

34.19.4.37 pandas.api.types.is_interval

`pandas.api.types.is_interval()`

34.19.4.38 pandas.api.types.is_number

`pandas.api.types.is_number(obj)`

Check if the object is a number.

Parameters **obj** : The object to check.

Returns **is_number** : bool

Whether *obj* is a number or not.

Examples

```
>>> is_number(1)
True
>>> is_number("foo")
False
```

34.19.4.39 pandas.api.types.is_period

`pandas.api.types.is_period(arr)`

Check whether an array-like is a periodical index.

Parameters **arr** : array-like

The array-like to check.

Returns **boolean** : Whether or not the array-like is a periodical index.

Examples

```
>>> is_period([1, 2, 3])
False
>>> is_period(pd.Index([1, 2, 3]))
False
>>> is_period(pd.PeriodIndex(["2017-01-01"], freq="D"))
True
```

34.19.4.40 pandas.api.types.is_re

`pandas.api.types.is_re(obj)`

Check if the object is a regex pattern instance.

Parameters **obj** : The object to check.

Returns **is_regex** : bool

Whether *obj* is a regex pattern.

Examples

```
>>> is_re(re.compile(".*"))
True
>>> is_re("foo")
False
```

34.19.4.41 pandas.api.types.is_re_compilable

`pandas.api.types.is_re_compilable(obj)`

Check if the object can be compiled into a regex pattern instance.

Parameters **obj** : The object to check.

Returns **is_regex_compilable** : bool

Whether *obj* can be compiled as a regex pattern.

Examples

```
>>> is_re_compilable(".*")
True
>>> is_re_compilable(1)
False
```

34.19.4.42 pandas.api.types.is_scalar

`pandas.api.types.`**`is_scalar`**`()`

Return True if given value is scalar.

This includes: - numpy array scalar (e.g. np.int64) - Python builtin numerics - Python builtin byte arrays and strings - None - instances of datetime.datetime - instances of datetime.timedelta - Period - instances of decimal.Decimal - Interval

CHAPTER

THIRTYFIVE

DEVELOPER

This section will focus on downstream applications of pandas.

35.1 Storing pandas DataFrame objects in Apache Parquet format

The Apache Parquet format provides key-value metadata at the file and column level, stored in the footer of the Parquet file:

```
5: optional list<KeyValue> key_value_metadata
```

where `KeyValue` is

```
struct KeyValue {
  1: required string key
  2: optional string value
}
```

So that a `pandas.DataFrame` can be faithfully reconstructed, we store a `pandas` metadata key in the `FileMetaData` with the the value stored as :

```
{'index_columns': ['__index_level_0__', '__index_level_1__', ...],
 'column_indexes': [<ci0>, <ci1>, ..., <ciN>],
 'columns': [<c0>, <c1>, ...],
 'pandas_version': $VERSION}
```

Here, `<c0>`/`<ci0>` and so forth are dictionaries containing the metadata for each column. This has JSON form:

```
{'name': column_name,
 'pandas_type': pandas_type,
 'numpy_type': numpy_type,
 'metadata': metadata}
```

`pandas_type` is the logical type of the column, and is one of:

- Boolean: `'bool'`
- Integers: `'int8'`, `'int16'`, `'int32'`, `'int64'`, `'uint8'`, `'uint16'`, `'uint32'`, `'uint64'`
- Floats: `'float16'`, `'float32'`, `'float64'`
- Date and Time Types: `'datetime'`, `'datetimetz'`,`'timedelta'`
- String: `'unicode'`, `'bytes'`

- Categorical: `'categorical'`
- Other Python objects: `'object'`

The `numpy_type` is the physical storage type of the column, which is the result of `str(dtype)` for the underlying NumPy array that holds the data. So for `datetimetz` this is `datetime64[ns]` and for categorical, it may be any of the supported integer categorical types.

The `metadata` field is `None` except for:

- `datetimetz`: `{'timezone': zone, 'unit': 'ns'}`, e.g. `{'timezone', 'America/New_York', 'unit': 'ns'}`. The `'unit'` is optional, and if omitted it is assumed to be nanoseconds.
- `categorical`: `{'num_categories': K, 'ordered': is_ordered, 'type': $TYPE}`
  - Here `'type'` is optional, and can be a nested pandas type specification here (but not categorical)
- `unicode`: `{'encoding': encoding}`
  - The encoding is optional, and if not present is UTF-8
- `object`: `{'encoding': encoding}`. Objects can be serialized and stored in `BYTE_ARRAY` Parquet columns. The encoding can be one of:
  - `'pickle'`
  - `'msgpack'`
  - `'bson'`
  - `'json'`
- `timedelta`: `{'unit': 'ns'}`. The `'unit'` is optional, and if omitted it is assumed to be nanoseconds. This metadata is optional altogether

For types other than these, the `'metadata'` key can be omitted. Implementations can assume `None` if the key is not present.

As an example of fully-formed metadata:

```
{'index_columns': ['__index_level_0__'],
 'column_indexes': [
     {'name': None,
      'pandas_type': 'string',
      'numpy_type': 'object',
      'metadata': None}
 ],
 'columns': [
     {'name': 'c0',
      'pandas_type': 'int8',
      'numpy_type': 'int8',
      'metadata': None},
     {'name': 'c1',
      'pandas_type': 'bytes',
      'numpy_type': 'object',
      'metadata': None},
     {'name': 'c2',
      'pandas_type': 'categorical',
      'numpy_type': 'int16',
      'metadata': {'num_categories': 1000, 'ordered': False}},
     {'name': 'c3',
      'pandas_type': 'datetimetz',
      'numpy_type': 'datetime64[ns]',
      'metadata': {'timezone': 'America/Los_Angeles'}},
```

```
    {'name': 'c4',
     'pandas_type': 'object',
     'numpy_type': 'object',
     'metadata': {'encoding': 'pickle'}},
    {'name': '__index_level_0__',
     'pandas_type': 'int64',
     'numpy_type': 'int64',
     'metadata': None}
],
'pandas_version': '0.20.0'}
```

CHAPTER

THIRTYSIX

INTERNALS

This section will provide a look into some of pandas internals.

36.1 Indexing

In pandas there are a few objects implemented which can serve as valid containers for the axis labels:

- `Index`: the generic "ordered set" object, an ndarray of object dtype assuming nothing about its contents. The labels must be hashable (and likely immutable) and unique. Populates a dict of label to location in Cython to do `O(1)` lookups.
- `Int64Index`: a version of `Index` highly optimized for 64-bit integer data, such as time stamps
- `Float64Index`: a version of `Index` highly optimized for 64-bit float data
- `MultiIndex`: the standard hierarchical index object
- `DatetimeIndex`: An Index object with `Timestamp` boxed elements (impl are the int64 values)
- `TimedeltaIndex`: An Index object with `Timedelta` boxed elements (impl are the in64 values)
- `PeriodIndex`: An Index object with Period elements

There are functions that make the creation of a regular index easy:

- `date_range`: fixed frequency date range generated from a time rule or DateOffset. An ndarray of Python datetime objects
- `period_range`: fixed frequency date range generated from a time rule or DateOffset. An ndarray of `Period` objects, representing Timespans

The motivation for having an `Index` class in the first place was to enable different implementations of indexing. This means that it's possible for you, the user, to implement a custom `Index` subclass that may be better suited to a particular application than the ones provided in pandas.

From an internal implementation point of view, the relevant methods that an `Index` must define are one or more of the following (depending on how incompatible the new object internals are with the `Index` functions):

- `get_loc`: returns an "indexer" (an integer, or in some cases a slice object) for a label
- `slice_locs`: returns the "range" to slice between two labels
- `get_indexer`: Computes the indexing vector for reindexing / data alignment purposes. See the source / docstrings for more on this
- `get_indexer_non_unique`: Computes the indexing vector for reindexing / data alignment purposes when the index is non-unique. See the source / docstrings for more on this
- `reindex`: Does any pre-conversion of the input index then calls `get_indexer`

- `union`, `intersection`: computes the union or intersection of two Index objects
- `insert`: Inserts a new label into an Index, yielding a new object
- `delete`: Delete a label, yielding a new object
- `drop`: Deletes a set of labels
- `take`: Analogous to ndarray.take

36.1.1 MultiIndex

Internally, the `MultiIndex` consists of a few things: the **levels**, the integer **labels**, and the level **names**:

```
In [1]: index = pd.MultiIndex.from_product([range(3), ['one', 'two']], names=['first',
↪ 'second'])

In [2]: index
Out[2]:
MultiIndex(levels=[[0, 1, 2], ['one', 'two']],
           labels=[[0, 0, 1, 1, 2, 2], [0, 1, 0, 1, 0, 1]],
           names=['first', 'second'])

In [3]: index.levels
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪FrozenList([[0, 1, 2], ['one', 'two']])

In [4]: index.labels
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪FrozenList([[0, 0, 1, 1, 2, 2], [0, 1, 0, 1, 0, 1]])

In [5]: index.names
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
↪FrozenList(['first', 'second'])
```

You can probably guess that the labels determine which unique element is identified with that location at each layer of the index. It's important to note that sortedness is determined **solely** from the integer labels and does not check (or care) whether the levels themselves are sorted. Fortunately, the constructors `from_tuples` and `from_arrays` ensure that this is true, but if you compute the levels and labels yourself, please be careful.

36.2 Subclassing pandas Data Structures

Warning: There are some easier alternatives before considering subclassing `pandas` data structures.

1. Extensible method chains with *pipe*
2. Use *composition*. See here.

This section describes how to subclass `pandas` data structures to meet more specific needs. There are 2 points which need attention:

1. Override constructor properties.
2. Define original properties

Note: You can find a nice example in geopandas project.

36.2.1 Override Constructor Properties

Each data structure has constructor properties to specifying data constructors. By overriding these properties, you can retain defined-classes through `pandas` data manipulations.

There are 3 constructors to be defined:

- `_constructor`: Used when a manipulation result has the same dimesions as the original.
- `_constructor_sliced`: Used when a manipulation result has one lower dimension(s) as the original, such as `DataFrame` single columns slicing.
- `_constructor_expanddim`: Used when a manipulation result has one higher dimension as the original, such as `Series.to_frame()` and `DataFrame.to_panel()`.

Following table shows how `pandas` data structures define constructor properties by default.

Property Attributes	`Series`	`DataFrame`	`Panel`
`_constructor`	`Series`	`DataFrame`	`Panel`
`_constructor_sliced`	`NotImplementedError`	`Series`	`DataFrame`
`_constructor_expanddim`	`DataFrame`	`Panel`	`NotImplementedError`

Below example shows how to define `SubclassedSeries` and `SubclassedDataFrame` overriding constructor properties.

```
class SubclassedSeries(Series):

    @property
    def _constructor(self):
        return SubclassedSeries

    @property
    def _constructor_expanddim(self):
        return SubclassedDataFrame

class SubclassedDataFrame(DataFrame):

    @property
    def _constructor(self):
        return SubclassedDataFrame

    @property
    def _constructor_sliced(self):
        return SubclassedSeries
```

```
>>> s = SubclassedSeries([1, 2, 3])
>>> type(s)
<class '__main__.SubclassedSeries'>

>>> to_framed = s.to_frame()
>>> type(to_framed)
<class '__main__.SubclassedDataFrame'>

>>> df = SubclassedDataFrame({'A', [1, 2, 3], 'B': [4, 5, 6], 'C': [7, 8, 9]})
>>> df
```

```
   A  B  C
0  1  4  7
1  2  5  8
2  3  6  9

>>> type(df)
<class '__main__.SubclassedDataFrame'>

>>> sliced1 = df[['A', 'B']]
>>> sliced1
   A  B
0  1  4
1  2  5
2  3  6
>>> type(sliced1)
<class '__main__.SubclassedDataFrame'>

>>> sliced2 = df['A']
>>> sliced2
0    1
1    2
2    3
Name: A, dtype: int64
>>> type(sliced2)
<class '__main__.SubclassedSeries'>
```

36.2.2 Define Original Properties

To let original data structures have additional properties, you should let `pandas` know what properties are added. `pandas` maps unknown properties to data names overriding `__getattribute__`. Defining original properties can be done in one of 2 ways:

1. Define `_internal_names` and `_internal_names_set` for temporary properties which WILL NOT be passed to manipulation results.
2. Define `_metadata` for normal properties which will be passed to manipulation results.

Below is an example to define 2 original properties, "internal_cache" as a temporary property and "added_property" as a normal property

```
class SubclassedDataFrame2(DataFrame):

    # temporary properties
    _internal_names = pd.DataFrame._internal_names + ['internal_cache']
    _internal_names_set = set(_internal_names)

    # normal properties
    _metadata = ['added_property']

    @property
    def _constructor(self):
        return SubclassedDataFrame2
```

```
>>> df = SubclassedDataFrame2({'A', [1, 2, 3], 'B': [4, 5, 6], 'C': [7, 8, 9]})
>>> df
   A  B  C
0  1  4  7
```

```
1  2  5  8
2  3  6  9

>>> df.internal_cache = 'cached'
>>> df.added_property = 'property'

>>> df.internal_cache
cached
>>> df.added_property
property

# properties defined in _internal_names is reset after manipulation
>>> df[['A', 'B']].internal_cache
AttributeError: 'SubclassedDataFrame2' object has no attribute 'internal_cache'

# properties defined in _metadata are retained
>>> df[['A', 'B']].added_property
property
```

CHAPTER

THIRTYSEVEN

RELEASE NOTES

This is the list of changes to pandas between each release. For full details, see the commit logs at http://github.com/pandas-dev/pandas

What is it

pandas is a Python package providing fast, flexible, and expressive data structures designed to make working with "relational" or "labeled" data both easy and intuitive. It aims to be the fundamental high-level building block for doing practical, real world data analysis in Python. Additionally, it has the broader goal of becoming the most powerful and flexible open source data analysis / manipulation tool available in any language.

Where to get it

- Source code: http://github.com/pandas-dev/pandas
- Binary installers on PyPI: http://pypi.python.org/pypi/pandas
- Documentation: http://pandas.pydata.org

37.1 pandas 0.21.0

Release date: October 27, 2017

This is a major release from 0.20.3 and includes a number of API changes, deprecations, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Integration with Apache Parquet, including a new top-level `read_parquet()` function and `DataFrame.to_parquet()` method, see *here*.
- New user-facing `pandas.api.types.CategoricalDtype` for specifying categoricals independent of the data, see *here*.
- The behavior of `sum` and `prod` on all-NaN Series/DataFrames is now consistent and no longer depends on whether bottleneck is installed, see *here*.
- Compatibility fixes for pypy, see *here*.
- Additions to the `drop`, `reindex` and `rename` API to make them more consistent, see *here*.
- Addition of the new methods `DataFrame.infer_objects` (see *here*) and `GroupBy.pipe` (see *here*).
- Indexing with a list of labels, where one or more of the labels is missing, is deprecated and will raise a KeyError in a future version, see *here*.

See the *v0.21.0 Whatsnew* overview for an extensive list of all enhancements and bugs that have been fixed in 0.21.0

37.1.1 Thanks

A total of 206 people contributed to this release. People with a "+" by their names contributed a patch for the first time.

37.1.1.1 Contributors

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- topper-123 +
- tsdlovell
- ysau +
- zzgao +

37.2 pandas 0.20.0 / 0.20.1

Release date: May 5, 2017

This is a major release from 0.19.2 and includes a number of API changes, deprecations, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- New `.agg()` API for Series/DataFrame similar to the groupby-rolling-resample API's, see *here*
- Integration with the `feather-format`, including a new top-level `pd.read_feather()` and `DataFrame.to_feather()` method, see *here*.
- The `.ix` indexer has been deprecated, see *here*
- `Panel` has been deprecated, see *here*
- Addition of an `IntervalIndex` and `Interval` scalar type, see *here*
- Improved user API when grouping by index levels in `.groupby()`, see *here*
- Improved support for `UInt64` dtypes, see *here*
- A new orient for JSON serialization, `orient='table'`, that uses the Table Schema spec and that gives the possibility for a more interactive repr in the Jupyter Notebook, see *here*
- Experimental support for exporting styled DataFrames (`DataFrame.style`) to Excel, see *here*
- Window binary corr/cov operations now return a MultiIndexed `DataFrame` rather than a `Panel`, as `Panel` is now deprecated, see *here*
- Support for S3 handling now uses `s3fs`, see *here*
- Google BigQuery support now uses the `pandas-gbq` library, see *here*

See the *v0.20.1 Whatsnew* overview for an extensive list of all enhancements and bugs that have been fixed in 0.20.1.

Note: This is a combined release for 0.20.0 and and 0.20.1. Version 0.20.1 contains one additional change for backwards-compatibility with downstream projects using pandas' `utils` routines. (GH16250)

37.2.1 Thanks

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- bastewart
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- Ben Welsh
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- bmagnusson
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- Carlos Souza
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- Christoph Paulik
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37.3 pandas 0.19.2

Release date: December 24, 2016

This is a minor bug-fix release in the 0.19.x series and includes some small regression fixes, bug fixes and performance improvements.

Highlights include:

- Compatibility with Python 3.6
- Added a Pandas Cheat Sheet. (GH13202).

See the *v0.19.2 Whatsnew* page for an overview of all bugs that have been fixed in 0.19.2.

37.3.1 Thanks

- Ajay Saxena
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- gfyoung
- hesham shabana
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- Julian Santander
- Kerby Shedden
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- Kevin Sheppard
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- Matti Picus
- Matt Roeschke
- Maximilian Roos
- Mykola Golubyev
- Nate Yoder
- Nicholas Ver Halen
- Pawel Kordek
- Pietro Battiston
- Rodolfo Fernandez
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- Yaroslav Halchenko

37.4 pandas 0.19.1

Release date: November 3, 2016

This is a minor bug-fix release from 0.19.0 and includes some small regression fixes, bug fixes and performance improvements.

See the *v0.19.1 Whatsnew* page for an overview of all bugs that have been fixed in 0.19.1.

37.4.1 Thanks

- Adam Chainz
- Anthonios Partheniou
- Arash Rouhani
- Ben Kandel
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- chris-b1

- Chris Warth
- David Krych
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- Jeff Reback
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- Jon M. Mease
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- Josh Owen
- Keshav Ramaswamy
- Larry Ren
- mattrijk
- Michael Felt
- paul-mannino
- Piotr Chromiec
- Robert Bradshaw
- Sinhrks
- Thiago Serafim
- Tom Bird

37.5 pandas 0.19.0

Release date: October 2, 2016

This is a major release from 0.18.1 and includes number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- `merge_asof()` for asof-style time-series joining, see *here*
- `.rolling()` is now time-series aware, see *here*
- `read_csv()` now supports parsing `Categorical` data, see *here*
- A function `union_categorical()` has been added for combining categoricals, see *here*
- `PeriodIndex` now has its own `period` dtype, and changed to be more consistent with other `Index` classes. See *here*
- Sparse data structures gained enhanced support of `int` and `bool` dtypes, see *here*
- Comparison operations with `Series` no longer ignores the index, see *here* for an overview of the API changes.
- Introduction of a pandas development API for utility functions, see *here*.

- Deprecation of `Panel4D` and `PanelND`. We recommend to represent these types of n-dimensional data with the xarray package.
- Removal of the previously deprecated modules `pandas.io.data`, `pandas.io.wb`, `pandas.tools.rplot`.

See the *v0.19.0 Whatsnew* overview for an extensive list of all enhancements and bugs that have been fixed in 0.19.0.

37.5.1 Thanks

- adneu
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- Jordan Erenrich
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- znmean
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37.6 pandas 0.18.1

Release date: (May 3, 2016)

This is a minor release from 0.18.0 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements.

Highlights include:

- `.groupby(...)` has been enhanced to provide convenient syntax when working with `.rolling(..)`, `.expanding(..)` and `.resample(..)` per group, see *here*
- `pd.to_datetime()` has gained the ability to assemble dates from a `DataFrame`, see *here*
- Method chaining improvements, see *here*.
- Custom business hour offset, see *here*.
- Many bug fixes in the handling of `sparse`, see *here*
- Expanded the *Tutorials section* with a feature on modern pandas, courtesy of @TomAugsburger. (GH13045).

See the *v0.18.1 Whatsnew* overview for an extensive list of all enhancements and bugs that have been fixed in 0.18.1.

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- Andrew Fiore-Gartland
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- nileracecrew
- onesandzeroes
- rs2
- sinhrks
- tsdlovell

37.7 pandas 0.18.0

Release date: (March 13, 2016)

This is a major release from 0.17.1 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Moving and expanding window functions are now methods on Series and DataFrame, similar to `.groupby`, see *here*.
- Adding support for a `RangeIndex` as a specialized form of the `Int64Index` for memory savings, see *here*.
- API breaking change to the `.resample` method to make it more `.groupby` like, see *here*.
- Removal of support for positional indexing with floats, which was deprecated since 0.14.0. This will now raise a `TypeError`, see *here*.
- The `.to_xarray()` function has been added for compatibility with the xarray package, see *here*.
- The `read_sas` function has been enhanced to read `sas7bdat` files, see *here*.
- Addition of the *.str.extractall() method*, and API changes to the *.str.extract() method* and *.str.cat() method*.
- `pd.test()` top-level nose test runner is available (GH4327).

See the *v0.18.0 Whatsnew* overview for an extensive list of all enhancements and bugs that have been fixed in 0.18.0.

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- ARF
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- jfoo
- kaustuv deolal
- llllllllll
- ranarag
- rockg
- scls19fr
- seales
- sinhrks
- srib
- surveymedia.ca
- tworec

37.8 pandas 0.17.1

Release date: (November 21, 2015)

This is a minor release from 0.17.0 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements.

Highlights include:

- Support for Conditional HTML Formatting, see *here*

- Releasing the GIL on the csv reader & other ops, see *here*
- Regression in `DataFrame.drop_duplicates` from 0.16.2, causing incorrect results on integer values (GH11376)

See the *v0.17.1 Whatsnew* overview for an extensive list of all enhancements and bugs that have been fixed in 0.17.1.

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37.9 pandas 0.17.0

Release date: (October 9, 2015)

This is a major release from 0.16.2 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Release the Global Interpreter Lock (GIL) on some cython operations, see *here*
- Plotting methods are now available as attributes of the `.plot` accessor, see *here*
- The sorting API has been revamped to remove some long-time inconsistencies, see *here*
- Support for a `datetime64[ns]` with timezones as a first-class dtype, see *here*
- The default for `to_datetime` will now be to `raise` when presented with unparseable formats, previously this would return the original input. Also, date parse functions now return consistent results. See *here*
- The default for `dropna` in `HDFStore` has changed to `False`, to store by default all rows even if they are all `NaN`, see *here*
- Datetime accessor (`dt`) now supports `Series.dt.strftime` to generate formatted strings for datetime-likes, and `Series.dt.total_seconds` to generate each duration of the timedelta in seconds. See *here*
- `Period` and `PeriodIndex` can handle multiplied freq like `3D`, which corresponding to 3 days span. See *here*
- Development installed versions of pandas will now have `PEP440` compliant version strings (GH9518)
- Development support for benchmarking with the Air Speed Velocity library (GH8316)
- Support for reading SAS xport files, see *here*
- Documentation comparing SAS to *pandas*, see *here*
- Removal of the automatic TimeSeries broadcasting, deprecated since 0.8.0, see *here*
- Display format with plain text can optionally align with Unicode East Asian Width, see *here*
- Compatibility with Python 3.5 (GH11097)
- Compatibility with matplotlib 1.5.0 (GH11111)

See the *v0.17.0 Whatsnew* overview for an extensive list of all enhancements and bugs that have been fixed in 0.17.0.

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- ganego
- jreback
- juricast
- larvian
- maximilianr
- msund
- rekcahpassyla
- robertzk
- scls19fr
- seth-p
- sinhrks
- springcoil
- terrytangyuan
- tzinckgraf

37.10 pandas 0.16.2

Release date: (June 12, 2015)

This is a minor release from 0.16.1 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements.

Highlights include:

- A new `pipe` method, see *here*
- Documentation on how to use numba with *pandas*, see *here*

See the *v0.16.2 Whatsnew* overview for an extensive list of all enhancements and bugs that have been fixed in 0.16.2.

37.10.1 Thanks

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- Morton Fox
- Robin Wilson
- Thomas Grainger
- Tom Ajamian
- Tom Augspurger
- Yoshiki Vázquez Baeza
- Younggun Kim
- austinc
- behzad nouri
- jreback
- lexual
- rekcahpassyla
- scls19fr
- sinhrks

37.11 pandas 0.16.1

Release date: (May 11, 2015)

This is a minor release from 0.16.0 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements. A small number of API changes were necessary to fix existing bugs.

See the *v0.16.1 Whatsnew* overview for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.16.1.

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- Scott Sanderson
- Stephan Hoyer
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- Tom Augspurger
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- behzad nouri
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- floydsoft
- flying-sheep
- gfr
- jnmclarty
- jreback
- ksanghai
- lucas
- mschmohl
- ptype
- rockg
- scls19fr
- sinhrks

37.12 pandas 0.16.0

Release date: (March 22, 2015)

This is a major release from 0.15.2 and includes a number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

Highlights include:

- `DataFrame.assign` method, see *here*

- `Series.to_coo/from_coo` methods to interact with `scipy.sparse`, see *here*
- Backwards incompatible change to `Timedelta` to conform the `.seconds` attribute with `datetime.timedelta`, see *here*
- Changes to the `.loc` slicing API to conform with the behavior of `.ix` see *here*
- Changes to the default for ordering in the `Categorical` constructor, see *here*
- The `pandas.tools.rplot`, `pandas.sandbox.qtpandas` and `pandas.rpy` modules are deprecated. We refer users to external packages like seaborn, pandas-qt and rpy2 for similar or equivalent functionality, see *here*

See the *v0.16.0 Whatsnew* overview or the issue tracker on GitHub for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.16.0.

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- clham
- hsperr
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- jnmclarty
- josham
- jreback
- omtinez
- roch
- sinhrks
- unutbu

37.13 pandas 0.15.2

Release date: (December 12, 2014)

This is a minor release from 0.15.1 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements. A small number of API changes were necessary to fix existing bugs.

See the *v0.15.2 Whatsnew* overview for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.15.2.

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- behzad nouri
- broessli
- charalampos papaloizou
- immerrr
- jnmclarty
- jreback
- mgilbert
- onesandzeroes
- peadarcoyle
- rockg
- seth-p
- sinhrks
- unutbu
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37.14 pandas 0.15.1

Release date: (November 9, 2014)

This is a minor release from 0.15.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

See the *v0.15.1 Whatsnew* overview for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.15.1.

37.14.1 Thanks

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- Sanghee Kim
- Stephan Hoyer
- TomAugspurger
- WANG Aiyong
- behzad nouri
- immerrr
- jnmclarty
- jreback
- pallav-fdsi
- unutbu

37.15 pandas 0.15.0

Release date: (October 18, 2014)

This is a major release from 0.14.1 and includes a number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

Highlights include:

- Drop support for numpy < 1.7.0 (GH7711)
- The `Categorical` type was integrated as a first-class pandas type, see *here*
- New scalar type `Timedelta`, and a new index type `TimedeltaIndex`, see *here*
- New DataFrame default display for `df.info()` to include memory usage, see *Memory Usage*
- New datetimelike properties accessor `.dt` for Series, see *Datetimelike Properties*
- Split indexing documentation into *Indexing and Selecting Data* and *MultiIndex / Advanced Indexing*
- Split out string methods documentation into *Working with Text Data*
- `read_csv` will now by default ignore blank lines when parsing, see *here*
- API change in using Indexes in set operations, see *here*
- Internal refactoring of the `Index` class to no longer sub-class `ndarray`, see *Internal Refactoring*
- dropping support for `PyTables` less than version 3.0.0, and `numexpr` less than version 2.1 (GH7990)

See the *v0.15.0 Whatsnew* overview or the issue tracker on GitHub for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.15.0.

