
pandas: powerful Python data analysis toolkit

Release 0.10.1

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

Source Repository: <http://github.com/pydata/pandas>

Issues & Ideas: <https://github.com/pydata/pandas/issues>

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

Developer Mailing List: <http://groups.google.com/group/pystatsmodels>

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.

WHAT'S NEW

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

1.1 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.

1.1.1 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](#))

1.1.2 New features

- MySQL support for database (contribution from Dan Allan)

1.1.3 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 [1530]: store = HDFStore('store.h5')

In [1531]: df = DataFrame(randn(8, 3), index=date_range('1/1/2000', periods=8),
.....:                  columns=['A', 'B', 'C'])
.....:

In [1532]: df['string'] = 'foo'

In [1533]: df.ix[4:6, 'string'] = np.nan

In [1534]: df.ix[7:9, 'string'] = 'bar'

In [1535]: df['string2'] = 'cool'

In [1536]: df
Out[1536]:
```

	A	B	C	string	string2
2000-01-01	0.741687	0.035967	-2.700230	foo	cool
2000-01-02	0.777316	1.201654	0.775594	foo	cool
2000-01-03	0.916695	-0.511978	0.805595	foo	cool
2000-01-04	-0.517789	-0.980332	-1.325032	foo	cool
2000-01-05	0.015397	1.063654	-0.297355	NaN	cool
2000-01-06	1.118334	-1.750153	0.507924	NaN	cool
2000-01-07	-0.163195	0.285564	-0.332279	foo	cool
2000-01-08	-0.516040	-0.531297	-0.409554	bar	cool

```
# on-disk operations
In [1537]: store.append('df', df, data_columns = ['B', 'C', 'string', 'string2'])

In [1538]: store.select('df', [ 'B > 0', 'string == foo' ])
Out[1538]:
```

	A	B	C	string	string2
2000-01-01	0.741687	0.035967	-2.700230	foo	cool
2000-01-02	0.777316	1.201654	0.775594	foo	cool
2000-01-07	-0.163195	0.285564	-0.332279	foo	cool

```
# this is in-memory version of this type of selection
In [1539]: df[(df.B > 0) & (df.string == 'foo')]
Out[1539]:
```

	A	B	C	string	string2
2000-01-01	0.741687	0.035967	-2.700230	foo	cool
2000-01-02	0.777316	1.201654	0.775594	foo	cool
2000-01-07	-0.163195	0.285564	-0.332279	foo	cool

Retrieving unique values in an indexable or data column.

```
In [1540]: store.unique('df', 'index')
Out[1540]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2000-01-01 00:00:00, ..., 2000-01-08 00:00:00]
Length: 8, Freq: None, Timezone: None

In [1541]: store.unique('df', 'string')
Out[1541]: Index([bar, foo], dtype=object)
```

You can now store datetime64 in data columns

```
In [1542]: df_mixed = df.copy()
```

```
In [1543]: df_mixed['datetime64'] = Timestamp('20010102')
```

```
In [1544]: df_mixed.ix[3:4,['A','B']] = np.nan
```

```
In [1545]: store.append('df_mixed', df_mixed)
```

```
In [1546]: df_mixed1 = store.select('df_mixed')
```

```
In [1547]: df_mixed1
```

```
Out [1547]:
```

	A	B	C	string	string2	datetime64
2000-01-01	0.741687	0.035967	-2.700230	foo	cool	2001-01-02 00:00:00
2000-01-02	0.777316	1.201654	0.775594	foo	cool	2001-01-02 00:00:00
2000-01-03	0.916695	-0.511978	0.805595	foo	cool	2001-01-02 00:00:00
2000-01-04	NaN	NaN	-1.325032	foo	cool	2001-01-02 00:00:00
2000-01-05	0.015397	1.063654	-0.297355	NaN	cool	2001-01-02 00:00:00
2000-01-06	1.118334	-1.750153	0.507924	NaN	cool	2001-01-02 00:00:00
2000-01-07	-0.163195	0.285564	-0.332279	foo	cool	2001-01-02 00:00:00
2000-01-08	-0.516040	-0.531297	-0.409554	bar	cool	2001-01-02 00:00:00

```
In [1548]: df_mixed1.get_dtype_counts()
```

```
Out [1548]:
```

datetime64[ns]	1
float64	3
object	2

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 [1549]: store.select('df', columns = ['A', 'B'])
```

```
Out [1549]:
```

	A	B
2000-01-01	0.741687	0.035967
2000-01-02	0.777316	1.201654
2000-01-03	0.916695	-0.511978
2000-01-04	-0.517789	-0.980332
2000-01-05	0.015397	1.063654
2000-01-06	1.118334	-1.750153
2000-01-07	-0.163195	0.285564
2000-01-08	-0.516040	-0.531297

HDFStore now serializes multi-index dataframes when appending tables.

```
In [1550]: 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 [1551]: df = DataFrame(np.random.randn(10, 3), index=index,
.....:                    columns=['A', 'B', 'C'])
.....:
```

```
In [1552]: df
```

```
Out [1552]:
```

	A	B	C
foo bar			
foo one	0.055458	-0.000871	-0.156757

```
two    -1.193604    0.768787 -0.228047
three   0.054979   -0.423256  0.175289
bar one  -0.961203  -0.302857  0.047525
two    -0.987381  -0.082381  1.122844
baz two   0.357760  -1.287685 -0.555503
three  -1.721204  -0.040879 -1.742960
qux one  -1.263551  -0.952076  1.253998
two    -0.994435  -1.857899 -1.409501
three   2.056446   0.686683  0.295824
```

```
In [1553]: store.append('mi',df)
```

```
In [1554]: store.select('mi')
```

```
Out[1554]:
```

	A	B	C
foo bar			
foo one	0.055458	-0.000871	-0.156757
two	-1.193604	0.768787	-0.228047
three	0.054979	-0.423256	0.175289
bar one	-0.961203	-0.302857	0.047525
two	-0.987381	-0.082381	1.122844
baz two	0.357760	-1.287685	-0.555503
three	-1.721204	-0.040879	-1.742960
qux one	-1.263551	-0.952076	1.253998
two	-0.994435	-1.857899	-1.409501
three	2.056446	0.686683	0.295824

```
# the levels are automatically included as data columns
```

```
In [1555]: store.select('mi', Term('foo=bar'))
```

```
Out[1555]:
```

	A	B	C
foo bar			
bar one	-0.961203	-0.302857	0.047525
two	-0.987381	-0.082381	1.122844

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 [1556]: df_mt = DataFrame(randn(8, 6), index=date_range('1/1/2000', periods=8),
.....:                      columns=['A', 'B', 'C', 'D', 'E', 'F'])
.....:
```

```
In [1557]: df_mt['foo'] = 'bar'
```

```
# you can also create the tables individually
```

```
In [1558]: store.append_to_multiple({'df1_mt' : ['A','B'], 'df2_mt' : None }, df_mt, selector = 'df')
```

```
In [1559]: store
```

```
Out[1559]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/df          frame_table  (typ->appendable,nrows->8,ncols->5,indexers->[index],dc->[B,C,stri
/df1_mt      frame_table  (typ->appendable,nrows->8,ncols->2,indexers->[index],dc->[A,B])
/df2_mt      frame_table  (typ->appendable,nrows->8,ncols->5,indexers->[index])
/df_mixed    frame_table  (typ->appendable,nrows->8,ncols->6,indexers->[index])
/mi          frame_table  (typ->appendable_multi,nrows->10,ncols->5,indexers->[index],dc->[ba
```

```
# individual tables were created
```

```
In [1560]: store.select('df1_mt')
```

```
Out[1560]:
```

	A	B
2000-01-01	0.452273	0.853944
2000-01-02	-0.388093	0.086667
2000-01-03	-0.727640	-0.341083
2000-01-04	1.973282	-0.336809
2000-01-05	0.436261	-0.543731
2000-01-06	-0.068377	-0.215977
2000-01-07	1.203168	0.564612
2000-01-08	-0.414547	2.005601

```
In [1561]: store.select('df2_mt')
```

```
Out[1561]:
```

	C	D	E	F	foo
2000-01-01	0.585509	0.483793	1.387714	-0.261908	bar
2000-01-02	0.269055	0.011450	-0.104465	-0.406944	bar
2000-01-03	0.478604	0.463990	1.237388	0.628084	bar
2000-01-04	0.963953	0.053805	1.182483	0.566182	bar
2000-01-05	-0.320155	2.545145	0.301306	1.967739	bar
2000-01-06	-1.038566	-0.911641	-1.172296	1.539279	bar
2000-01-07	-0.836731	0.283662	-0.357312	1.295667	bar
2000-01-08	-0.601194	-0.134764	0.280262	-0.627031	bar

```
# as a multiple
```

```
In [1562]: store.select_as_multiple(['df1_mt', 'df2_mt'], where = [ 'A>0', 'B>0' ], selector = 'df1_mt')
```

```
Out[1562]:
```

	A	B	C	D	E	F	foo
2000-01-01	0.452273	0.853944	0.585509	0.483793	1.387714	-0.261908	bar
2000-01-07	1.203168	0.564612	-0.836731	0.283662	-0.357312	1.295667	bar

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 automatically create indices 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 significantly 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.

1.2 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.

1.2.1 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

1.2.2 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 [1563]: import pandas as pd
```

```
In [1564]: df = pd.DataFrame(np.random.randn(6, 4),
.....:                      index=pd.date_range('1/1/2000', periods=6))
.....:
```

```
In [1565]: df
```

```
Out [1565]:
```

	0	1	2	3
2000-01-01	1.197755	0.443238	-0.793423	0.450845
2000-01-02	-0.833944	1.497871	-0.062647	0.156242
2000-01-03	0.752988	1.193476	-1.622707	0.924629
2000-01-04	0.865121	-0.192174	-0.924645	1.035467
2000-01-05	-0.237298	-0.193078	-0.113703	-1.510585
2000-01-06	0.426243	-0.863411	0.386999	1.318817

```
# deprecated now
```

```
In [1566]: df - df[0]
```

```
Out [1566]:
```

	0	1	2	3
2000-01-01	0	-0.754517	-1.991178	-0.746911
2000-01-02	0	2.331815	0.771297	0.990186
2000-01-03	0	0.440488	-2.375695	0.171640
2000-01-04	0	-1.057295	-1.789767	0.170346
2000-01-05	0	0.044219	0.123595	-1.273288
2000-01-06	0	-1.289654	-0.039243	0.892574

```
# Change your code to
```

```
In [1567]: df.sub(df[0], axis=0) # align on axis 0 (rows)
```

```
Out [1567]:
```

	0	1	2	3
2000-01-01	0	-0.754517	-1.991178	-0.746911
2000-01-02	0	2.331815	0.771297	0.990186
2000-01-03	0	0.440488	-2.375695	0.171640
2000-01-04	0	-1.057295	-1.789767	0.170346
2000-01-05	0	0.044219	0.123595	-1.273288
2000-01-06	0	-1.289654	-0.039243	0.892574

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 frequencies 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).

Note:

```
In [1568]: dates = pd.date_range('1/1/2000', '1/5/2000', freq='4h')
```

```
In [1569]: series = Series(np.arange(len(dates)), index=dates)
```

```
In [1570]: series
```

```
Out [1570]:
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
```

```
In [1571]: series.resample('D', how='sum')
```

```
Out [1571]:
2000-01-01    15
2000-01-02    51
2000-01-03    87
2000-01-04   123
2000-01-05    24
Freq: D
```

```
# old behavior
```

```
In [1572]: series.resample('D', how='sum', closed='right', label='right')
```

```
Out [1572]:
2000-01-01    0
2000-01-02   21
2000-01-03   57
2000-01-04   93
2000-01-05  129
Freq: D
```

- Infinity and negative infinity are no longer treated as NA by `isnull` and `notnull`. That they every were was a relic of early pandas. This behavior can be re-enabled globally by the `mode.use_inf_as_null` option:

```
In [1573]: s = pd.Series([1.5, np.inf, 3.4, -np.inf])
```

```
In [1574]: pd.isnull(s)
```



```
Out[1574]:
```

```
0    False
1    False
2    False
3    False
```

```
In [1575]: s.fillna(0)
```

```
Out[1575]:
```

```
0    1.500000
1         inf
2    3.400000
3        -inf
```

```
In [1576]: pd.set_option('use_inf_as_null', True)
```

```
In [1577]: pd.isnull(s)
```

```
Out[1577]:
```

```
0    False
1     True
2    False
3     True
```

```
In [1578]: s.fillna(0)
```

```
Out[1578]:
```

```
0    1.5
1    0.0
2    3.4
3    0.0
```

```
In [1579]: 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 [1580]: data= 'a,b,c\n1,Yes,2\n3,No,4'
```

```
In [1581]: print data
```

```
a,b,c
1,Yes,2
3,No,4
```

```
In [1582]: pd.read_csv(StringIO(data), header=None)
```

```
Out[1582]:
```

```
   0  1  2
0  a  b  c
1  1  Yes 2
2  3  No  4
```

```
In [1583]: pd.read_csv(StringIO(data), header=None, prefix='X')
```

```
Out[1583]:
```

```
   X0   X1 X2
0  a    b  c
1  1  Yes  2
2  3   No  4
```

- 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 [1584]: print data
a,b,c
1,Yes,2
3,No,4
```

```
In [1585]: pd.read_csv(StringIO(data))
Out[1585]:
   a    b  c
0  1  Yes  2
1  3   No  4
```

```
In [1586]: pd.read_csv(StringIO(data), true_values=['Yes'], false_values=['No'])
Out[1586]:
   a    b  c
0  1  True  2
1  3 False  4
```

- 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 [1587]: s = Series([np.nan, 1., 2., np.nan, 4])
```

```
In [1588]: s
Out[1588]:
0    NaN
1     1
2     2
3    NaN
4     4
```

```
In [1589]: s.fillna(0)
Out[1589]:
0     0
1     1
2     2
3     0
4     4
```

```
In [1590]: s.fillna(method='pad')
Out[1590]:
0    NaN
1     1
2     2
3     2
4     4
```

Convenience methods `ffill` and `bfill` have been added:

```
In [1591]: s.ffill()
Out[1591]:
0    NaN
1     1
2     2
3     2
4     4
```

- `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 [1592]: def f(x):
.....:     return Series([ x, x**2 ], index = ['x', 'x^2'])
.....:
```

```
In [1593]: s = Series(np.random.rand(5))
```

```
In [1594]: s
Out[1594]:
0    0.713026
1    0.539601
2    0.046682
3    0.536308
4    0.373040
```

```
In [1595]: s.apply(f)
Out[1595]:
      x      x^2
0  0.713026  0.508406
1  0.539601  0.291170
2  0.046682  0.002179
3  0.536308  0.287626
4  0.373040  0.139159
```

- 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 [1596]: get_option("display.max_rows")
Out[1596]: 100
```

- `to_string()` methods now always return unicode strings ([GH2224](#)).