37.15.1 Thanks

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- Max Chang
- mcjcode
- Michael Mueller
- Michael W Schatzow
- Mike Kelly
- Mortada Mehyar
- mtrbean
- Nathan Sanders
- Nathan Typanski
- onesandzeroes
- Paul Masurel
- Phillip Cloud
- Pietro Battiston
- RenzoBertocchi
- rockg
- Ross Petchler
- seth-p
- Shahul Hameed
- Shashank Agarwal
- sinhrks
- someben
- stahlous
- stas-sl
- Stephan Hoyer
- thatneat
- tom-alcorn
- TomAugspurger
- Tom Augspurger

- Tony Lorenzo
- unknown
- unutbu
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- Wilfred Hughes
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- zachcp

37.16 pandas 0.14.1

Release date: (July 11, 2014)

This is a minor release from 0.14.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

Highlights include:

- New methods `select_dtypes()` to select columns based on the dtype and `sem()` to calculate the standard error of the mean.
- Support for dateutil timezones (see *docs*).
- Support for ignoring full line comments in the `read_csv()` text parser.
- New documentation section on *Options and Settings*.
- Lots of bug fixes.

See the *v0.14.1 Whatsnew* overview or the issue tracker on GitHub for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.14.1.

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- David Stephens
- DSM

- dsm054
- helger
- immerrr
- Jacob Schaer
- jaimefrio
- Jan Schulz
- John David Reaver
- John W. O'Brien
- Joris Van den Bossche
- jreback
- Julien Danjou
- Kevin Sheppard
- K.-Michael Aye
- Kyle Meyer
- lexual
- Matthew Brett
- Matt Wittmann
- Michael Mueller
- Mortada Mehyar
- onesandzeroes
- Phillip Cloud
- Rob Levy
- rockg
- sanguineturtle
- Schaer, Jacob C
- seth-p
- sinhrks
- Stephan Hoyer
- Thomas Kluyver
- Todd Jennings
- TomAugspurger
- unknown
- yelite

37.17 pandas 0.14.0

Release date: (May 31, 2014)

This is a major release from 0.13.1 and includes a number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

Highlights include:

- Officially support Python 3.4
- SQL interfaces updated to use `sqlalchemy`, see *here*.
- Display interface changes, see *here*
- MultiIndexing using Slicers, see *here*.
- Ability to join a singly-indexed DataFrame with a multi-indexed DataFrame, see *here*
- More consistency in groupby results and more flexible groupby specifications, see *here*
- Holiday calendars are now supported in `CustomBusinessDay`, see *here*
- Several improvements in plotting functions, including: hexbin, area and pie plots, see *here*.
- Performance doc section on I/O operations, see *here*

See the *v0.14.0 Whatsnew* overview or the issue tracker on GitHub for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.14.0.

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- Clark Fitzgerald
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- Dan Birken
- danielballan
- Daniel Waeber
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- hugo
- immerrr
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- mikebailey
- Mike Kelly
- Nipun Batra
- Noah Spies
- ojdo
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- Patrick O'Keeffe
- phaebz
- Phillip Cloud
- Pietro Battiston
- PKEuS
- Randy Carnevale
- ribonoous
- Robert Gibboni
- rockg
- sinhrks
- Skipper Seabold
- SplashDance
- Stephan Hoyer
- Tim Cera
- Tobias Brandt
- Todd Jennings
- TomAugspurger
- Tom Augspurger
- unutbu

- westurner
- Yaroslav Halchenko
- y-p
- zach powers

37.18 pandas 0.13.1

Release date: (February 3, 2014)

37.18.1 New Features

- Added `date_format` and `datetime_format` attribute to `ExcelWriter`. (GH4133)

37.18.2 API Changes

- `Series.sort` will raise a `ValueError` (rather than a `TypeError`) on sorting an object that is a view of another (GH5856, GH5853)
- Raise/Warn `SettingWithCopyError` (according to the option `chained_assignment` in more cases, when detecting chained assignment, related (GH5938, GH6025)
- DataFrame.head(0) returns self instead of empty frame (GH5846)
- `autocorrelation_plot` now accepts `**kwargs`. (GH5623)
- `convert_objects` now accepts a `convert_timedeltas='coerce'` argument to allow forced dtype conversion of timedeltas (GH5458,:issue:*5689*)
- Add `-NaN` and `-nan` to the default set of NA values (GH5952). See *NA Values*.
- `NDFrame` now has an `equals` method. (GH5283)
- `DataFrame.apply` will use the `reduce` argument to determine whether a `Series` or a `DataFrame` should be returned when the `DataFrame` is empty (GH6007).

37.18.3 Experimental Features

37.18.4 Improvements to existing features

- perf improvements in Series datetime/timedelta binary operations (GH5801)
- *option_context* context manager now available as top-level API (GH5752)
- df.info() view now display dtype info per column (GH5682)
- df.info() now honors option max_info_rows, disable null counts for large frames (GH5974)
- perf improvements in DataFrame `count/dropna` for `axis=1`
- Series.str.contains now has a *regex=False* keyword which can be faster for plain (non-regex) string patterns. (GH5879)
- support `dtypes` property on `Series/Panel/Panel4D`

- extend `Panel.apply` to allow arbitrary functions (rather than only ufuncs) (GH1148) allow multiple axes to be used to operate on slabs of a `Panel`
- The `ArrayFormatter` for `datetime` and `timedelta64` now intelligently limit precision based on the values in the array (GH3401)
- `pd.show_versions()` is now available for convenience when reporting issues.
- perf improvements to Series.str.extract (GH5944)
- perf improvements in `dtypes/ftypes` methods (GH5968)
- perf improvements in indexing with object dtypes (GH5968)
- improved dtype inference for `timedelta` like passed to constructors (GH5458, GH5689)
- escape special characters when writing to latex (:issue: *5374*)
- perf improvements in `DataFrame.apply` (GH6013)
- `pd.read_csv` and `pd.to_datetime` learned a new `infer_datetime_format` keyword which greatly improves parsing perf in many cases. Thanks to @lexual for suggesting and @danbirken for rapidly implementing. (GH5490,:issue:*6021*)
- add ability to recognize '%p' format code (am/pm) to date parsers when the specific format is supplied (GH5361)
- Fix performance regression in JSON IO (GH5765)
- performance regression in Index construction from Series (GH6150)

37.18.5 Bug Fixes

- Bug in `io.wb.get_countries` not including all countries (GH6008)
- Bug in Series replace with timestamp dict (GH5797)
- read_csv/read_table now respects the *prefix* kwarg (GH5732).
- Bug in selection with missing values via `.ix` from a duplicate indexed DataFrame failing (GH5835)
- Fix issue of boolean comparison on empty DataFrames (GH5808)
- Bug in isnull handling `NaT` in an object array (GH5443)
- Bug in `to_datetime` when passed a `np.nan` or integer datelike and a format string (GH5863)
- Bug in groupby dtype conversion with datetimelike (GH5869)
- Regression in handling of empty Series as indexers to Series (GH5877)
- Bug in internal caching, related to (GH5727)
- Testing bug in reading JSON/msgpack from a non-filepath on windows under py3 (GH5874)
- Bug when assigning to .ix[tuple(...)] (GH5896)
- Bug in fully reindexing a Panel (GH5905)
- Bug in idxmin/max with object dtypes (GH5914)
- Bug in `BusinessDay` when adding n days to a date not on offset when n>5 and n%5==0 (GH5890)
- Bug in assigning to chained series with a series via ix (GH5928)
- Bug in creating an empty DataFrame, copying, then assigning (GH5932)
- Bug in DataFrame.tail with empty frame (GH5846)

- Bug in propagating metadata on `resample` (GH5862)
- Fixed string-representation of `NaT` to be "NaT" (GH5708)
- Fixed string-representation for Timestamp to show nanoseconds if present (GH5912)
- `pd.match` not returning passed sentinel
- `Panel.to_frame()` no longer fails when `major_axis` is a `MultiIndex` (GH5402).
- Bug in `pd.read_msgpack` with inferring a `DateTimeIndex` frequency incorrectly (GH5947)
- Fixed `to_datetime` for array with both Tz-aware datetimes and `NaT`'s (GH5961)
- Bug in rolling skew/kurtosis when passed a Series with bad data (GH5749)
- Bug in scipy `interpolate` methods with a datetime index (GH5975)
- Bug in NaT comparison if a mixed datetime/np.datetime64 with NaT were passed (GH5968)
- Fixed bug with `pd.concat` losing dtype information if all inputs are empty (GH5742)
- Recent changes in IPython cause warnings to be emitted when using previous versions of pandas in QTConsole, now fixed. If you're using an older version and need to suppress the warnings, see (GH5922).
- Bug in merging `timedelta` dtypes (GH5695)
- Bug in plotting.scatter_matrix function. Wrong alignment among diagonal and off-diagonal plots, see (GH5497).
- Regression in Series with a multi-index via ix (GH6018)
- Bug in Series.xs with a multi-index (GH6018)
- Bug in Series construction of mixed type with datelike and an integer (which should result in object type and not automatic conversion) (GH6028)
- Possible segfault when chained indexing with an object array under numpy 1.7.1 (GH6026, GH6056)
- Bug in setting using fancy indexing a single element with a non-scalar (e.g. a list), (GH6043)
- `to_sql` did not respect `if_exists` (GH4110 GH4304)
- Regression in `.get(None)` indexing from 0.12 (GH5652)
- Subtle `iloc` indexing bug, surfaced in (GH6059)
- Bug with insert of strings into DatetimeIndex (GH5818)
- Fixed unicode bug in to_html/HTML repr (GH6098)
- Fixed missing arg validation in get_options_data (GH6105)
- Bug in assignment with duplicate columns in a frame where the locations are a slice (e.g. next to each other) (GH6120)
- Bug in propogating _ref_locs during construction of a DataFrame with dups index/columns (GH6121)
- Bug in `DataFrame.apply` when using mixed datelike reductions (GH6125)
- Bug in `DataFrame.append` when appending a row with different columns (GH6129)
- Bug in DataFrame construction with recarray and non-ns datetime dtype (GH6140)
- Bug in `.loc` setitem indexing with a dataframe on rhs, multiple item setting, and a datetimelike (GH6152)
- Fixed a bug in `query`/`eval` during lexicographic string comparisons (GH6155).
- Fixed a bug in `query` where the index of a single-element `Series` was being thrown away (GH6148).

- Bug in `HDFStore` on appending a dataframe with multi-indexed columns to an existing table (GH6167)
- Consistency with dtypes in setting an empty DataFrame (GH6171)
- Bug in selecting on a multi-index `HDFStore` even in the presence of under specified column spec (GH6169)
- Bug in `nanops.var` with `ddof=1` and 1 elements would sometimes return `inf` rather than `nan` on some platforms (GH6136)
- Bug in Series and DataFrame bar plots ignoring the `use_index` keyword (GH6209)
- Bug in groupby with mixed str/int under python3 fixed; `argsort` was failing (GH6212)

37.19 pandas 0.13.0

Release date: January 3, 2014

37.19.1 New Features

- `plot(kind='kde')` now accepts the optional parameters `bw_method` and `ind`, passed to scipy.stats.gaussian_kde() (for scipy >= 0.11.0) to set the bandwidth, and to gkde.evaluate() to specify the indicies at which it is evaluated, respectively. See scipy docs. (GH4298)
- Added `isin` method to DataFrame (GH4211)
- `df.to_clipboard()` learned a new `excel` keyword that let's you paste df data directly into excel (enabled by default). (GH5070).
- Clipboard functionality now works with PySide (GH4282)
- New `extract` string method returns regex matches more conveniently (GH4685)
- Auto-detect field widths in read_fwf when unspecified (GH4488)
- `to_csv()` now outputs datetime objects according to a specified format string via the `date_format` keyword (GH4313)
- Added `LastWeekOfMonth` DateOffset (GH4637)
- Added `cumcount` groupby method (GH4646)
- Added `FY5253`, and `FY5253Quarter` DateOffsets (GH4511)
- Added `mode()` method to `Series` and `DataFrame` to get the statistical mode(s) of a column/series. (GH5367)

37.19.2 Experimental Features

- The new *`eval()`* function implements expression evaluation using `numexpr` behind the scenes. This results in large speedups for complicated expressions involving large DataFrames/Series.
- *`DataFrame`* has a new *`eval()`* that evaluates an expression in the context of the `DataFrame`; allows inline expression assignment
- A *`query()`* method has been added that allows you to select elements of a `DataFrame` using a natural query syntax nearly identical to Python syntax.
- `pd.eval` and friends now evaluate operations involving `datetime64` objects in Python space because `numexpr` cannot handle `NaT` values (GH4897).

- Add msgpack support via `pd.read_msgpack()` and `pd.to_msgpack()` / `df.to_msgpack()` for serialization of arbitrary pandas (and python objects) in a lightweight portable binary format (GH686, GH5506)
- Added PySide support for the qtpandas DataFrameModel and DataFrameWidget.
- Added `pandas.io.gbq` for reading from (and writing to) Google BigQuery into a DataFrame. (GH4140)

37.19.3 Improvements to existing features

- `read_html` now raises a `URLError` instead of catching and raising a `ValueError` (GH4303, GH4305)
- `read_excel` now supports an integer in its `sheetname` argument giving the index of the sheet to read in (GH4301).
- `get_dummies` works with NaN (GH4446)
- Added a test for `read_clipboard()` and `to_clipboard()` (GH4282)
- Added bins argument to `value_counts` (GH3945), also sort and ascending, now available in Series method as well as top-level function.
- Text parser now treats anything that reads like inf ("inf", "Inf", "-Inf", "iNf", etc.) to infinity. (GH4220, GH4219), affecting `read_table`, `read_csv`, etc.
- Added a more informative error message when plot arguments contain overlapping color and style arguments (GH4402)
- Significant table writing performance improvements in `HDFStore`
- JSON date serialization now performed in low-level C code.
- JSON support for encoding datetime.time
- Expanded JSON docs, more info about orient options and the use of the numpy param when decoding.
- Add `drop_level` argument to xs (GH4180)
- Can now resample a DataFrame with ohlc (GH2320)
- `Index.copy()` and `MultiIndex.copy()` now accept keyword arguments to change attributes (i.e., `names`, `levels`, `labels`) (GH4039)
- Add `rename` and `set_names` methods to `Index` as well as `set_names`, `set_levels`, `set_labels` to `MultiIndex`. (GH4039) with improved validation for all (GH4039, GH4794)
- A Series of dtype `timedelta64[ns]` can now be divided/multiplied by an integer series (GH4521)
- A Series of dtype `timedelta64[ns]` can now be divided by another `timedelta64[ns]` object to yield a `float64` dtyped Series. This is frequency conversion; astyping is also supported.
- Timedelta64 support `fillna/ffill/bfill` with an integer interpreted as seconds, or a `timedelta` (GH3371)
- Box numeric ops on `timedelta` Series (GH4984)
- Datetime64 support `ffill/bfill`
- Performance improvements with `__getitem__` on `DataFrames` with when the key is a column
- Support for using a `DatetimeIndex/PeriodsIndex` directly in a datelike calculation e.g. s-s.index (GH4629)
- Better/cleaned up exceptions in core/common, io/excel and core/format (GH4721, GH3954), as well as cleaned up test cases in tests/test_frame, tests/test_multilevel (GH4732).

- Performance improvement of timeseries plotting with PeriodIndex and added test to vbench (GH4705 and GH4722)
- Add `axis` and `level` keywords to `where`, so that the `other` argument can now be an alignable pandas object.
- `to_datetime` with a format of '%Y%m%d' now parses much faster
- It's now easier to hook new Excel writers into pandas (just subclass `ExcelWriter` and register your engine). You can specify an `engine` in `to_excel` or in `ExcelWriter`. You can also specify which writers you want to use by default with config options `io.excel.xlsx.writer` and `io.excel.xls.writer`. (GH4745, GH4750)
- `Panel.to_excel()` now accepts keyword arguments that will be passed to its `DataFrame`'s `to_excel()` methods. (GH4750)
- Added XlsxWriter as an optional `ExcelWriter` engine. This is about 5x faster than the default openpyxl xlsx writer and is equivalent in speed to the xlwt xls writer module. (GH4542)
- allow DataFrame constructor to accept more list-like objects, e.g. list of `collections.Sequence` and `array.Array` objects (GH3783, GH4297, GH4851), thanks @lgautier
- DataFrame constructor now accepts a numpy masked record array (GH3478), thanks @jnothman
- `__getitem__` with `tuple` key (e.g., `[:, 2]`) on `Series` without `MultiIndex` raises `ValueError` (GH4759, GH4837)
- `read_json` now raises a (more informative) `ValueError` when the dict contains a bad key and `orient='split'` (GH4730, GH4838)
- `read_stata` now accepts Stata 13 format (GH4291)
- `ExcelWriter` and `ExcelFile` can be used as contextmanagers. (GH3441, GH4933)
- `pandas` is now tested with two different versions of `statsmodels` (0.4.3 and 0.5.0) (GH4981).
- Better string representations of `MultiIndex` (including ability to roundtrip via `repr`). (GH3347, GH4935)
- Both ExcelFile and read_excel to accept an xlrd.Book for the io (formerly path_or_buf) argument; this requires engine to be set. (GH4961).
- `concat` now gives a more informative error message when passed objects that cannot be concatenated (GH4608).
- Add `halflife` option to exponentially weighted moving functions (PR GH4998)
- `to_dict` now takes `records` as a possible outtype. Returns an array of column-keyed dictionaries. (GH4936)
- `tz_localize` can infer a fall daylight savings transition based on the structure of unlocalized data (GH4230)
- DatetimeIndex is now in the API documentation
- Improve support for converting R datasets to pandas objects (more informative index for timeseries and numeric, support for factors, dist, and high-dimensional arrays).
- *`read_html()`* now supports the `parse_dates`, `tupleize_cols` and `thousands` parameters (GH4770).
- *`json_normalize()`* is a new method to allow you to create a flat table from semi-structured JSON data. *See the docs* (GH1067)
- `DataFrame.from_records()` will now accept generators (GH4910)
- `DataFrame.interpolate()` and `Series.interpolate()` have been expanded to include interpolation methods from scipy. (GH4434, GH1892)

- `Series` now supports a `to_frame` method to convert it to a single-column DataFrame (GH5164)
- DatetimeIndex (and date_range) can now be constructed in a left- or right-open fashion using the `closed` parameter (GH4579)
- Python csv parser now supports usecols (GH4335)
- Added support for Google Analytics v3 API segment IDs that also supports v2 IDs. (GH5271)
- `NDFrame.drop()` now accepts names as well as integers for the axis argument. (GH5354)
- Added short docstrings to a few methods that were missing them + fixed the docstrings for Panel flex methods. (GH5336)
- `NDFrame.drop()`, `NDFrame.dropna()`, and `.drop_duplicates()` all accept `inplace` as a keyword argument; however, this only means that the wrapper is updated inplace, a copy is still made internally. (GH1960, GH5247, GH5628, and related GH2325 [still not closed])
- Fixed bug in *tools.plotting.andrews_curvres* so that lines are drawn grouped by color as expected.
- `read_excel()` now tries to convert integral floats (like `1.0`) to int by default. (GH5394)
- Excel writers now have a default option `merge_cells` in `to_excel()` to merge cells in MultiIndex and Hierarchical Rows. Note: using this option it is no longer possible to round trip Excel files with merged MultiIndex and Hierarchical Rows. Set the `merge_cells` to `False` to restore the previous behaviour. (GH5254)
- The FRED DataReader now accepts multiple series (:issue‘3413‘)
- StataWriter adjusts variable names to Stata’s limitations (GH5709)

37.19.4 API Changes

- `DataFrame.reindex()` and forward/backward filling now raises ValueError if either index is not monotonic (GH4483, GH4484).
- `pandas` now is Python 2/3 compatible without the need for 2to3 thanks to @jtratner. As a result, pandas now uses iterators more extensively. This also led to the introduction of substantive parts of the Benjamin Peterson’s `six` library into compat. (GH4384, GH4375, GH4372)
- `pandas.util.compat` and `pandas.util.py3compat` have been merged into `pandas.compat`. `pandas.compat` now includes many functions allowing 2/3 compatibility. It contains both list and iterator versions of range, filter, map and zip, plus other necessary elements for Python 3 compatibility. `lmap`, `lzip`, `lrange` and `lfilter` all produce lists instead of iterators, for compatibility with `numpy`, subscripting and `pandas` constructors.(GH4384, GH4375, GH4372)
- deprecated `iterkv`, which will be removed in a future release (was just an alias of iteritems used to get around `2to3`‘s changes). (GH4384, GH4375, GH4372)
- `Series.get` with negative indexers now returns the same as `[]` (GH4390)
- allow `ix/loc` for Series/DataFrame/Panel to set on any axis even when the single-key is not currently contained in the index for that axis (GH2578, GH5226, GH5632, GH5720, GH5744, GH5756)
- Default export for `to_clipboard` is now csv with a sep of *t* for compat (GH3368)
- `at` now will enlarge the object inplace (and return the same) (GH2578)
- `DataFrame.plot` will scatter plot x versus y by passing `kind='scatter'` (GH2215)
- `HDFStore`
  - `append_to_multiple` automatically synchronizes writing rows to multiple tables and adds a `dropna` kwarg (GH4698)

  - handle a passed `Series` in table format (GH4330)
  - added an `is_open` property to indicate if the underlying file handle is_open; a closed store will now report 'CLOSED' when viewing the store (rather than raising an error) (GH4409)
  - a close of a `HDFStore` now will close that instance of the `HDFStore` but will only close the actual file if the ref count (by `PyTables`) w.r.t. all of the open handles are 0. Essentially you have a local instance of `HDFStore` referenced by a variable. Once you close it, it will report closed. Other references (to the same file) will continue to operate until they themselves are closed. Performing an action on a closed file will raise `ClosedFileError`
  - removed the `_quiet` attribute, replace by a `DuplicateWarning` if retrieving duplicate rows from a table (GH4367)
  - removed the `warn` argument from `open`. Instead a `PossibleDataLossError` exception will be raised if you try to use `mode='w'` with an OPEN file handle (GH4367)
  - allow a passed locations array or mask as a `where` condition (GH4467)
  - add the keyword `dropna=True` to `append` to change whether ALL nan rows are not written to the store (default is `True`, ALL nan rows are NOT written), also settable via the option `io.hdf.dropna_table` (GH4625)
  - the `format` keyword now replaces the `table` keyword; allowed values are `fixed(f)|table(t)` the `Storer` format has been renamed to `Fixed`
  - a column multi-index will be recreated properly (GH4710); raise on trying to use a multi-index with data_columns on the same axis
  - `select_as_coordinates` will now return an `Int64Index` of the resultant selection set
  - support `timedelta64[ns]` as a serialization type (GH3577)
  - store *datetime.date* objects as ordinals rather then timetuples to avoid timezone issues (GH2852), thanks @tavistmorph and @numpand
  - `numexpr` 2.2.2 fixes incompatibility in PyTables 2.4 (GH4908)
  - `flush` now accepts an `fsync` parameter, which defaults to `False` (GH5364)
  - `unicode` indices not supported on `table` formats (GH5386)
  - pass thru store creation arguments; can be used to support in-memory stores

- `JSON`
  - added `date_unit` parameter to specify resolution of timestamps. Options are seconds, milliseconds, microseconds and nanoseconds. (GH4362, GH4498).
  - added `default_handler` parameter to allow a callable to be passed which will be responsible for handling otherwise unserialiable objects. (GH5138)

- `Index` and `MultiIndex` changes (GH4039):
  - Setting `levels` and `labels` directly on `MultiIndex` is now deprecated. Instead, you can use the `set_levels()` and `set_labels()` methods.
  - `levels`, `labels` and `names` properties no longer return lists, but instead return containers that do not allow setting of items ('mostly immutable')
  - `levels`, `labels` and `names` are validated upon setting and are either copied or shallow-copied.
  - inplace setting of `levels` or `labels` now correctly invalidates the cached properties. (GH5238).
  - `__deepcopy__` now returns a shallow copy (currently: a view) of the data - allowing metadata changes.

  - `MultiIndex.astype()` now only allows `np.object_`-like dtypes and now returns a `MultiIndex` rather than an `Index`. (GH4039)
  - Added `is_` method to `Index` that allows fast equality comparison of views (similar to `np.may_share_memory` but no false positives, and changes on `levels` and `labels` setting on `MultiIndex`). (GH4859 , GH4909)
  - Aliased `__iadd__` to `__add__`. (GH4996)
  - Added `is_` method to `Index` that allows fast equality comparison of views (similar to `np.may_share_memory` but no false positives, and changes on `levels` and `labels` setting on `MultiIndex`). (GH4859, GH4909)

- Infer and downcast dtype if `downcast='infer'` is passed to `fillna/ffill/bfill` (GH4604)
- `__nonzero__` for all NDFrame objects, will now raise a `ValueError`, this reverts back to (GH1073, GH4633) behavior. Add `.bool()` method to `NDFrame` objects to facilitate evaluating of single-element boolean Series
- `DataFrame.update()` no longer raises a `DataConflictError`, it now will raise a `ValueError` instead (if necessary) (GH4732)
- `Series.isin()` and `DataFrame.isin()` now raise a `TypeError` when passed a string (GH4763). Pass a `list` of one element (containing the string) instead.
- Remove undocumented/unused `kind` keyword argument from `read_excel`, and `ExcelFile`. (GH4713, GH4712)
- The `method` argument of `NDFrame.replace()` is valid again, so that a a list can be passed to `to_replace` (GH4743).
- provide automatic dtype conversions on _reduce operations (GH3371)
- exclude non-numerics if mixed types with datelike in _reduce operations (GH3371)
- default for `tupleize_cols` is now `False` for both `to_csv` and `read_csv`. Fair warning in 0.12 (GH3604)
- moved timedeltas support to pandas.tseries.timedeltas.py; add timedeltas string parsing, add top-level `to_timedelta` function
- `NDFrame` now is compatible with Python's toplevel `abs()` function (GH4821).
- raise a `TypeError` on invalid comparison ops on Series/DataFrame (e.g. integer/datetime) (GH4968)
- Added a new index type, `Float64Index`. This will be automatically created when passing floating values in index creation. This enables a pure label-based slicing paradigm that makes `[],ix,loc` for scalar indexing and slicing work exactly the same. Indexing on other index types are preserved (and positional fallback for `[],ix`), with the exception, that floating point slicing on indexes on non `Float64Index` will raise a `TypeError`, e.g. `Series(range(5))[3.5:4.5]` (GH263,:issue:*5375*)
- Make Categorical repr nicer (GH4368)
- Remove deprecated `Factor` (GH3650)
- Remove deprecated `set_printoptions/reset_printoptions` (:issue:`3046`)
- Remove deprecated `_verbose_info` (GH3215)
- Begin removing methods that don't make sense on `GroupBy` objects (GH4887).
- Remove deprecated `read_clipboard/to_clipboard/ExcelFile/ExcelWriter` from `pandas.io.parsers` (GH3717)

- All non-Index NDFrames (`Series`, `DataFrame`, `Panel`, `Panel4D`, `SparsePanel`, etc.), now support the entire set of arithmetic operators and arithmetic flex methods (add, sub, mul, etc.). `SparsePanel` does not support `pow` or `mod` with non-scalars. (GH3765)
- Arithmetic func factories are now passed real names (suitable for using with super) (GH5240)
- Provide numpy compatibility with 1.7 for a calling convention like `np.prod(pandas_object)` as numpy call with additional keyword args (GH4435)
- Provide __dir__ method (and local context) for tab completion / remove ipython completers code (GH4501)
- Support non-unique axes in a Panel via indexing operations (GH4960)
- `.truncate` will raise a `ValueError` if invalid before and afters dates are given (GH5242)
- `Timestamp` now supports `now/today/utcnow` class methods (GH5339)
- default for *display.max_seq_len* is now 100 rather then *None*. This activates truncated display ("...") of long sequences in various places. (GH3391)
- **All** division with `NDFrame` - likes is now truedivision, regardless of the future import. You can use `//` and `floordiv` to do integer division.

```
In [3]: arr = np.array([1, 2, 3, 4])

In [4]: arr2 = np.array([5, 3, 2, 1])

In [5]: arr / arr2
Out[5]: array([0, 0, 1, 4])

In [6]: pd.Series(arr) / pd.Series(arr2) # no future import required
Out[6]:
0    0.200000
1    0.666667
2    1.500000
3    4.000000
dtype: float64
```

- raise/warn `SettingWithCopyError/Warning` exception/warning when setting of a copy thru chained assignment is detected, settable via option `mode.chained_assignment`
- test the list of `NA` values in the csv parser. add `N/A`, `#NA` as independent default na values (GH5521)
- The refactoring involving''Series'' deriving from `NDFrame` breaks `rpy2<=2.3.8`. an Issue has been opened against rpy2 and a workaround is detailed in GH5698. Thanks @JanSchulz.
- `Series.argmin` and `Series.argmax` are now aliased to `Series.idxmin` and `Series.idxmax`. These return the *index* of the min or max element respectively. Prior to 0.13.0 these would return the position of the min / max element (GH6214)

37.19.5 Internal Refactoring

In 0.13.0 there is a major refactor primarily to subclass `Series` from `NDFrame`, which is the base class currently for `DataFrame` and `Panel`, to unify methods and behaviors. Series formerly subclassed directly from `ndarray`. (GH4080, GH3862, GH816) See *Internal Refactoring*

- Refactor of series.py/frame.py/panel.py to move common code to generic.py
- added `_setup_axes` to created generic NDFrame structures
- moved methods

  - `from_axes`, `_wrap_array`, `axes`, `ix`, `loc`, `iloc`, `shape`, `empty`, `swapaxes`, `transpose`, `pop`
  - `__iter__`, `keys`, `__contains__`, `__len__`, `__neg__`, `__invert__`
  - `convert_objects`, `as_blocks`, `as_matrix`, `values`
  - `__getstate__`, `__setstate__` (compat remains in frame/panel)
  - `__getattr__`, `__setattr__`
  - `_indexed_same`, `reindex_like`, `align`, `where`, `mask`
  - `fillna`, `replace` (`Series` replace is now consistent with `DataFrame`)
  - `filter` (also added axis argument to selectively filter on a different axis)
  - `reindex`, `reindex_axis`, `take`
  - `truncate` (moved to become part of `NDFrame`)
  - `isnull/notnull` now available on `NDFrame` objects
- These are API changes which make `Panel` more consistent with `DataFrame`
- `swapaxes` on a `Panel` with the same axes specified now return a copy
- support attribute access for setting
- `filter` supports same API as original `DataFrame` filter
- `fillna` refactored to `core/generic.py`, while > 3ndim is `NotImplemented`
- Series now inherits from `NDFrame` rather than directly from `ndarray`. There are several minor changes that affect the API.
- numpy functions that do not support the array interface will now return `ndarrays` rather than series, e.g. `np.diff`, `np.ones_like`, `np.where`
- `Series(0.5)` would previously return the scalar `0.5`, this is no longer supported
- `TimeSeries` is now an alias for `Series`. the property `is_time_series` can be used to distinguish (if desired)
- Refactor of Sparse objects to use BlockManager
- Created a new block type in internals, `SparseBlock`, which can hold multi-dtypes and is non-consolidatable. `SparseSeries` and `SparseDataFrame` now inherit more methods from there hierarchy (Series/DataFrame), and no longer inherit from `SparseArray` (which instead is the object of the `SparseBlock`)
- Sparse suite now supports integration with non-sparse data. Non-float sparse data is supportable (partially implemented)
- Operations on sparse structures within DataFrames should preserve sparseness, merging type operations will convert to dense (and back to sparse), so might be somewhat inefficient
- enable setitem on `SparseSeries` for boolean/integer/slices
- `SparsePanels` implementation is unchanged (e.g. not using BlockManager, needs work)
- added `ftypes` method to Series/DataFame, similar to `dtypes`, but indicates if the underlying is sparse/dense (as well as the dtype)
- All `NDFrame` objects now have a `_prop_attributes`, which can be used to indicate various values to propagate to a new object from an existing (e.g. name in `Series` will follow more automatically now)

- Internal type checking is now done via a suite of generated classes, allowing `isinstance(value, klass)` without having to directly import the klass, courtesy of @jtratner
- Bug in Series update where the parent frame is not updating its cache based on changes (GH4080, GH5216) or types (GH3217), fillna (GH3386)
- Indexing with dtype conversions fixed (GH4463, GH4204)
- Refactor `Series.reindex` to core/generic.py (GH4604, GH4618), allow `method=` in reindexing on a Series to work
- `Series.copy` no longer accepts the `order` parameter and is now consistent with `NDFrame` copy
- Refactor `rename` methods to core/generic.py; fixes `Series.rename` for (GH4605), and adds `rename` with the same signature for `Panel`
- Series (for index) / Panel (for items) now as attribute access to its elements (GH1903)
- Refactor `clip` methods to core/generic.py (GH4798)
- Refactor of `_get_numeric_data/_get_bool_data` to core/generic.py, allowing Series/Panel functionality
- Refactor of Series arithmetic with time-like objects (datetime/timedelta/time etc.) into a separate, cleaned up wrapper class. (GH4613)
- Complex compat for `Series` with `ndarray`. (GH4819)
- Removed unnecessary `rwproperty` from codebase in favor of builtin property. (GH4843)
- Refactor object level numeric methods (mean/sum/min/max...) from object level modules to `core/generic.py` (GH4435).
- Refactor cum objects to core/generic.py (GH4435), note that these have a more numpy-like function signature.
- *`read_html()`* now uses `TextParser` to parse HTML data from bs4/lxml (GH4770).
- Removed the `keep_internal` keyword parameter in `pandas/core/groupby.py` because it wasn't being used (GH5102).
- Base `DateOffsets` are no longer all instantiated on importing pandas, instead they are generated and cached on the fly. The internal representation and handling of DateOffsets has also been clarified. (GH5189, related GH5004)
- `MultiIndex` constructor now validates that passed levels and labels are compatible. (GH5213, GH5214)
- Unity `dropna` for Series/DataFrame signature (GH5250), tests from GH5234, courtesy of @rockg
- Rewrite assert_almost_equal() in cython for performance (GH4398)
- Added an internal `_update_inplace` method to facilitate updating `NDFrame` wrappers on inplace ops (only is for convenience of caller, doesn't actually prevent copies). (GH5247)

37.19.6 Bug Fixes

- `HDFStore`
  - raising an invalid `TypeError` rather than `ValueError` when appending with a different block ordering (GH4096)
  - `read_hdf` was not respecting as passed `mode` (GH4504)
  - appending a 0-len table will work correctly (GH4273)
  - `to_hdf` was raising when passing both arguments `append` and `table` (GH4584)

  - reading from a store with duplicate columns across dtypes would raise (GH4767)
  - Fixed a bug where `ValueError` wasn't correctly raised when column names weren't strings (GH4956)
  - A zero length series written in Fixed format not deserializing properly. (GH4708)
  - Fixed decoding perf issue on pyt3 (GH5441)
  - Validate levels in a multi-index before storing (GH5527)
  - Correctly handle `data_columns` with a Panel (GH5717)
- Fixed bug in tslib.tz_convert(vals, tz1, tz2): it could raise IndexError exception while trying to access trans[pos + 1] (GH4496)
- The `by` argument now works correctly with the `layout` argument (GH4102, GH4014) in `*.hist` plotting methods
- Fixed bug in `PeriodIndex.map` where using `str` would return the str representation of the index (GH4136)
- Fixed test failure `test_time_series_plot_color_with_empty_kwargs` when using custom matplotlib default colors (GH4345)
- Fix running of stata IO tests. Now uses temporary files to write (GH4353)
- Fixed an issue where `DataFrame.sum` was slower than `DataFrame.mean` for integer valued frames (GH4365)
- `read_html` tests now work with Python 2.6 (GH4351)
- Fixed bug where `network` testing was throwing `NameError` because a local variable was undefined (GH4381)
- In `to_json`, raise if a passed `orient` would cause loss of data because of a duplicate index (GH4359)
- In `to_json`, fix date handling so milliseconds are the default timestamp as the docstring says (GH4362).
- `as_index` is no longer ignored when doing groupby apply (GH4648, GH3417)
- JSON NaT handling fixed, NaTs are now serialized to *null* (GH4498)
- Fixed JSON handling of escapable characters in JSON object keys (GH4593)
- Fixed passing `keep_default_na=False` when `na_values=None` (GH4318)
- Fixed bug with `values` raising an error on a DataFrame with duplicate columns and mixed dtypes, surfaced in (GH4377)
- Fixed bug with duplicate columns and type conversion in `read_json` when `orient='split'` (GH4377)
- Fixed JSON bug where locales with decimal separators other than '.' threw exceptions when encoding / decoding certain values. (GH4918)
- Fix `.iat` indexing with a `PeriodIndex` (GH4390)
- Fixed an issue where `PeriodIndex` joining with self was returning a new instance rather than the same instance (GH4379); also adds a test for this for the other index types
- Fixed a bug with all the dtypes being converted to object when using the CSV cparser with the usecols parameter (GH3192)
- Fix an issue in merging blocks where the resulting DataFrame had partially set _ref_locs (GH4403)
- Fixed an issue where hist subplots were being overwritten when they were called using the top level matplotlib API (GH4408)
- Fixed a bug where calling `Series.astype(str)` would truncate the string (GH4405, GH4437)

- Fixed a py3 compat issue where bytes were being repr'd as tuples (GH4455)
- Fixed Panel attribute naming conflict if item is named 'a' (GH3440)
- Fixed an issue where duplicate indexes were raising when plotting (GH4486)
- Fixed an issue where cumsum and cumprod didn't work with bool dtypes (GH4170, GH4440)
- Fixed Panel slicing issued in `xs` that was returning an incorrect dimmed object (GH4016)
- Fix resampling bug where custom reduce function not used if only one group (GH3849, GH4494)
- Fixed Panel assignment with a transposed frame (GH3830)
- Raise on set indexing with a Panel and a Panel as a value which needs alignment (GH3777)
- frozenset objects now raise in the `Series` constructor (GH4482, GH4480)
- Fixed issue with sorting a duplicate multi-index that has multiple dtypes (GH4516)
- Fixed bug in `DataFrame.set_values` which was causing name attributes to be lost when expanding the index. (GH3742, GH4039)
- Fixed issue where individual `names`, `levels` and `labels` could be set on `MultiIndex` without validation (GH3714, GH4039)
- Fixed (GH3334) in pivot_table. Margins did not compute if values is the index.
- Fix bug in having a rhs of `np.timedelta64` or `np.offsets.DateOffset` when operating with datetimes (GH4532)
- Fix arithmetic with series/datetimeindex and `np.timedelta64` not working the same (GH4134) and buggy timedelta in numpy 1.6 (GH4135)
- Fix bug in `pd.read_clipboard` on windows with PY3 (GH4561); not decoding properly
- `tslib.get_period_field()` and `tslib.get_period_field_arr()` now raise if code argument out of range (GH4519, GH4520)
- Fix boolean indexing on an empty series loses index names (GH4235), infer_dtype works with empty arrays.
- Fix reindexing with multiple axes; if an axes match was not replacing the current axes, leading to a possible lazay frequency inference issue (GH3317)
- Fixed issue where `DataFrame.apply` was reraising exceptions incorrectly (causing the original stack trace to be truncated).
- Fix selection with `ix/loc` and non_unique selectors (GH4619)
- Fix assignment with iloc/loc involving a dtype change in an existing column (GH4312, GH5702) have internal setitem_with_indexer in core/indexing to use Block.setitem
- Fixed bug where thousands operator was not handled correctly for floating point numbers in csv_import (GH4322)
- Fix an issue with CacheableOffset not properly being used by many DateOffset; this prevented the DateOffset from being cached (GH4609)
- Fix boolean comparison with a DataFrame on the lhs, and a list/tuple on the rhs (GH4576)
- Fix error/dtype conversion with setitem of `None` on `Series/DataFrame` (GH4667)
- Fix decoding based on a passed in non-default encoding in `pd.read_stata` (GH4626)
- Fix `DataFrame.from_records` with a plain-vanilla `ndarray`. (GH4727)
- Fix some inconsistencies with `Index.rename` and `MultiIndex.rename`, etc. (GH4718, GH4628)

- Bug in using `iloc/loc` with a cross-sectional and duplicate indicies (GH4726)
- Bug with using `QUOTE_NONE` with `to_csv` causing `Exception`. (GH4328)
- Bug with Series indexing not raising an error when the right-hand-side has an incorrect length (GH2702)
- Bug in multi-indexing with a partial string selection as one part of a MultIndex (GH4758)
- Bug with reindexing on the index with a non-unique index will now raise `ValueError` (GH4746)
- Bug in setting with `loc/ix` a single indexer with a multi-index axis and a numpy array, related to (GH3777)
- Bug in concatenation with duplicate columns across dtypes not merging with axis=0 (GH4771, GH4975)
- Bug in `iloc` with a slice index failing (GH4771)
- Incorrect error message with no colspecs or width in `read_fwf`. (GH4774)
- Fix bugs in indexing in a Series with a duplicate index (GH4548, GH4550)
- Fixed bug with reading compressed files with `read_fwf` in Python 3. (GH3963)
- Fixed an issue with a duplicate index and assignment with a dtype change (GH4686)
- Fixed bug with reading compressed files in as `bytes` rather than `str` in Python 3. Simplifies bytes-producing file-handling in Python 3 (GH3963, GH4785).
- Fixed an issue related to ticklocs/ticklabels with log scale bar plots across different versions of matplotlib (GH4789)
- Suppressed DeprecationWarning associated with internal calls issued by repr() (GH4391)
- Fixed an issue with a duplicate index and duplicate selector with `.loc` (GH4825)
- Fixed an issue with `DataFrame.sort_index` where, when sorting by a single column and passing a list for `ascending`, the argument for `ascending` was being interpreted as `True` (GH4839, GH4846)
- Fixed `Panel.tshift` not working. Added *freq* support to `Panel.shift` (GH4853)
- Fix an issue in TextFileReader w/ Python engine (i.e. PythonParser) with thousands != ”,” (GH4596)
- Bug in getitem with a duplicate index when using where (GH4879)
- Fix Type inference code coerces float column into datetime (GH4601)
- Fixed `_ensure_numeric` does not check for complex numbers (GH4902)
- Fixed a bug in `Series.hist` where two figures were being created when the `by` argument was passed (GH4112, GH4113).
- Fixed a bug in `convert_objects` for > 2 ndims (GH4937)
- Fixed a bug in DataFrame/Panel cache insertion and subsequent indexing (GH4939, GH5424)
- Fixed string methods for `FrozenNDArray` and `FrozenList` (GH4929)
- Fixed a bug with setting invalid or out-of-range values in indexing enlargement scenarios (GH4940)
- Tests for fillna on empty Series (GH4346), thanks @immerrr
- Fixed `copy()` to shallow copy axes/indices as well and thereby keep separate metadata. (GH4202, GH4830)
- Fixed skiprows option in Python parser for read_csv (GH4382)
- Fixed bug preventing `cut` from working with `np.inf` levels without explicitly passing labels (GH3415)
- Fixed wrong check for overlapping in `DatetimeIndex.union` (GH4564)
- Fixed conflict between thousands separator and date parser in csv_parser (GH4678)

- Fix appending when dtypes are not the same (error showing mixing float/np.datetime64) (GH4993)
- Fix repr for DateOffset. No longer show duplicate entries in kwds. Removed unused offset fields. (GH4638)
- Fixed wrong index name during read_csv if using usecols. Applies to c parser only. (GH4201)
- `Timestamp` objects can now appear in the left hand side of a comparison operation with a `Series` or `DataFrame` object (GH4982).
- Fix a bug when indexing with `np.nan` via `iloc/loc` (GH5016)
- Fixed a bug where low memory c parser could create different types in different chunks of the same file. Now coerces to numerical type or raises warning. (GH3866)
- Fix a bug where reshaping a `Series` to its own shape raised `TypeError` (GH4554) and other reshaping issues.
- Bug in setting with `ix/loc` and a mixed int/string index (GH4544)
- Make sure series-series boolean comparisons are label based (GH4947)
- Bug in multi-level indexing with a Timestamp partial indexer (GH4294)
- Tests/fix for multi-index construction of an all-nan frame (GH4078)
- Fixed a bug where *read_html()* wasn't correctly inferring values of tables with commas (GH5029)
- Fixed a bug where *read_html()* wasn't providing a stable ordering of returned tables (GH4770, GH5029).
- Fixed a bug where *read_html()* was incorrectly parsing when passed `index_col=0` (GH5066).
- Fixed a bug where *read_html()* was incorrectly inferring the type of headers (GH5048).
- Fixed a bug where `DatetimeIndex` joins with `PeriodIndex` caused a stack overflow (GH3899).
- Fixed a bug where `groupby` objects didn't allow plots (GH5102).
- Fixed a bug where `groupby` objects weren't tab-completing column names (GH5102).
- Fixed a bug where `groupby.plot()` and friends were duplicating figures multiple times (GH5102).
- Provide automatic conversion of `object` dtypes on fillna, related (GH5103)
- Fixed a bug where default options were being overwritten in the option parser cleaning (GH5121).
- Treat a list/ndarray identically for `iloc` indexing with list-like (GH5006)
- Fix `MultiIndex.get_level_values()` with missing values (GH5074)
- Fix bound checking for Timestamp() with datetime64 input (GH4065)
- Fix a bug where `TestReadHtml` wasn't calling the correct `read_html()` function (GH5150).
- Fix a bug with `NDFrame.replace()` which made replacement appear as though it was (incorrectly) using regular expressions (GH5143).
- Fix better error message for to_datetime (GH4928)
- Made sure different locales are tested on travis-ci (GH4918). Also adds a couple of utilities for getting locales and setting locales with a context manager.
- Fixed segfault on `isnull(MultiIndex)` (now raises an error instead) (GH5123, GH5125)
- Allow duplicate indices when performing operations that align (GH5185, GH5639)
- Compound dtypes in a constructor raise `NotImplementedError` (GH5191)
- Bug in comparing duplicate frames (GH4421) related
- Bug in describe on duplicate frames

- Bug in `to_datetime` with a format and `coerce=True` not raising (GH5195)
- Bug in `loc` setting with multiple indexers and a rhs of a Series that needs broadcasting (GH5206)
- Fixed bug where inplace setting of levels or labels on `MultiIndex` would not clear cached `values` property and therefore return wrong `values`. (GH5215)
- Fixed bug where filtering a grouped DataFrame or Series did not maintain the original ordering (GH4621).
- Fixed `Period` with a business date freq to always roll-forward if on a non-business date. (GH5203)
- Fixed bug in Excel writers where frames with duplicate column names weren't written correctly. (GH5235)
- Fixed issue with `drop` and a non-unique index on Series (GH5248)
- Fixed seg fault in C parser caused by passing more names than columns in the file. (GH5156)
- Fix `Series.isin` with date/time-like dtypes (GH5021)
- C and Python Parser can now handle the more common multi-index column format which doesn't have a row for index names (GH4702)
- Bug when trying to use an out-of-bounds date as an object dtype (GH5312)
- Bug when trying to display an embedded PandasObject (GH5324)
- Allows operating of Timestamps to return a datetime if the result is out-of-bounds related (GH5312)
- Fix return value/type signature of `initObjToJSON()` to be compatible with numpy's `import_array()` (GH5334, GH5326)
- Bug when renaming then set_index on a DataFrame (GH5344)
- Test suite no longer leaves around temporary files when testing graphics. (GH5347) (thanks for catching this @yarikoptic!)
- Fixed html tests on win32. (GH4580)
- Make sure that `head/tail` are `iloc` based, (GH5370)
- Fixed bug for `PeriodIndex` string representation if there are 1 or 2 elements. (GH5372)
- The GroupBy methods `transform` and `filter` can be used on Series and DataFrames that have repeated (non-unique) indices. (GH4620)
- Fix empty series not printing name in repr (GH4651)
- Make tests create temp files in temp directory by default. (GH5419)
- `pd.to_timedelta` of a scalar returns a scalar (GH5410)
- `pd.to_timedelta` accepts `NaN` and `NaT`, returning `NaT` instead of raising (GH5437)
- performance improvements in `isnull` on larger size pandas objects
- Fixed various setitem with 1d ndarray that does not have a matching length to the indexer (GH5508)
- Bug in getitem with a multi-index and `iloc` (GH5528)
- Bug in delitem on a Series (GH5542)
- Bug fix in apply when using custom function and objects are not mutated (GH5545)
- Bug in selecting from a non-unique index with `loc` (GH5553)
- Bug in groupby returning non-consistent types when user function returns a `None`, (GH5592)
- Work around regression in numpy 1.7.0 which erroneously raises IndexError from `ndarray.item` (GH5666)
- Bug in repeated indexing of object with resultant non-unique index (GH5678)

- Bug in fillna with Series and a passed series/dict (GH5703)
- Bug in groupby transform with a datetime-like grouper (GH5712)
- Bug in multi-index selection in PY3 when using certain keys (GH5725)
- Row-wise concat of differing dtypes failing in certain cases (GH5754)

37.20 pandas 0.12.0

Release date: 2013-07-24

37.20.1 New Features

- `pd.read_html()` can now parse HTML strings, files or urls and returns a list of `DataFrame` s courtesy of @cpcloud. (GH3477, GH3605, GH3606)
- Support for reading Amazon S3 files. (GH3504)
- Added module for reading and writing JSON strings/files: pandas.io.json includes `to_json` DataFrame/Series method, and a `read_json` top-level reader various issues (GH1226, GH3804, GH3876, GH3867, GH1305)
- Added module for reading and writing Stata files: pandas.io.stata (GH1512) includes `to_stata` DataFrame method, and a `read_stata` top-level reader
- Added support for writing in `to_csv` and reading in `read_csv`, multi-index columns. The `header` option in `read_csv` now accepts a list of the rows from which to read the index. Added the option, `tupleize_cols` to provide compatibility for the pre 0.12 behavior of writing and reading multi-index columns via a list of tuples. The default in 0.12 is to write lists of tuples and *not* interpret list of tuples as a multi-index column. Note: The default value will change in 0.12 to make the default *to* write and read multi-index columns in the new format. (GH3571, GH1651, GH3141)
- Add iterator to `Series.str` (GH3638)
- `pd.set_option()` now allows N option, value pairs (GH3667).
- Added keyword parameters for different types of scatter_matrix subplots
- A `filter` method on grouped Series or DataFrames returns a subset of the original (GH3680, GH919)
- Access to historical Google Finance data in pandas.io.data (GH3814)
- DataFrame plotting methods can sample column colors from a Matplotlib colormap via the `colormap` keyword. (GH3860)

37.20.2 Improvements to existing features

- Fixed various issues with internal pprinting code, the repr() for various objects including TimeStamp and Index now produces valid python code strings and can be used to recreate the object, (GH3038, GH3379, GH3251, GH3460)
- `convert_objects` now accepts a `copy` parameter (defaults to `True`)
- `HDFStore`
  - will retain index attributes (freq,tz,name) on recreation (GH3499,:issue:*4098*)

  - will warn with a `AttributeConflictWarning` if you are attempting to append an index with a different frequency than the existing, or attempting to append an index with a different name than the existing
  - support datelike columns with a timezone as data_columns (GH2852)
  - table writing performance improvements.
  - support python3 (via `PyTables 3.0.0`) (GH3750)
- Add modulo operator to Series, DataFrame
- Add `date` method to DatetimeIndex
- Add `dropna` argument to pivot_table (:issue: *3820*)
- Simplified the API and added a describe method to Categorical
- `melt` now accepts the optional parameters `var_name` and `value_name` to specify custom column names of the returned DataFrame (GH3649), thanks @hoechenberger. If `var_name` is not specified and `dataframe.columns.name` is not None, then this will be used as the `var_name` (GH4144). Also support for MultiIndex columns.
- clipboard functions use pyperclip (no dependencies on Windows, alternative dependencies offered for Linux) (GH3837).
- Plotting functions now raise a `TypeError` before trying to plot anything if the associated objects have have a dtype of `object` (GH1818, GH3572, GH3911, GH3912), but they will try to convert object arrays to numeric arrays if possible so that you can still plot, for example, an object array with floats. This happens before any drawing takes place which eliminates any spurious plots from showing up.
- Added Faq section on repr display options, to help users customize their setup.
- `where` operations that result in block splitting are much faster (GH3733)
- Series and DataFrame hist methods now take a `figsize` argument (GH3834)
- DatetimeIndexes no longer try to convert mixed-integer indexes during join operations (GH3877)
- Add `unit` keyword to `Timestamp` and `to_datetime` to enable passing of integers or floats that are in an epoch unit of `D, s, ms, us, ns`, thanks @mtkini (GH3969) (e.g. unix timestamps or epoch `s`, with fractional seconds allowed) (GH3540)
- DataFrame corr method (spearman) is now cythonized.
- Improved `network` test decorator to catch `IOError` (and therefore `URLError` as well). Added `with_connectivity_check` decorator to allow explicitly checking a website as a proxy for seeing if there is network connectivity. Plus, new `optional_args` decorator factory for decorators. (GH3910, GH3914)
- `read_csv` will now throw a more informative error message when a file contains no columns, e.g., all newline characters
- Added `layout` keyword to DataFrame.hist() for more customizable layout (GH4050)
- Timestamp.min and Timestamp.max now represent valid Timestamp instances instead of the default datetime.min and datetime.max (respectively), thanks @SleepingPills
- `read_html` now raises when no tables are found and BeautifulSoup==4.2.0 is detected (GH4214)

37.20.3 API Changes

- `HDFStore`
  - When removing an object, `remove(key)` raises `KeyError` if the key is not a valid store object.