1.2.3 New features

1.2.4 Wide DataFrame Printing

Instead of printing the summary information, pandas now splits the string representation across multiple rows by default:

```
In [1597]: wide_frame = DataFrame(randn(5, 16))
```

```
In [1598]: wide_frame
```

```
Out[1598]:
```

	0	1	2	3	4	5	6	7	\
0	0.091848	-0.318810	0.950676	-1.016290	-0.267508	0.115960	-0.615949	-0.373060	
1	-0.234083	-0.254881	-0.142302	1.291962	0.876700	1.704647	0.046376	0.158167	
2	0.191589	-0.243287	1.684079	-0.637764	-0.323699	-1.378458	-0.868599	1.916736	
3	1.247851	0.246737	1.454094	-1.166264	-0.560671	1.027488	0.252915	-0.154549	
4	-0.417236	1.721160	-0.058702	-1.297767	0.871349	-0.177241	0.207366	2.592691	
	8	9	10	11	12	13	14	15	
0	0.276398	-1.947432	-1.183044	-3.030491	-1.055515	-0.177967	1.269136	0.668999	
1	1.503229	-0.335678	0.157359	0.828373	0.860863	0.618679	-0.507624	-1.174443	
2	1.562215	0.133322	0.345906	-1.778234	-1.223208	-0.480258	-0.285245	0.775414	
3	0.181686	-0.268458	-0.124345	0.443256	-0.778424	2.147255	-0.731309	0.281577	
4	0.423204	-0.006209	0.314186	0.363193	0.196151	-1.598514	-0.843566	-0.353828	

The old behavior of printing out summary information can be achieved via the ‘expand_frame_repr’ print option:

```
In [1599]: pd.set_option('expand_frame_repr', False)
```

```
In [1600]: wide_frame
```

```
Out[1600]:
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
Int64Index: 5 entries, 0 to 4
```

```
Data columns:
```

0	5	non-null values
1	5	non-null values
2	5	non-null values
3	5	non-null values
4	5	non-null values
5	5	non-null values
6	5	non-null values
7	5	non-null values
8	5	non-null values
9	5	non-null values
10	5	non-null values
11	5	non-null values
12	5	non-null values
13	5	non-null values
14	5	non-null values
15	5	non-null values

```
dtypes: float64(16)
```

The width of each line can be changed via ‘line_width’ (80 by default):

```
In [1601]: pd.set_option('line_width', 40)
```

```
In [1602]: wide_frame
```

```
Out[1602]:
```

	0	1	2	3	\
0	0.091848	-0.318810	0.950676	-1.016290	
1	-0.234083	-0.254881	-0.142302	1.291962	
2	0.191589	-0.243287	1.684079	-0.637764	
3	1.247851	0.246737	1.454094	-1.166264	
4	-0.417236	1.721160	-0.058702	-1.297767	
	4	5	6	7	\
0	-0.267508	0.115960	-0.615949	-0.373060	
1	0.876700	1.704647	0.046376	0.158167	
2	-0.323699	-1.378458	-0.868599	1.916736	
3	-0.560671	1.027488	0.252915	-0.154549	

```

4  0.871349 -0.177241  0.207366  2.592691
      8      9      10      11  \
0  0.276398 -1.947432 -1.183044 -3.030491
1  1.503229 -0.335678  0.157359  0.828373
2  1.562215  0.133322  0.345906 -1.778234
3  0.181686 -0.268458 -0.124345  0.443256
4  0.423204 -0.006209  0.314186  0.363193
      12      13      14      15
0 -1.055515 -0.177967  1.269136  0.668999
1  0.860863  0.618679 -0.507624 -1.174443
2 -1.223208 -0.480258 -0.285245  0.775414
3 -0.778424  2.147255 -0.731309  0.281577
4  0.196151 -1.598514 -0.843566 -0.353828

```

1.2.5 Updated PyTables Support

[Docs](#) for PyTables Table format & several enhancements to the api. Here is a taste of what to expect.

```
In [1603]: store = HDFStore('store.h5')
```

```
In [1604]: df = DataFrame(randn(8, 3), index=date_range('1/1/2000', periods=8),
.....:                  columns=['A', 'B', 'C'])
.....:
```

```
In [1605]: df
```

```
Out[1605]:
```

	A	B	C
2000-01-01	0.516740	-2.335539	-0.715006
2000-01-02	-0.399224	0.798589	2.101702
2000-01-03	-0.190649	0.595370	-1.672567
2000-01-04	0.786765	0.133175	-1.077265
2000-01-05	0.861068	1.982854	-1.059177
2000-01-06	2.050701	-0.615165	-0.601019
2000-01-07	-1.062777	-1.577586	-0.585584
2000-01-08	1.833699	-0.483165	0.652315

```
# appending data frames
```

```
In [1606]: df1 = df[0:4]
```

```
In [1607]: df2 = df[4:]
```

```
In [1608]: store.append('df', df1)
```

```
In [1609]: store.append('df', df2)
```

```
In [1610]: store
```

```
Out[1610]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/df          frame_table  (typ->appendable,nrows->8,ncols->3,indexers->[index])
```

```
# selecting the entire store
```

```
In [1611]: store.select('df')
```

```
Out[1611]:
```

	A	B	C
2000-01-01	0.516740	-2.335539	-0.715006
2000-01-02	-0.399224	0.798589	2.101702

```
2000-01-03 -0.190649  0.595370 -1.672567
2000-01-04  0.786765  0.133175 -1.077265
2000-01-05  0.861068  1.982854 -1.059177
2000-01-06  2.050701 -0.615165 -0.601019
2000-01-07 -1.062777 -1.577586 -0.585584
2000-01-08  1.833699 -0.483165  0.652315
```

```
In [1612]: 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 [1613]: wp
```

```
Out[1613]:
<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 [1614]: store.append('wp', wp)
```

```
# selecting via A QUERY
```

```
In [1615]: store.select('wp',
.....:                  [ Term('major_axis>20000102'), Term('minor_axis', '=', ['A', 'B']) ])
.....:
```

```
Out[1615]:
<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 [1616]: store.remove('wp', [ 'major_axis', '>', wp.major_axis[3] ])
```

```
Out[1616]: 4
```

```
In [1617]: store.select('wp')
```

```
Out[1617]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 4 (major_axis) x 4 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-04 00:00:00
Minor_axis axis: A to D
```

```
# deleting a store
```

```
In [1618]: del store['df']
```

```
In [1619]: store
```

```
Out[1619]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/wp                wide_table    (typ->appendable,nrows->16,ncols->2,indexers->[major_axis,minor_axis])
```

Enhancements

- added ability to hierarchical keys

```

In [1620]: store.put('foo/bar/bah', df)

In [1621]: store.append('food/orange', df)

In [1622]: store.append('food/apple', df)

In [1623]: store
Out[1623]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/wp                wide_table    (typ->appendable,nrows->16,ncols->2,indexers->[major_ax
/food/apple        frame_table   (typ->appendable,nrows->8,ncols->3,indexers->[index])
/food/orange       frame_table   (typ->appendable,nrows->8,ncols->3,indexers->[index])
/foo/bar/bah       frame         (shape->[8,3])

# remove all nodes under this level
In [1624]: store.remove('food')

In [1625]: store
Out[1625]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/wp                wide_table    (typ->appendable,nrows->16,ncols->2,indexers->[major_ax
/foo/bar/bah       frame         (shape->[8,3])

```

- added mixed-dtype support!

```

In [1626]: df['string'] = 'string'

In [1627]: df['int']     = 1

In [1628]: store.append('df',df)

In [1629]: df1 = store.select('df')

In [1630]: df1
Out[1630]:
           A           B           C  string  int
2000-01-01  0.516740 -2.335539 -0.715006  string    1
2000-01-02 -0.399224  0.798589  2.101702  string    1
2000-01-03 -0.190649  0.595370 -1.672567  string    1
2000-01-04  0.786765  0.133175 -1.077265  string    1
2000-01-05  0.861068  1.982854 -1.059177  string    1
2000-01-06  2.050701 -0.615165 -0.601019  string    1
2000-01-07 -1.062777 -1.577586 -0.585584  string    1
2000-01-08  1.833699 -0.483165  0.652315  string    1

In [1631]: df1.get_dtype_counts()
Out[1631]:
float64    3
int64      1
object     1

```

- performance improvements 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 char-

acters ([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.

1.2.6 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 [1632]: 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 [1633]: p4d
Out[1633]:
<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.

1.3 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`.

1.3.1 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 [1634]: df = DataFrame(np.random.randint(0, 2, (6, 3)), columns=['A', 'B', 'C'])
```

```
In [1635]: df.sort(['A', 'B'], ascending=[1, 0])
```

```
Out[1635]:
```

	A	B	C
1	0	1	0
2	1	1	0
3	1	1	1
4	1	1	0
0	1	0	1
5	1	0	1

- *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 [1636]: df = DataFrame(np.random.randn(6, 3), columns=['A', 'B', 'C'])
```

```
In [1637]: df.ix[2:4] = np.nan
```

```
In [1638]: df.rank()
```

```
Out[1638]:
```

	A	B	C
0	1	3	2
1	2	1	1
2	NaN	NaN	NaN
3	NaN	NaN	NaN
4	NaN	NaN	NaN
5	3	2	3

```
In [1639]: df.rank(na_option='top')
```

```
Out[1639]:
```

	A	B	C
0	4	6	5
1	5	4	4
2	2	2	2
3	2	2	2
4	2	2	2
5	6	5	6

```
In [1640]: df.rank(na_option='bottom')
```

```
Out[1640]:
```

	A	B	C
0	1	3	2
1	2	1	1
2	5	5	5
3	5	5	5
4	5	5	5
5	3	2	3

- *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 [1641]: df = DataFrame(np.random.randn(5, 3), columns = ['A', 'B', 'C'])
```

```
In [1642]: df
```

```
Out[1642]:
```

	A	B	C
0	-1.381185	0.365239	-1.810632
1	-0.673382	-1.967580	-0.401183
2	-0.583047	-0.998625	-0.629277
3	-0.548001	-0.852612	-0.126250
4	1.765997	-1.593297	-0.966162

```
In [1643]: df[df['A'] > 0]
```

```
Out[1643]:
```

	A	B	C
4	1.765997	-1.593297	-0.966162

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 [1644]: df[df>0]
```

```
Out[1644]:
```

	A	B	C
0	NaN	0.365239	NaN
1	NaN	NaN	NaN
2	NaN	NaN	NaN
3	NaN	NaN	NaN
4	1.765997	NaN	NaN

```
In [1645]: df.where(df>0)
```

```
Out[1645]:
```

	A	B	C
0	NaN	0.365239	NaN
1	NaN	NaN	NaN
2	NaN	NaN	NaN
3	NaN	NaN	NaN
4	1.765997	NaN	NaN

```
In [1646]: df.where(df>0, -df)
```

```
Out[1646]:
```

	A	B	C
0	1.381185	0.365239	1.810632
1	0.673382	1.967580	0.401183
2	0.583047	0.998625	0.629277
3	0.548001	0.852612	0.126250
4	1.765997	1.593297	0.966162

Furthermore, `where` now aligns the input boolean condition (`ndarray` or `DataFrame`), such that partial selection with setting is possible. This is analogous to partial setting via `.ix` (but on the contents rather than the axis labels)

```
In [1647]: df2 = df.copy()
```

```
In [1648]: df2[ df2[1:4] > 0 ] = 3
```

```
In [1649]: df2
```

```
Out [1649]:
```

	A	B	C
0	-1.381185	0.365239	-1.810632
1	-0.673382	-1.967580	-0.401183
2	-0.583047	-0.998625	-0.629277
3	-0.548001	-0.852612	-0.126250
4	1.765997	-1.593297	-0.966162

`DataFrame.mask` is the inverse boolean operation of *where*.

```
In [1650]: df.mask(df<=0)
```

```
Out [1650]:
```

	A	B	C
0	NaN	0.365239	NaN
1	NaN	NaN	NaN
2	NaN	NaN	NaN
3	NaN	NaN	NaN
4	1.765997	NaN	NaN

- Enable referencing of Excel columns by their column names (GH1936)

```
In [1651]: xl = ExcelFile('data/test.xls')
```

```
In [1652]: xl.parse('Sheet1', index_col=0, parse_dates=True,
.....:              parse_cols='A:D')
```

```
Out [1652]:
```

	A	B	C
2000-01-03	0.980269	3.685731	-0.364217
2000-01-04	1.047916	-0.041232	-0.161812
2000-01-05	0.498581	0.731168	-0.537677
2000-01-06	1.120202	1.567621	0.003641
2000-01-07	-0.487094	0.571455	-1.611639
2000-01-10	0.836649	0.246462	0.588543
2000-01-11	-0.157161	1.340307	1.195778

- 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)

1.3.2 API changes

- Upsampling data with a PeriodIndex will result in a higher frequency TimeSeries that spans the original time window

```
In [1653]: prng = period_range('2012Q1', periods=2, freq='Q')
```

```
In [1654]: s = Series(np.random.randn(len(prng)), prng)
```

```
In [1655]: s.resample('M')
```

```
Out [1655]:
```

```
2012-01    -0.332601
2012-02         NaN
2012-03         NaN
2012-04   -1.327330
2012-05         NaN
2012-06         NaN
Freq: M
```

- `Period.end_time` now returns the last nanosecond in the time interval (GH2124, GH2125, GH1764)

```
In [1656]: p = Period('2012')

In [1657]: p.end_time
Out[1657]: <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 [1658]: data = 'A,B,C\n00001,001,5\n00002,002,6'

In [1659]: from cStringIO import StringIO

In [1660]: read_csv(StringIO(data), converters={'A' : lambda x: x.strip()})
Out[1660]:
```

	A	B	C
0	00001	1	5
1	00002	2	6

See the [full release notes](#) or issue tracker on GitHub for a complete list.

1.4 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.

1.4.1 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)

1.4.2 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 [1661]: from StringIO import StringIO
```

```
In [1662]: data = '0,0,1\n1,1,0\n0,1,0'
```

```
In [1663]: df = read_csv(StringIO(data), header=None)
```

```
In [1664]: df
```

```
Out[1664]:
```

```
   0  1  2
0  0  0  1
1  1  1  0
2  0  1  0
```

- 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 [1665]: s1 = Series([1, 2, 3])
```

```
In [1666]: s1
```

```
Out[1666]:
```

```
0    1
1    2
2    3
```

```
In [1667]: s2 = Series(s1, index=['foo', 'bar', 'baz'])
```

```
In [1668]: s2
```

```
Out[1668]:
```

```
foo    NaN
bar    NaN
baz    NaN
```

- 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 `TypeError`s 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.

1.5 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.

1.5.1 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)

1.5.2 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 improvements

1.6 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. Lingerin 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.

1.6.1 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)

1.6.2 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.

1.6.3 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_localize` methods to `TimeSeries` and `DataFrame`. All timestamps are stored as UTC; Timestamps from `DatetimeIndex` objects with time zone set will be localized to local time. Time zone conversions are therefore essentially free. User needs to know very little about `pytz` library now; only time zone names 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 *ts*`shift` method for leading/lagging using the frequency (if any) of the index, as opposed to a naive lead/lag using `shift`

1.6.4 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

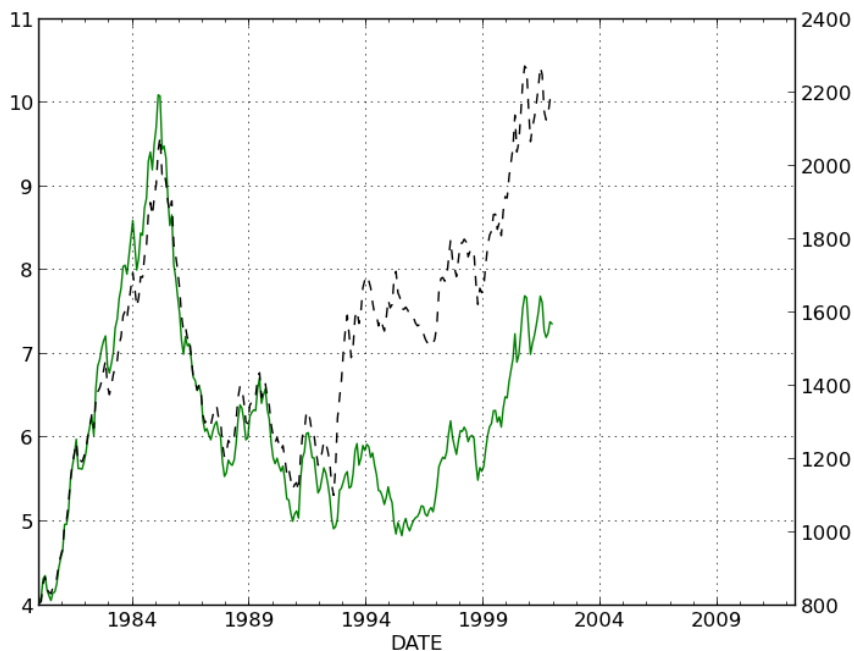
1.6.5 New plotting methods

`Series.plot` now supports a `secondary_y` option:

```
In [1669]: plt.figure()
Out[1669]: <matplotlib.figure.Figure at 0x1ba9e310>

In [1670]: fx['FR'].plot(style='g')
Out[1670]: <matplotlib.axes.AxesSubplot at 0x1ba93e10>

In [1671]: fx['IT'].plot(style='k--', secondary_y=True)
Out[1671]: <matplotlib.axes.AxesSubplot at 0x1ba93e10>
```



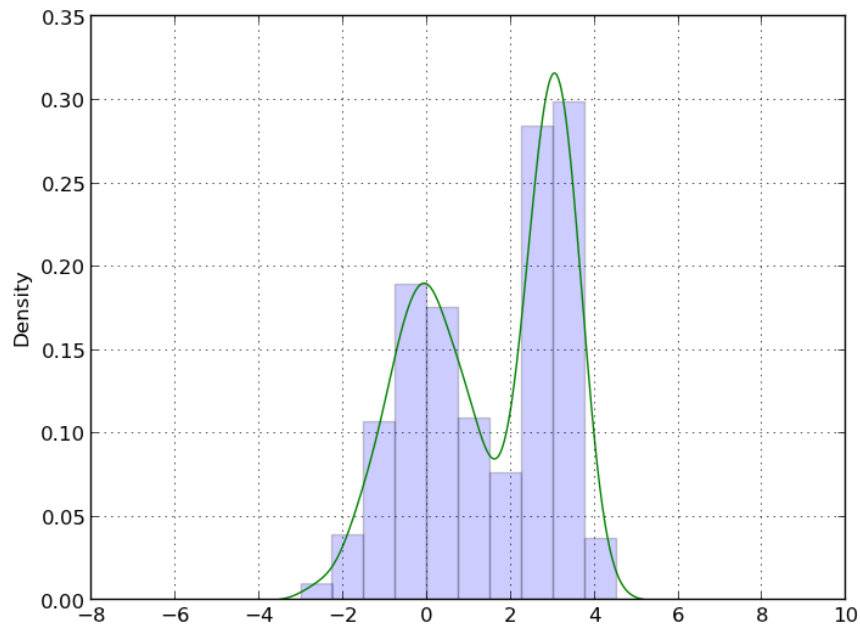
Vytautas Jancauskas, the 2012 GSOC participant, has added many new plot types. For example, `'kde'` is a new option:

```
In [1672]: s = Series(np.concatenate((np.random.randn(1000),
.....:                                np.random.randn(1000) * 0.5 + 3)))
.....:

In [1673]: plt.figure()
Out[1673]: <matplotlib.figure.Figure at 0x1ba9e410>

In [1674]: s.hist(normed=True, alpha=0.2)
Out[1674]: <matplotlib.axes.AxesSubplot at 0x1c3d6dd0>

In [1675]: s.plot(kind='kde')
Out[1675]: <matplotlib.axes.AxesSubplot at 0x1c3d6dd0>
```



See [the plotting page](#) for much more.

1.6.6 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.

1.6.7 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 [1676]: import datetime

In [1677]: rng = date_range('1/1/2000', periods=10)

In [1678]: rng[5]
Out[1678]: <Timestamp: 2000-01-06 00:00:00>

In [1679]: isinstance(rng[5], datetime.datetime)
Out[1679]: True

In [1680]: rng_asarray = np.asarray(rng)

In [1681]: scalar_val = rng_asarray[5]

In [1682]: type(scalar_val)
Out[1682]: 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 [1683]: stamp_array = rng.asobject
```

```
In [1684]: stamp_array
```

```
Out[1684]: 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,
```

```
In [1685]: stamp_array[5]
```

```
Out[1685]: <Timestamp: 2000-01-06 00:00:00>
```

To get an array of proper `datetime.datetime` objects, use the `to_pydatetime` method:

```
In [1686]: dt_array = rng.to_pydatetime()
```

```
In [1687]: dt_array
```

```
Out[1687]:
```

```
array([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 [1688]: dt_array[5]
```

```
Out[1688]: 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 [1689]: rng = date_range('1/1/2000', periods=10)
```

```
In [1690]: rng
```

```
Out[1690]:
```

```
<class 'pandas.tseries.index.DatetimeIndex'>
[2000-01-01 00:00:00, ..., 2000-01-10 00:00:00]
Length: 10, Freq: D, Timezone: None
```

```
In [1691]: np.asarray(rng)
```

```
Out[1691]:
```

```
array([1970-01-11 184:00:00, 1970-01-11 208:00:00, 1970-01-11 232:00:00,
       1970-01-11 00:00:00, 1970-01-11 24:00:00, 1970-01-11 48:00:00,
       1970-01-11 72:00:00, 1970-01-11 96:00:00, 1970-01-11 120:00:00,
       1970-01-11 144:00:00], dtype=datetime64[ns])
```

```
In [1692]: converted = np.asarray(rng, dtype=object)
```

```
In [1693]: converted[5]
```

```
Out[1693]: datetime.datetime(1970, 1, 11, 48, 0)
```

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.

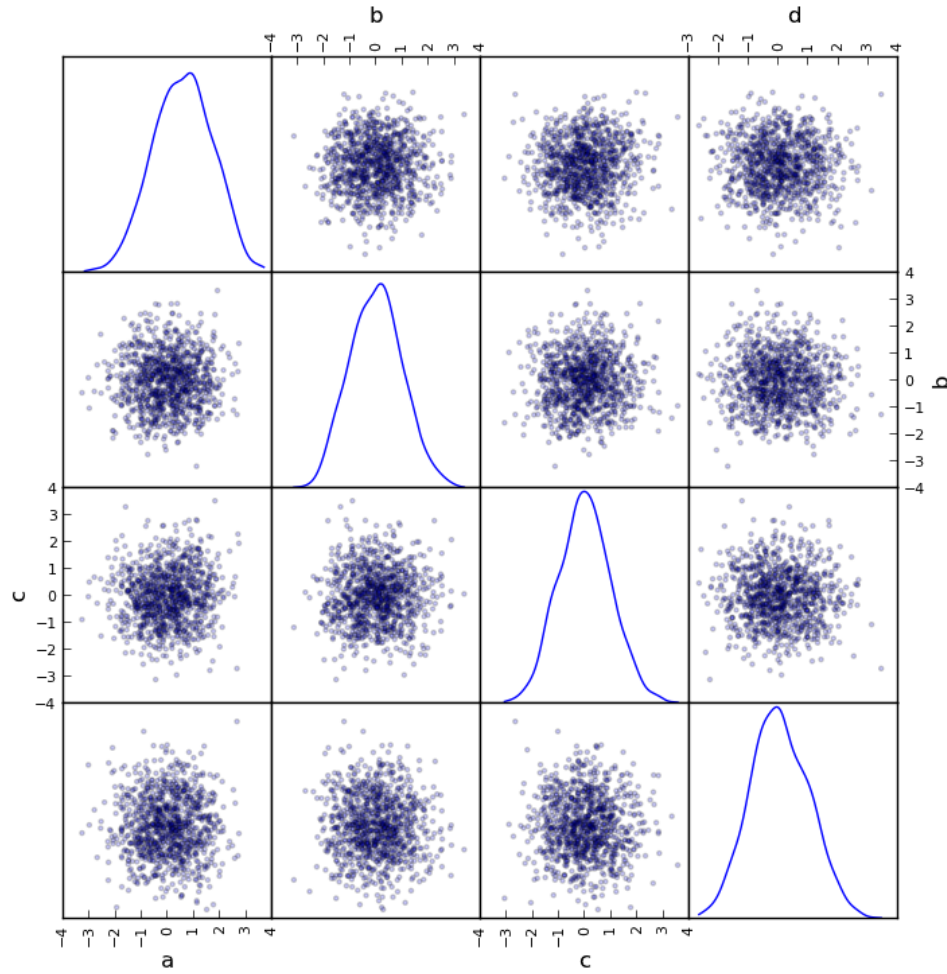
1.7 v.0.7.3 (April 12, 2012)

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.

1.7.1 New features

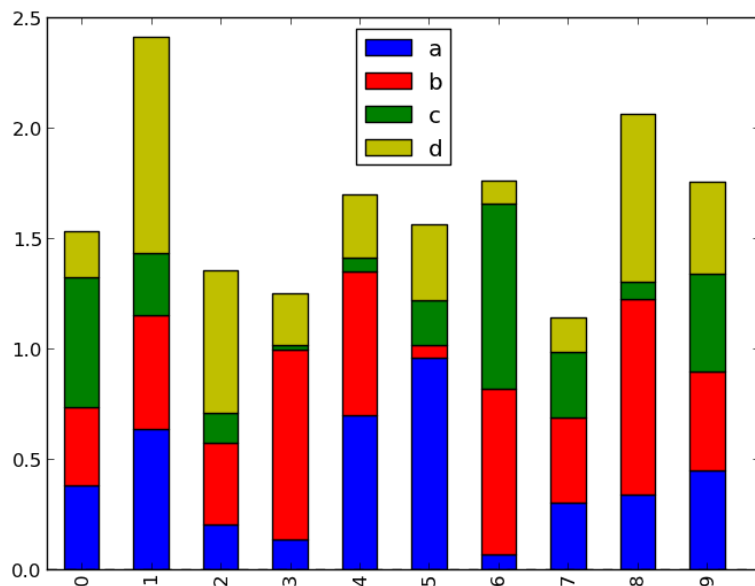
- New *fixed width file reader*, `read_fwf`
- New *scatter_matrix* function for making a scatter plot matrix

```
from pandas.tools.plotting import scatter_matrix
scatter_matrix(df, alpha=0.2)
```

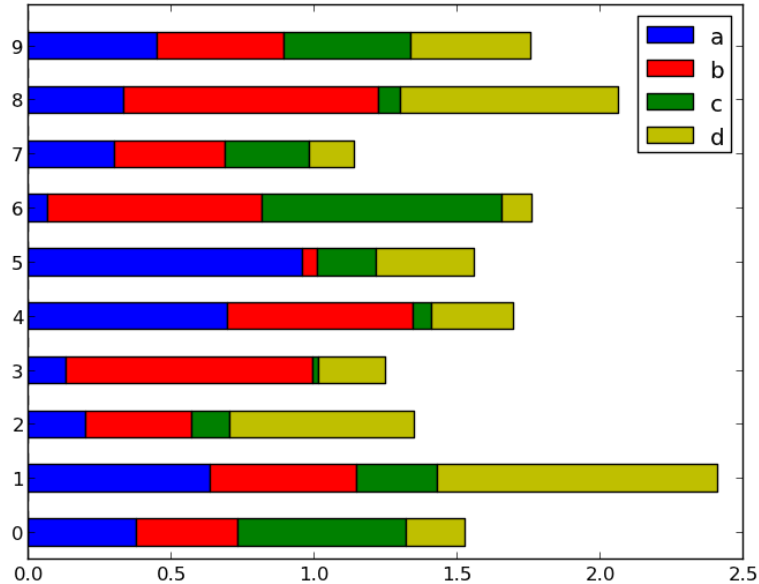


- Add stacked argument to Series and DataFrame's plot method for *stacked bar plots*.

```
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

1.7.2 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 [1694]: series = Series(['Steve', np.nan, 'Joe'])
```

```
In [1695]: series == 'Steve'
```

```
Out[1695]:  
0      True  
1     False  
2     False
```

```
In [1696]: series != 'Steve'
```

```
Out[1696]:  
0     False  
1       True  
2       True
```

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 [1697]: mask = series == 'Steve'
```

```
In [1698]: series[mask & series.notnull()]
```

```
Out[1698]: 0      Steve
```

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.

1.7.3 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 [1699]: 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 [1700]: df
```

```
Out[1700]:
```

	A	B	C	D
0	foo	one	0.255678	-0.295328
1	bar	one	0.055213	-2.208596
2	foo	two	-0.190798	-0.097122
3	bar	three	0.247394	0.289633
4	foo	two	0.453403	0.160891
5	bar	two	1.925709	-1.902936
6	foo	one	0.714705	-0.348722
7	foo	three	1.781358	0.352378

```
In [1701]: grouped = df.groupby('A')['C']
```

```
In [1702]: grouped.describe()
```

```
Out[1702]:
```

A		
bar	count	3.000000
	mean	0.742772
	std	1.028950
	min	0.055213
	25%	0.151304
	50%	0.247394
	75%	1.086551
	max	1.925709
foo	count	5.000000
	mean	0.602869
	std	0.737247
	min	-0.190798
	25%	0.255678
	50%	0.453403
	75%	0.714705
	max	1.781358

```
In [1703]: grouped.apply(lambda x: x.order()[-2:]) # top 2 values
```

```
Out[1703]:
```

A		
bar	3	0.247394
	5	1.925709
foo	6	0.714705
	7	1.781358

1.8 v.0.7.2 (March 16, 2012)

This release targets bugs in 0.7.1, and adds a few minor features.

1.8.1 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)

1.8.2 Performance improvements

- Use khash for `Series.value_counts`, add `raw` function to `algorithms.py` (GH861)
- Intercept `__builtin__.sum` in `groupby` (GH885)

1.9 v.0.7.1 (February 29, 2012)

This release includes a few new features and addresses over a dozen bugs in 0.7.0.

1.9.1 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`

1.9.2 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)

1.10 v.0.7.0 (February 9, 2012)

1.10.1 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 [1704]: df = DataFrame(randn(10, 4))
```

```
In [1705]: df.apply(lambda x: x.describe())
```

```
Out[1705]:
```

	0	1	2	3
count	10.000000	10.000000	10.000000	10.000000
mean	0.467956	-0.271208	0.320479	0.255854
std	1.371729	0.759631	0.962485	0.661379
min	-2.055090	-1.349964	-0.905821	-0.904464
25%	-0.357215	-0.622232	-0.529872	-0.186021
50%	0.576651	-0.298812	0.317472	0.345715
75%	1.710590	-0.184047	1.031023	0.830109
max	2.061568	1.147814	1.641604	1.034401

- *Add* `reorder_levels` method to Series and DataFrame (PR534)
- *Add* dict-like `get` function to DataFrame and Panel (PR521)
- *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, PR552, others)
- *Add* attribute-based item access to Panel and add IPython completion (PR563)
- *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 ([PR563](#))
- *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`.