  - raise a `TypeError` on passing `where` or `columns` to select with a Storer; these are invalid parameters at this time (GH4189)
  - can now specify an `encoding` option to `append/put` to enable alternate encodings (GH3750)
  - enable support for `iterator/chunksize` with `read_hdf`
- The repr() for (Multi)Index now obeys display.max_seq_items rather then numpy threshold print options. (GH3426, GH3466)
- Added mangle_dupe_cols option to read_table/csv, allowing users to control legacy behaviour re dupe cols (A, A.1, A.2 vs A, A) (GH3468) Note: The default value will change in 0.12 to the "no mangle" behaviour, If your code relies on this behaviour, explicitly specify mangle_dupe_cols=True in your calls.
- Do not allow astypes on `datetime64[ns]` except to `object`, and `timedelta64[ns]` to `object/int` (GH3425)
- The behavior of `datetime64` dtypes has changed with respect to certain so-called reduction operations (GH3726). The following operations now raise a `TypeError` when performed on a `Series` and return an *empty* `Series` when performed on a `DataFrame` similar to performing these operations on, for example, a `DataFrame` of `slice` objects: - sum, prod, mean, std, var, skew, kurt, corr, and cov
- Do not allow datetimelike/timedeltalike creation except with valid types (e.g. cannot pass `datetime64[ms]`) (GH3423)
- Add `squeeze` keyword to `groupby` to allow reduction from DataFrame -> Series if groups are unique. Regression from 0.10.1, partial revert on (GH2893) with (GH3596)
- Raise on `iloc` when boolean indexing with a label based indexer mask e.g. a boolean Series, even with integer labels, will raise. Since `iloc` is purely positional based, the labels on the Series are not alignable (GH3631)
- The `raise_on_error` option to plotting methods is obviated by GH3572, so it is removed. Plots now always raise when data cannot be plotted or the object being plotted has a dtype of `object`.
- `DataFrame.interpolate()` is now deprecated. Please use `DataFrame.fillna()` and `DataFrame.replace()` instead (GH3582, GH3675, GH3676).
- the `method` and `axis` arguments of `DataFrame.replace()` are deprecated
- `DataFrame.replace` 's `infer_types` parameter is removed and now performs conversion by default. (GH3907)
- Deprecated display.height, display.width is now only a formatting option does not control triggering of summary, similar to < 0.11.0.
- Add the keyword `allow_duplicates` to `DataFrame.insert` to allow a duplicate column to be inserted if `True`, default is `False` (same as prior to 0.12) (GH3679)
- io API changes
  - added `pandas.io.api` for i/o imports
  - removed `Excel` support to `pandas.io.excel`
  - added top-level `pd.read_sql` and `to_sql` DataFrame methods
  - removed `clipboard` support to `pandas.io.clipboard`
  - replace top-level and instance methods `save` and `load` with top-level `read_pickle` and `to_pickle` instance method, `save` and `load` will give deprecation warning.
- the `method` and `axis` arguments of `DataFrame.replace()` are deprecated
- set FutureWarning to require data_source, and to replace year/month with expiry date in pandas.io options. This is in preparation to add options data from Google (GH3822)

- the `method` and `axis` arguments of `DataFrame.replace()` are deprecated
- Implement `__nonzero__` for `NDFrame` objects (GH3691, GH3696)
- `as_matrix` with mixed signed and unsigned dtypes will result in 2 x the lcd of the unsigned as an int, maxing with `int64`, to avoid precision issues (GH3733)
- `na_values` in a list provided to `read_csv/read_excel` will match string and numeric versions e.g. `na_values=['99']` will match 99 whether the column ends up being int, float, or string (GH3611)
- `read_html` now defaults to `None` when reading, and falls back on `bs4` + `html5lib` when lxml fails to parse. a list of parsers to try until success is also valid
- more consistency in the to_datetime return types (give string/array of string inputs) (GH3888)
- The internal `pandas` class hierarchy has changed (slightly). The previous `PandasObject` now is called `PandasContainer` and a new `PandasObject` has become the baseclass for `PandasContainer` as well as `Index`, `Categorical`, `GroupBy`, `SparseList`, and `SparseArray` (+ their base classes). Currently, `PandasObject` provides string methods (from `StringMixin`). (GH4090, GH4092)
- New `StringMixin` that, given a `__unicode__` method, gets python 2 and python 3 compatible string methods (`__str__`, `__bytes__`, and `__repr__`). Plus string safety throughout. Now employed in many places throughout the pandas library. (GH4090, GH4092)

37.20.4 Experimental Features

- Added experimental `CustomBusinessDay` class to support `DateOffsets` with custom holiday calendars and custom weekmasks. (GH2301)

37.20.5 Bug Fixes

- Fixed an esoteric excel reading bug, xlrd>= 0.9.0 now required for excel support. Should provide python3 support (for reading) which has been lacking. (GH3164)
- Disallow Series constructor called with MultiIndex which caused segfault (GH4187)
- Allow unioning of date ranges sharing a timezone (GH3491)
- Fix to_csv issue when having a large number of rows and `NaT` in some columns (GH3437)
- `.loc` was not raising when passed an integer list (GH3449)
- Unordered time series selection was misbehaving when using label slicing (GH3448)
- Fix sorting in a frame with a list of columns which contains datetime64[ns] dtypes (GH3461)
- DataFrames fetched via FRED now handle '.' as a NaN. (GH3469)
- Fix regression in a DataFrame apply with axis=1, objects were not being converted back to base dtypes correctly (GH3480)
- Fix issue when storing uint dtypes in an HDFStore. (GH3493)
- Non-unique index support clarified (GH3468)
  - Addressed handling of dupe columns in df.to_csv new and old (GH3454, GH3457)
  - Fix assigning a new index to a duplicate index in a DataFrame would fail (GH3468)
  - Fix construction of a DataFrame with a duplicate index
  - ref_locs support to allow duplicative indices across dtypes, allows iget support to always find the index (even across dtypes) (GH2194)

  - applymap on a DataFrame with a non-unique index now works (removed warning) (GH2786), and fix (GH3230)
  - Fix to_csv to handle non-unique columns (GH3495)
  - Duplicate indexes with getitem will return items in the correct order (GH3455, GH3457) and handle missing elements like unique indices (GH3561)
  - Duplicate indexes with and empty DataFrame.from_records will return a correct frame (GH3562)
  - Concat to produce a non-unique columns when duplicates are across dtypes is fixed (GH3602)
  - Non-unique indexing with a slice via `loc` and friends fixed (GH3659)
  - Allow insert/delete to non-unique columns (GH3679)
  - Extend `reindex` to correctly deal with non-unique indices (GH3679)
  - `DataFrame.itertuples()` now works with frames with duplicate column names (GH3873)
  - Bug in non-unique indexing via `iloc` (GH4017); added `takeable` argument to `reindex` for location-based taking
  - Allow non-unique indexing in series via `.ix/.loc` and `__getitem__` (GH4246)
  - Fixed non-unique indexing memory allocation issue with `.ix/.loc` (GH4280)

- Fixed bug in groupby with empty series referencing a variable before assignment. (GH3510)
- Allow index name to be used in groupby for non MultiIndex (GH4014)
- Fixed bug in mixed-frame assignment with aligned series (GH3492)
- Fixed bug in selecting month/quarter/year from a series would not select the time element on the last day (GH3546)
- Fixed a couple of MultiIndex rendering bugs in df.to_html() (GH3547, GH3553)
- Properly convert np.datetime64 objects in a Series (GH3416)
- Raise a `TypeError` on invalid datetime/timedelta operations e.g. add datetimes, multiple timedelta x datetime
- Fix `.diff` on datelike and timedelta operations (GH3100)
- `combine_first` not returning the same dtype in cases where it can (GH3552)
- Fixed bug with `Panel.transpose` argument aliases (GH3556)
- Fixed platform bug in `PeriodIndex.take` (GH3579)
- Fixed bud in incorrect conversion of datetime64[ns] in `combine_first` (GH3593)
- Fixed bug in reset_index with `NaN` in a multi-index (GH3586)
- `fillna` methods now raise a `TypeError` when the `value` parameter is a `list` or `tuple`.
- Fixed bug where a time-series was being selected in preference to an actual column name in a frame (GH3594)
- Make secondary_y work properly for bar plots (GH3598)
- Fix modulo and integer division on Series,DataFrames to act similary to `float` dtypes to return `np.nan` or `np.inf` as appropriate (GH3590)
- Fix incorrect dtype on groupby with `as_index=False` (GH3610)
- Fix `read_csv/read_excel` to correctly encode identical na_values, e.g. `na_values=[-999.0,-999]` was failing (GH3611)
- Disable HTML output in qtconsole again. (GH3657)

- Reworked the new repr display logic, which users found confusing. (GH3663)
- Fix indexing issue in ndim >= 3 with `iloc` (GH3617)
- Correctly parse date columns with embedded (nan/NaT) into datetime64[ns] dtype in `read_csv` when `parse_dates` is specified (GH3062)
- Fix not consolidating before to_csv (GH3624)
- Fix alignment issue when setitem in a DataFrame with a piece of a DataFrame (GH3626) or a mixed DataFrame and a Series (GH3668)
- Fix plotting of unordered DatetimeIndex (GH3601)
- `sql.write_frame` failing when writing a single column to sqlite (GH3628), thanks to @stonebig
- Fix pivoting with `nan` in the index (GH3558)
- Fix running of bs4 tests when it is not installed (GH3605)
- Fix parsing of html table (GH3606)
- `read_html()` now only allows a single backend: `html5lib` (GH3616)
- `convert_objects` with `convert_dates='coerce'` was parsing some single-letter strings into today's date
- `DataFrame.from_records` did not accept empty recarrays (GH3682)
- `DataFrame.to_csv` will succeed with the deprecated option `nanRep`, @tdsmith
- `DataFrame.to_html` and `DataFrame.to_latex` now accept a path for their first argument (GH3702)
- Fix file tokenization error with r delimiter and quoted fields (GH3453)
- Groupby transform with item-by-item not upcasting correctly (GH3740)
- Incorrectly read a HDFStore multi-index Frame with a column specification (GH3748)
- `read_html` now correctly skips tests (GH3741)
- PandasObjects raise TypeError when trying to hash (GH3882)
- Fix incorrect arguments passed to concat that are not list-like (e.g. concat(df1,df2)) (GH3481)
- Correctly parse when passed the `dtype=str` (or other variable-len string dtypes) in `read_csv` (GH3795)
- Fix index name not propagating when using `loc/ix` (GH3880)
- Fix groupby when applying a custom function resulting in a returned DataFrame was not converting dtypes (GH3911)
- Fixed a bug where `DataFrame.replace` with a compiled regular expression in the `to_replace` argument wasn't working (GH3907)
- Fixed `__truediv__` in Python 2.7 with `numexpr` installed to actually do true division when dividing two integer arrays with at least 10000 cells total (GH3764)
- Indexing with a string with seconds resolution not selecting from a time index (GH3925)
- csv parsers would loop infinitely if `iterator=True` but no `chunksize` was specified (GH3967), python parser failing with `chunksize=1`
- Fix index name not propagating when using `shift`
- Fixed dropna=False being ignored with multi-index stack (GH3997)
- Fixed flattening of columns when renaming MultiIndex columns DataFrame (GH4004)

- Fix `Series.clip` for datetime series. NA/NaN threshold values will now throw ValueError (GH3996)
- Fixed insertion issue into DataFrame, after rename (GH4032)
- Fixed testing issue where too many sockets where open thus leading to a connection reset issue (GH3982, GH3985, GH4028, GH4054)
- Fixed failing tests in test_yahoo, test_google where symbols were not retrieved but were being accessed (GH3982, GH3985, GH4028, GH4054)
- `Series.hist` will now take the figure from the current environment if one is not passed
- Fixed bug where a 1xN DataFrame would barf on a 1xN mask (GH4071)
- Fixed running of `tox` under python3 where the pickle import was getting rewritten in an incompatible way (GH4062, GH4063)
- Fixed bug where sharex and sharey were not being passed to grouped_hist (GH4089)
- Fix bug where `HDFStore` will fail to append because of a different block ordering on-disk (GH4096)
- Better error messages on inserting incompatible columns to a frame (GH4107)
- Fixed bug in `DataFrame.replace` where a nested dict wasn't being iterated over when regex=False (GH4115)
- Fixed bug in `convert_objects(convert_numeric=True)` where a mixed numeric and object Series/Frame was not converting properly (GH4119)
- Fixed bugs in multi-index selection with column multi-index and duplicates (GH4145, GH4146)
- Fixed bug in the parsing of microseconds when using the `format` argument in `to_datetime` (GH4152)
- Fixed bug in `PandasAutoDateLocator` where `invert_xaxis` triggered incorrectly `MilliSecondLocator` (GH3990)
- Fixed bug in `Series.where` where broadcasting a single element input vector to the length of the series resulted in multiplying the value inside the input (GH4192)
- Fixed bug in plotting that wasn't raising on invalid colormap for matplotlib 1.1.1 (GH4215)
- Fixed the legend displaying in `DataFrame.plot(kind='kde')` (GH4216)
- Fixed bug where Index slices weren't carrying the name attribute (GH4226)
- Fixed bug in initializing `DatetimeIndex` with an array of strings in a certain time zone (GH4229)
- Fixed bug where html5lib wasn't being properly skipped (GH4265)
- Fixed bug where get_data_famafrench wasn't using the correct file edges (GH4281)

37.21 pandas 0.11.0

Release date: 2013-04-22

37.21.1 New Features

- New documentation section, `10 Minutes to Pandas`
- New documentation section, `Cookbook`
- Allow mixed dtypes (e.g `float32/float64/int32/int16/int8`) to coexist in DataFrames and propagate in operations

- Add function to pandas.io.data for retrieving stock index components from Yahoo! finance (GH2795)
- Support slicing with time objects (GH2681)
- Added `.iloc` attribute, to support strict integer based indexing, analogous to `.ix` (GH2922)
- Added `.loc` attribute, to support strict label based indexing, analogous to `.ix` (GH3053)
- Added `.iat` attribute, to support fast scalar access via integers (replaces `iget_value/iset_value`)
- Added `.at` attribute, to support fast scalar access via labels (replaces `get_value/set_value`)
- Moved functionality from `irow,icol,iget_value/iset_value` to `.iloc` indexer (via `_ixs` methods in each object)
- Added support for expression evaluation using the `numexpr` library
- Added `convert=boolean` to `take` routines to translate negative indices to positive, defaults to True
- Added to_series() method to indices, to facilitate the creation of indexers (GH3275)

37.21.2 Improvements to existing features

- Improved performance of df.to_csv() by up to 10x in some cases. (GH3059)
- added `blocks` attribute to DataFrames, to return a dict of dtypes to homogeneously dtyped DataFrames
- added keyword `convert_numeric` to `convert_objects()` to try to convert object dtypes to numeric types (default is False)
- `convert_dates` in `convert_objects` can now be `coerce` which will return a datetime64[ns] dtype with non-convertibles set as `NaT`; will preserve an all-nan object (e.g. strings), default is True (to perform soft-conversion
- Series print output now includes the dtype by default
- Optimize internal reindexing routines (GH2819, GH2867)
- `describe_option()` now reports the default and current value of options.
- Add `format` option to `pandas.to_datetime` with faster conversion of strings that can be parsed with datetime.strptime
- Add `axes` property to `Series` for compatibility
- Add `xs` function to `Series` for compatibility
- Allow setitem in a frame where only mixed numerics are present (e.g. int and float), (GH3037)
- `HDFStore`
  - Provide dotted attribute access to `get` from stores (e.g. store.df == store['df'])
  - New keywords `iterator=boolean`, and `chunksize=number_in_a_chunk` are provided to support iteration on `select` and `select_as_multiple` (GH3076)
  - support `read_hdf/to_hdf` API similar to `read_csv/to_csv` (GH3222)
- Add `squeeze` method to possibly remove length 1 dimensions from an object.

```
In [1]: p = pd.Panel(np.random.randn(3,4,4),items=['ItemA','ItemB','ItemC'],
   ...:              major_axis=pd.date_range('20010102',periods=4),
   ...:              minor_axis=['A','B','C','D'])
   ...:
```

```
In [2]: p
Out[2]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 4 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2001-01-02 00:00:00 to 2001-01-05 00:00:00
Minor_axis axis: A to D

In [3]: p.reindex(items=['ItemA']).squeeze()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
                   A         B         C         D
2001-01-02  0.469112 -0.282863 -1.509059 -1.135632
2001-01-03  1.212112 -0.173215  0.119209 -1.044236
2001-01-04 -0.861849 -2.104569 -0.494929  1.071804
2001-01-05  0.721555 -0.706771 -1.039575  0.271860

In [4]: p.reindex(items=['ItemA'],minor=['B']).squeeze()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
 ↪
2001-01-02   -0.282863
2001-01-03   -0.173215
2001-01-04   -2.104569
2001-01-05   -0.706771
Freq: D, Name: B, dtype: float64
```

- Improvement to Yahoo API access in `pd.io.data.Options` (GH2758)
- added option *display.max_seq_items* to control the number of elements printed per sequence pprinting it. (GH2979)
- added option *display.chop_threshold* to control display of small numerical values. (GH2739)
- added option *display.max_info_rows* to prevent verbose_info from being calculated for frames above 1M rows (configurable). (GH2807, GH2918)
- value_counts() now accepts a "normalize" argument, for normalized histograms. (GH2710).
- DataFrame.from_records now accepts not only dicts but any instance of the collections.Mapping ABC.
- Allow selection semantics via a string with a datelike index to work in both Series and DataFrames (GH3070)

```
In [5]: idx = pd.date_range("2001-10-1", periods=5, freq='M')

In [6]: ts = pd.Series(np.random.rand(len(idx)),index=idx)

In [7]: ts['2001']
Out[7]:
2001-10-31    0.838796
2001-11-30    0.897333
2001-12-31    0.732592
Freq: M, dtype: float64

In [8]: df = pd.DataFrame(dict(A = ts))

In [9]: df['2001']
Out[9]:
                   A
2001-10-31  0.838796
```

```
2001-11-30  0.897333
2001-12-31  0.732592
```

- added option *display.mpl_style* providing a sleeker visual style for plots. Based on https://gist.github.com/huyng/816622 (GH3075).
- Improved performance across several core functions by taking memory ordering of arrays into account. Courtesy of @stephenwlin (GH3130)
- Improved performance of groupby transform method (GH2121)
- Handle "ragged" CSV files missing trailing delimiters in rows with missing fields when also providing explicit list of column names (so the parser knows how many columns to expect in the result) (GH2981)
- On a mixed DataFrame, allow setting with indexers with ndarray/DataFrame on rhs (GH3216)
- Treat boolean values as integers (values 1 and 0) for numeric operations. (GH2641)
- Add `time` method to DatetimeIndex (GH3180)
- Return NA when using Series.str[...] for values that are not long enough (GH3223)
- Display cursor coordinate information in time-series plots (GH1670)
- to_html() now accepts an optional "escape" argument to control reserved HTML character escaping (enabled by default) and escapes `&`, in addition to < and >. (GH2919)

37.21.3 API Changes

- Do not automatically upcast numeric specified dtypes to `int64` or `float64` (GH622 and GH797)
- DataFrame construction of lists and scalars, with no dtype present, will result in casting to `int64` or `float64`, regardless of platform. This is not an apparent change in the API, but noting it.
- Guarantee that `convert_objects()` for Series/DataFrame always returns a copy
- groupby operations will respect dtypes for numeric float operations (float32/float64); other types will be operated on, and will try to cast back to the input dtype (e.g. if an int is passed, as long as the output doesn't have nans, then an int will be returned)
- backfill/pad/take/diff/ohlc will now support `float32/int16/int8` operations
- Block types will upcast as needed in where/masking operations (GH2793)
- Series now automatically will try to set the correct dtype based on passed datetimelike objects (datetime/Timestamp)
  - timedelta64 are returned in appropriate cases (e.g. Series - Series, when both are datetime64)
  - mixed datetimes and objects (GH2751) in a constructor will be cast correctly
  - astype on datetimes to object are now handled (as well as NaT conversions to np.nan)
  - all timedelta like objects will be correctly assigned to `timedelta64` with mixed `NaN` and/or `NaT` allowed
- arguments to DataFrame.clip were inconsistent to numpy and Series clipping (GH2747)
- util.testing.assert_frame_equal now checks the column and index names (GH2964)
- Constructors will now return a more informative ValueError on failures when invalid shapes are passed
- Don't suppress TypeError in GroupBy.agg (GH3238)
- Methods return None when inplace=True (GH1893)

- `HDFStore`
  - added the method `select_column` to select a single column from a table as a Series.
  - deprecated the `unique` method, can be replicated by `select_column(key,column).unique()`
  - `min_itemsize` parameter will now automatically create data_columns for passed keys
- Downcast on pivot if possible (GH3283), adds argument `downcast` to `fillna`
- Introduced options *display.height/width* for explicitly specifying terminal height/width in characters. Deprecated display.line_width, now replaced by display.width. These defaults are in effect for scripts as well, so unless disabled, previously very wide output will now be output as "expand_repr" style wrapped output.
- Various defaults for options (including display.max_rows) have been revised, after a brief survey concluded they were wrong for everyone. Now at w=80,h=60.
- HTML repr output in IPython qtconsole is once again controlled by the option *display.notebook_repr_html*, and on by default.

37.21.4 Bug Fixes

- Fix seg fault on empty data frame when fillna with `pad` or `backfill` (GH2778)
- Single element ndarrays of datetimelike objects are handled (e.g. np.array(datetime(2001,1,1,0,0))), w/o dtype being passed
- 0-dim ndarrays with a passed dtype are handled correctly (e.g. np.array(0.,dtype='float32'))
- Fix some boolean indexing inconsistencies in Series.__getitem__/__setitem__ (GH2776)
- Fix issues with DataFrame and Series constructor with integers that overflow `int64` and some mixed typed type lists (GH2845)
- `HDFStore`
  - Fix weird PyTables error when using too many selectors in a where also correctly filter on any number of values in a Term expression (so not using numexpr filtering, but isin filtering)
  - Internally, change all variables to be private-like (now have leading underscore)
  - Fixes for query parsing to correctly interpret boolean and != (GH2849, GH2973)
  - Fixes for pathological case on SparseSeries with 0-len array and compression (GH2931)
  - Fixes bug with writing rows if part of a block was all-nan (GH3012)
  - Exceptions are now ValueError or TypeError as needed
  - A table will now raise if min_itemsize contains fields which are not queryables
- Bug showing up in applymap where some object type columns are converted (GH2909) had an incorrect default in convert_objects
- TimeDeltas
  - Series ops with a Timestamp on the rhs was throwing an exception (GH2898) added tests for Series ops with datetimes,timedeltas,Timestamps, and datelike Series on both lhs and rhs
  - Fixed subtle timedelta64 inference issue on py3 & numpy 1.7.0 (GH3094)
  - Fixed some formatting issues on timedelta when negative
  - Support null checking on timedelta64, representing (and formatting) with NaT
  - Support setitem with np.nan value, converts to NaT

  - Support min/max ops in a Dataframe (abs not working, nor do we error on non-supported ops)
  - Support idxmin/idxmax/abs/max/min in a Series (GH2989, GH2982)
- Bug on in-place putmasking on an `integer` series that needs to be converted to `float` (GH2746)
- Bug in argsort of `datetime64[ns]` Series with `NaT` (GH2967)
- Bug in value_counts of `datetime64[ns]` Series (GH3002)
- Fixed printing of `NaT` in an index
- Bug in idxmin/idxmax of `datetime64[ns]` Series with `NaT` (GH2982)
- Bug in `icol, take` with negative indicies was producing incorrect return values (see GH2922, GH2892), also check for out-of-bounds indices (GH3029)
- Bug in DataFrame column insertion when the column creation fails, existing frame is left in an irrecoverable state (GH3010)
- Bug in DataFrame update, combine_first where non-specified values could cause dtype changes (GH3016, GH3041)
- Bug in groupby with first/last where dtypes could change (GH3041, GH2763)
- Formatting of an index that has `nan` was inconsistent or wrong (would fill from other values), (GH2850)
- Unstack of a frame with no nans would always cause dtype upcasting (GH2929)
- Fix scalar datetime.datetime parsing bug in read_csv (GH3071)
- Fixed slow printing of large Dataframes, due to inefficient dtype reporting (GH2807)
- Fixed a segfault when using a function as grouper in groupby (GH3035)
- Fix pretty-printing of infinite data structures (closes GH2978)
- Fixed exception when plotting timeseries bearing a timezone (closes GH2877)
- str.contains ignored na argument (GH2806)
- Substitute warning for segfault when grouping with categorical grouper of mismatched length (GH3011)
- Fix exception in SparseSeries.density (GH2083)
- Fix upsampling bug with closed='left' and daily to daily data (GH3020)
- Fixed missing tick bars on scatter_matrix plot (GH3063)
- Fixed bug in Timestamp(d,tz=foo) when d is date() rather then datetime() (GH2993)
- series.plot(kind='bar') now respects pylab color schem (GH3115)
- Fixed bug in reshape if not passed correct input, now raises TypeError (GH2719)
- Fixed a bug where Series ctor did not respect ordering if OrderedDict passed in (GH3282)
- Fix NameError issue on RESO_US (GH2787)
- Allow selection in an *unordered* timeseries to work similary to an *ordered* timeseries (GH2437).
- Fix implemented `.xs` when called with `axes=1` and a level parameter (GH2903)
- Timestamp now supports the class method fromordinal similar to datetimes (GH3042)
- Fix issue with indexing a series with a boolean key and specifiying a 1-len list on the rhs (GH2745) or a list on the rhs (GH3235)
- Fixed bug in groupby apply when kernel generate list of arrays having unequal len (GH1738)

- fixed handling of rolling_corr with center=True which could produce corr>1 (GH3155)
- Fixed issues where indices can be passed as 'index/column' in addition to 0/1 for the axis parameter
- PeriodIndex.tolist now boxes to Period (GH3178)
- PeriodIndex.get_loc KeyError now reports Period instead of ordinal (GH3179)
- df.to_records bug when handling MultiIndex (GH3189)
- Fix Series.__getitem__ segfault when index less than -length (GH3168)
- Fix bug when using Timestamp as a date parser (GH2932)
- Fix bug creating date range from Timestamp with time zone and passing same time zone (GH2926)
- Add comparison operators to Period object (GH2781)
- Fix bug when concatenating two Series into a DataFrame when they have the same name (GH2797)
- Fix automatic color cycling when plotting consecutive timeseries without color arguments (GH2816)
- fixed bug in the pickling of PeriodIndex (GH2891)
- Upcast/split blocks when needed in a mixed DataFrame when setitem with an indexer (GH3216)
- Invoking df.applymap on a dataframe with dupe cols now raises a ValueError (GH2786)
- Apply with invalid returned indices raise correct Exception (GH2808)
- Fixed a bug in plotting log-scale bar plots (GH3247)
- df.plot() grid on/off now obeys the mpl default style, just like series.plot(). (GH3233)
- Fixed a bug in the legend of plotting.andrews_curves() (GH3278)
- Produce a series on apply if we only generate a singular series and have a simple index (GH2893)
- Fix Python ASCII file parsing when integer falls outside of floating point spacing (GH3258)
- fixed pretty priniting of sets (GH3294)
- Panel() and Panel.from_dict() now respects ordering when give OrderedDict (GH3303)
- DataFrame where with a datetimelike incorrectly selecting (GH3311)
- Ensure index casts work even in Int64Index
- Fix set_index segfault when passing MultiIndex (GH3308)
- Ensure pickles created in py2 can be read in py3
- Insert ellipsis in MultiIndex summary repr (GH3348)
- Groupby will handle mutation among an input groups columns (and fallback to non-fast apply) (GH3380)
- Eliminated unicode errors on FreeBSD when using MPL GTK backend (GH3360)
- Period.strftime should return unicode strings always (GH3363)
- Respect passed read_* chunksize in get_chunk function (GH3406)

37.22 pandas 0.10.1

Release date: 2013-01-22

37.22.1 New Features

- Add data interface to World Bank WDI pandas.io.wb (GH2592)

37.22.2 API Changes

- Restored inplace=True behavior returning self (same object) with deprecation warning until 0.11 (GH1893)
- `HDFStore`
  - refactored HFDStore to deal with non-table stores as objects, will allow future enhancements
  - removed keyword `compression` from `put` (replaced by keyword `complib` to be consistent across library)
  - warn *PerformanceWarning* if you are attempting to store types that will be pickled by PyTables