1.10.2 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 [1706]: s = Series(randn(10), index=range(0, 20, 2))
```

```
In [1707]: s
```

```
Out[1707]:
0      0.910822
2      0.695714
4     -0.955386
6      0.359339
8     -0.189177
10     -1.168504
12     -1.381056
14      0.786651
16      0.288704
18      0.148544
```

```
In [1708]: s[0]
```

```
Out[1708]: 0.910822002253868
```

```
In [1709]: s[2]
```

```
Out[1709]: 0.69571446395605785
```

```
In [1710]: s[4]
```

```
Out[1710]: -0.95538648457113173
```

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

1.10.3 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 [1711]: s = Series(randn(6), index=list('gmkaec'))
```

```
In [1712]: s
Out[1712]:
g    0.842702
m   -1.876494
k   -0.365497
a   -2.231289
e    0.716546
c   -0.069151
```

Then this is OK:

```
In [1713]: s.ix['k':'e']
Out[1713]:
k   -0.365497
a   -2.231289
e    0.716546
```

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 [1714]: s2 = s.sort_index()
```

```
In [1715]: s2
```

```
Out[1715]:
```

```
a    -2.231289
c    -0.069151
e     0.716546
g     0.842702
k    -0.365497
m    -1.876494
```

```
In [1716]: s2.ix['b':'h']
```

```
Out[1716]:
```

```
c    -0.069151
e     0.716546
g     0.842702
```

1.10.4 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 [1717]: s = Series(randn(6), index=list('acegkm'))
```

```
In [1718]: s
```

```
Out[1718]:
```

```
a    -0.651033
c    -1.163455
e     1.627107
g     2.008883
k    -0.431064
m    -1.687776
```

```
In [1719]: s[['m', 'a', 'c', 'e']]
```

```
Out[1719]:
```

```
m    -1.687776
a    -0.651033
c    -1.163455
e     1.627107
```

```
In [1720]: s['b':'l']
```

```
Out[1720]:
```

```
c    -1.163455
e     1.627107
g     2.008883
k    -0.431064
```

```
In [1721]: s['c':'k']
```

```
Out[1721]:
```

```
c    -1.163455
e     1.627107
g     2.008883
k    -0.431064
```

In the case of integer indexes, the behavior will be exactly as before (shadowing `ndarray`):

```
In [1722]: s = Series(randn(6), index=range(0, 12, 2))
```

```
In [1723]: s[[4, 0, 2]]
```

```
Out[1723]:
```

```
4    -0.593879
0    -0.271860
2     1.101084
```

```
In [1724]: s[1:5]
```

```
Out[1724]:
```

```
2     1.101084
4    -0.593879
6     0.873445
8     2.880726
```

If you wish to do indexing with sequences and slicing on an integer index with label semantics, use `ix`.

1.10.5 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](#))

1.10.6 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)

1.11 v.0.6.1 (December 13, 2011)

1.11.1 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 (PR435)
- `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* (PR453)
- 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 (PR482)
- *Can pass* DataFrame/DataFrame and DataFrame/Series to `rolling_corr/rolling_cov` (GH #462)
- `MultiIndex.get_level_values` can *accept the level name*

1.11.2 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)

1.12 v.0.6.0 (November 25, 2011)

1.12.1 New Features

- *Added* `melt` function to `pandas.core.reshape`
- *Added* `level` parameter to `group by level` in Series and DataFrame descriptive statistics (PR313)

- *Added* `head` and `tail` methods to `Series`, analogous to `DataFrame` (PR296)
- *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` (PR321)
- *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, PR362)
- *Added* `fast_get_value` and `put_value` methods to `DataFrame` (GH360)
- *Added* `cov` instance methods to `Series` and `DataFrame` (GH194, PR362)
- *Added* `kind='bar'` option to `DataFrame.plot` (PR348)
- *Added* `idxmin` and `idxmax` to `Series` and `DataFrame` (PR286)
- *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 (PR387)
- *Added* support for `MaskedArray` data in `DataFrame`, masked values converted to `NaN` (PR396)
- *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)

1.12.2 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 ([PR355](#))
- 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](#))

1.13 v.0.5.0 (October 24, 2011)

1.13.1 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. ([PR233](#), [GH230](#))
- *Implemented* `Series.describe` for Series containing objects ([PR241](#))
- *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 ([PR334](#))
- *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` (PR244)
- TODO: DOCS ABOUT TAKE METHODS

1.13.2 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

1.14 v.0.4.3 through v0.4.1 (September 25 - October 9, 2011)

1.14.1 New Features

- Added Python 3 support using 2to3 (PR200)
- *Added* name attribute to `Series`, now prints as part of `Series.__repr__`
- *Added* instance methods `isnull` and `notnull` to `Series` (PR209, GH203)
- *Added* `Series.align` method for aligning two series with choice of join method (ENH56)
- *Added* method `get_level_values` to `MultiIndex` (IS188)
- *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` (PR146)
- `read_csv` can *read* multiple columns into a `MultiIndex`; `DataFrame`'s `to_csv` method writes out a corresponding `MultiIndex` (PR151)
- `DataFrame.rename` has a new `copy` parameter to *rename* a `DataFrame` in place (ENHed)
- *Enable* unstacking by name (PR142)
- *Enable* `sortlevel` to work by level (PR141)

1.14.2 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

INSTALLATION

You have the option to install an [official release](#) or to build the [development version](#). If you choose to install from source and are running Windows, you will have to ensure that you have a compatible C compiler (MinGW or Visual Studio) installed. [How-to install MinGW on Windows](#)

2.1 Python version support

Officially Python 2.5 to 2.7 and Python 3.1+, although Python 3 support is less well tested. Python 2.4 support is being phased out since the userbase has shrunk significantly. Continuing Python 2.4 support will require either monetary development support or someone contributing to the project to maintain compatibility.

2.2 Binary installers

2.2.1 All platforms

Stable installers available on [PyPI](#)

Preliminary builds and installers on the [Pandas download page](#) .

2.2.2 Overview

Platform	Distribution	Status	Download / Repository Link	Install method
Windows	all	stable	<i>All platforms</i>	<code>pip install pandas</code>
Mac	all	stable	<i>All platforms</i>	<code>pip install pandas</code>
Linux	Debian	stable	official Debian repository	<code>sudo apt-get install python-pandas</code>
Linux	Debian & Ubuntu	unstable (latest packages)	NeuroDebian	<code>sudo apt-get install python-pandas</code>
Linux	Ubuntu	stable	official Ubuntu repository	<code>sudo apt-get install python-pandas</code>
Linux	Ubuntu	unstable (daily builds)	PythonXY PPA; activate by: <code>sudo add-apt-repository ppa:pythonxy/pythonxy-devel</code> && <code>sudo apt-get update</code>	<code>sudo apt-get install python-pandas</code>
Linux	Open-Suse & Fedora	stable	OpenSuse Repository	<code>zypper in python-pandas</code>

2.3 Dependencies

- NumPy: 1.6.1 or higher
- python-dateutil 1.5
- pytz
 - Needed for time zone support

2.4 Optional dependencies

- Cython: Only necessary to build development version. Version 0.17.1 or higher.
- SciPy: miscellaneous statistical functions
- PyTables: necessary for HDF5-based storage
- matplotlib: for plotting
- statsmodels
 - Needed for parts of `pandas.stats`
- openpyxl, xlrd/xlwt
 - openpyxl version 1.6.1 or higher
 - Needed for Excel I/O

Note: Without the optional dependencies, many useful features will not work. Hence, it is highly recommended that you install these. A packaged distribution like the [Enthought Python Distribution](#) may be worth considering.

2.5 Installing from source

Note: Installing from the git repository requires a recent installation of [Cython](#) as the cythonized C sources are no longer checked into source control. Released source distributions will contain the built C files. I recommend installing the latest Cython via `easy_install -U Cython`

The source code is hosted at <http://github.com/pydata/pandas>, it can be checked out using git and compiled / installed like so:

```
git clone git://github.com/pydata/pandas.git
cd pandas
python setup.py install
```

Make sure you have Cython installed when installing from the repository, rather than a tarball or pypi.

On Windows, I suggest installing the MinGW compiler suite following the directions linked to above. Once configured properly, run the following on the command line:

```
python setup.py build --compiler=mingw32
python setup.py install
```

Note that you will not be able to import pandas if you open an interpreter in the source directory unless you build the C extensions in place:

```
python setup.py build_ext --inplace
```

The most recent version of MinGW (any installer dated after 2011-08-03) has removed the ‘-mno-cygwin’ option but Distutils has not yet been updated to reflect that. Thus, you may run into an error like “unrecognized command line option ‘-mno-cygwin’”. Until the bug is fixed in Distutils, you may need to install a slightly older version of MinGW (2011-08-02 installer).

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 [nose](#) and run:

```
$ nosetests pandas
.....
.....S.....
.....
.....
.....
.....
.....
.....
.....
.....
```

```
.....S.....  
....  
-----  
Ran 818 tests in 21.631s  
  
OK (SKIP=2)
```

FREQUENTLY ASKED QUESTIONS (FAQ)

Pandas is a powerful tool and already has a plethora of data manipulation operations implemented, most of them are very fast as well. It's very possible however that certain functionality that would make your life easier is missing. In that case you have several options:

1. Open an issue on [Github](#), explain your need and the sort of functionality you would like to see implemented.
2. Fork the repo, Implement the functionality yourself and open a PR on Github.
3. Write a method that performs the operation you are interested in and Monkey-patch the pandas class as part of your IPython profile startup or PYTHONSTARTUP file.

For example, here is an example of adding an `just_foo_cols()` method to the dataframe class:

```
In [452]: import pandas as pd

In [453]: def just_foo_cols(self):
.....:     """Get a list of column names containing the string 'foo'
.....:     """
.....:     return [x for x in self.columns if 'foo' in x]
.....:

In [454]: pd.DataFrame.just_foo_cols = just_foo_cols # monkey-patch the DataFrame class

In [455]: df = pd.DataFrame([range(4)], columns= ["A", "foo", "foozball", "bar"])

In [456]: df.just_foo_cols()
Out[456]: ['foo', 'foozball']

In [457]: del pd.DataFrame.just_foo_cols # you can also remove the new method
```

Monkey-patching is usually frowned upon because it makes your code less portable and can cause subtle bugs in some circumstances. Monkey-patching existing methods is usually a bad idea in that respect. When used with proper care, however, it's a very useful tool to have.

3.1 Migrating from `scikits.timeseries` to `pandas >= 0.8.0`

Starting with pandas 0.8.0, users of `scikits.timeseries` should have all of the features that they need to migrate their code to use pandas. Portions of the `scikits.timeseries` codebase for implementing calendar logic and timespan frequency

conversions (but **not** resampling, that has all been implemented from scratch from the ground up) have been ported to the pandas codebase.

The `scikits.timeseries` notions of `Date` and `DateArray` are responsible for implementing calendar logic:

```
In [16]: dt = ts.Date('Q', '1984Q3')

# sic
In [17]: dt
Out[17]: <Q-DEC : 1984Q1>

In [18]: dt.asfreq('D', 'start')
Out[18]: <D : 01-Jan-1984>

In [19]: dt.asfreq('D', 'end')
Out[19]: <D : 31-Mar-1984>

In [20]: dt + 3
Out[20]: <Q-DEC : 1984Q4>
```

`Date` and `DateArray` from `scikits.timeseries` have been reincarnated in pandas `Period` and `PeriodIndex`:

```
In [458]: pnow('D') # scikits.timeseries.now()
Out[458]: Period('2013-01-22', 'D')

In [459]: Period(year=2007, month=3, day=15, freq='D')
Out[459]: Period('2007-03-15', 'D')

In [460]: p = Period('1984Q3')

In [461]: p
Out[461]: Period('1984Q3', 'Q-DEC')

In [462]: p.asfreq('D', 'start')
Out[462]: Period('1984-07-01', 'D')

In [463]: p.asfreq('D', 'end')
Out[463]: Period('1984-09-30', 'D')

In [464]: (p + 3).asfreq('T') + 6 * 60 + 30
Out[464]: Period('1985-07-01 06:29', 'T')

In [465]: rng = period_range('1990', '2010', freq='A')

In [466]: rng
Out[466]:
<class 'pandas.tseries.period.PeriodIndex'>
freq: A-DEC
[1990, ..., 2010]
length: 21

In [467]: rng.asfreq('B', 'end') - 3
Out[467]:
<class 'pandas.tseries.period.PeriodIndex'>
freq: B
[1990-12-26, ..., 2010-12-28]
length: 21
```


scikits.timeseries	pandas	Notes
Date	Period	A span of time, from yearly through to secondly
DateArray	PeriodIndex	An array of timespans
convert	resample	Frequency conversion in scikits.timeseries
convert_to_annual	pivot_annual	currently supports up to daily frequency, see issue 736

3.1.1 PeriodIndex / DateArray properties and functions

The scikits.timeseries DateArray had a number of information properties. Here are the pandas equivalents:

scikits.timeseries	pandas	Notes
get_steps	<code>np.diff(idx.values)</code>	
has_missing_dates	<code>not idx.is_full</code>	
is_full	<code>idx.is_full</code>	
is_valid	<code>idx.is_monotonic</code> and <code>idx.is_unique</code>	
is_chronological	<code>is_monotonic</code>	
<code>arr.sort_chronologically()</code>	<code>idx.order()</code>	

3.1.2 Frequency conversion

Frequency conversion is implemented using the `resample` method on `TimeSeries` and `DataFrame` objects (multiple time series). `resample` also works on panels (3D). Here is some code that resamples daily data to montly with scikits.timeseries:

```
In [468]: import scikits.timeseries as ts
```

```
In [469]: data = ts.time_series(np.random.randn(50), start_date='Jan-2000', freq='M')
```

```
In [470]: data
```

```
Out[470]:
timeseries([ 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  0.4047  0.577 -1.715
 -1.0393 -0.3706 -1.1579 -1.3443  0.8449  1.0758 -0.109  1.6436 -1.4694
 0.357  -0.6746 -1.7769 -0.9689 -1.2945  0.4137  0.2767 -0.472 -0.014
 -0.3625 -0.0062 -0.9231  0.8957  0.8052],
          dates = [Jan-2013 ... Feb-2017],
          freq = M)
```

```
In [471]: data.convert('A', func=np.mean)
```

```
Out[471]:
timeseries([-0.394509620575 -0.24462765889 -0.221632512996 -0.453772693384
 0.8504806638],
          dates = [2013 ... 2017],
          freq = A-DEC)
```

Here is the equivalent pandas code:

```
In [472]: rng = period_range('Jan-2000', periods=50, freq='M')
```

```
In [473]: data = Series(np.random.randn(50), index=rng)
```

```
In [474]: data
```

```
Out[474]:
2000-01    -1.206412
```

```
2000-02    2.565646
2000-03    1.431256
2000-04    1.340309
2000-05   -1.170299
2000-06   -0.226169
2000-07    0.410835
2000-08    0.813850
2000-09    0.132003
2000-10   -0.827317
2000-11   -0.076467
2000-12   -1.187678
2001-01    1.130127
2001-02   -1.436737
2001-03   -1.413681
2001-04    1.607920
2001-05    1.024180
2001-06    0.569605
2001-07    0.875906
2001-08   -2.211372
2001-09    0.974466
2001-10   -2.006747
2001-11   -0.410001
2001-12   -0.078638
2002-01    0.545952
2002-02   -1.219217
2002-03   -1.226825
2002-04    0.769804
2002-05   -1.281247
2002-06   -0.727707
2002-07   -0.121306
2002-08   -0.097883
2002-09    0.695775
2002-10    0.341734
2002-11    0.959726
2002-12   -1.110336
2003-01   -0.619976
2003-02    0.149748
2003-03   -0.732339
2003-04    0.687738
2003-05    0.176444
2003-06    0.403310
2003-07   -0.154951
2003-08    0.301624
2003-09   -2.179861
2003-10   -1.369849
2003-11   -0.954208
2003-12    1.462696
2004-01   -1.743161
2004-02   -0.826591
Freq: M
```

```
In [475]: data.resample('A', how=np.mean)
```

```
Out[475]:
```

```
2000    0.166630
2001   -0.114581
2002   -0.205961
2003   -0.235802
2004   -1.284876
```

Freq: A-DEC

3.1.3 Plotting

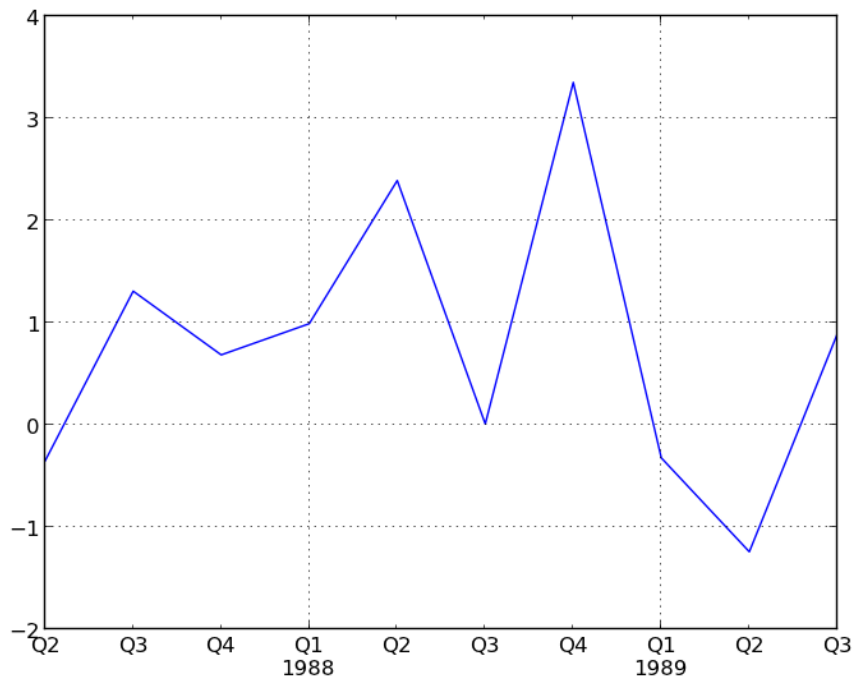
Much of the plotting functionality of `scikits.timeseries` has been ported and adopted to pandas's data structures. For example:

```
In [476]: rng = period_range('1987Q2', periods=10, freq='Q-DEC')
```

```
In [477]: data = Series(np.random.randn(10), index=rng)
```

```
In [478]: plt.figure(); data.plot()
```

```
Out[478]: <matplotlib.axes.AxesSubplot at 0x7ddf4d0>
```



3.1.4 Converting to and from period format

Use the `to_timestamp` and `to_period` instance methods.

3.1.5 Treatment of missing data

Unlike `scikits.timeseries`, pandas data structures are not based on NumPy's `MaskedArray` object. Missing data is represented as `NaN` in numerical arrays and either as `None` or `NaN` in non-numerical arrays. Implementing a version of pandas's data structures that use `MaskedArray` is possible but would require the involvement of a dedicated maintainer. Active pandas developers are not interested in this.

3.1.6 Resampling with timestamps and periods

`resample` has a `kind` argument which allows you to resample time series with a `DatetimeIndex` to `PeriodIndex`:

```
In [479]: rng = date_range('1/1/2000', periods=200, freq='D')
```

```
In [480]: data = Series(np.random.randn(200), index=rng)
```

```
In [481]: data[:10]
```

```
Out[481]:
2000-01-01    -0.487602
2000-01-02    -0.082240
2000-01-03    -2.182937
2000-01-04     0.380396
2000-01-05     0.084844
2000-01-06     0.432390
2000-01-07     1.519970
2000-01-08    -0.493662
2000-01-09     0.600178
2000-01-10     0.274230
Freq: D
```

```
In [482]: data.index
```

```
Out[482]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2000-01-01 00:00:00, ..., 2000-07-18 00:00:00]
Length: 200, Freq: D, Timezone: None
```

```
In [483]: data.resample('M', kind='period')
```

```
Out[483]:
2000-01     0.163775
2000-02     0.026549
2000-03    -0.089563
2000-04    -0.079405
2000-05     0.160348
2000-06     0.101725
2000-07    -0.708770
Freq: M
```

Similarly, resampling from periods to timestamps is possible with an optional interval ('start' or 'end') convention:

```
In [484]: rng = period_range('Jan-2000', periods=50, freq='M')
```

```
In [485]: data = Series(np.random.randn(50), index=rng)
```

```
In [486]: resampled = data.resample('A', kind='timestamp', convention='end')
```

```
In [487]: resampled.index
```

```
Out[487]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2000-12-31 00:00:00, ..., 2004-12-31 00:00:00]
Length: 5, Freq: A-DEC, Timezone: None
```

PACKAGE OVERVIEW

`pandas` consists of the following things

- A set of labeled array data structures, the primary of which are `Series/TimeSeries` 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.)
- Static and moving window linear and `panel regression`

4.1 Data structures at a glance

Dimensions	Name	Description
1	Series	1D labeled homogeneously-typed array
1	Time-Series	Series with index containing datetimes
2	DataFrame	General 2D labeled, size-mutable tabular structure with potentially heterogeneously-typed columns
3	Panel	General 3D labeled, also size-mutable array

4.1.1 Why more than 1 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 `Panel` is a container for `DataFrame` objects. 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-contiguosness 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](#).

Longer discussions occur on the [developer mailing list](#), and commercial support inquiries for Lambda Foundry should be sent to: support@lambdafoundry.com

4.4 Credits

pandas development began at [AQR Capital Management](#) in April 2008. It was open-sourced at the end of 2009. AQR continued to provide resources for development through the end of 2011, and continues to contribute bug reports today.

Since January 2012, [Lambda Foundry](#), has been providing development resources, as well as commercial support, training, and consulting for pandas.

pandas is only made possible by a group of people around the world like you who have contributed new code, bug reports, fixes, comments and ideas. A complete list can be found [on Github](#).

4.5 Development Team

pandas is a part of the PyData project. The PyData Development Team is a collection of developers focused on the improvement of Python’s data libraries. The core team that coordinates development can be found on [Github](#). If you’re interested in contributing, please visit the [project website](#).

4.6 License

```
=====
License
=====
```

pandas is distributed under a 3-clause ("Simplified" or "New") BSD license. Parts of NumPy, SciPy, numpydoc, bottleneck, which all have BSD-compatible licenses, are included. Their licenses follow the pandas license.

```
pandas license
=====
```

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```
About the Copyright Holders
=====
```

AQR Capital Management began pandas development in 2008. Development was led by Wes McKinney. AQR released the source under this license in 2009. Wes is now an employee of Lambda Foundry, and remains the pandas project lead.

The PyData Development Team is the collection of developers of the PyData project. This includes all of the PyData sub-projects, including pandas. The core team that coordinates development on GitHub can be found here: <http://github.com/pydata>.

Full credits for pandas contributors can be found in the documentation.

Our Copyright Policy

=====

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```

Other licenses can be found in the LICENSES directory.

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 [305]: import numpy as np

# will use a lot in examples
In [306]: randn = np.random.randn

In [307]: from pandas import *
```

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.

When using pandas, we recommend the following import convention:

```
import pandas as pd
```

5.1 Series

`Series` is a one-dimensional labeled array (technically a subclass of `ndarray`) 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 = 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 [308]: s = Series(randn(5), index=['a', 'b', 'c', 'd', 'e'])
```

```
In [309]: s
```

```
Out[309]:  
a    0.314  
b   -0.002  
c    0.072  
d    0.893  
e    0.681
```

```
In [310]: s.index
```

```
Out[310]: Index([a, b, c, d, e], dtype=object)
```

```
In [311]: Series(randn(5))
```

```
Out[311]:  
0   -0.340  
1    0.215  
2   -0.078  
3   -0.178  
4    0.491
```

Note: Starting in v0.8.0, pandas supports non-unique index values. In previous version, if the index values are not unique an exception will **not** be raised immediately, but attempting any operation involving the index will later result in an exception. In other words, the Index object containing the labels “lazily” checks whether the values are unique. 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 [312]: d = {'a' : 0., 'b' : 1., 'c' : 2.}
```

```
In [313]: Series(d)
```

```
Out[313]:  
a    0  
b    1  
c    2
```

```
In [314]: Series(d, index=['b', 'c', 'd', 'a'])
```

```
Out[314]:  
b    1  
c    2  
d   NaN  
a    0
```

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 [315]: Series(5., index=['a', 'b', 'c', 'd', 'e'])
```

```
Out[315]:  
a    5  
b    5
```

```
c    5
d    5
e    5
```

5.1.1 Series is ndarray-like

As a subclass of ndarray, Series is a valid argument to most NumPy functions and behaves similarly to a NumPy array. However, things like slicing also slice the index.

```
In [316]: s[0]
Out[316]: 0.31422552353417077
```

```
In [317]: s[:3]
Out[317]:
a    0.314
b   -0.002
c    0.072
```

```
In [318]: s[s > s.median()]
Out[318]:
d    0.893
e    0.681
```

```
In [319]: s[[4, 3, 1]]
Out[319]:
e    0.681
d    0.893
b   -0.002
```

```
In [320]: np.exp(s)
Out[320]:
a    1.369
b    0.998
c    1.074
d    2.441
e    1.975
```

We will address array-based indexing in a separate *section*.

5.1.2 Series is dict-like

A Series is like a fixed-size dict in that you can get and set values by index label:

```
In [321]: s['a']
Out[321]: 0.31422552353417077
```

```
In [322]: s['e'] = 12.
```

```
In [323]: s
Out[323]:
a    0.314
b   -0.002
c    0.072
d    0.893
e   12.000
```

```
In [324]: 'e' in s
Out[324]: True
```

```
In [325]: 'f' in s
Out[325]: 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 [326]: s.get('f')
```

```
In [327]: s.get('f', np.nan)
Out[327]: nan
```

5.1.3 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 [328]: s + s
Out[328]:
a      0.628
b     -0.003
c      0.144
d      1.785
e     24.000
```

```
In [329]: s * 2
Out[329]:
a      0.628
b     -0.003
c      0.144
d      1.785
e     24.000
```

```
In [330]: np.exp(s)
Out[330]:
a      1.369
b      0.998
c      1.074
d      2.441
e    162754.791
```

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 [331]: s[1:] + s[:-1]
Out[331]:
a      NaN
b     -0.003
c      0.144
d      1.785
e      NaN
```

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.

5.1.4 Name attribute

Series can also have a name attribute:

```
In [332]: s = Series(np.random.randn(5), name='something')
```

```
In [333]: s
```

```
Out[333]:
0    -1.360
1     1.592
2     1.007
3     0.698
4    -1.891
Name: something
```

```
In [334]: s.name
```

```
Out[334]: 'something'
```

The Series name will be assigned automatically in many cases, in particular when taking 1D slices of DataFrame as you will see below.

5.2 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.

5.2.1 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 [335]: d = {'one' : Series([1., 2., 3.], index=['a', 'b', 'c']),
.....:        'two' : Series([1., 2., 3., 4.], index=['a', 'b', 'c', 'd'])}
.....:
```

```
In [336]: df = DataFrame(d)
```

```
In [337]: df
```

```
Out[337]:
```

	one	two
a	1	1
b	2	2
c	3	3
d	NaN	4

```
In [338]: DataFrame(d, index=['d', 'b', 'a'])
```

```
Out[338]:
```

	one	two
d	NaN	4
b	2	2
a	1	1

```
In [339]: DataFrame(d, index=['d', 'b', 'a'], columns=['two', 'three'])
```

```
Out[339]:
```

	two	three
d	4	NaN
b	2	NaN
a	1	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 [340]: df.index
```

```
Out[340]: Index([a, b, c, d], dtype=object)
```

```
In [341]: df.columns
```

```
Out[341]: Index([one, two], dtype=object)
```

5.2.2 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 [342]: d = {'one' : [1., 2., 3., 4.],
.....:        'two' : [4., 3., 2., 1.]}
.....:
```

```
In [343]: DataFrame(d)
```

```
Out[343]:
```

	one	two
--	-----	-----

```
0    1    4
1    2    3
2    3    2
3    4    1
```

```
In [344]: DataFrame(d, index=['a', 'b', 'c', 'd'])
```

```
Out[344]:
```

```
      one  two
a      1    4
b      2    3
c      3    2
d      4    1
```

5.2.3 From structured or record array

This case is handled identically to a dict of arrays.

```
In [345]: data = np.zeros((2,), dtype=[('A', 'i4'), ('B', 'f4'), ('C', 'a10')])
```

```
In [346]: data[:] = [(1, 2., 'Hello'), (2, 3., "World")]
```

```
In [347]: DataFrame(data)
```

```
Out[347]:
```

```
      A  B      C
0  1  2  Hello
1  2  3  World
```

```
In [348]: DataFrame(data, index=['first', 'second'])
```

```
Out[348]:
```

```
      A  B      C
first  1  2  Hello
second 2  3  World
```

```
In [349]: DataFrame(data, columns=['C', 'A', 'B'])
```

```
Out[349]:
```

```
      C  A  B
0  Hello  1  2
1  World  2  3
```

Note: DataFrame is not intended to work exactly like a 2-dimensional NumPy ndarray.