37.22.3 Improvements to existing features

- `HDFStore`
  - enables storing of multi-index dataframes (closes GH1277)
  - support data column indexing and selection, via `data_columns` keyword in append
  - support write chunking to reduce memory footprint, via `chunksize` keyword to append
  - support automagic indexing via `index` keyword to append
  - support `expectedrows` keyword in append to inform `PyTables` about the expected tablesize
  - support `start` and `stop` keywords in select to limit the row selection space
  - added `get_store` context manager to automatically import with pandas
  - added column filtering via `columns` keyword in select
  - added methods append_to_multiple/select_as_multiple/select_as_coordinates to do multiple-table append/selection
  - added support for datetime64 in columns
  - added method `unique` to select the unique values in an indexable or data column
  - added method `copy` to copy an existing store (and possibly upgrade)
  - show the shape of the data on disk for non-table stores when printing the store
  - added ability to read PyTables flavor tables (allows compatibility to other HDF5 systems)
- Add `logx` option to DataFrame/Series.plot (GH2327, GH2565)
- Support reading gzipped data from file-like object
- `pivot_table` aggfunc can be anything used in GroupBy.aggregate (GH2643)
- Implement DataFrame merges in case where set cardinalities might overflow 64-bit integer (GH2690)
- Raise exception in C file parser if integer dtype specified and have NA values. (GH2631)
- Attempt to parse ISO8601 format dates when parse_dates=True in read_csv for major performance boost in such cases (GH2698)
- Add methods `neg` and `inv` to Series

- Implement `kind` option in `ExcelFile` to indicate whether it's an XLS or XLSX file (GH2613)
- Documented a fast-path in pd.read_csv when parsing iso8601 datetime strings yielding as much as a 20x speedup. (GH5993)

37.22.4 Bug Fixes

- Fix read_csv/read_table multithreading issues (GH2608)
- `HDFStore`
  - correctly handle `nan` elements in string columns; serialize via the `nan_rep` keyword to append
  - raise correctly on non-implemented column types (unicode/date)
  - handle correctly `Term` passed types (e.g. `index<1000`, when index is `Int64`), (closes GH512)
  - handle Timestamp correctly in data_columns (closes GH2637)
  - contains correctly matches on non-natural names
  - correctly store `float32` dtypes in tables (if not other float types in the same table)
- Fix DataFrame.info bug with UTF8-encoded columns. (GH2576)
- Fix DatetimeIndex handling of FixedOffset tz (GH2604)
- More robust detection of being in IPython session for wide DataFrame console formatting (GH2585)
- Fix platform issues with `file:///` in unit test (GH2564)
- Fix bug and possible segfault when grouping by hierarchical level that contains NA values (GH2616)
- Ensure that MultiIndex tuples can be constructed with NAs (GH2616)
- Fix int64 overflow issue when unstacking MultiIndex with many levels (GH2616)
- Exclude non-numeric data from DataFrame.quantile by default (GH2625)
- Fix a Cython C int64 boxing issue causing read_csv to return incorrect results (GH2599)
- Fix groupby summing performance issue on boolean data (GH2692)
- Don't bork Series containing datetime64 values with to_datetime (GH2699)
- Fix DataFrame.from_records corner case when passed columns, index column, but empty record list (GH2633)
- Fix C parser-tokenizer bug with trailing fields. (GH2668)
- Don't exclude non-numeric data from GroupBy.max/min (GH2700)
- Don't lose time zone when calling DatetimeIndex.drop (GH2621)
- Fix setitem on a Series with a boolean key and a non-scalar as value (GH2686)
- Box datetime64 values in Series.apply/map (GH2627, GH2689)
- Upconvert datetime + datetime64 values when concatenating frames (GH2624)
- Raise a more helpful error message in merge operations when one DataFrame has duplicate columns (GH2649)
- Fix partial date parsing issue occuring only when code is run at EOM (GH2618)
- Prevent MemoryError when using counting sort in sortlevel with high-cardinality MultiIndex objects (GH2684)
- Fix Period resampling bug when all values fall into a single bin (GH2070)
- Fix buggy interaction with usecols argument in read_csv when there is an implicit first index column (GH2654)

- Fix bug in `Index.summary()` where string format methods were being called incorrectly. (GH3869)

37.23 pandas 0.10.0

Release date: 2012-12-17

37.23.1 New Features

- Brand new high-performance delimited file parsing engine written in C and Cython. 50% or better performance in many standard use cases with a fraction as much memory usage. (GH407, GH821)
- Many new file parser (read_csv, read_table) features:
  - Support for on-the-fly gzip or bz2 decompression (*compression* option)
  - Ability to get back numpy.recarray instead of DataFrame (*as_recarray=True*)
  - *dtype* option: explicit column dtypes
  - *usecols* option: specify list of columns to be read from a file. Good for reading very wide files with many irrelevant columns (GH1216 GH926, GH2465)
  - Enhanced unicode decoding support via *encoding* option
  - *skipinitialspace* dialect option
  - Can specify strings to be recognized as True (*true_values*) or False (*false_values*)
  - High-performance *delim_whitespace* option for whitespace-delimited files; a preferred alternative to the 's+' regular expression delimiter
  - Option to skip "bad" lines (wrong number of fields) that would otherwise have caused an error in the past (*error_bad_lines* and *warn_bad_lines* options)
  - Substantially improved performance in the parsing of integers with thousands markers and lines with comments
  - Easy of European (and other) decimal formats (*decimal* option) (GH584, GH2466)
  - Custom line terminators (e.g. lineterminator='~') (GH2457)
  - Handling of no trailing commas in CSV files (GH2333)
  - Ability to handle fractional seconds in date_converters (GH2209)
  - read_csv allow scalar arg to na_values (GH1944)
  - Explicit column dtype specification in read_* functions (GH1858)
  - Easier CSV dialect specification (GH1743)
  - Improve parser performance when handling special characters (GH1204)
- Google Analytics API integration with easy oauth2 workflow (GH2283)
- Add error handling to Series.str.encode/decode (GH2276)
- Add `where` and `mask` to Series (GH2337)
- Grouped histogram via *by* keyword in Series/DataFrame.hist (GH2186)
- Support optional `min_periods` keyword in `corr` and `cov` for both Series and DataFrame (GH2002)
- Add `duplicated` and `drop_duplicates` functions to Series (GH1923)

- Add docs for `HDFStore table` format
- 'density' property in *SparseSeries* (GH2384)
- Add `ffill` and `bfill` convenience functions for forward- and backfilling time series data (GH2284)
- New option configuration system and functions *set_option*, *get_option*, *describe_option*, and *reset_option*. Deprecate *set_printoptions* and *reset_printoptions* (GH2393). You can also access options as attributes via `pandas.options.X`
- Wide DataFrames can be viewed more easily in the console with new *expand_frame_repr* and *line_width* configuration options. This is on by default now (GH2436)
- Scikits.timeseries-like moving window functions via `rolling_window` (GH1270)

37.23.2 Experimental Features

- Add support for Panel4D, a named 4 Dimensional structure
- Add support for ndpanel factory functions, to create custom, domain-specific N-Dimensional containers

37.23.3 API Changes

- The default binning/labeling behavior for `resample` has been changed to *closed='left', label='left'* for daily and lower frequencies. This had been a large source of confusion for users. See "what's new" page for more on this. (GH2410)
- Methods with `inplace` option now return None instead of the calling (modified) object (GH1893)
- The special case DataFrame - TimeSeries doing column-by-column broadcasting has been deprecated. Users should explicitly do e.g. df.sub(ts, axis=0) instead. This is a legacy hack and can lead to subtle bugs.
- inf/-inf are no longer considered as NA by isnull/notnull. To be clear, this is legacy cruft from early pandas. This behavior can be globally re-enabled using the new option `mode.use_inf_as_null` (GH2050, GH1919)
- `pandas.merge` will now default to `sort=False`. For many use cases sorting the join keys is not necessary, and doing it by default is wasteful
- Specify `header=0` explicitly to replace existing column names in file in read_* functions.
- Default column names for header-less parsed files (yielded by read_csv, etc.) are now the integers 0, 1, ... A new argument *prefix* has been added; to get the v0.9.x behavior specify `prefix='X'` (GH2034). This API change was made to make the default column names more consistent with the DataFrame constructor's default column names when none are specified.
- DataFrame selection using a boolean frame now preserves input shape
- If function passed to Series.apply yields a Series, result will be a DataFrame (GH2316)
- Values like YES/NO/yes/no will not be considered as boolean by default any longer in the file parsers. This can be customized using the new `true_values` and `false_values` options (GH2360)
- *obj.fillna()* is no longer valid; make *method='pad'* no longer the default option, to be more explicit about what kind of filling to perform. Add *ffill/bfill* convenience functions per above (GH2284)
- *HDFStore.keys()* now returns an absolute path-name for each key
- *to_string()* now always returns a unicode string. (GH2224)
- File parsers will not handle NA sentinel values arising from passed converter functions

37.23.4 Improvements to existing features

- Add `nrows` option to DataFrame.from_records for iterators (GH1794)
- Unstack/reshape algorithm rewrite to avoid high memory use in cases where the number of observed key-tuples is much smaller than the total possible number that could occur (GH2278). Also improves performance in most cases.
- Support duplicate columns in DataFrame.from_records (GH2179)
- Add `normalize` option to Series/DataFrame.asfreq (GH2137)
- SparseSeries and SparseDataFrame construction from empty and scalar values now no longer create dense ndarrays unnecessarily (GH2322)
- `HDFStore` now supports hierarchical keys (GH2397)
- Support multiple query selection formats for `HDFStore tables` (GH1996)
- Support `del store['df']` syntax to delete HDFStores
- Add multi-dtype support for `HDFStore tables`
- `min_itemsize` parameter can be specified in `HDFStore table` creation
- Indexing support in `HDFStore tables` (GH698)
- Add *line_terminator* option to DataFrame.to_csv (GH2383)
- added implementation of str(x)/unicode(x)/bytes(x) to major pandas data structures, which should do the right thing on both py2.x and py3.x. (GH2224)
- Reduce groupby.apply overhead substantially by low-level manipulation of internal NumPy arrays in DataFrames (GH535)
- Implement `value_vars` in `melt` and add `melt` to pandas namespace (GH2412)
- Added boolean comparison operators to Panel
- Enable `Series.str.strip/lstrip/rstrip` methods to take an argument (GH2411)
- The DataFrame ctor now respects column ordering when given an OrderedDict (GH2455)
- Assigning DatetimeIndex to Series changes the class to TimeSeries (GH2139)
- Improve performance of .value_counts method on non-integer data (GH2480)
- `get_level_values` method for MultiIndex return Index instead of ndarray (GH2449)
- `convert_to_r_dataframe` conversion for datetime values (GH2351)
- Allow `DataFrame.to_csv` to represent inf and nan differently (GH2026)
- Add `min_i` argument to `nancorr` to specify minimum required observations (GH2002)
- Add `inplace` option to `sortlevel` / `sort` functions on DataFrame (GH1873)
- Enable DataFrame to accept scalar constructor values like Series (GH1856)
- DataFrame.from_records now takes optional `size` parameter (GH1794)
- include iris dataset (GH1709)
- No datetime64 DataFrame column conversion of datetime.datetime with tzinfo (GH1581)
- Micro-optimizations in DataFrame for tracking state of internal consolidation (GH217)
- Format parameter in DataFrame.to_csv (GH1525)

- Partial string slicing for `DatetimeIndex` for daily and higher frequencies (GH2306)
- Implement `col_space` parameter in `to_html` and `to_string` in DataFrame (GH1000)
- Override `Series.tolist` and box datetime64 types (GH2447)
- Optimize `unstack` memory usage by compressing indices (GH2278)
- Fix HTML repr in IPython qtconsole if opening window is small (GH2275)
- Escape more special characters in console output (GH2492)
- df.select now invokes bool on the result of crit(x) (GH2487)

37.23.5 Bug Fixes

- Fix major performance regression in DataFrame.iteritems (GH2273)
- Fixes bug when negative period passed to Series/DataFrame.diff (GH2266)
- Escape tabs in console output to avoid alignment issues (GH2038)
- Properly box datetime64 values when retrieving cross-section from mixed-dtype DataFrame (GH2272)
- Fix concatenation bug leading to GH2057, GH2257
- Fix regression in Index console formatting (GH2319)
- Box Period data when assigning PeriodIndex to frame column (GH2243, GH2281)
- Raise exception on calling reset_index on Series with inplace=True (GH2277)
- Enable setting multiple columns in DataFrame with hierarchical columns (GH2295)
- Respect dtype=object in DataFrame constructor (GH2291)
- Fix DatetimeIndex.join bug with tz-aware indexes and how='outer' (GH2317)
- pop(...) and del works with DataFrame with duplicate columns (GH2349)
- Treat empty strings as NA in date parsing (rather than let dateutil do something weird) (GH2263)
- Prevent uint64 -> int64 overflows (GH2355)
- Enable joins between MultiIndex and regular Index (GH2024)
- Fix time zone metadata issue when unioning non-overlapping DatetimeIndex objects (GH2367)
- Raise/handle int64 overflows in parsers (GH2247)
- Deleting of consecutive rows in `HDFStore tables` is much faster than before
- Appending on a HDFStore would fail if the table was not first created via `put`
- Use *col_space* argument as minimum column width in DataFrame.to_html (GH2328)
- Fix tz-aware DatetimeIndex.to_period (GH2232)
- Fix DataFrame row indexing case with MultiIndex (GH2314)
- Fix to_excel exporting issues with Timestamp objects in index (GH2294)
- Fixes assigning scalars and array to hierarchical column chunk (GH1803)
- Fixed a UnicodeDecodeError with series tidy_repr (GH2225)
- Fixed issued with duplicate keys in an index (GH2347, GH2380)
- Fixed issues re: Hash randomization, default on starting w/ py3.3 (GH2331)

- Fixed issue with missing attributes after loading a pickled dataframe (GH2431)
- Fix Timestamp formatting with tzoffset time zone in dateutil 2.1 (GH2443)
- Fix GroupBy.apply issue when using BinGrouper to do ts binning (GH2300)
- Fix issues resulting from datetime.datetime columns being converted to datetime64 when calling DataFrame.apply. (GH2374)
- Raise exception when calling to_panel on non uniquely-indexed frame (GH2441)
- Improved detection of console encoding on IPython zmq frontends (GH2458)
- Preserve time zone when .append-ing two time series (GH2260)
- Box timestamps when calling reset_index on time-zone-aware index rather than creating a tz-less datetime64 column (GH2262)
- Enable searching non-string columns in DataFrame.filter(like=...) (GH2467)
- Fixed issue with losing nanosecond precision upon conversion to DatetimeIndex(GH2252)
- Handle timezones in Datetime.normalize (GH2338)
- Fix test case where dtype specification with endianness causes failures on big endian machines (GH2318)
- Fix plotting bug where upsampling causes data to appear shifted in time (GH2448)
- Fix `read_csv` failure for UTF-16 with BOM and skiprows(GH2298)
- read_csv with names arg not implicitly setting header=None(GH2459)
- Unrecognized compression mode causes segfault in read_csv(GH2474)
- In read_csv, header=0 and passed names should discard first row(GH2269)
- Correctly route to stdout/stderr in read_table (GH2071)
- Fix exception when Timestamp.to_datetime is called on a Timestamp with tzoffset (GH2471)
- Fixed unintentional conversion of datetime64 to long in groupby.first() (GH2133)
- Union of empty DataFrames now return empty with concatenated index (GH2307)
- DataFrame.sort_index raises more helpful exception if sorting by column with duplicates (GH2488)
- DataFrame.to_string formatters can be list, too (GH2520)
- DataFrame.combine_first will always result in the union of the index and columns, even if one DataFrame is length-zero (GH2525)
- Fix several DataFrame.icol/irow with duplicate indices issues (GH2228, GH2259)
- Use Series names for column names when using concat with axis=1 (GH2489)
- Raise Exception if start, end, periods all passed to date_range (GH2538)
- Fix Panel resampling issue (GH2537)

37.24 pandas 0.9.1

Release date: 2012-11-14

37.24.1 New Features

- Can specify multiple sort orders in DataFrame/Series.sort/sort_index (GH928)
- New *top* and *bottom* options for handling NAs in rank (GH1508, GH2159)
- Add *where* and *mask* functions to DataFrame (GH2109, GH2151)
- Add *at_time* and *between_time* functions to DataFrame (GH2149)
- Add flexible *pow* and *rpow* methods to DataFrame (GH2190)

37.24.2 API Changes

- Upsampling period index "spans" intervals. Example: annual periods upsampled to monthly will span all months in each year
- Period.end_time will yield timestamp at last nanosecond in the interval (GH2124, GH2125, GH1764)
- File parsers no longer coerce to float or bool for columns that have custom converters specified (GH2184)

37.24.3 Improvements to existing features

- Time rule inference for week-of-month (e.g. WOM-2FRI) rules (GH2140)
- Improve performance of datetime + business day offset with large number of offset periods
- Improve HTML display of DataFrame objects with hierarchical columns
- Enable referencing of Excel columns by their column names (GH1936)
- DataFrame.dot can accept ndarrays (GH2042)
- Support negative periods in Panel.shift (GH2164)
- Make .drop(...) work with non-unique indexes (GH2101)
- Improve performance of Series/DataFrame.diff (re: GH2087)
- Support unary ~ (__invert__) in DataFrame (GH2110)
- Turn off pandas-style tick locators and formatters (GH2205)
- DataFrame[DataFrame] uses DataFrame.where to compute masked frame (GH2230)

37.24.4 Bug Fixes

- Fix some duplicate-column DataFrame constructor issues (GH2079)
- Fix bar plot color cycle issues (GH2082)
- Fix off-center grid for stacked bar plots (GH2157)
- Fix plotting bug if inferred frequency is offset with N > 1 (GH2126)
- Implement comparisons on date offsets with fixed delta (GH2078)
- Handle inf/-inf correctly in read_* parser functions (GH2041)
- Fix matplotlib unicode interaction bug
- Make WLS r-squared match statsmodels 0.5.0 fixed value

- Fix zero-trimming DataFrame formatting bug
- Correctly compute/box datetime64 min/max values from Series.min/max (GH2083)
- Fix unstacking edge case with unrepresented groups (GH2100)
- Fix Series.str failures when using pipe pattern '|' (GH2119)
- Fix pretty-printing of dict entries in Series, DataFrame (GH2144)
- Cast other datetime64 values to nanoseconds in DataFrame ctor (GH2095)
- Alias Timestamp.astimezone to tz_convert, so will yield Timestamp (GH2060)
- Fix timedelta64 formatting from Series (GH2165, GH2146)
- Handle None values gracefully in dict passed to Panel constructor (GH2075)
- Box datetime64 values as Timestamp objects in Series/DataFrame.iget (GH2148)
- Fix Timestamp indexing bug in DatetimeIndex.insert (GH2155)
- Use index name(s) (if any) in DataFrame.to_records (GH2161)
- Don't lose index names in Panel.to_frame/DataFrame.to_panel (GH2163)
- Work around length-0 boolean indexing NumPy bug (GH2096)
- Fix partial integer indexing bug in DataFrame.xs (GH2107)
- Fix variety of cut/qcut string-bin formatting bugs (GH1978, GH1979)
- Raise Exception when xs view not possible of MultiIndex'd DataFrame (GH2117)
- Fix groupby(...).first() issue with datetime64 (GH2133)
- Better floating point error robustness in some rolling_* functions (GH2114, GH2527)
- Fix ewma NA handling in the middle of Series (GH2128)
- Fix numerical precision issues in diff with integer data (GH2087)
- Fix bug in MultiIndex.__getitem__ with NA values (GH2008)
- Fix DataFrame.from_records dict-arg bug when passing columns (GH2179)
- Fix Series and DataFrame.diff for integer dtypes (GH2087, GH2174)
- Fix bug when taking intersection of DatetimeIndex with empty index (GH2129)
- Pass through timezone information when calling DataFrame.align (GH2127)
- Properly sort when joining on datetime64 values (GH2196)
- Fix indexing bug in which False/True were being coerced to 0/1 (GH2199)
- Many unicode formatting fixes (GH2201)
- Fix improper MultiIndex conversion issue when assigning e.g. DataFrame.index (GH2200)
- Fix conversion of mixed-type DataFrame to ndarray with dup columns (GH2236)
- Fix duplicate columns issue (GH2218, GH2219)
- Fix SparseSeries.__pow__ issue with NA input (GH2220)
- Fix icol with integer sequence failure (GH2228)
- Fixed resampling tz-aware time series issue (GH2245)
- SparseDataFrame.icol was not returning SparseSeries (GH2227, GH2229)

- Enable ExcelWriter to handle PeriodIndex (GH2240)
- Fix issue constructing DataFrame from empty Series with name (GH2234)
- Use console-width detection in interactive sessions only (GH1610)
- Fix parallel_coordinates legend bug with mpl 1.2.0 (GH2237)
- Make tz_localize work in corner case of empty Series (GH2248)

37.25 pandas 0.9.0

Release date: 10/7/2012

37.25.1 New Features

- Add `str.encode` and `str.decode` to Series (GH1706)
- Add *to_latex* method to DataFrame (GH1735)
- Add convenient expanding window equivalents of all rolling_* ops (GH1785)
- Add Options class to pandas.io.data for fetching options data from Yahoo! Finance (GH1748, GH1739)
- Recognize and convert more boolean values in file parsing (Yes, No, TRUE, FALSE, variants thereof) (GH1691, GH1295)
- Add Panel.update method, analogous to DataFrame.update (GH1999, GH1988)

37.25.2 Improvements to existing features

- Proper handling of NA values in merge operations (GH1990)
- Add `flags` option for `re.compile` in some Series.str methods (GH1659)
- Parsing of UTC date strings in read_* functions (GH1693)
- Handle generator input to Series (GH1679)
- Add *na_action='ignore'* to Series.map to quietly propagate NAs (GH1661)
- Add args/kwds options to Series.apply (GH1829)
- Add inplace option to Series/DataFrame.reset_index (GH1797)
- Add `level` parameter to `Series.reset_index`
- Add quoting option for DataFrame.to_csv (GH1902)
- Indicate long column value truncation in DataFrame output with ... (GH1854)
- DataFrame.dot will not do data alignment, and also work with Series (GH1915)
- Add `na` option for missing data handling in some vectorized string methods (GH1689)
- If index_label=False in DataFrame.to_csv, do not print fields/commas in the text output. Results in easier importing into R (GH1583)
- Can pass tuple/list of axes to DataFrame.dropna to simplify repeated calls (dropping both columns and rows) (GH924)
- Improve DataFrame.to_html output for hierarchically-indexed rows (do not repeat levels) (GH1929)

- TimeSeries.between_time can now select times across midnight (GH1871)
- Enable *skip_footer* parameter in *ExcelFile.parse* (GH1843)

37.25.3 API Changes

- Change default header names in read_* functions to more Pythonic X0, X1, etc. instead of X.1, X.2. (GH2000)
- Deprecated `day_of_year` API removed from PeriodIndex, use `dayofyear` (GH1723)
- Don't modify NumPy suppress printoption at import time
- The internal HDF5 data arrangement for DataFrames has been transposed. Legacy files will still be readable by HDFStore (GH1834, GH1824)
- Legacy cruft removed: pandas.stats.misc.quantileTS
- Use ISO8601 format for Period repr: monthly, daily, and on down (GH1776)
- Empty DataFrame columns are now created as object dtype. This will prevent a class of TypeErrors that was occurring in code where the dtype of a column would depend on the presence of data or not (e.g. a SQL query having results) (GH1783)
- Setting parts of DataFrame/Panel using ix now aligns input Series/DataFrame (GH1630)
- *first* and *last* methods in *GroupBy* no longer drop non-numeric columns (GH1809)
- Resolved inconsistencies in specifying custom NA values in text parser. *na_values* of type dict no longer override default NAs unless *keep_default_na* is set to false explicitly (GH1657)
- Enable *skipfooter* parameter in text parsers as an alias for *skip_footer*

37.25.4 Bug Fixes

- Perform arithmetic column-by-column in mixed-type DataFrame to avoid type upcasting issues. Caused downstream DataFrame.diff bug (GH1896)
- Fix matplotlib auto-color assignment when no custom spectrum passed. Also respect passed color keyword argument (GH1711)
- Fix resampling logical error with closed='left' (GH1726)
- Fix critical DatetimeIndex.union bugs (GH1730, GH1719, GH1745, GH1702, GH1753)
- Fix critical DatetimeIndex.intersection bug with unanchored offsets (GH1708)
- Fix MM-YYYY time series indexing case (GH1672)
- Fix case where Categorical group key was not being passed into index in GroupBy result (GH1701)
- Handle Ellipsis in Series.__getitem__/__setitem__ (GH1721)
- Fix some bugs with handling datetime64 scalars of other units in NumPy 1.6 and 1.7 (GH1717)
- Fix performance issue in MultiIndex.format (GH1746)
- Fixed GroupBy bugs interacting with DatetimeIndex asof / map methods (GH1677)
- Handle factors with NAs in pandas.rpy (GH1615)
- Fix statsmodels import in pandas.stats.var (GH1734)
- Fix DataFrame repr/info summary with non-unique columns (GH1700)
- Fix Series.iget_value for non-unique indexes (GH1694)

- Don't lose tzinfo when passing DatetimeIndex as DataFrame column (GH1682)
- Fix tz conversion with time zones that haven't had any DST transitions since first date in the array (GH1673)
- Fix field access with UTC->local conversion on unsorted arrays (GH1756)
- Fix isnull handling of array-like (list) inputs (GH1755)
- Fix regression in handling of Series in Series constructor (GH1671)
- Fix comparison of Int64Index with DatetimeIndex (GH1681)
- Fix min_periods handling in new rolling_max/min at array start (GH1695)
- Fix errors with how='median' and generic NumPy resampling in some cases caused by SeriesBinGrouper (GH1648, GH1688)
- When grouping by level, exclude unobserved levels (GH1697)
- Don't lose tzinfo in DatetimeIndex when shifting by different offset (GH1683)
- Hack to support storing data with a zero-length axis in HDFStore (GH1707)
- Fix DatetimeIndex tz-aware range generation issue (GH1674)
- Fix method='time' interpolation with intraday data (GH1698)
- Don't plot all-NA DataFrame columns as zeros (GH1696)
- Fix bug in scatter_plot with by option (GH1716)
- Fix performance problem in infer_freq with lots of non-unique stamps (GH1686)
- Fix handling of PeriodIndex as argument to create MultiIndex (GH1705)
- Fix re: unicode MultiIndex level names in Series/DataFrame repr (GH1736)
- Handle PeriodIndex in to_datetime instance method (GH1703)
- Support StaticTzInfo in DatetimeIndex infrastructure (GH1692)
- Allow MultiIndex setops with length-0 other type indexes (GH1727)
- Fix handling of DatetimeIndex in DataFrame.to_records (GH1720)
- Fix handling of general objects in isnull on which bool(...) fails (GH1749)
- Fix .ix indexing with MultiIndex ambiguity (GH1678)
- Fix .ix setting logic error with non-unique MultiIndex (GH1750)
- Basic indexing now works on MultiIndex with > 1000000 elements, regression from earlier version of pandas (GH1757)
- Handle non-float64 dtypes in fast DataFrame.corr/cov code paths (GH1761)
- Fix DatetimeIndex.isin to function properly (GH1763)
- Fix conversion of array of tz-aware datetime.datetime to DatetimeIndex with right time zone (GH1777)
- Fix DST issues with generating ancxhored date ranges (GH1778)
- Fix issue calling sort on result of Series.unique (GH1807)
- Fix numerical issue leading to square root of negative number in rolling_std (GH1840)
- Let Series.str.split accept no arguments (like str.split) (GH1859)
- Allow user to have dateutil 2.1 installed on a Python 2 system (GH1851)
- Catch ImportError less aggressively in pandas/__init__.py (GH1845)

- Fix pip source installation bug when installing from GitHub (GH1805)
- Fix error when window size > array size in rolling_apply (GH1850)
- Fix pip source installation issues via SSH from GitHub
- Fix OLS.summary when column is a tuple (GH1837)
- Fix bug in __doc__ patching when -OO passed to interpreter (GH1792 GH1741 GH1774)
- Fix unicode console encoding issue in IPython notebook (GH1782, GH1768)
- Fix unicode formatting issue with Series.name (GH1782)
- Fix bug in DataFrame.duplicated with datetime64 columns (GH1833)
- Fix bug in Panel internals resulting in error when doing fillna after truncate not changing size of panel (GH1823)
- Prevent segfault due to MultiIndex not being supported in HDFStore table format (GH1848)
- Fix UnboundLocalError in Panel.__setitem__ and add better error (GH1826)
- Fix to_csv issues with list of string entries. Isnull works on list of strings now too (GH1791)
- Fix Timestamp comparisons with datetime values outside the nanosecond range (1677-2262)
- Revert to prior behavior of normalize_date with datetime.date objects (return datetime)
- Fix broken interaction between np.nansum and Series.any/all
- Fix bug with multiple column date parsers (GH1866)
- DatetimeIndex.union(Int64Index) was broken
- Make plot x vs y interface consistent with integer indexing (GH1842)
- set_index inplace modified data even if unique check fails (GH1831)
- Only use Q-OCT/NOV/DEC in quarterly frequency inference (GH1789)
- Upcast to dtype=object when unstacking boolean DataFrame (GH1820)
- Fix float64/float32 merging bug (GH1849)
- Fixes to Period.start_time for non-daily frequencies (GH1857)
- Fix failure when converter used on index_col in read_csv (GH1835)
- Implement PeriodIndex.append so that pandas.concat works correctly (GH1815)
- Avoid Cython out-of-bounds access causing segfault sometimes in pad_2d, backfill_2d
- Fix resampling error with intraday times and anchored target time (like AS-DEC) (GH1772)
- Fix .ix indexing bugs with mixed-integer indexes (GH1799)
- Respect passed color keyword argument in Series.plot (GH1890)
- Fix rolling_min/max when the window is larger than the size of the input array. Check other malformed inputs (GH1899, GH1897)
- Rolling variance / standard deviation with only a single observation in window (GH1884)
- Fix unicode sheet name failure in to_excel (GH1828)
- Override DatetimeIndex.min/max to return Timestamp objects (GH1895)
- Fix column name formatting issue in length-truncated column (GH1906)
- Fix broken handling of copying Index metadata to new instances created by view(...) calls inside the NumPy infrastructure

- Support datetime.date again in DateOffset.rollback/rollforward
- Raise Exception if set passed to Series constructor (GH1913)
- Add TypeError when appending HDFStore table w/ wrong index type (GH1881)
- Don't raise exception on empty inputs in EW functions (e.g. ewma) (GH1900)
- Make asof work correctly with PeriodIndex (GH1883)
- Fix extlinks in doc build
- Fill boolean DataFrame with NaN when calling shift (GH1814)
- Fix setuptools bug causing pip not to Cythonize .pyx files sometimes
- Fix negative integer indexing regression in .ix from 0.7.x (GH1888)
- Fix error while retrieving timezone and utc offset from subclasses of datetime.tzinfo without .zone and ._utcoffset attributes (GH1922)
- Fix DataFrame formatting of small, non-zero FP numbers (GH1911)
- Various fixes by upcasting of date -> datetime (GH1395)
- Raise better exception when passing multiple functions with the same name, such as lambdas, to GroupBy.aggregate
- Fix DataFrame.apply with axis=1 on a non-unique index (GH1878)
- Proper handling of Index subclasses in pandas.unique (GH1759)
- Set index names in DataFrame.from_records (GH1744)
- Fix time series indexing error with duplicates, under and over hash table size cutoff (GH1821)
- Handle list keys in addition to tuples in DataFrame.xs when partial-indexing a hierarchically-indexed DataFrame (GH1796)
- Support multiple column selection in DataFrame.__getitem__ with duplicate columns (GH1943)
- Fix time zone localization bug causing improper fields (e.g. hours) in time zones that have not had a UTC transition in a long time (GH1946)
- Fix errors when parsing and working with with fixed offset timezones (GH1922, GH1928)
- Fix text parser bug when handling UTC datetime objects generated by dateutil (GH1693)
- Fix plotting bug when 'B' is the inferred frequency but index actually contains weekends (GH1668, GH1669)
- Fix plot styling bugs (GH1666, GH1665, GH1658)
- Fix plotting bug with index/columns with unicode (GH1685)
- Fix DataFrame constructor bug when passed Series with datetime64 dtype in a dict (GH1680)
- Fixed regression in generating DatetimeIndex using timezone aware datetime.datetime (GH1676)
- Fix DataFrame bug when printing concatenated DataFrames with duplicated columns (GH1675)
- Fixed bug when plotting time series with multiple intraday frequencies (GH1732)
- Fix bug in DataFrame.duplicated to enable iterables other than list-types as input argument (GH1773)
- Fix resample bug when passed list of lambdas as *how* argument (GH1808)
- Repr fix for MultiIndex level with all NAs (GH1971)
- Fix PeriodIndex slicing bug when slice start/end are out-of-bounds (GH1977)

- Fix read_table bug when parsing unicode (GH1975)
- Fix BlockManager.iget bug when dealing with non-unique MultiIndex as columns (GH1970)
- Fix reset_index bug if both drop and level are specified (GH1957)
- Work around unsafe NumPy object->int casting with Cython function (GH1987)
- Fix datetime64 formatting bug in DataFrame.to_csv (GH1993)
- Default start date in pandas.io.data to 1/1/2000 as the docs say (GH2011)

37.26 pandas 0.8.1

Release date: July 22, 2012

37.26.1 New Features

- Add vectorized, NA-friendly string methods to Series (GH1621, GH620)
- Can pass dict of per-column line styles to DataFrame.plot (GH1559)
- Selective plotting to secondary y-axis on same subplot (GH1640)
- Add new `bootstrap_plot` plot function
- Add new `parallel_coordinates` plot function (GH1488)
- Add `radviz` plot function (GH1566)
- Add `multi_sparse` option to `set_printoptions` to modify display of hierarchical indexes (GH1538)
- Add `dropna` method to Panel (GH171)

37.26.2 Improvements to existing features

- Use moving min/max algorithms from Bottleneck in rolling_min/rolling_max for > 100x speedup. (GH1504, GH50)
- Add Cython group median method for >15x speedup (GH1358)
- Drastically improve `to_datetime` performance on ISO8601 datetime strings (with no time zones) (GH1571)
- Improve single-key groupby performance on large data sets, accelerate use of groupby with a Categorical variable
- Add ability to append hierarchical index levels with `set_index` and to drop single levels with `reset_index` (GH1569, GH1577)
- Always apply passed functions in `resample`, even if upsampling (GH1596)
- Avoid unnecessary copies in DataFrame constructor with explicit dtype (GH1572)
- Cleaner DatetimeIndex string representation with 1 or 2 elements (GH1611)
- Improve performance of array-of-Period to PeriodIndex, convert such arrays to PeriodIndex inside Index (GH1215)
- More informative string representation for weekly Period objects (GH1503)
- Accelerate 3-axis multi data selection from homogeneous Panel (GH979)

- Add `adjust` option to ewma to disable adjustment factor (GH1584)
- Add new matplotlib converters for high frequency time series plotting (GH1599)
- Handling of tz-aware datetime.datetime objects in to_datetime; raise Exception unless utc=True given (GH1581)

37.26.3 Bug Fixes

- Fix NA handling in DataFrame.to_panel (GH1582)
- Handle TypeError issues inside PyObject_RichCompareBool calls in khash (GH1318)
- Fix resampling bug to lower case daily frequency (GH1588)
- Fix kendall/spearman DataFrame.corr bug with no overlap (GH1595)
- Fix bug in DataFrame.set_index (GH1592)
- Don't ignore axes in boxplot if by specified (GH1565)
- Fix Panel .ix indexing with integers bug (GH1603)
- Fix Partial indexing bugs (years, months, ...) with PeriodIndex (GH1601)
- Fix MultiIndex console formatting issue (GH1606)
- Unordered index with duplicates doesn't yield scalar location for single entry (GH1586)
- Fix resampling of tz-aware time series with "anchored" freq (GH1591)
- Fix DataFrame.rank error on integer data (GH1589)
- Selection of multiple SparseDataFrame columns by list in __getitem__ (GH1585)
- Override Index.tolist for compatibility with MultiIndex (GH1576)
- Fix hierarchical summing bug with MultiIndex of length 1 (GH1568)
- Work around numpy.concatenate use/bug in Series.set_value (GH1561)
- Ensure Series/DataFrame are sorted before resampling (GH1580)
- Fix unhandled IndexError when indexing very large time series (GH1562)
- Fix DatetimeIndex intersection logic error with irregular indexes (GH1551)
- Fix unit test errors on Python 3 (GH1550)
- Fix .ix indexing bugs in duplicate DataFrame index (GH1201)
- Better handle errors with non-existing objects in HDFStore (GH1254)
- Don't copy int64 array data in DatetimeIndex when copy=False (GH1624)
- Fix resampling of conforming periods quarterly to annual (GH1622)
- Don't lose index name on resampling (GH1631)
- Support python-dateutil version 2.1 (GH1637)
- Fix broken scatter_matrix axis labeling, esp. with time series (GH1625)
- Fix cases where extra keywords weren't being passed on to matplotlib from Series.plot (GH1636)
- Fix BusinessMonthBegin logic for dates before 1st bday of month (GH1645)
- Ensure string alias converted (valid in DatetimeIndex.get_loc) in DataFrame.xs / __getitem__ (GH1644)
- Fix use of string alias timestamps with tz-aware time series (GH1647)

- Fix Series.max/min and Series.describe on len-0 series (GH1650)
- Handle None values in dict passed to concat (GH1649)
- Fix Series.interpolate with method='values' and DatetimeIndex (GH1646)
- Fix IndexError in left merges on a DataFrame with 0-length (GH1628)
- Fix DataFrame column width display with UTF-8 encoded characters (GH1620)
- Handle case in pandas.io.data.get_data_yahoo where Yahoo! returns duplicate dates for most recent business day
- Avoid downsampling when plotting mixed frequencies on the same subplot (GH1619)
- Fix read_csv bug when reading a single line (GH1553)
- Fix bug in C code causing monthly periods prior to December 1969 to be off (GH1570)

37.27 pandas 0.8.0

Release date: 6/29/2012

37.27.1 New Features

- New unified DatetimeIndex class for nanosecond-level timestamp data
- New Timestamp datetime.datetime subclass with easy time zone conversions, and support for nanoseconds
- New PeriodIndex class for timespans, calendar logic, and Period scalar object
- High performance resampling of timestamp and period data. New *resample* method of all pandas data structures
- New frequency names plus shortcut string aliases like '15h', '1h30min'
- Time series string indexing shorthand (GH222)
- Add week, dayofyear array and other timestamp array-valued field accessor functions to DatetimeIndex
- Add GroupBy.prod optimized aggregation function and 'prod' fast time series conversion method (GH1018)
- Implement robust frequency inference function and *inferred_freq* attribute on DatetimeIndex (GH391)
- New `tz_convert` and `tz_localize` methods in Series / DataFrame
- Convert DatetimeIndexes to UTC if time zones are different in join/setops (GH864)
- Add limit argument for forward/backward filling to reindex, fillna, etc. (GH825 and others)
- Add support for indexes (dates or otherwise) with duplicates and common sense indexing/selection functionality
- Series/DataFrame.update methods, in-place variant of combine_first (GH961)
- Add `match` function to API (GH502)
- Add Cython-optimized first, last, min, max, prod functions to GroupBy (GH994, GH1043)
- Dates can be split across multiple columns (GH1227, GH1186)
- Add experimental support for converting pandas DataFrame to R data.frame via rpy2 (GH350, GH1212)
- Can pass list of (name, function) to GroupBy.aggregate to get aggregates in a particular order (GH610)
- Can pass dicts with lists of functions or dicts to GroupBy aggregate to do much more flexible multiple function aggregation (GH642, GH610)

- New ordered_merge functions for merging DataFrames with ordered data. Also supports group-wise merging for panel data (GH813)
- Add keys() method to DataFrame
- Add flexible replace method for replacing potentially values to Series and DataFrame (GH929, GH1241)
- Add 'kde' plot kind for Series/DataFrame.plot (GH1059)
- More flexible multiple function aggregation with GroupBy
- Add pct_change function to Series/DataFrame
- Add option to interpolate by Index values in Series.interpolate (GH1206)
- Add `max_colwidth` option for DataFrame, defaulting to 50
- Conversion of DataFrame through rpy2 to R data.frame (GH1282,)
- Add keys() method on DataFrame (GH1240)
- Add new `match` function to API (similar to R) (GH502)
- Add dayfirst option to parsers (GH854)
- Add `method` argument to `align` method for forward/backward fillin (GH216)
- Add Panel.transpose method for rearranging axes (GH695)
- Add new `cut` function (patterned after R) for discretizing data into equal range-length bins or arbitrary breaks of your choosing (GH415)
- Add new `qcut` for cutting with quantiles (GH1378)
- Add `value_counts` top level array method (GH1392)
- Added Andrews curves plot tupe (GH1325)
- Add lag plot (GH1440)
- Add autocorrelation_plot (GH1425)
- Add support for tox and Travis CI (GH1382)
- Add support for Categorical use in GroupBy (GH292)
- Add `any` and `all` methods to DataFrame (GH1416)
- Add `secondary_y` option to Series.plot
- Add experimental `lreshape` function for reshaping wide to long

37.27.2 Improvements to existing features

- Switch to klib/khash-based hash tables in Index classes for better performance in many cases and lower memory footprint
- Shipping some functions from scipy.stats to reduce dependency, e.g. Series.describe and DataFrame.describe (GH1092)
- Can create MultiIndex by passing list of lists or list of arrays to Series, DataFrame constructor, etc. (GH831)
- Can pass arrays in addition to column names to DataFrame.set_index (GH402)
- Improve the speed of "square" reindexing of homogeneous DataFrame objects by significant margin (GH836)
- Handle more dtypes when passed MaskedArrays in DataFrame constructor (GH406)

- Improved performance of join operations on integer keys (GH682)
- Can pass multiple columns to GroupBy object, e.g. grouped[[col1, col2]] to only aggregate a subset of the value columns (GH383)
- Add histogram / kde plot options for scatter_matrix diagonals (GH1237)
- Add inplace option to Series/DataFrame.rename and sort_index, DataFrame.drop_duplicates (GH805, GH207)
- More helpful error message when nothing passed to Series.reindex (GH1267)
- Can mix array and scalars as dict-value inputs to DataFrame ctor (GH1329)
- Use DataFrame columns' name for legend title in plots
- Preserve frequency in DatetimeIndex when possible in boolean indexing operations
- Promote datetime.date values in data alignment operations (GH867)
- Add `order` method to Index classes (GH1028)
- Avoid hash table creation in large monotonic hash table indexes (GH1160)
- Store time zones in HDFStore (GH1232)
- Enable storage of sparse data structures in HDFStore (GH85)
- Enable Series.asof to work with arrays of timestamp inputs
- Cython implementation of DataFrame.corr speeds up by > 100x (GH1349, GH1354)
- Exclude "nuisance" columns automatically in GroupBy.transform (GH1364)
- Support functions-as-strings in GroupBy.transform (GH1362)
- Use index name as xlabel/ylabel in plots (GH1415)
- Add `convert_dtype` option to Series.apply to be able to leave data as dtype=object (GH1414)
- Can specify all index level names in concat (GH1419)
- Add `dialect` keyword to parsers for quoting conventions (GH1363)
- Enable DataFrame[bool_DataFrame] += value (GH1366)
- Add `retries` argument to `get_data_yahoo` to try to prevent Yahoo! API 404s (GH826)
- Improve performance of reshaping by using O(N) categorical sorting
- Series names will be used for index of DataFrame if no index passed (GH1494)
- Header argument in DataFrame.to_csv can accept a list of column names to use instead of the object's columns (GH921)
- Add `raise_conflict` argument to DataFrame.update (GH1526)
- Support file-like objects in ExcelFile (GH1529)

37.27.3 API Changes

- Rename *pandas._tseries* to *pandas.lib*
- Rename Factor to Categorical and add improvements. Numerous Categorical bug fixes
- Frequency name overhaul, WEEKDAY/EOM and rules with @ deprecated. get_legacy_offset_name backwards compatibility function added
- Raise ValueError in DataFrame.__nonzero__, so "if df" no longer works (GH1073)

- Change BDay (business day) to not normalize dates by default (GH506)
- Remove deprecated DataMatrix name
- Default merge suffixes for overlap now have underscores instead of periods to facilitate tab completion, etc. (GH1239)
- Deprecation of offset, time_rule timeRule parameters throughout codebase
- Series.append and DataFrame.append no longer check for duplicate indexes by default, add verify_integrity parameter (GH1394)
- Refactor Factor class, old constructor moved to Factor.from_array
- Modified internals of MultiIndex to use less memory (no longer represented as array of tuples) internally, speed up construction time and many methods which construct intermediate hierarchical indexes (GH1467)

37.27.4 Bug Fixes

- Fix OverflowError from storing pre-1970 dates in HDFStore by switching to datetime64 (GH179)
- Fix logical error with February leap year end in YearEnd offset
- Series([False, nan]) was getting casted to float64 (GH1074)
- Fix binary operations between boolean Series and object Series with booleans and NAs (GH1074, GH1079)
- Couldn't assign whole array to column in mixed-type DataFrame via .ix (GH1142)
- Fix label slicing issues with float index values (GH1167)
- Fix segfault caused by empty groups passed to groupby (GH1048)
- Fix occasionally misbehaved reindexing in the presence of NaN labels (GH522)
- Fix imprecise logic causing weird Series results from .apply (GH1183)
- Unstack multiple levels in one shot, avoiding empty columns in some cases. Fix pivot table bug (GH1181)
- Fix formatting of MultiIndex on Series/DataFrame when index name coincides with label (GH1217)
- Handle Excel 2003 #N/A as NaN from xlrd (GH1213, GH1225)
- Fix timestamp locale-related deserialization issues with HDFStore by moving to datetime64 representation (GH1081, GH809)
- Fix DataFrame.duplicated/drop_duplicates NA value handling (GH557)
- Actually raise exceptions in fast reducer (GH1243)
- Fix various timezone-handling bugs from 0.7.3 (GH969)
- GroupBy on level=0 discarded index name (GH1313)
- Better error message with unmergeable DataFrames (GH1307)
- Series.__repr__ alignment fix with unicode index values (GH1279)
- Better error message if nothing passed to reindex (GH1267)
- More robust NA handling in DataFrame.drop_duplicates (GH557)
- Resolve locale-based and pre-epoch HDF5 timestamp deserialization issues (GH973, GH1081, GH179)
- Implement Series.repeat (GH1229)
- Fix indexing with namedtuple and other tuple subclasses (GH1026)

- Fix float64 slicing bug (GH1167)
- Parsing integers with commas (GH796)
- Fix groupby improper data type when group consists of one value (GH1065)
- Fix negative variance possibility in nanvar resulting from floating point error (GH1090)
- Consistently set name on groupby pieces (GH184)
- Treat dict return values as Series in GroupBy.apply (GH823)
- Respect column selection for DataFrame in in GroupBy.transform (GH1365)
- Fix MultiIndex partial indexing bug (GH1352)
- Enable assignment of rows in mixed-type DataFrame via .ix (GH1432)
- Reset index mapping when grouping Series in Cython (GH1423)
- Fix outer/inner DataFrame.join with non-unique indexes (GH1421)
- Fix MultiIndex groupby bugs with empty lower levels (GH1401)
- Calling fillna with a Series will have same behavior as with dict (GH1486)
- SparseSeries reduction bug (GH1375)
- Fix unicode serialization issue in HDFStore (GH1361)
- Pass keywords to pyplot.boxplot in DataFrame.boxplot (GH1493)
- Bug fixes in MonthBegin (GH1483)
- Preserve MultiIndex names in drop (GH1513)
- Fix Panel DataFrame slice-assignment bug (GH1533)
- Don't use locals() in read_* functions (GH1547)

37.28 pandas 0.7.3

Release date: April 12, 2012

37.28.1 New Features

- Support for non-unique indexes: indexing and selection, many-to-one and many-to-many joins (GH1306)
- Added fixed-width file reader, read_fwf (GH952)
- Add group_keys argument to groupby to not add group names to MultiIndex in result of apply (GH938)
- DataFrame can now accept non-integer label slicing (GH946). Previously only DataFrame.ix was able to do so.
- DataFrame.apply now retains name attributes on Series objects (GH983)
- Numeric DataFrame comparisons with non-numeric values now raises proper TypeError (GH943). Previously raise "PandasError: DataFrame constructor not properly called!"
- Add `kurt` methods to Series and DataFrame (GH964)
- Can pass dict of column -> list/set NA values for text parsers (GH754)
- Allows users specified NA values in text parsers (GH754)

- Parsers checks for openpyxl dependency and raises ImportError if not found (GH1007)
- New factory function to create HDFStore objects that can be used in a with statement so users do not have to explicitly call HDFStore.close (GH1005)
- pivot_table is now more flexible with same parameters as groupby (GH941)
- Added stacked bar plots (GH987)
- scatter_matrix method in pandas/tools/plotting.py (GH935)
- DataFrame.boxplot returns plot results for ex-post styling (GH985)
- Short version number accessible as pandas.version.short_version (GH930)
- Additional documentation in panel.to_frame (GH942)
- More informative Series.apply docstring regarding element-wise apply (GH977)
- Notes on rpy2 installation (GH1006)
- Add rotation and font size options to hist method (GH1012)
- Use exogenous / X variable index in result of OLS.y_predict. Add OLS.predict method (GH1027, GH1008)

37.28.2 API Changes

- Calling apply on grouped Series, e.g. describe(), will no longer yield DataFrame by default. Will have to call unstack() to get prior behavior
- NA handling in non-numeric comparisons has been tightened up (GH933, GH953)
- No longer assign dummy names key_0, key_1, etc. to groupby index (GH1291)

37.28.3 Bug Fixes

- Fix logic error when selecting part of a row in a DataFrame with a MultiIndex index (GH1013)
- Series comparison with Series of differing length causes crash (GH1016).
- Fix bug in indexing when selecting section of hierarchically-indexed row (GH1013)
- DataFrame.plot(logy=True) has no effect (GH1011).
- Broken arithmetic operations between SparsePanel-Panel (GH1015)
- Unicode repr issues in MultiIndex with non-ASCII characters (GH1010)
- DataFrame.lookup() returns inconsistent results if exact match not present (GH1001)
- DataFrame arithmetic operations not treating None as NA (GH992)
- DataFrameGroupBy.apply returns incorrect result (GH991)
- Series.reshape returns incorrect result for multiple dimensions (GH989)
- Series.std and Series.var ignores ddof parameter (GH934)
- DataFrame.append loses index names (GH980)
- DataFrame.plot(kind='bar') ignores color argument (GH958)
- Inconsistent Index comparison results (GH948)
- Improper int dtype DataFrame construction from data with NaN (GH846)

- Removes default 'result' name in groupby results (GH995)
- DataFrame.from_records no longer mutate input columns (GH975)
- Use Index name when grouping by it (GH1313)

37.29 pandas 0.7.2

Release date: March 16, 2012

37.29.1 New Features

- Add additional tie-breaking methods in DataFrame.rank (GH874)
- Add ascending parameter to rank in Series, DataFrame (GH875)
- Add sort_columns parameter to allow unsorted plots (GH918)
- IPython tab completion on GroupBy objects

37.29.2 API Changes

- Series.sum returns 0 instead of NA when called on an empty series. Analogously for a DataFrame whose rows or columns are length 0 (GH844)

37.29.3 Improvements to existing features

- Don't use groups dict in Grouper.size (GH860)
- Use khash for Series.value_counts, add raw function to algorithms.py (GH861)
- Enable column access via attributes on GroupBy (GH882)
- Enable setting existing columns (only) via attributes on DataFrame, Panel (GH883)
- Intercept __builtin__.sum in groupby (GH885)
- Can pass dict to DataFrame.fillna to use different values per column (GH661)
- Can select multiple hierarchical groups by passing list of values in .ix (GH134)
- Add level keyword to `drop` for dropping values from a level (GH159)
- Add `coerce_float` option on DataFrame.from_records (GH893)
- Raise exception if passed date_parser fails in `read_csv`
- Add `axis` option to DataFrame.fillna (GH174)
- Fixes to Panel to make it easier to subclass (GH888)

37.29.4 Bug Fixes

- Fix overflow-related bugs in groupby (GH850, GH851)
- Fix unhelpful error message in parsers (GH856)
- Better err msg for failed boolean slicing of dataframe (GH859)

- Series.count cannot accept a string (level name) in the level argument (GH869)
- Group index platform int check (GH870)
- concat on axis=1 and ignore_index=True raises TypeError (GH871)
- Further unicode handling issues resolved (GH795)
- Fix failure in multiindex-based access in Panel (GH880)
- Fix DataFrame boolean slice assignment failure (GH881)
- Fix combineAdd NotImplementedError for SparseDataFrame (GH887)
- Fix DataFrame.to_html encoding and columns (GH890, GH891, GH909)
- Fix na-filling handling in mixed-type DataFrame (GH910)
- Fix to DataFrame.set_value with non-existant row/col (GH911)
- Fix malformed block in groupby when excluding nuisance columns (GH916)
- Fix inconsistant NA handling in dtype=object arrays (GH925)
- Fix missing center-of-mass computation in ewmcov (GH862)
- Don't raise exception when opening read-only HDF5 file (GH847)
- Fix possible out-of-bounds memory access in 0-length Series (GH917)

37.30 pandas 0.7.1

Release date: February 29, 2012

37.30.1 New Features

- Add `to_clipboard` function to pandas namespace for writing objects to the system clipboard (GH774)
- Add `itertuples` method to DataFrame for iterating through the rows of a dataframe as tuples (GH818)
- Add ability to pass fill_value and method to DataFrame and Series align method (GH806, GH807)
- Add fill_value option to reindex, align methods (GH784)
- Enable concat to produce DataFrame from Series (GH787)
- Add `between` method to Series (GH802)
- Add HTML representation hook to DataFrame for the IPython HTML notebook (GH773)
- Support for reading Excel 2007 XML documents using openpyxl

37.30.2 Improvements to existing features

- Improve performance and memory usage of fillna on DataFrame
- Can concatenate a list of Series along axis=1 to obtain a DataFrame (GH787)