5.2.4 From a list of dicts

```
In [350]: data2 = [{'a': 1, 'b': 2}, {'a': 5, 'b': 10, 'c': 20}]
```

```
In [351]: DataFrame(data2)
```

```
Out[351]:
```

```
      a  b  c
0     1  2 NaN
1     5 10 20
```

```
In [352]: DataFrame(data2, index=['first', 'second'])
```

```
Out[352]:
```

```
      a  b  c
```

```
first    1    2 NaN
second   5   10  20
```

```
In [353]: DataFrame(data2, columns=['a', 'b'])
Out[353]:
   a  b
0  1  2
1  5 10
```

5.2.5 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.

5.2.6 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 [354]: data
Out[354]:
array([(1, 2.0, 'Hello'), (2, 3.0, 'World')],
      dtype=[('A', '<i4'), ('B', '<f4'), ('C', '<S10')])
```

```
In [355]: DataFrame.from_records(data, index='C')
Out[355]:
   A  B
C
Hello 1  2
World 2  3
```

`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 [356]: DataFrame.from_items([('A', [1, 2, 3]), ('B', [4, 5, 6])])
Out[356]:
   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 [357]: DataFrame.from_items([(('A', [1, 2, 3]), ('B', [4, 5, 6])),
.....:                        orient='index', columns=['one', 'two', 'three'])
.....:
Out[357]:
```

	one	two	three
A	1	2	3
B	4	5	6

5.2.7 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 [358]: df['one']
Out[358]:
```

a	1
b	2
c	3
d	NaN

Name: one

```
In [359]: df['three'] = df['one'] * df['two']
```

```
In [360]: df['flag'] = df['one'] > 2
```

```
In [361]: df
Out[361]:
```

	one	two	three	flag
a	1	1	1	False
b	2	2	4	False
c	3	3	9	True
d	NaN	4	NaN	False

Columns can be deleted or popped like with a dict:

```
In [362]: del df['two']
```

```
In [363]: three = df.pop('three')
```

```
In [364]: df
Out[364]:
```

	one	flag
a	1	False
b	2	False
c	3	True
d	NaN	False

When inserting a scalar value, it will naturally be propagated to fill the column:

```
In [365]: df['foo'] = 'bar'
```

```
In [366]: df
Out[366]:
```

	one	flag	foo
a	1	False	bar

```
b    2  False  bar
c    3   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 [367]: df['one_trunc'] = df['one'][:2]
```

```
In [368]: df
```

```
Out[368]:
   one  flag  foo  one_trunc
a    1  False  bar          1
b    2  False  bar          2
c    3   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 [369]: df.insert(1, 'bar', df['one'])
```

```
In [370]: df
```

```
Out[370]:
   one  bar  flag  foo  one_trunc
a    1    1  False  bar          1
b    2    2  False  bar          2
c    3    3   True  bar         NaN
d  NaN  NaN  False  bar         NaN
```

5.2.8 Indexing / Selection

The basics of indexing are as follows:

Operation	Syntax	Result
Select column	<code>df[col]</code>	Series
Select row by label	<code>df.xs(label)</code> or <code>df.ix[label]</code>	Series
Select row by location (int)	<code>df.ix[loc]</code>	Series
Slice rows	<code>df[5:10]</code>	DataFrame
Select rows by boolean vector	<code>df[bool_vec]</code>	DataFrame

Row selection, for example, returns a Series whose index is the columns of the DataFrame:

```
In [371]: df.xs('b')
```

```
Out[371]:
one          2
bar          2
flag        False
foo         bar
one_trunc     2
Name: b
```

```
In [372]: df.ix[2]
```

```
Out[372]:
one          3
bar          3
```

```
flag          True
foo           bar
one_trunc     NaN
Name: c
```

Note if a DataFrame contains columns of multiple dtypes, the dtype of the row will be chosen to accommodate all of the data types (dtype=object is the most general).

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](#).

5.2.9 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 [373]: df = DataFrame(randn(10, 4), columns=['A', 'B', 'C', 'D'])
```

```
In [374]: df2 = DataFrame(randn(7, 3), columns=['A', 'B', 'C'])
```

```
In [375]: df + df2
```

```
Out[375]:
```

	A	B	C	D
0	0.229	1.547	-1.499	NaN
1	0.121	-0.234	-0.705	NaN
2	-0.561	-1.550	0.643	NaN
3	-0.263	1.071	-0.060	NaN
4	-2.588	-0.752	-1.227	NaN
5	0.628	-0.095	-3.236	NaN
6	0.983	-0.823	-0.720	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 [376]: df - df.ix[0]
```

```
Out[376]:
```

	A	B	C	D
0	0.000	0.000	0.000	0.000
1	0.879	-2.485	0.133	-0.958
2	0.246	-1.482	0.106	0.685
3	0.482	-1.571	0.099	-0.054
4	-0.511	-1.333	-0.217	0.772
5	0.114	-1.401	-1.682	0.386
6	1.131	-1.280	0.060	-0.113
7	-0.313	-3.004	1.531	0.829
8	-0.232	-1.702	-0.982	-0.460
9	0.113	-1.353	-0.456	0.598

In the special case of working with time series data, if the Series is a TimeSeries (which it will be automatically if the index contains datetime objects), and the DataFrame index also contains dates, the broadcasting will be column-wise:

```
In [377]: index = date_range('1/1/2000', periods=8)
```

```
In [378]: df = DataFrame(randn(8, 3), index=index,
.....:                  columns=['A', 'B', 'C'])
```

```
.....:

In [379]: df
Out[379]:
```

	A	B	C
2000-01-01	0.302	1.113	-0.543
2000-01-02	-2.696	0.431	-0.431
2000-01-03	1.667	0.717	-0.920
2000-01-04	-0.025	0.069	0.602
2000-01-05	0.867	0.093	-2.607
2000-01-06	0.309	-0.548	-2.045
2000-01-07	-1.666	-1.440	1.326
2000-01-08	0.222	1.841	1.165

```


In [380]: type(df['A'])
Out[380]: pandas.core.series.TimeSeries

In [381]: df - df['A']
Out[381]:
```

	A	B	C
2000-01-01	0	0.811	-0.845
2000-01-02	0	3.127	2.264
2000-01-03	0	-0.950	-2.586
2000-01-04	0	0.094	0.626
2000-01-05	0	-0.774	-3.474
2000-01-06	0	-0.858	-2.354
2000-01-07	0	0.226	2.993
2000-01-08	0	1.619	0.943

Technical purity aside, this case is so common in practice that supporting the special case is preferable to the alternative of forcing the user to transpose and do column-based alignment like so:

```
In [382]: (df.T - df['A']).T
Out[382]:
```

	A	B	C
2000-01-01	0	0.811	-0.845
2000-01-02	0	3.127	2.264
2000-01-03	0	-0.950	-2.586
2000-01-04	0	0.094	0.626
2000-01-05	0	-0.774	-3.474
2000-01-06	0	-0.858	-2.354
2000-01-07	0	0.226	2.993
2000-01-08	0	1.619	0.943

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 [383]: df * 5 + 2
Out[383]:
```

	A	B	C
2000-01-01	3.510	7.563	-0.714
2000-01-02	-11.478	4.156	-0.155
2000-01-03	10.333	5.583	-2.599
2000-01-04	1.877	2.345	5.009
2000-01-05	6.333	2.465	-11.034
2000-01-06	3.547	-0.742	-8.224
2000-01-07	-6.331	-5.199	8.632
2000-01-08	3.108	11.205	7.826

```
In [384]: 1 / df
```

```
Out[384]:
```

	A	B	C
2000-01-01	3.312	0.899	-1.842
2000-01-02	-0.371	2.319	-2.320
2000-01-03	0.600	1.395	-1.087
2000-01-04	-40.659	14.493	1.662
2000-01-05	1.154	10.763	-0.384
2000-01-06	3.233	-1.823	-0.489
2000-01-07	-0.600	-0.695	0.754
2000-01-08	4.511	0.543	0.858

```
In [385]: df ** 4
```

```
Out[385]:
```

	A	B	C
2000-01-01	8.312e-03	1.532e+00	0.087
2000-01-02	5.279e+01	3.460e-02	0.035
2000-01-03	7.715e+00	2.638e-01	0.716
2000-01-04	3.659e-07	2.266e-05	0.131
2000-01-05	5.640e-01	7.452e-05	46.184
2000-01-06	9.152e-03	9.045e-02	17.482
2000-01-07	7.709e+00	4.297e+00	3.095
2000-01-08	2.415e-03	1.149e+01	1.843

Boolean operators work as well:

```
In [386]: df1 = DataFrame({'a' : [1, 0, 1], 'b' : [0, 1, 1] }, dtype=bool)
```

```
In [387]: df2 = DataFrame({'a' : [0, 1, 1], 'b' : [1, 1, 0] }, dtype=bool)
```

```
In [388]: df1 & df2
```

```
Out[388]:
```

	a	b
0	False	False
1	False	True
2	True	False

```
In [389]: df1 | df2
```

```
Out[389]:
```

	a	b
0	True	True
1	True	True
2	True	True

```
In [390]: df1 ^ df2
```

```
Out[390]:
```

	a	b
0	True	True
1	True	False
2	False	True

```
In [391]: -df1
```

```
Out[391]:
```

	a	b
0	False	True
1	True	False
2	False	False

5.2.10 Transposing

To transpose, access the `T` attribute (also the `transpose` function), similar to an `ndarray`:

```
# only show the first 5 rows
```

```
In [392]: df[:5].T
```

```
Out[392]:
```

	2000-01-01	2000-01-02	2000-01-03	2000-01-04	2000-01-05
A	0.302	-2.696	1.667	-0.025	0.867
B	1.113	0.431	0.717	0.069	0.093
C	-0.543	-0.431	-0.920	0.602	-2.607

5.2.11 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 [393]: np.exp(df)
```

```
Out[393]:
```

	A	B	C
2000-01-01	1.352	3.042	0.581
2000-01-02	0.068	1.539	0.650
2000-01-03	5.294	2.048	0.399
2000-01-04	0.976	1.071	1.825
2000-01-05	2.379	1.097	0.074
2000-01-06	1.362	0.578	0.129
2000-01-07	0.189	0.237	3.767
2000-01-08	1.248	6.303	3.206

```
In [394]: np.asarray(df)
```

```
Out[394]:
```

```
array([[ 0.3019,  1.1125, -0.5428],
       [-2.6955,  0.4313, -0.4311],
       [ 1.6666,  0.7167, -0.9197],
       [-0.0246,  0.069 ,  0.6018],
       [ 0.8666,  0.0929, -2.6069],
       [ 0.3093, -0.5484, -2.0448],
       [-1.6663, -1.4398,  1.3264],
       [ 0.2217,  1.841 ,  1.1651]])
```

The `dot` method on `DataFrame` implements matrix multiplication:

```
In [395]: df.T.dot(df)
```

```
Out[395]:
```

	A	B	C
A	13.808	3.084	-5.393
B	3.084	7.714	-0.293
C	-5.393	-0.293	15.782

Similarly, the `dot` method on `Series` implements dot product:

```
In [396]: s1 = Series(np.arange(5,10))
```

```
In [397]: s1.dot(s1)
```

```
Out[397]: 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.

5.2.12 Console display

For very large DataFrame objects, only a summary will be printed to the console (here I am reading a CSV version of the **baseball** dataset from the **plyr** R package):

```
In [398]: baseball = read_csv('data/baseball.csv')
```

```
In [399]: print baseball
<class 'pandas.core.frame.DataFrame'>
Int64Index: 100 entries, 88641 to 89534
Data columns:
id          100  non-null values
year        100  non-null values
stint       100  non-null values
team        100  non-null values
lg          100  non-null values
g           100  non-null values
ab          100  non-null values
r           100  non-null values
h           100  non-null values
X2b         100  non-null values
X3b         100  non-null values
hr          100  non-null values
rbi         100  non-null values
sb          100  non-null values
cs          100  non-null values
bb          100  non-null values
so          100  non-null values
ibb         100  non-null values
hbp         100  non-null values
sh          100  non-null values
sf          100  non-null values
gidp        100  non-null values
dtypes: float64(9), int64(10), object(3)
```