37.30.3 Bug Fixes

- Fix memory leak when inserting large number of columns into a single DataFrame (GH790)
- Appending length-0 DataFrame with new columns would not result in those new columns being part of the resulting concatenated DataFrame (GH782)
- Fixed groupby corner case when passing dictionary grouper and as_index is False (GH819)
- Fixed bug whereby bool array sometimes had object dtype (GH820)
- Fix exception thrown on np.diff (GH816)
- Fix to_records where columns are non-strings (GH822)
- Fix Index.intersection where indices have incomparable types (GH811)
- Fix ExcelFile throwing an exception for two-line file (GH837)
- Add clearer error message in csv parser (GH835)
- Fix loss of fractional seconds in HDFStore (GH513)
- Fix DataFrame join where columns have datetimes (GH787)
- Work around numpy performance issue in take (GH817)
- Improve comparison operations for NA-friendliness (GH801)
- Fix indexing operation for floating point values (GH780, GH798)
- Fix groupby case resulting in malformed dataframe (GH814)
- Fix behavior of reindex of Series dropping name (GH812)
- Improve on redudant groupby computation (GH775)
- Catch possible NA assignment to int/bool series with exception (GH839)

37.31 pandas 0.7.0

Release date: 2/9/2012

37.31.1 New Features

- New `merge` function for efficiently performing full gamut of database / relational-algebra operations. Refactored existing join methods to use the new infrastructure, resulting in substantial performance gains (GH220, GH249, GH267)
- New `concat` function for concatenating DataFrame or Panel objects along an axis. Can form union or intersection of the other axes. Improves performance of `DataFrame.append` (GH468, GH479, GH273)
- Handle differently-indexed output values in `DataFrame.apply` (GH498)
- Can pass list of dicts (e.g., a list of shallow JSON objects) to DataFrame constructor (GH526)
- Add `reorder_levels` method to Series and DataFrame (GH534)
- Add dict-like `get` function to DataFrame and Panel (GH521)
- `DataFrame.iterrows` method for efficiently iterating through the rows of a DataFrame
- Added `DataFrame.to_panel` with code adapted from `LongPanel.to_long`

- `reindex_axis` method added to DataFrame
- Add `level` option to binary arithmetic functions on `DataFrame` and `Series`
- Add `level` option to the `reindex` and `align` methods on Series and DataFrame for broadcasting values across a level (GH542, GH552, others)
- Add attribute-based item access to `Panel` and add IPython completion (PR GH554)
- Add `logy` option to `Series.plot` for log-scaling on the Y axis
- Add `index`, `header`, and `justify` options to `DataFrame.to_string`. Add option to (GH570, GH571)
- Can pass multiple DataFrames to `DataFrame.join` to join on index (GH115)
- Can pass multiple Panels to `Panel.join` (GH115)
- Can pass multiple DataFrames to *DataFrame.append* to concatenate (stack) and multiple Series to `Series.append` too
- Added `justify` argument to `DataFrame.to_string` to allow different alignment of column headers
- Add `sort` option to GroupBy to allow disabling sorting of the group keys for potential speedups (GH595)
- Can pass MaskedArray to Series constructor (GH563)
- Add Panel item access via attributes and IPython completion (GH554)
- Implement `DataFrame.lookup`, fancy-indexing analogue for retrieving values given a sequence of row and column labels (GH338)
- Add `verbose` option to `read_csv` and `read_table` to show number of NA values inserted in non-numeric columns (GH614)
- Can pass a list of dicts or Series to `DataFrame.append` to concatenate multiple rows (GH464)
- Add `level` argument to `DataFrame.xs` for selecting data from other MultiIndex levels. Can take one or more levels with potentially a tuple of keys for flexible retrieval of data (GH371, GH629)
- New `crosstab` function for easily computing frequency tables (GH170)
- Can pass a list of functions to aggregate with groupby on a DataFrame, yielding an aggregated result with hierarchical columns (GH166)
- Add integer-indexing functions `iget` in Series and `irow` / `iget` in DataFrame (GH628)
- Add new `Series.unique` function, significantly faster than `numpy.unique` (GH658)
- Add new `cummin` and `cummax` instance methods to `Series` and `DataFrame` (GH647)
- Add new `value_range` function to return min/max of a dataframe (GH288)
- Add `drop` parameter to `reset_index` method of `DataFrame` and added method to `Series` as well (GH699)
- Add `isin` method to Index objects, works just like `Series.isin` (GH GH657)
- Implement array interface on Panel so that ufuncs work (re: GH740)
- Add `sort` option to `DataFrame.join` (GH731)
- Improved handling of NAs (propagation) in binary operations with dtype=object arrays (GH737)
- Add `abs` method to Pandas objects
- Added `algorithms` module to start collecting central algos

37.31.2 API Changes

- Label-indexing with integer indexes now raises KeyError if a label is not found instead of falling back on location-based indexing (GH700)
- Label-based slicing via `ix` or `[]` on Series will now only work if exact matches for the labels are found or if the index is monotonic (for range selections)
- Label-based slicing and sequences of labels can be passed to `[]` on a Series for both getting and setting (GH86)
- *[]* operator (`__getitem__` and `__setitem__`) will raise KeyError with integer indexes when an index is not contained in the index. The prior behavior would fall back on position-based indexing if a key was not found in the index which would lead to subtle bugs. This is now consistent with the behavior of `.ix` on DataFrame and friends (GH328)
- Rename `DataFrame.delevel` to `DataFrame.reset_index` and add deprecation warning
- *Series.sort* (an in-place operation) called on a Series which is a view on a larger array (e.g. a column in a DataFrame) will generate an Exception to prevent accidentally modifying the data source (GH316)
- Refactor to remove deprecated `LongPanel` class (GH552)
- Deprecated `Panel.to_long`, renamed to `to_frame`
- Deprecated `colSpace` argument in `DataFrame.to_string`, renamed to `col_space`
- Rename `precision` to `accuracy` in engineering float formatter (GH GH395)
- The default delimiter for `read_csv` is comma rather than letting `csv.Sniffer` infer it
- Rename `col_or_columns` argument in `DataFrame.drop_duplicates` (GH GH734)

37.31.3 Improvements to existing features

- Better error message in DataFrame constructor when passed column labels don't match data (GH497)
- Substantially improve performance of multi-GroupBy aggregation when a Python function is passed, reuse ndarray object in Cython (GH496)
- Can store objects indexed by tuples and floats in HDFStore (GH492)
- Don't print length by default in Series.to_string, add *length* option (GH GH489)
- Improve Cython code for multi-groupby to aggregate without having to sort the data (GH93)
- Improve MultiIndex reindexing speed by storing tuples in the MultiIndex, test for backwards unpickling compatibility
- Improve column reindexing performance by using specialized Cython take function
- Further performance tweaking of Series.__getitem__ for standard use cases
- Avoid Index dict creation in some cases (i.e. when getting slices, etc.), regression from prior versions
- Friendlier error message in setup.py if NumPy not installed
- Use common set of NA-handling operations (sum, mean, etc.) in Panel class also (GH536)
- Default name assignment when calling `reset_index` on DataFrame with a regular (non-hierarchical) index (GH476)
- Use Cythonized groupers when possible in Series/DataFrame stat ops with `level` parameter passed (GH545)
- Ported skiplist data structure to C to speed up `rolling_median` by about 5-10x in most typical use cases (GH374)

- Some performance enhancements in constructing a Panel from a dict of DataFrame objects
- Made `Index._get_duplicates` a public method by removing the underscore
- Prettier printing of floats, and column spacing fix (GH395, GH571)
- Add `bold_rows` option to DataFrame.to_html (GH586)
- Improve the performance of `DataFrame.sort_index` by up to 5x or more when sorting by multiple columns
- Substantially improve performance of DataFrame and Series constructors when passed a nested dict or dict, respectively (GH540, GH621)
- Modified setup.py so that pip / setuptools will install dependencies (GH GH507, various pull requests)
- Unstack called on DataFrame with non-MultiIndex will return Series (GH GH477)
- Improve DataFrame.to_string and console formatting to be more consistent in the number of displayed digits (GH395)
- Use bottleneck if available for performing NaN-friendly statistical operations that it implemented (GH91)
- Monkey-patch context to traceback in `DataFrame.apply` to indicate which row/column the function application failed on (GH614)
- Improved ability of read_table and read_clipboard to parse console-formatted DataFrames (can read the row of index names, etc.)
- Can pass list of group labels (without having to convert to an ndarray yourself) to `groupby` in some cases (GH659)
- Use `kind` argument to Series.order for selecting different sort kinds (GH668)
- Add option to Series.to_csv to omit the index (GH684)
- Add `delimiter` as an alternative to `sep` in `read_csv` and other parsing functions
- Substantially improved performance of groupby on DataFrames with many columns by aggregating blocks of columns all at once (GH745)
- Can pass a file handle or StringIO to Series/DataFrame.to_csv (GH765)
- Can pass sequence of integers to DataFrame.irow(icol) and Series.iget, (GH GH654)
- Prototypes for some vectorized string functions
- Add float64 hash table to solve the Series.unique problem with NAs (GH714)
- Memoize objects when reading from file to reduce memory footprint
- Can get and set a column of a DataFrame with hierarchical columns containing "empty" ('') lower levels without passing the empty levels (PR GH768)

37.31.4 Bug Fixes

- Raise exception in out-of-bounds indexing of Series instead of seg-faulting, regression from earlier releases (GH495)
- Fix error when joining DataFrames of different dtypes within the same typeclass (e.g. float32 and float64) (GH486)
- Fix bug in Series.min/Series.max on objects like datetime.datetime (GH GH487)
- Preserve index names in Index.union (GH501)

- Fix bug in Index joining causing subclass information (like DateRange type) to be lost in some cases (GH500)
- Accept empty list as input to DataFrame constructor, regression from 0.6.0 (GH491)
- Can output DataFrame and Series with ndarray objects in a dtype=object array (GH490)
- Return empty string from Series.to_string when called on empty Series (GH GH488)
- Fix exception passing empty list to DataFrame.from_records
- Fix Index.format bug (excluding name field) with datetimes with time info
- Fix scalar value access in Series to always return NumPy scalars, regression from prior versions (GH510)
- Handle rows skipped at beginning of file in read_* functions (GH505)
- Handle improper dtype casting in `set_value` methods
- Unary '-' / __neg__ operator on DataFrame was returning integer values
- Unbox 0-dim ndarrays from certain operators like all, any in Series
- Fix handling of missing columns (was combine_first-specific) in DataFrame.combine for general case (GH529)
- Fix type inference logic with boolean lists and arrays in DataFrame indexing
- Use centered sum of squares in R-square computation if entity_effects=True in panel regression
- Handle all NA case in Series.{corr, cov}, was raising exception (GH548)
- Aggregating by multiple levels with `level` argument to DataFrame, Series stat method, was broken (GH545)
- Fix Cython buf when converter passed to read_csv produced a numeric array (buffer dtype mismatch when passed to Cython type inference function) (GH GH546)
- Fix exception when setting scalar value using .ix on a DataFrame with a MultiIndex (GH551)
- Fix outer join between two DateRanges with different offsets that returned an invalid DateRange
- Cleanup DataFrame.from_records failure where index argument is an integer
- Fix Data.from_records failure when passed a dictionary
- Fix NA handling in {Series, DataFrame}.rank with non-floating point dtypes
- Fix bug related to integer type-checking in .ix-based indexing
- Handle non-string index name passed to DataFrame.from_records
- DataFrame.insert caused the columns name(s) field to be discarded (GH527)
- Fix erroneous in monotonic many-to-one left joins
- Fix DataFrame.to_string to remove extra column white space (GH571)
- Format floats to default to same number of digits (GH395)
- Added decorator to copy docstring from one function to another (GH449)
- Fix error in monotonic many-to-one left joins
- Fix __eq__ comparison between DateOffsets with different relativedelta keywords passed
- Fix exception caused by parser converter returning strings (GH583)
- Fix MultiIndex formatting bug with integer names (GH601)
- Fix bug in handling of non-numeric aggregates in Series.groupby (GH612)
- Fix TypeError with tuple subclasses (e.g. namedtuple) in DataFrame.from_records (GH611)

- Catch misreported console size when running IPython within Emacs
- Fix minor bug in pivot table margins, loss of index names and length-1 'All' tuple in row labels
- Add support for legacy WidePanel objects to be read from HDFStore
- Fix out-of-bounds segfault in pad_object and backfill_object methods when either source or target array are empty
- Could not create a new column in a DataFrame from a list of tuples
- Fix bugs preventing SparseDataFrame and SparseSeries working with groupby (GH666)
- Use sort kind in Series.sort / argsort (GH668)
- Fix DataFrame operations on non-scalar, non-pandas objects (GH672)
- Don't convert DataFrame column to integer type when passing integer to __setitem__ (GH669)
- Fix downstream bug in pivot_table caused by integer level names in MultiIndex (GH678)
- Fix SparseSeries.combine_first when passed a dense Series (GH687)
- Fix performance regression in HDFStore loading when DataFrame or Panel stored in table format with datetimes
- Raise Exception in DateRange when offset with n=0 is passed (GH683)
- Fix get/set inconsistency with .ix property and integer location but non-integer index (GH707)
- Use right dropna function for SparseSeries. Return dense Series for NA fill value (GH730)
- Fix Index.format bug causing incorrectly string-formatted Series with datetime indexes (GH726, GH758)
- Fix errors caused by object dtype arrays passed to ols (GH759)
- Fix error where column names lost when passing list of labels to DataFrame.__getitem__, (GH662)
- Fix error whereby top-level week iterator overwrote week instance
- Fix circular reference causing memory leak in sparse array / series / frame, (GH663)
- Fix integer-slicing from integers-as-floats (GH670)
- Fix zero division errors in nanops from object dtype arrays in all NA case (GH676)
- Fix csv encoding when using unicode (GH705, GH717, GH738)
- Fix assumption that each object contains every unique block type in concat, (GH708)
- Fix sortedness check of multiindex in to_panel (GH719, 720)
- Fix that None was not treated as NA in PyObjectHashtable
- Fix hashing dtype because of endianness confusion (GH747, GH748)
- Fix SparseSeries.dropna to return dense Series in case of NA fill value (GH GH730)
- Use map_infer instead of np.vectorize. handle NA sentinels if converter yields numeric array, (GH753)
- Fixes and improvements to DataFrame.rank (GH742)
- Fix catching AttributeError instead of NameError for bottleneck
- Try to cast non-MultiIndex to better dtype when calling reset_index (GH726 GH440)
- Fix #1.QNAN0' float bug on 2.6/win64
- Allow subclasses of dicts in DataFrame constructor, with tests
- Fix problem whereby set_index destroys column multiindex (GH764)

- Hack around bug in generating DateRange from naive DateOffset (GH770)
- Fix bug in DateRange.intersection causing incorrect results with some overlapping ranges (GH771)

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37.32 pandas 0.6.1

Release date: 12/13/2011

37.32.1 API Changes

- Rename *names* argument in DataFrame.from_records to *columns*. Add deprecation warning
- Boolean get/set operations on Series with boolean Series will reindex instead of requiring that the indexes be exactly equal (GH429)

37.32.2 New Features

- Can pass Series to DataFrame.append with ignore_index=True for appending a single row (GH430)
- Add Spearman and Kendall correlation options to Series.corr and DataFrame.corr (GH428)
- Add new *get_value* and *set_value* methods to Series, DataFrame, and Panel to very low-overhead access to scalar elements. df.get_value(row, column) is about 3x faster than df[column][row] by handling fewer cases (GH437, GH438). Add similar methods to sparse data structures for compatibility
- Add Qt table widget to sandbox (GH435)
- DataFrame.align can accept Series arguments, add axis keyword (GH461)
- Implement new SparseList and SparseArray data structures. SparseSeries now derives from SparseArray (GH463)
- max_columns / max_rows options in set_printoptions (GH453)
- Implement Series.rank and DataFrame.rank, fast versions of scipy.stats.rankdata (GH428)
- Implement DataFrame.from_items alternate constructor (GH444)
- DataFrame.convert_objects method for inferring better dtypes for object columns (GH302)
- Add rolling_corr_pairwise function for computing Panel of correlation matrices (GH189)
- Add *margins* option to *pivot_table* for computing subgroup aggregates (GH GH114)
- Add *Series.from_csv* function (GH482)

37.32.3 Improvements to existing features

- Improve memory usage of *DataFrame.describe* (do not copy data unnecessarily) (GH425)
- Use same formatting function for outputting floating point Series to console as in DataFrame (GH420)
- DataFrame.delevel will try to infer better dtype for new columns (GH440)
- Exclude non-numeric types in DataFrame.{corr, cov}
- Override Index.astype to enable dtype casting (GH412)
- Use same float formatting function for Series.__repr__ (GH420)
- Use available console width to output DataFrame columns (GH453)
- Accept ndarrays when setting items in Panel (GH452)
- Infer console width when printing __repr__ of DataFrame to console (PR GH453)

- Optimize scalar value lookups in the general case by 25% or more in Series and DataFrame
- Can pass DataFrame/DataFrame and DataFrame/Series to rolling_corr/rolling_cov (GH462)
- Fix performance regression in cross-sectional count in DataFrame, affecting DataFrame.dropna speed
- Column deletion in DataFrame copies no data (computes views on blocks) (GH GH158)
- MultiIndex.get_level_values can take the level name
- More helpful error message when DataFrame.plot fails on one of the columns (GH478)
- Improve performance of DataFrame.{index, columns} attribute lookup

37.32.4 Bug Fixes

- Fix O(K^2) memory leak caused by inserting many columns without consolidating, had been present since 0.4.0 (GH467)
- *DataFrame.count* should return Series with zero instead of NA with length-0 axis (GH423)
- Fix Yahoo! Finance API usage in pandas.io.data (GH419, GH427)
- Fix upstream bug causing failure in Series.align with empty Series (GH434)
- Function passed to DataFrame.apply can return a list, as long as it's the right length. Regression from 0.4 (GH432)
- Don't "accidentally" upcast scalar values when indexing using .ix (GH431)
- Fix groupby exception raised with as_index=False and single column selected (GH421)
- Implement DateOffset.__ne__ causing downstream bug (GH456)
- Fix __doc__-related issue when converting py -> pyo with py2exe
- Bug fix in left join Cython code with duplicate monotonic labels
- Fix bug when unstacking multiple levels described in GH451
- Exclude NA values in dtype=object arrays, regression from 0.5.0 (GH469)
- Use Cython map_infer function in DataFrame.applymap to properly infer output type, handle tuple return values and other things that were breaking (GH465)
- Handle floating point index values in HDFStore (GH454)
- Fixed stale column reference bug (cached Series object) caused by type change / item deletion in DataFrame (GH473)
- Index.get_loc should always raise Exception when there are duplicates
- Handle differently-indexed Series input to DataFrame constructor (GH475)
- Omit nuisance columns in multi-groupby with Python function
- Buglet in handling of single grouping in general apply
- Handle type inference properly when passing list of lists or tuples to DataFrame constructor (GH484)
- Preserve Index / MultiIndex names in GroupBy.apply concatenation step (GH GH481)

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37.33 pandas 0.6.0

Release date: 11/25/2011

37.33.1 API Changes

- Arithmetic methods like *sum* will attempt to sum dtype=object values by default instead of excluding them (GH382)

37.33.2 New Features

- Add *melt* function to *pandas.core.reshape*
- Add *level* parameter to group by level in Series and DataFrame descriptive statistics (GH313)
- Add *head* and *tail* methods to Series, analogous to to DataFrame (PR GH296)
- Add *Series.isin* function which checks if each value is contained in a passed sequence (GH289)
- Add *float_format* option to *Series.to_string*
- Add *skip_footer* (GH291) and *converters* (GH343) options to *read_csv* and *read_table*
- Add proper, tested weighted least squares to standard and panel OLS (GH GH303)
- Add *drop_duplicates* and *duplicated* functions for removing duplicate DataFrame rows and checking for duplicate rows, respectively (GH319)

- Implement logical (boolean) operators `&`, `|`, `^` on DataFrame (GH347)
- Add *Series.mad*, mean absolute deviation, matching DataFrame
- Add *QuarterEnd* DateOffset (GH321)
- Add matrix multiplication function *dot* to DataFrame (GH65)
- Add *orient* option to *Panel.from_dict* to ease creation of mixed-type Panels (GH359, GH301)
- Add *DataFrame.from_dict* with similar *orient* option
- Can now pass list of tuples or list of lists to *DataFrame.from_records* for fast conversion to DataFrame (GH357)
- Can pass multiple levels to groupby, e.g. *df.groupby(level=[0, 1])* (GH GH103)
- Can sort by multiple columns in *DataFrame.sort_index* (GH92, GH362)
- Add fast *get_value* and *put_value* methods to DataFrame and micro-performance tweaks (GH360)
- Add *cov* instance methods to Series and DataFrame (GH194, GH362)
- Add bar plot option to *DataFrame.plot* (GH348)
- Add *idxmin* and *idxmax* functions to Series and DataFrame for computing index labels achieving maximum and minimum values (GH286)
- Add *read_clipboard* function for parsing DataFrame from OS clipboard, should work across platforms (GH300)
- Add *nunique* function to Series for counting unique elements (GH297)
- DataFrame constructor will use Series name if no columns passed (GH373)
- Support regular expressions and longer delimiters in read_table/read_csv, but does not handle quoted strings yet (GH364)
- Add *DataFrame.to_html* for formatting DataFrame to HTML (GH387)
- MaskedArray can be passed to DataFrame constructor and masked values will be converted to NaN (GH396)
- Add *DataFrame.boxplot* function (GH368, others)
- Can pass extra args, kwds to DataFrame.apply (GH376)

37.33.3 Improvements to existing features

- Raise more helpful exception if date parsing fails in DateRange (GH298)
- Vastly improved performance of GroupBy on axes with a MultiIndex (GH299)
- Print level names in hierarchical index in Series repr (GH305)
- Return DataFrame when performing GroupBy on selected column and as_index=False (GH308)
- Can pass vector to *on* argument in *DataFrame.join* (GH312)
- Don't show Series name if it's None in the repr, also omit length for short Series (GH317)
- Show legend by default in *DataFrame.plot*, add *legend* boolean flag (GH GH324)
- Significantly improved performance of *Series.order*, which also makes np.unique called on a Series faster (GH327)
- Faster cythonized count by level in Series and DataFrame (GH341)
- Raise exception if dateutil 2.0 installed on Python 2.x runtime (GH346)
- Significant GroupBy performance enhancement with multiple keys with many "empty" combinations

- New Cython vectorized function *map_infer* speeds up *Series.apply* and *Series.map* significantly when passed elementwise Python function, motivated by GH355
- Cythonized *cache_readonly*, resulting in substantial micro-performance enhancements throughout the codebase (GH361)
- Special Cython matrix iterator for applying arbitrary reduction operations with 3-5x better performance than *np.apply_along_axis* (GH309)
- Add *raw* option to *DataFrame.apply* for getting better performance when the passed function only requires an ndarray (GH309)
- Improve performance of *MultiIndex.from_tuples*
- Can pass multiple levels to *stack* and *unstack* (GH370)
- Can pass multiple values columns to *pivot_table* (GH381)
- Can call *DataFrame.delevel* with standard Index with name set (GH393)
- Use Series name in GroupBy for result index (GH363)
- Refactor Series/DataFrame stat methods to use common set of NaN-friendly function
- Handle NumPy scalar integers at C level in Cython conversion routines

37.33.4 Bug Fixes

- Fix bug in *DataFrame.to_csv* when writing a DataFrame with an index name (GH290)
- DataFrame should clear its Series caches on consolidation, was causing "stale" Series to be returned in some corner cases (GH304)
- DataFrame constructor failed if a column had a list of tuples (GH293)
- Ensure that *Series.apply* always returns a Series and implement *Series.round* (GH314)
- Support boolean columns in Cythonized groupby functions (GH315)
- *DataFrame.describe* should not fail if there are no numeric columns, instead return categorical describe (GH323)
- Fixed bug which could cause columns to be printed in wrong order in *DataFrame.to_string* if specific list of columns passed (GH325)
- Fix legend plotting failure if DataFrame columns are integers (GH326)
- Shift start date back by one month for Yahoo! Finance API in pandas.io.data (GH329)
- Fix *DataFrame.join* failure on unconsolidated inputs (GH331)
- DataFrame.min/max will no longer fail on mixed-type DataFrame (GH337)
- Fix *read_csv* / *read_table* failure when passing list to index_col that is not in ascending order (GH349)
- Fix failure passing Int64Index to Index.union when both are monotonic
- Fix error when passing SparseSeries to (dense) DataFrame constructor
- Added missing bang at top of setup.py (GH352)
- Change *is_monotonic* on MultiIndex so it properly compares the tuples
- Fix MultiIndex outer join logic (GH351)
- Set index name attribute with single-key groupby (GH358)

- Bug fix in reflexive binary addition in Series and DataFrame for non-commutative operations (like string concatenation) (GH353)
- setupegg.py will invoke Cython (GH192)
- Fix block consolidation bug after inserting column into MultiIndex (GH366)
- Fix bug in join operations between Index and Int64Index (GH367)
- Handle min_periods=0 case in moving window functions (GH365)
- Fixed corner cases in DataFrame.apply/pivot with empty DataFrame (GH378)
- Fixed repr exception when Series name is a tuple
- Always return DateRange from *asfreq* (GH390)
- Pass level names to *swaplavel* (GH379)
- Don't lose index names in *MultiIndex.droplevel* (GH394)
- Infer more proper return type in *DataFrame.apply* when no columns or rows depending on whether the passed function is a reduction (GH389)
- Always return NA/NaN from Series.min/max and DataFrame.min/max when all of a row/column/values are NA (GH384)
- Enable partial setting with .ix / advanced indexing (GH397)
- Handle mixed-type DataFrames correctly in unstack, do not lose type information (GH403)
- Fix integer name formatting bug in Index.format and in Series.__repr__
- Handle label types other than string passed to groupby (GH405)
- Fix bug in .ix-based indexing with partial retrieval when a label is not contained in a level
- Index name was not being pickled (GH408)
- Level name should be passed to result index in GroupBy.apply (GH416)

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37.34 pandas 0.5.0

Release date: 10/24/2011

This release of pandas includes a number of API changes (see below) and cleanup of deprecated APIs from pre-0.4.0 releases. There are also bug fixes, new features, numerous significant performance enhancements, and includes a new ipython completer hook to enable tab completion of DataFrame columns accesses and attributes (a new feature).

In addition to the changes listed here from 0.4.3 to 0.5.0, the minor releases 4.1, 0.4.2, and 0.4.3 brought some significant new functionality and performance improvements that are worth taking a look at.

Thanks to all for bug reports, contributed patches and generally providing feedback on the library.

37.34.1 API Changes

- *read_table*, *read_csv*, and *ExcelFile.parse* default arguments for *index_col* is now None. To use one or more of the columns as the resulting DataFrame's index, these must be explicitly specified now
- Parsing functions like *read_csv* no longer parse dates by default (GH GH225)
- Removed *weights* option in panel regression which was not doing anything principled (GH155)
- Changed *buffer* argument name in *Series.to_string* to *buf*
- *Series.to_string* and *DataFrame.to_string* now return strings by default instead of printing to sys.stdout
- Deprecated *nanRep* argument in various *to_string* and *to_csv* functions in favor of *na_rep*. Will be removed in 0.6 (GH275)
- Renamed *delimiter* to *sep* in *DataFrame.from_csv* for consistency
- Changed order of *Series.clip* arguments to match those of *numpy.clip* and added (unimplemented) *out* argument so *numpy.clip* can be called on a Series (GH272)
- Series functions renamed (and thus deprecated) in 0.4 series have been removed:
  - *asOf*, use *asof*
  - *toDict*, use *to_dict*
  - *toString*, use *to_string*
  - *toCSV*, use *to_csv*
  - *merge*, use *map*
  - *applymap*, use *apply*
  - *combineFirst*, use *combine_first*
  - *_firstTimeWithValue* use *first_valid_index*

  - *_lastTimeWithValue* use *last_valid_index*
- DataFrame functions renamed / deprecated in 0.4 series have been removed:
  - *asMatrix* method, use *as_matrix* or *values* attribute
  - *combineFirst*, use *combine_first*
  - *getXS*, use *xs*
  - *merge*, use *join*
  - *fromRecords*, use *from_records*
  - *fromcsv*, use *from_csv*
  - *toRecords*, use *to_records*
  - *toDict*, use *to_dict*
  - *toString*, use *to_string*
  - *toCSV*, use *to_csv*
  - *_firstTimeWithValue* use *first_valid_index*
  - *_lastTimeWithValue* use *last_valid_index*
  - *toDataMatrix* is no longer needed
  - *rows()* method, use *index* attribute
  - *cols()* method, use *columns* attribute
  - *dropEmptyRows()*, use *dropna(how='all')*
  - *dropIncompleteRows()*, use *dropna()*
  - *tapply(f)*, use *apply(f, axis=1)*
  - *tgroupby(keyfunc, aggfunc)*, use *groupby* with *axis=1*

37.34.2 Deprecations Removed

- *indexField* argument in *DataFrame.from_records*
- *missingAtEnd* argument in *Series.order*. Use *na_last* instead
- *Series.fromValue* classmethod, use regular *Series* constructor instead
- Functions *parseCSV*, *parseText*, and *parseExcel* methods in *pandas.io.parsers* have been removed
- *Index.asOfDate* function
- *Panel.getMinorXS* (use *minor_xs*) and *Panel.getMajorXS* (use *major_xs*)
- *Panel.toWide*, use *Panel.to_wide* instead

37.34.3 New Features

- Added *DataFrame.align* method with standard join options
- Added *parse_dates* option to *read_csv* and *read_table* methods to optionally try to parse dates in the index columns

- Add *nrows*, *chunksize*, and *iterator* arguments to *read_csv* and *read_table*. The last two return a new *TextParser* class capable of lazily iterating through chunks of a flat file (GH242)
- Added ability to join on multiple columns in *DataFrame.join* (GH214)
- Added private *_get_duplicates* function to *Index* for identifying duplicate values more easily
- Added column attribute access to DataFrame, e.g. df.A equivalent to df['A'] if 'A' is a column in the DataFrame (GH213)
- Added IPython tab completion hook for DataFrame columns. (GH233, GH230)
- Implement *Series.describe* for Series containing objects (GH241)
- Add inner join option to *DataFrame.join* when joining on key(s) (GH248)
- Can select set of DataFrame columns by passing a list to *__getitem__* (GH GH253)
- Can use & and | to intersection / union Index objects, respectively (GH GH261)
- Added *pivot_table* convenience function to pandas namespace (GH234)
- Implemented *Panel.rename_axis* function (GH243)
- DataFrame will show index level names in console output
- Implemented *Panel.take*
- Add *set_eng_float_format* function for setting alternate DataFrame floating point string formatting
- Add convenience *set_index* function for creating a DataFrame index from its existing columns

37.34.4 Improvements to existing features

- Major performance improvements in file parsing functions *read_csv* and *read_table*
- Added Cython function for converting tuples to ndarray very fast. Speeds up many MultiIndex-related operations
- File parsing functions like *read_csv* and *read_table* will explicitly check if a parsed index has duplicates and raise a more helpful exception rather than deferring the check until later
- Refactored merging / joining code into a tidy class and disabled unnecessary computations in the float/object case, thus getting about 10% better performance (GH211)
- Improved speed of *DataFrame.xs* on mixed-type DataFrame objects by about 5x, regression from 0.3.0 (GH215)
- With new *DataFrame.align* method, speeding up binary operations between differently-indexed DataFrame objects by 10-25%.
- Significantly sped up conversion of nested dict into DataFrame (GH212)
- Can pass hierarchical index level name to *groupby* instead of the level number if desired (GH223)
- Add support for different delimiters in *DataFrame.to_csv* (GH244)
- Add more helpful error message when importing pandas post-installation from the source directory (GH250)
- Significantly speed up DataFrame *__repr__* and *count* on large mixed-type DataFrame objects
- Better handling of pyx file dependencies in Cython module build (GH271)

37.34.5 Bug Fixes

- *read_csv* / *read_table* fixes
  - Be less aggressive about converting float->int in cases of floating point representations of integers like 1.0, 2.0, etc.
  - "True"/"False" will not get correctly converted to boolean
  - Index name attribute will get set when specifying an index column
  - Passing column names should force *header=None* (GH257)
  - Don't modify passed column names when *index_col* is not None (GH258)
  - Can sniff CSV separator in zip file (since seek is not supported, was failing before)
- Worked around matplotlib "bug" in which series[:, np.newaxis] fails. Should be reported upstream to matplotlib (GH224)
- DataFrame.iteritems was not returning Series with the name attribute set. Also neither was DataFrame._series
- Can store datetime.date objects in HDFStore (GH231)
- Index and Series names are now stored in HDFStore
- Fixed problem in which data would get upcasted to object dtype in GroupBy.apply operations (GH237)
- Fixed outer join bug with empty DataFrame (GH238)
- Can create empty Panel (GH239)
- Fix join on single key when passing list with 1 entry (GH246)
- Don't raise Exception on plotting DataFrame with an all-NA column (GH251, GH254)
- Bug min/max errors when called on integer DataFrames (GH241)
- *DataFrame.iteritems* and *DataFrame._series* not assigning name attribute
- Panel.__repr__ raised exception on length-0 major/minor axes
- *DataFrame.join* on key with empty DataFrame produced incorrect columns
- Implemented *MultiIndex.diff* (GH260)
- *Int64Index.take* and *MultiIndex.take* lost name field, fix downstream issue GH262
- Can pass list of tuples to *Series* (GH270)
- Can pass level name to *DataFrame.stack*
- Support set operations between MultiIndex and Index
- Fix many corner cases in MultiIndex set operations - Fix MultiIndex-handling bug with GroupBy.apply when returned groups are not indexed the same
- Fix corner case bugs in DataFrame.apply
- Setting DataFrame index did not cause Series cache to get cleared
- Various int32 -> int64 platform-specific issues
- Don't be too aggressive converting to integer when parsing file with MultiIndex (GH285)
- Fix bug when slicing Series with negative indices before beginning

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37.35 pandas 0.4.3

Release date: 10/9/2011

is is largely a bugfix release from 0.4.2 but also includes a handful of new d enhanced features. Also, pandas can now be installed and used on Python 3 hanks Thomas Kluyver!).

37.35.1 New Features

- Python 3 support using 2to3 (GH200, Thomas Kluyver)
- Add *name* attribute to *Series* and added relevant logic and tests. Name now prints as part of *Series.__repr__*
- Add *name* attribute to standard Index so that stacking / unstacking does not discard names and so that indexed DataFrame objects can be reliably round-tripped to flat files, pickle, HDF5, etc.
- Add *isnull* and *notnull* as instance methods on Series (GH209, GH203)

37.35.2 Improvements to existing features

- Skip xlrd-related unit tests if not installed
- *Index.append* and *MultiIndex.append* can accept a list of Index objects to concatenate together
- Altered binary operations on differently-indexed SparseSeries objects to use the integer-based (dense) alignment logic which is faster with a larger number of blocks (GH205)
- Refactored *Series.__repr__* to be a bit more clean and consistent

37.35.3 API Changes

- *Series.describe* and *DataFrame.describe* now bring the 25% and 75% quartiles instead of the 10% and 90% deciles. The other outputs have not changed
- *Series.toString* will print deprecation warning, has been de-camelCased to *to_string*

37.35.4 Bug Fixes

- Fix broken interaction between *Index* and *Int64Index* when calling intersection. Implement *Int64Index.intersection*
- *MultiIndex.sortlevel* discarded the level names (GH202)
- Fix bugs in groupby, join, and append due to improper concatenation of *MultiIndex* objects (GH201)

- Fix regression from 0.4.1, *isnull* and *notnull* ceased to work on other kinds of Python scalar objects like *datetime.datetime*
- Raise more helpful exception when attempting to write empty DataFrame or LongPanel to *HDFStore* (GH204)
- Use stdlib csv module to properly escape strings with commas in *DataFrame.to_csv* (GH206, Thomas Kluyver)
- Fix Python ndarray access in Cython code for sparse blocked index integrity check
- Fix bug writing Series to CSV in Python 3 (GH209)
- Miscellaneous Python 3 bugfixes

37.35.5 Thanks

- Thomas Kluyver
- rsamson

37.36 pandas 0.4.2

Release date: 10/3/2011

is is a performance optimization release with several bug fixes. The new t64Index and new merging / joining Cython code and related Python frastructure are the main new additions

37.36.1 New Features

- Added fast *Int64Index* type with specialized join, union, intersection. Will result in significant performance enhancements for int64-based time series (e.g. using NumPy's datetime64 one day) and also faster operations on DataFrame objects storing record array-like data.
- Refactored *Index* classes to have a *join* method and associated data alignment routines throughout the codebase to be able to leverage optimized joining / merging routines.
- Added *Series.align* method for aligning two series with choice of join method
- Wrote faster Cython data alignment / merging routines resulting in substantial speed increases
- Added *is_monotonic* property to *Index* classes with associated Cython code to evaluate the monotonicity of the *Index* values
- Add method *get_level_values* to *MultiIndex*
- Implemented shallow copy of *BlockManager* object in *DataFrame* internals

37.36.2 Improvements to existing features

- Improved performance of *isnull* and *notnull*, a regression from v0.3.0 (GH187)
- Wrote templating / code generation script to auto-generate Cython code for various functions which need to be available for the 4 major data types used in pandas (float64, bool, object, int64)
- Refactored code related to *DataFrame.join* so that intermediate aligned copies of the data in each *DataFrame* argument do not need to be created. Substantial performance increases result (GH176)
- Substantially improved performance of generic *Index.intersection* and *Index.union*

- Improved performance of *DateRange.union* with overlapping ranges and non-cacheable offsets (like Minute). Implemented analogous fast *DateRange.intersection* for overlapping ranges.
- Implemented *BlockManager.take* resulting in significantly faster *take* performance on mixed-type *DataFrame* objects (GH104)
- Improved performance of *Series.sort_index*
- Significant groupby performance enhancement: removed unnecessary integrity checks in DataFrame internals that were slowing down slicing operations to retrieve groups
- Added informative Exception when passing dict to DataFrame groupby aggregation with axis != 0

37.36.3 API Changes

37.36.4 Bug Fixes

- Fixed minor unhandled exception in Cython code implementing fast groupby aggregation operations
- Fixed bug in unstacking code manifesting with more than 3 hierarchical levels
- Throw exception when step specified in label-based slice (GH185)
- Fix isnull to correctly work with np.float32. Fix upstream bug described in GH182
- Finish implementation of as_index=False in groupby for DataFrame aggregation (GH181)
- Raise SkipTest for pre-epoch HDFStore failure. Real fix will be sorted out via datetime64 dtype

37.36.5 Thanks

- Uri Laserson
- Scott Sinclair

37.37 pandas 0.4.1

Release date: 9/25/2011

is is primarily a bug fix release but includes some new features and improvements

37.37.1 New Features

- Added new *DataFrame* methods *get_dtype_counts* and property *dtypes*
- Setting of values using `.ix` indexing attribute in mixed-type DataFrame objects has been implemented (fixes GH135)
- *read_csv* can read multiple columns into a *MultiIndex*. DataFrame's *to_csv* method will properly write out a *MultiIndex* which can be read back (GH151, thanks to Skipper Seabold)
- Wrote fast time series merging / joining methods in Cython. Will be integrated later into DataFrame.join and related functions
- Added *ignore_index* option to *DataFrame.append* for combining unindexed records stored in a DataFrame

37.37.2 Improvements to existing features

- Some speed enhancements with internal Index type-checking function
- *DataFrame.rename* has a new *copy* parameter which can rename a DataFrame in place
- Enable unstacking by level name (GH142)
- Enable sortlevel to work by level name (GH141)
- *read_csv* can automatically "sniff" other kinds of delimiters using *csv.Sniffer* (GH146)
- Improved speed of unit test suite by about 40%
- Exception will not be raised calling *HDFStore.remove* on non-existent node with where clause
- Optimized *_ensure_index* function resulting in performance savings in type-checking Index objects

37.37.3 API Changes

37.37.4 Bug Fixes

- Fixed DataFrame constructor bug causing downstream problems (e.g. .copy() failing) when passing a Series as the values along with a column name and index
- Fixed single-key groupby on DataFrame with as_index=False (GH160)
- *Series.shift* was failing on integer Series (GH154)
- *unstack* methods were producing incorrect output in the case of duplicate hierarchical labels. An exception will now be raised (GH147)
- Calling *count* with level argument caused reduceat failure or segfault in earlier NumPy (GH169)
- Fixed *DataFrame.corrwith* to automatically exclude non-numeric data (GH GH144)
- Unicode handling bug fixes in *DataFrame.to_string* (GH138)
- Excluding OLS degenerate unit test case that was causing platform specific failure (GH149)
- Skip blosc-dependent unit tests for PyTables < 2.2 (GH137)
- Calling *copy* on *DateRange* did not copy over attributes to the new object (GH168)
- Fix bug in *HDFStore* in which Panel data could be appended to a Table with different item order, thus resulting in an incorrect result read back

37.37.5 Thanks

- Yaroslav Halchenko
- Jeff Reback
- Skipper Seabold
- Dan Lovell
- Nick Pentreath

37.38 pandas 0.4.0

Release date: 9/12/2011

37.38.1 New Features

- *pandas.core.sparse* module: "Sparse" (mostly-NA, or some other fill value) versions of *Series*, *DataFrame*, and *Panel*. For low-density data, this will result in significant performance boosts, and smaller memory footprint. Added *to_sparse* methods to *Series*, *DataFrame*, and *Panel*. See online documentation for more on these
- Fancy indexing operator on Series / DataFrame, e.g. via .ix operator. Both getting and setting of values is supported; however, setting values will only currently work on homogeneously-typed DataFrame objects. Things like:
  - series.ix[[d1, d2, d3]]
  - frame.ix[5:10, ['C', 'B', 'A']], frame.ix[5:10, 'A':'C']
  - frame.ix[date1:date2]
- Significantly enhanced *groupby* functionality
  - Can groupby multiple keys, e.g. df.groupby(['key1', 'key2']). Iteration with multiple groupings products a flattened tuple
  - "Nuisance" columns (non-aggregatable) will automatically be excluded from DataFrame aggregation operations
  - Added automatic "dispatching to Series / DataFrame methods to more easily invoke methods on groups. e.g. s.groupby(crit).std() will work even though *std* is not implemented on the *GroupBy* class
- Hierarchical / multi-level indexing
  - New the *MultiIndex* class. Integrated *MultiIndex* into *Series* and *DataFrame* fancy indexing, slicing, __getitem__ and __setitem, reindexing, etc. Added *level* keyword argument to *groupby* to enable grouping by a level of a *MultiIndex*
- New data reshaping functions: *stack* and *unstack* on DataFrame and Series
  - Integrate with MultiIndex to enable sophisticated reshaping of data
- *Index* objects (labels for axes) are now capable of holding tuples
- *Series.describe*, *DataFrame.describe*: produces an R-like table of summary statistics about each data column
- *DataFrame.quantile*, *Series.quantile* for computing sample quantiles of data across requested axis
- Added general *DataFrame.dropna* method to replace *dropIncompleteRows* and *dropEmptyRows*, deprecated those.
- *Series* arithmetic methods with optional fill_value for missing data, e.g. a.add(b, fill_value=0). If a location is missing for both it will still be missing in the result though.
- fill_value option has been added to *DataFrame*.{add, mul, sub, div} methods similar to *Series*
- Boolean indexing with *DataFrame* objects: data[data > 0.1] = 0.1 or data[data> other] = 1.
- *pytz* / tzinfo support in *DateRange*
  - *tz_localize*, *tz_normalize*, and *tz_validate* methods added
- Added *ExcelFile* class to *pandas.io.parsers* for parsing multiple sheets out of a single Excel 2003 document

- *GroupBy* aggregations can now optionally *broadcast*, e.g. produce an object of the same size with the aggregated value propagated
- Added *select* function in all data structures: reindex axis based on arbitrary criterion (function returning boolean value), e.g. frame.select(lambda x: 'foo' in x, axis=1)
- *DataFrame.consolidate* method, API function relating to redesigned internals
- *DataFrame.insert* method for inserting column at a specified location rather than the default __setitem__ behavior (which puts it at the end)
- *HDFStore* class in *pandas.io.pytables* has been largely rewritten using patches from Jeff Reback from others. It now supports mixed-type *DataFrame* and *Series* data and can store *Panel* objects. It also has the option to query *DataFrame* and *Panel* data. Loading data from legacy *HDFStore* files is supported explicitly in the code
- Added *set_printoptions* method to modify appearance of DataFrame tabular output
- *rolling_quantile* functions; a moving version of *Series.quantile* / *DataFrame.quantile*
- Generic *rolling_apply* moving window function
- New *drop* method added to *Series*, *DataFrame*, etc. which can drop a set of labels from an axis, producing a new object
- *reindex* methods now sport a *copy* option so that data is not forced to be copied then the resulting object is indexed the same
- Added *sort_index* methods to Series and Panel. Renamed *DataFrame.sort* to *sort_index*. Leaving *DataFrame.sort* for now.
- Added `skipna` option to statistical instance methods on all the data structures
- *pandas.io.data* module providing a consistent interface for reading time series data from several different sources

37.38.2 Improvements to existing features

- The 2-dimensional *DataFrame* and *DataMatrix* classes have been extensively redesigned internally into a single class *DataFrame*, preserving where possible their optimal performance characteristics. This should reduce confusion from users about which class to use.
  - Note that under the hood there is a new essentially "lazy evaluation" scheme within respect to adding columns to DataFrame. During some operations, like-typed blocks will be "consolidated" but not before.
- *DataFrame* accessing columns repeatedly is now significantly faster than *DataMatrix* used to be in 0.3.0 due to an internal Series caching mechanism (which are all views on the underlying data)
- Column ordering for mixed type data is now completely consistent in *DataFrame*. In prior releases, there was inconsistent column ordering in *DataMatrix*
- Improved console / string formatting of DataMatrix with negative numbers
- Improved tabular data parsing functions, *read_table* and *read_csv*:
  - Added *skiprows* and *na_values* arguments to *pandas.io.parsers* functions for more flexible IO
  - *parseCSV* / *read_csv* functions and others in *pandas.io.parsers* now can take a list of custom NA values, and also a list of rows to skip
- Can slice *DataFrame* and get a view of the data (when homogeneously typed), e.g. frame.xs(idx, copy=False) or frame.ix[idx]
- Many speed optimizations throughout *Series* and *DataFrame*

- Eager evaluation of groups when calling `groupby` functions, so if there is an exception with the grouping function it will raised immediately versus sometime later on when the groups are needed
- *datetools.WeekOfMonth* offset can be parameterized with *n* different than 1 or -1.
- Statistical methods on DataFrame like *mean*, *std*, *var*, *skew* will now ignore non-numerical data. Before a not very useful error message was generated. A flag *numeric_only* has been added to *DataFrame.sum* and *DataFrame.count* to enable this behavior in those methods if so desired (disabled by default)
- *DataFrame.pivot* generalized to enable pivoting multiple columns into a *DataFrame* with hierarchical columns
- *DataFrame* constructor can accept structured / record arrays
- *Panel* constructor can accept a dict of DataFrame-like objects. Do not need to use *from_dict* anymore (*from_dict* is there to stay, though).

37.38.3 API Changes

- The *DataMatrix* variable now refers to *DataFrame*, will be removed within two releases
- *WidePanel* is now known as *Panel*. The *WidePanel* variable in the pandas namespace now refers to the renamed *Panel* class
- *LongPanel* and *Panel* / *WidePanel* now no longer have a common subclass. *LongPanel* is now a subclass of *DataFrame* having a number of additional methods and a hierarchical index instead of the old *LongPanelIndex* object, which has been removed. Legacy *LongPanel* pickles may not load properly
- Cython is now required to build *pandas* from a development branch. This was done to avoid continuing to check in cythonized C files into source control. Builds from released source distributions will not require Cython
- Cython code has been moved up to a top level *pandas/src* directory. Cython extension modules have been renamed and promoted from the *lib* subpackage to the top level, i.e.
  - *pandas.lib.tseries* -> *pandas._tseries*
  - *pandas.lib.sparse* -> *pandas._sparse*
- *DataFrame* pickling format has changed. Backwards compatibility for legacy pickles is provided, but it's recommended to consider PyTables-based *HDFStore* for storing data with a longer expected shelf life
- A *copy* argument has been added to the *DataFrame* constructor to avoid unnecessary copying of data. Data is no longer copied by default when passed into the constructor
- Handling of boolean dtype in *DataFrame* has been improved to support storage of boolean data with NA / NaN values. Before it was being converted to float64 so this should not (in theory) cause API breakage
- To optimize performance, Index objects now only check that their labels are unique when uniqueness matters (i.e. when someone goes to perform a lookup). This is a potentially dangerous tradeoff, but will lead to much better performance in many places (like groupby).
- Boolean indexing using Series must now have the same indices (labels)
- Backwards compatibility support for begin/end/nPeriods keyword arguments in DateRange class has been removed
- More intuitive / shorter filling aliases *ffill* (for *pad*) and *bfill* (for *backfill*) have been added to the functions that use them: *reindex*, *asfreq*, *fillna*.
- *pandas.core.mixins* code moved to *pandas.core.generic*
- *buffer* keyword arguments (e.g. *DataFrame.toString*) renamed to *buf* to avoid using Python built-in name
- *DataFrame.rows()* removed (use *DataFrame.index*)

- Added deprecation warning to *DataFrame.cols()*, to be removed in next release
- *DataFrame* deprecations and de-camelCasing: *merge*, *asMatrix*, *toDataMatrix*, *_firstTimeWithValue*, *_lastTimeWithValue*, *toRecords*, *fromRecords*, *tgroupby*, *toString*
- *pandas.io.parsers* method deprecations
  - *parseCSV* is now *read_csv* and keyword arguments have been de-camelCased
  - *parseText* is now *read_table*
  - *parseExcel* is replaced by the *ExcelFile* class and its *parse* method
- *fillMethod* arguments (deprecated in prior release) removed, should be replaced with *method*
- *Series.fill*, *DataFrame.fill*, and *Panel.fill* removed, use *fillna* instead
- *groupby* functions now exclude NA / NaN values from the list of groups. This matches R behavior with NAs in factors e.g. with the *tapply* function
- Removed *parseText*, *parseCSV* and *parseExcel* from pandas namespace
- *Series.combineFunc* renamed to *Series.combine* and made a bit more general with a *fill_value* keyword argument defaulting to NaN
- Removed *pandas.core.pytools* module. Code has been moved to *pandas.core.common*
- Tacked on *groupName* attribute for groups in GroupBy renamed to *name*
- Panel/LongPanel *dims* attribute renamed to *shape* to be more conformant
- Slicing a *Series* returns a view now
- More Series deprecations / renaming: *toCSV* to *to_csv*, *asOf* to *asof*, *merge* to *map*, *applymap* to *apply*, *toDict* to *to_dict*, *combineFirst* to *combine_first*. Will print *FutureWarning*.
- *DataFrame.to_csv* does not write an "index" column label by default anymore since the output file can be read back without it. However, there is a new `index_label` argument. So you can do `index_label='index'` to emulate the old behavior
- *datetools.Week* argument renamed from *dayOfWeek* to *weekday*
- *timeRule* argument in *shift* has been deprecated in favor of using the *offset* argument for everything. So you can still pass a time rule string to *offset*
- Added optional *encoding* argument to *read_csv*, *read_table*, *to_csv*, *from_csv* to handle unicode in python 2.x

37.38.4 Bug Fixes

- Column ordering in *pandas.io.parsers.parseCSV* will match CSV in the presence of mixed-type data
- Fixed handling of Excel 2003 dates in *pandas.io.parsers*
- *DateRange* caching was happening with high resolution *DateOffset* objects, e.g. *DateOffset(seconds=1)*. This has been fixed
- Fixed __truediv__ issue in *DataFrame*
- Fixed *DataFrame.toCSV* bug preventing IO round trips in some cases
- Fixed bug in *Series.plot* causing matplotlib to barf in exceptional cases
- Disabled *Index* objects from being hashable, like ndarrays
- Added *__ne__* implementation to *Index* so that operations like ts[ts != idx] will work
- Added *__ne__* implementation to *DataFrame*

- Bug / unintuitive result when calling *fillna* on unordered labels
- Bug calling *sum* on boolean DataFrame
- Bug fix when creating a DataFrame from a dict with scalar values
- Series.{sum, mean, std, ...} now return NA/NaN when the whole Series is NA
- NumPy 1.4 through 1.6 compatibility fixes
- Fixed bug in bias correction in *rolling_cov*, was affecting *rolling_corr* too
- R-square value was incorrect in the presence of fixed and time effects in the *PanelOLS* classes
- *HDFStore* can handle duplicates in table format, will take

37.38.5 Thanks

- Joon Ro
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- Chris Jordan-Squire

37.39 pandas 0.3.0

Release date: February 20, 2011

37.39.1 New features

- *corrwith* function to compute column- or row-wise correlations between two DataFrame objects
- Can boolean-index DataFrame objects, e.g. df[df > 2] = 2, px[px > last_px] = 0
- Added comparison magic methods (__lt__, __gt__, etc.)
- Flexible explicit arithmetic methods (add, mul, sub, div, etc.)
- Added *reindex_like* method
- Added *reindex_like* method to WidePanel
- Convenience functions for accessing SQL-like databases in *pandas.io.sql* module
- Added (still experimental) HDFStore class for storing pandas data structures using HDF5 / PyTables in *pandas.io.pytables* module
- Added WeekOfMonth date offset
- *pandas.rpy* (experimental) module created, provide some interfacing / conversion between rpy2 and pandas

37.39.2 Improvements to existing features

- Unit test coverage: 100% line coverage of core data structures
- Speed enhancement to rolling_{median, max, min}
- Column ordering between DataFrame and DataMatrix is now consistent: before DataFrame would not respect column order
- Improved {Series, DataFrame}.plot methods to be more flexible (can pass matplotlib Axis arguments, plot DataFrame columns in multiple subplots, etc.)

37.39.3 API Changes

- Exponentially-weighted moment functions in *pandas.stats.moments* have a more consistent API and accept a min_periods argument like their regular moving counterparts.
- **fillMethod** argument in Series, DataFrame changed to **method**, *FutureWarning* added.
- **fill** method in Series, DataFrame/DataMatrix, WidePanel renamed to **fillna**, *FutureWarning* added to **fill**
- Renamed **DataFrame.getXS** to **xs**, *FutureWarning* added
- Removed **cap** and **floor** functions from DataFrame, renamed to **clip_upper** and **clip_lower** for consistency with NumPy

37.39.4 Bug Fixes

- Fixed bug in IndexableSkiplist Cython code that was breaking rolling_max function
- Numerous numpy.int64-related indexing fixes
- Several NumPy 1.4.0 NaN-handling fixes
- Bug fixes to pandas.io.parsers.parseCSV
- Fixed *DateRange* caching issue with unusual date offsets
- Fixed bug in *DateRange.union*

- Fixed corner case in *IndexableSkiplist* implementation

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PYTHON MODULE INDEX

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