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 [400]: print baseball.ix[-20:, :12].to_string()
      id  year  stint team  lg    g  ab    r    h  X2b  X3b  hr
88641  womacto01  2006     2  CHN  NL   19   50     6   14     1     0     1
88643  schilcu01  2006     1  BOS  AL   31     2     0     1     0     0     0
88645  myersmi01  2006     1  NYA  AL   62     0     0     0     0     0     0
88649  helliri01  2006     1  MIL  NL   20     3     0     0     0     0     0
88650  johnsra05  2006     1  NYA  AL   33     6     0     1     0     0     0
88652  finlest01  2006     1  SFN  NL  139  426    66  105    21    12     6
88653  gonzalu01  2006     1  ARI  NL  153  586    93  159    52     2    15
88662  seleaa01  2006     1  LAN  NL   28    26     2     5     1     0     0
89177  francju01  2007     2  ATL  NL   15    40     1    10     3     0     0
89178  francju01  2007     1  NYN  NL   40    50     7    10     0     0     1
89330  zaungr01  2007     1  TOR  AL  110  331    43    80    24     1    10
89333  witasja01  2007     1  TBA  AL    3     0     0     0     0     0     0
89334  williwo02  2007     1  HOU  NL   33    59     3     6     0     0     1
89335  wickmbo01  2007     2  ARI  NL    8     0     0     0     0     0     0
89336  wickmbo01  2007     1  ATL  NL   47     0     0     0     0     0     0
89337  whitero02  2007     1  MIN  AL   38  109     8    19     4     0     4
89338  whiteri01  2007     1  HOU  NL   20     1     0     0     0     0     0
89339  wellsda01  2007     2  LAN  NL    7    15     2     4     1     0     0
89340  wellsda01  2007     1  SDN  NL   22    38     1     4     0     0     0
```

89341	weathda01	2007	1	CIN	NL	67	0	0	0	0	0
89343	walketo04	2007	1	OAK	AL	18	48	5	13	1	0
89345	wakefti01	2007	1	BOS	AL	1	2	0	0	0	0
89347	vizquom01	2007	1	SFN	NL	145	513	54	126	18	3
89348	villoro01	2007	1	NYA	AL	6	0	0	0	0	0
89352	valenjo03	2007	1	NYN	NL	51	166	18	40	11	1
89354	trachst01	2007	2	CHN	NL	4	7	0	1	0	0
89355	trachst01	2007	1	BAL	AL	3	5	0	0	0	0
89359	timlimi01	2007	1	BOS	AL	4	0	0	0	0	0
89360	thomeji01	2007	1	CHA	AL	130	432	79	119	19	0
89361	thomafr04	2007	1	TOR	AL	155	531	63	147	30	0
89363	tavarju01	2007	1	BOS	AL	2	4	0	1	0	0
89365	sweenma01	2007	2	LAN	NL	30	33	2	9	1	0
89366	sweenma01	2007	1	SFN	NL	76	90	18	23	8	0
89367	suppaje01	2007	1	MIL	NL	33	61	4	8	0	0
89368	stinnke01	2007	1	SLN	NL	26	82	7	13	3	0
89370	stantmi02	2007	1	CIN	NL	67	2	0	0	0	0
89371	stairma01	2007	1	TOR	AL	125	357	58	103	28	1
89372	sprinru01	2007	1	SLN	NL	72	1	0	0	0	0
89374	sosasa01	2007	1	TEX	AL	114	412	53	104	24	1
89375	smoltjo01	2007	1	ATL	NL	30	54	1	5	1	0
89378	sheffga01	2007	1	DET	AL	133	494	107	131	20	1
89381	seleaa01	2007	1	NYN	NL	31	4	0	0	0	0
89382	seaneru01	2007	1	LAN	NL	68	1	0	0	0	0
89383	schmija01	2007	1	LAN	NL	6	7	1	1	0	0
89384	schilcu01	2007	1	BOS	AL	1	2	0	1	0	0
89385	sandere02	2007	1	KCA	AL	24	73	12	23	7	0
89388	rogerke01	2007	1	DET	AL	1	2	0	0	0	0
89389	rodriiv01	2007	1	DET	AL	129	502	50	141	31	3
89396	ramirma02	2007	1	BOS	AL	133	483	84	143	33	1
89398	piazzmi01	2007	1	OAK	AL	83	309	33	85	17	1
89400	perezne01	2007	1	DET	AL	33	64	5	11	3	0
89402	parkch01	2007	1	NYN	NL	1	1	0	0	0	0
89406	oliveda02	2007	1	LAA	AL	5	0	0	0	0	0
89410	myersmi01	2007	1	NYA	AL	6	1	0	0	0	0
89411	mussimi01	2007	1	NYA	AL	2	2	0	0	0	0
89412	moyerja01	2007	1	PHI	NL	33	73	4	9	2	0
89420	mesajo01	2007	1	PHI	NL	38	0	0	0	0	0
89421	martipe02	2007	1	NYN	NL	5	9	1	1	1	0
89425	maddugr01	2007	1	SDN	NL	33	62	2	9	2	0
89426	mabryjo01	2007	1	COL	NL	28	34	4	4	1	0
89429	loftoke01	2007	2	CLE	AL	52	173	24	49	9	3
89430	loftoke01	2007	1	TEX	AL	84	317	62	96	16	3
89431	loaizes01	2007	1	LAN	NL	5	7	0	1	0	0
89438	kleskry01	2007	1	SFN	NL	116	362	51	94	27	3
89439	kentje01	2007	1	LAN	NL	136	494	78	149	36	1
89442	jonesto02	2007	1	DET	AL	5	0	0	0	0	0
89445	johnsra05	2007	1	ARI	NL	10	15	0	1	0	0
89450	hoffmtr01	2007	1	SDN	NL	60	0	0	0	0	0
89451	hernaro01	2007	2	LAN	NL	22	0	0	0	0	0
89452	hernaro01	2007	1	CLE	AL	2	0	0	0	0	0
89460	guarded01	2007	1	CIN	NL	15	0	0	0	0	0
89462	griffke02	2007	1	CIN	NL	144	528	78	146	24	1
89463	greensh01	2007	1	NYN	NL	130	446	62	130	30	1
89464	graffto01	2007	1	MIL	NL	86	231	34	55	8	0
89465	gordoto01	2007	1	PHI	NL	44	0	0	0	0	0
89466	gonzalu01	2007	1	LAN	NL	139	464	70	129	23	2
89467	gomezch02	2007	2	CLE	AL	19	53	4	15	2	0

89468	gomezch02	2007	1	BAL	AL	73	169	17	51	10	1	1
89469	glavito02	2007	1	NYN	NL	33	56	3	12	1	0	0
89473	floydc101	2007	1	CHN	NL	108	282	40	80	10	1	9
89474	finlest01	2007	1	COL	NL	43	94	9	17	3	0	1
89480	embreal01	2007	1	OAK	AL	4	0	0	0	0	0	0
89481	edmonji01	2007	1	SLN	NL	117	365	39	92	15	2	12
89482	easleda01	2007	1	NYN	NL	76	193	24	54	6	0	10
89489	delgaca01	2007	1	NYN	NL	139	538	71	139	30	0	24
89493	cormirh01	2007	1	CIN	NL	6	0	0	0	0	0	0
89494	coninje01	2007	2	NYN	NL	21	41	2	8	2	0	0
89495	coninje01	2007	1	CIN	NL	80	215	23	57	11	1	6
89497	clemero02	2007	1	NYA	AL	2	2	0	1	0	0	0
89498	claytro01	2007	2	BOS	AL	8	6	1	0	0	0	0
89499	claytro01	2007	1	TOR	AL	69	189	23	48	14	0	1
89501	cirilje01	2007	2	ARI	NL	28	40	6	8	4	0	0
89502	cirilje01	2007	1	MIN	AL	50	153	18	40	9	2	2
89521	bondsba01	2007	1	SFN	NL	126	340	75	94	14	0	28
89523	biggicr01	2007	1	HOU	NL	141	517	68	130	31	3	10
89525	benitar01	2007	2	FLO	NL	34	0	0	0	0	0	0
89526	benitar01	2007	1	SFN	NL	19	0	0	0	0	0	0
89530	ausmubr01	2007	1	HOU	NL	117	349	38	82	16	3	3
89533	aloumo01	2007	1	NYN	NL	87	328	51	112	19	1	13
89534	alomasa02	2007	1	NYN	NL	8	22	1	3	1	0	0

New since 0.10.0, wide DataFrames will now be printed across multiple rows by default:

```
In [401]: DataFrame(randn(3, 12))
Out[401]:
```

	0	1	2	3	4	5	6	7	8	9	10	11
0	-1.420521	1.616679	-1.030912	0.628297	-0.103189	-0.365475	-1.783911	-0.052526	0.652300	-0.840516	-1.405878	0.966204
1	0.652300	-0.840516	-1.405878	0.966204	0.351162	0.048154	0.485560	-1.291041	1.075002	0.526206	1.001947	-0.742489
2	1.075002	0.526206	1.001947	-0.742489	0.767153	1.275288	-1.187808	-0.545179	-1.408368	1.242233	0.952053	-0.172624
0	-1.408368	1.242233	0.952053	-0.172624	0.122389	1.652711	-0.381662	-1.328093	0.918173	-1.199261	0.371268	0.225621
1	0.122389	1.652711	-0.381662	-1.328093								
2	0.918173	-1.199261	0.371268	0.225621								

You can change how much to print on a single row by setting the `line_width` option:

```
In [402]: set_option('line_width', 40) # default is 80
```

```
In [403]: DataFrame(randn(3, 12))
Out[403]:
```

	0	1	2	3	4	5	6	7	8	9	10	11
0	-0.970022	-1.127997	-0.384526	-0.492429	-1.779882	-0.391166	0.575903	-1.343193	1.295440	0.027006	0.863536	0.189023
1	1.295440	0.027006	0.863536	0.189023	-0.822538	-1.590312	-0.061405	0.400325	-0.912154	0.946960	-0.257288	0.695208
2	-0.822538	-1.590312	-0.061405	0.400325	1.511027	0.289143	0.349037	1.998562	1.646841	0.462269	1.078574	0.883532
0	-1.779882	-0.391166	0.575903	-1.343193	0.915200	-1.052414	-0.910945	-0.174453	0.915200	-1.052414	-0.910945	-0.174453
1	-0.912154	0.946960	-0.257288	0.695208	1.056844	-0.077851	-0.057005	0.626302	1.056844	-0.077851	-0.057005	0.626302
2	1.511027	0.289143	0.349037	1.998562								

You can also disable this feature via the `expand_frame_repr` option:

```
In [404]: set_option('expand_frame_repr', False)
```

```
In [405]: DataFrame(randn(3, 12))
```

```
Out[405]:
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
Int64Index: 3 entries, 0 to 2
```

```
Data columns:
```

```
0      3  non-null values
```

```
1      3  non-null values
```

```
2      3  non-null values
```

```
3      3  non-null values
```

```
4      3  non-null values
```

```
5      3  non-null values
```

```
6      3  non-null values
```

```
7      3  non-null values
```

```
8      3  non-null values
```

```
9      3  non-null values
```

```
10     3  non-null values
```

```
11     3  non-null values
```

```
dtypes: float64(12)
```

5.2.13 DataFrame column types

The four main types stored in pandas objects are float, int, boolean, and object. A convenient `dtypes` attribute returns a Series with the data type of each column:

```
In [406]: baseball.dtypes
```

```
Out[406]:
```

```
id      object
```

```
year    int64
```

```
stint    int64
```

```
team     object
```

```
lg       object
```

```
g        int64
```

```
ab       int64
```

```
r        int64
```

```
h        int64
```

```
X2b      int64
```

```
X3b      int64
```

```
hr       int64
```

```
rbi      float64
```

```
sb       float64
```

```
cs       float64
```

```
bb       int64
```

```
so       float64
```

```
ibb      float64
```

```
hbp      float64
```

```
sh       float64
```

```
sf       float64
```

```
gidp     float64
```

The related method `get_dtype_counts` will return the number of columns of each type:

```
In [407]: baseball.get_dtype_counts()
```

```
Out[407]:
```

```
float64      9
```

```
int64       10
```

object 3

5.2.14 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 [408]: df = DataFrame({'foo1' : np.random.randn(5),
.....:                  'foo2' : np.random.randn(5)})
.....:
```

```
In [409]: df
Out[409]:
   foo1    foo2
0 -0.868315 -0.502919
1 -2.677551 -0.825049
2 -1.403487  0.518248
3 -0.561381 -0.438716
4  1.002897 -0.452045
```

```
In [410]: df.foo1
Out[410]:
0    -0.868315
1    -2.677551
2    -1.403487
3    -0.561381
4     1.002897
Name: foo1
```

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
```

5.3 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:

5.3.1 From 3D ndarray with optional axis labels

```
In [411]: 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 [412]: wp
Out[412]:
<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
```

5.3.2 From dict of DataFrame objects

```
In [413]: data = {'Item1' : DataFrame(randn(4, 3)),
.....:           'Item2' : DataFrame(randn(4, 2))}
.....:
```

```
In [414]: Panel(data)
Out[414]:
<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
<code>intersect</code>	<code>False</code>	drops elements whose indices do not align
<code>orient</code>	<code>items</code>	use <code>minor</code> to use DataFrames' columns as panel items

For example, compare to the construction above:

```
In [415]: Panel.from_dict(data, orient='minor')
Out[415]:
<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 [416]: df = DataFrame({'a': ['foo', 'bar', 'baz'],
.....:                   'b': np.random.randn(3)})
.....:
```

```
In [417]: df
Out[417]:
   a      b
0  foo  1.448717
1  bar  0.608653
2  baz -1.409338
```

```

In [418]: data = {'item1': df, 'item2': df}

In [419]: panel = Panel.from_dict(data, orient='minor')

In [420]: panel['a']
Out[420]:
   item1 item2
0    foo    foo
1    bar    bar
2    baz    baz

In [421]: panel['b']
Out[421]:
   item1    item2
0  1.448717  1.448717
1  0.608653  0.608653
2 -1.409338 -1.409338

In [422]: panel['b'].dtypes
Out[422]:
item1    float64
item2    float64

```

Note: Unfortunately 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. This will get worked on, of course, in future releases. And faster if you join me in working on the codebase.

5.3.3 From DataFrame using `to_panel` method

This method was introduced in v0.7 to replace `LongPanel.to_long`, and converts a DataFrame with a two-level index to a Panel.

```

In [423]: midx = MultiIndex(levels=[['one', 'two'], ['x', 'y']], labels=[[1,1,0,0],[1,0,1,0]])

In [424]: df = DataFrame({'A' : [1, 2, 3, 4], 'B' : [5, 6, 7, 8]}, index=midx)

In [425]: df.to_panel()
Out[425]:
<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

```

5.3.4 Item selection / addition / deletion

Similar to DataFrame functioning as a dict of Series, Panel is like a dict of DataFrames:

```

In [426]: wp['Item1']
Out[426]:
           A           B           C           D
2000-01-01 -1.362139 -0.098512 -0.491067  0.048491
2000-01-02  2.287810 -0.403876 -1.076283 -0.155956
2000-01-03  0.388741 -1.284588 -0.508030  0.841173

```

```
2000-01-04 -0.555843 -0.030913 -0.289758 1.318467
2000-01-05 1.025903 0.195796 0.030198 -0.349406
```

```
In [427]: 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.

5.3.5 Transposing

A Panel can be rearranged using its `transpose` method (which does not make a copy by default unless the data are heterogeneous):

```
In [428]: wp.transpose(2, 0, 1)
Out[428]:
<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
```

5.3.6 Indexing / Selection

Operation	Syntax	Result
Select item	<code>wp[item]</code>	DataFrame
Get slice at major_axis label	<code>wp.major_xs(val)</code>	DataFrame
Get slice at minor_axis label	<code>wp.minor_xs(val)</code>	DataFrame

For example, using the earlier example data, we could do:

```
In [429]: wp['Item1']
Out[429]:
           A           B           C           D
2000-01-01 -1.362139 -0.098512 -0.491067  0.048491
2000-01-02  2.287810 -0.403876 -1.076283 -0.155956
2000-01-03  0.388741 -1.284588 -0.508030  0.841173
2000-01-04 -0.555843 -0.030913 -0.289758  1.318467
2000-01-05  1.025903  0.195796  0.030198 -0.349406
```

```
In [430]: wp.major_xs(wp.major_axis[2])
Out[430]:
           Item1           Item2           Item3
A  0.388741  1.076202  0.361216
B -1.284588 -0.464905  2.763121
C -0.508030  0.432658 -1.174206
D  0.841173 -0.623043 -1.350105
```

```
In [431]: wp.minor_axis
Out[431]: Index([A, B, C, D], dtype=object)
```

```
In [432]: wp.minor_xs('C')
Out[432]:
           Item1           Item2           Item3
2000-01-01 -0.491067 -0.530157  0.926267
2000-01-02 -1.076283 -0.692498  1.554205
```

```
2000-01-03 -0.508030  0.432658 -1.174206
2000-01-04 -0.289758  1.771692 -0.163549
2000-01-05  0.030198 -0.016490 -1.831272
```

5.3.7 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 [433]: panel = Panel(np.random.randn(3, 5, 4), items=['one', 'two', 'three'],
.....:                  major_axis=date_range('1/1/2000', periods=5),
.....:                  minor_axis=['a', 'b', 'c', 'd'])
.....:
```

```
In [434]: panel.to_frame()
```

```
Out[434]:
```

		one	two	three
major	minor			
	2000-01-01	a	1.219834 -0.842503	1.130688
		b	-0.185793 -0.585949	1.348831
		c	-1.016665 -0.864916	-0.709279
2000-01-02		d	0.170971 0.031573	-0.125291
	a	0.411316 -1.170645	-1.746865	
	b	-0.773663 -0.655575	-0.802833	
	c	-0.028610 -1.297237	-0.824150	
2000-01-03		d	0.532592 -1.739996	-0.056603
	a	0.579638 -0.093661	1.443225	
	b	-1.514892 0.873783	-1.013384	
	c	1.528058 -1.803206	-0.591932	
2000-01-04		d	0.954347 -0.134374	0.679775
	a	-0.635819 -0.100241	-0.921819	
	b	0.009356 0.837864	-0.549326	
	c	-1.639594 1.326922	0.273431	
2000-01-05		d	-0.699057 1.224153	-0.189170
	a	-1.027240 -0.856153	-1.699029	
	b	-0.489779 -0.038563	0.589825	
	c	0.046080 0.521149	-0.065580	
	d	-0.104689 -1.270389	0.877266	

5.4 Panel4D (Experimental)

Panel4D is a 4-Dimensional named container very much like a Panel, but having 4 named dimensions. It is intended as a test bed for more N-Dimensional named containers.

- **labels:** axis 0, each item corresponds to a Panel contained inside
- **items:** axis 1, each item corresponds to a DataFrame contained inside
- **major_axis:** axis 2, it is the **index** (rows) of each of the DataFrames
- **minor_axis:** axis 3, it is the **columns** of each of the DataFrames

Panel4D is a sub-class of Panel, so most methods that work on Panels are applicable to Panel4D. The following methods are disabled:

- `join` , `to_frame` , `to_excel` , `to_sparse` , `groupby`

Construction of Panel4D works in a very similar manner to a Panel

5.4.1 From 4D ndarray with optional axis labels

```
In [435]: 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 [436]: p4d
Out[436]:
<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
```

5.4.2 From dict of Panel objects

```
In [437]: data = { 'Label1' : Panel({ 'Item1' : DataFrame(randn(4, 3)) }),
.....:             'Label2' : Panel({ 'Item2' : DataFrame(randn(4, 2)) }) }
.....:

In [438]: Panel4D(data)
Out[438]:
<class 'pandas.core.panelnd.Panel4D'>
Dimensions: 2 (labels) x 2 (items) x 4 (major_axis) x 3 (minor_axis)
Labels axis: Label1 to Label2
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 Panels**. Thus, they can be any of the other valid inputs to Panel as per above.

5.4.3 Slicing

Slicing works in a similar manner to a Panel. `[]` slices the first dimension. `.ix` allows you to slice arbitrarily and get back lower dimensional objects

```
In [439]: p4d['Label1']
Out[439]:
<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
```

4D -> Panel


```
In [440]: p4d.ix[:, :, :, 'A']
Out[440]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 2 (major_axis) x 5 (minor_axis)
Items axis: Label1 to Label2
Major_axis axis: Item1 to Item2
Minor_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
```

4D -> DataFrame

```
In [441]: p4d.ix[:, :, 0, 'A']
Out[441]:
      Label1      Label2
Item1  2.301716 -0.045494
Item2  1.454477  1.420470
```

4D -> Series

```
In [442]: p4d.ix[:, 0, 0, 'A']
Out[442]:
Label1      2.301716
Label2     -0.045494
Name: A
```

5.4.4 Transposing

A Panel4D can be rearranged using its `transpose` method (which does not make a copy by default unless the data are heterogeneous):

```
In [443]: p4d.transpose(3, 2, 1, 0)
Out[443]:
<class 'pandas.core.panelnd.Panel4D'>
Dimensions: 4 (labels) x 5 (items) x 2 (major_axis) x 2 (minor_axis)
Labels axis: A to D
Items axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
Major_axis axis: Item1 to Item2
Minor_axis axis: Label1 to Label2
```

5.5 PanelND (Experimental)

PanelND is a module with a set of factory functions to enable a user to construct N-dimensional named containers like Panel4D, with a custom set of axis labels. Thus a domain-specific container can easily be created.

The following creates a Panel5D. A new panel type object must be sliceable into a lower dimensional object. Here we slice to a Panel4D.

```
In [444]: from pandas.core import panelnd

In [445]: Panel5D = panelnd.create_nd_panel_factory(
.....:     klass_name = 'Panel5D',
.....:     axis_orders = [ 'cool', 'labels', 'items', 'major_axis', 'minor_axis'],
.....:     axis_slices = { 'labels' : 'labels', 'items' : 'items',
.....:                    'major_axis' : 'major_axis', 'minor_axis' : 'minor_axis' },
.....:     slicer      = Panel4D,
.....:     axis_aliases = { 'major' : 'major_axis', 'minor' : 'minor_axis' },
```

```
.....:     stat_axis     = 2)
.....:

In [446]: p5d = Panel5D(dict(C1 = p4d))

In [447]: p5d
Out[447]:
<class 'pandas.core.panelnd.Panel5D'>
Dimensions: 1 (cool) x 2 (labels) x 2 (items) x 5 (major_axis) x 4 (minor_axis)
Cool axis: C1 to C1
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

# print a slice of our 5D
In [448]: p5d.ix['C1', :, :, 0:3, :]
Out[448]:
<class 'pandas.core.panelnd.Panel4D'>
Dimensions: 2 (labels) x 2 (items) x 3 (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 2000-01-03 00:00:00
Minor_axis axis: A to D

# transpose it
In [449]: p5d.transpose(1,2,3,4,0)
Out[449]:
<class 'pandas.core.panelnd.Panel5D'>
Dimensions: 2 (cool) x 2 (labels) x 5 (items) x 4 (major_axis) x 1 (minor_axis)
Cool axis: Label1 to Label2
Labels axis: Item1 to Item2
Items axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
Major_axis axis: A to D
Minor_axis axis: C1 to C1

# look at the shape & dim
In [450]: p5d.shape
Out[450]: [1, 2, 2, 5, 4]

In [451]: p5d.ndim
Out[451]: 5
```

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 = date_range('1/1/2000', periods=8)

In [2]: s = Series(randn(5), index=['a', 'b', 'c', 'd', 'e'])

In [3]: df = DataFrame(randn(8, 3), index=index,
...:                   columns=['A', 'B', 'C'])
...:
...:

In [4]: wp = Panel(randn(2, 5, 4), items=['Item1', 'Item2'],
...:               major_axis=date_range('1/1/2000', periods=5),
...:               minor_axis=['A', 'B', 'C', 'D'])
...:
...:
```

6.1 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 = Series(randn(1000))

In [6]: long_series.head()
Out[6]:
0    -0.188701
1     0.221611
2     0.818818
3    -0.154786
4     1.265888

In [7]: long_series.tail(3)
Out[7]:
997     0.001671
998    -0.321809
999     1.555301
```

6.2 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	1.344566	-1.517348	-0.275191
2000-01-02	0.352352	0.637529	-0.443584

```
In [9]: df.columns = [x.lower() for x in df.columns]
```

```
In [10]: df
```

```
Out[10]:
```

	a	b	c
2000-01-01	1.344566	-1.517348	-0.275191
2000-01-02	0.352352	0.637529	-0.443584
2000-01-03	1.339956	0.220530	0.265034
2000-01-04	-0.528895	1.134347	-0.507686
2000-01-05	0.513787	-0.388459	-0.510560
2000-01-06	-2.385678	-0.978379	0.128792
2000-01-07	-0.266397	0.297856	-0.874300
2000-01-08	-0.576475	-1.191686	0.830680

To get the actual data inside a data structure, one need only access the **values** property:

```
In [11]: s.values
```

```
Out[11]: array([ 1.5949,  0.1199, -0.576 , -1.6068, -1.4438])
```

```
In [12]: df.values
```

```
Out[12]:
```

```
array([[ 1.3446, -1.5173, -0.2752],
       [ 0.3524,  0.6375, -0.4436],
       [ 1.34   ,  0.2205,  0.265  ],
       [-0.5289,  1.1343, -0.5077],
       [ 0.5138, -0.3885, -0.5106],
       [-2.3857, -0.9784,  0.1288],
       [-0.2664,  0.2979, -0.8743],
       [-0.5765, -1.1917,  0.8307]])
```

```
In [13]: wp.values
```

```
Out[13]:
```

```
array([[ 0.8978,  0.4515, -1.6502, -0.7005],
       [ 0.0675,  0.415  ,  0.5617,  1.2804],
       [ 0.463  , -0.5244,  0.0215, -1.0382],
       [ 0.3563, -0.0325,  0.4699, -1.1021],
       [ 1.5122,  1.3566,  0.6033,  1.2986]],
       [[ 0.488  , -1.3343,  0.9494,  0.6983],
       [ 0.4182, -2.566  ,  0.1071, -1.7964],
```

```
[ 0.9657,  0.1631,  1.1572, -1.1524],  
[ 0.5208,  0.7491,  1.4449,  0.6192],  
[-1.1609, -0.0222, -1.1475,  1.6003]]])
```

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.

6.3 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.

6.3.1 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]: d = {'one' : Series(randn(3), index=['a', 'b', 'c']),  
.....:      'two' : Series(randn(4), index=['a', 'b', 'c', 'd']),  
.....:      'three' : Series(randn(3), index=['b', 'c', 'd'])}  
.....:
```

```
In [15]: df = DataFrame(d)
```

```
In [16]: df
```

```
Out[16]:
```

	one	three	two
a	2.213700	NaN	-1.436616
b	0.115002	0.640476	-1.107900
c	0.008462	0.697707	0.844137
d	NaN	0.331810	-0.429735

```
In [17]: row = df.ix[1]
```

```
In [18]: column = df['two']
```

```
In [19]: df.sub(row, axis='columns')
```

```
Out[19]:
```

	one	three	two
a	2.098698	NaN	-0.328716
b	0.000000	0.000000	0.000000
c	-0.106539	0.057231	1.952037
d	NaN	-0.308666	0.678165

```
In [20]: df.sub(row, axis=1)
Out[20]:
```

	one	three	two
a	2.098698	NaN	-0.328716
b	0.000000	0.000000	0.000000
c	-0.106539	0.057231	1.952037
d	NaN	-0.308666	0.678165

```
In [21]: df.sub(column, axis='index')
Out[21]:
```

	one	three	two
a	3.650316	NaN	0
b	1.222901	1.748376	0
c	-0.835675	-0.146431	0
d	NaN	0.761545	0

```
In [22]: df.sub(column, axis=0)
Out[22]:
```

	one	three	two
a	3.650316	NaN	0
b	1.222901	1.748376	0
c	-0.835675	-0.146431	0
d	NaN	0.761545	0

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 [23]: major_mean = wp.mean(axis='major')

In [24]: major_mean
Out[24]:
```

	Item1	Item2
A	0.659351	0.246361
B	0.333252	-0.602065
C	0.001251	0.502204
D	-0.052362	-0.006203

```
In [25]: wp.sub(major_mean, axis='major')
Out[25]:
```

```
<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...

6.3.2 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 [26]: `df`

Out [26]:

	one	three	two
a	2.213700	NaN	-1.436616
b	0.115002	0.640476	-1.107900
c	0.008462	0.697707	0.844137
d	NaN	0.331810	-0.429735

In [27]: `df2`

Out [27]:

	one	three	two
a	2.213700	1.000000	-1.436616
b	0.115002	0.640476	-1.107900
c	0.008462	0.697707	0.844137
d	NaN	0.331810	-0.429735

In [28]: `df + df2`

Out [28]:

	one	three	two
a	4.427400	NaN	-2.873232
b	0.230003	1.280952	-2.215799
c	0.016925	1.395413	1.688275
d	NaN	0.663620	-0.859470

In [29]: `df.add(df2, fill_value=0)`

Out [29]:

	one	three	two
a	4.427400	1.000000	-2.873232
b	0.230003	1.280952	-2.215799
c	0.016925	1.395413	1.688275
d	NaN	0.663620	-0.859470

6.3.3 Flexible Comparisons

Starting in v0.8, pandas introduced binary comparison methods `eq`, `ne`, `lt`, `gt`, `le`, and `ge` to Series and DataFrame whose behavior is analogous to the binary arithmetic operations described above:

In [30]: `df.gt(df2)`

Out [30]:

	one	three	two
a	False	False	False
b	False	False	False
c	False	False	False
d	False	False	False

In [31]: `df2.ne(df)`

Out [31]:

	one	three	two
a	False	True	False
b	False	False	False
c	False	False	False
d	True	False	False

6.3.4 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 [32]: df1 = DataFrame({'A' : [1., np.nan, 3., 5., np.nan],
.....:                  'B' : [np.nan, 2., 3., np.nan, 6.]})
.....:

In [33]: df2 = DataFrame({'A' : [5., 2., 4., np.nan, 3., 7.],
.....:                  'B' : [np.nan, np.nan, 3., 4., 6., 8.]})
.....:

In [34]: df1
Out[34]:
   A    B
0  1 NaN
1 NaN  2
2  3  3
3  5 NaN
4 NaN  6

In [35]: df2
Out[35]:
   A    B
0  5 NaN
1  2 NaN
2  4  3
3 NaN  4
4  3  6
5  7  8

In [36]: df1.combine_first(df2)
Out[36]:
   A    B
0  1 NaN
1  2  2
2  3  3
3  5  4
4  3  6
5  7  8
```

6.3.5 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 (ie, columns whose names are the same).

So, for instance, to reproduce `combine_first` as above:

```
In [37]: combiner = lambda x, y: np.where(isnull(x), y, x)

In [38]: df1.combine(df2, combiner)
```



```
Out[38]:
```

```
   A  B
0  1 NaN
1  2   2
2  3   3
3  5   4
4  3   6
5  7   8
```

6.4 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 [39]: df
```

```
Out[39]:
```

```
      one      three      two
a  2.213700      NaN -1.436616
b  0.115002  0.640476 -1.107900
c  0.008462  0.697707  0.844137
d      NaN  0.331810 -0.429735
```

```
In [40]: df.mean(0)
```

```
Out[40]:
```

```
one      0.779055
three    0.556664
two      -0.532528
```

```
In [41]: df.mean(1)
```

```
Out[41]:
```

```
a      0.388542
b     -0.117474
c      0.516769
d     -0.048963
```

All such methods have a `skipna` option signaling whether to exclude missing data (`True` by default):

```
In [42]: df.sum(0, skipna=False)
```

```
Out[42]:
```

```
one      NaN
three    NaN
two     -2.130113
```

```
In [43]: df.sum(axis=1, skipna=True)
```

```
Out[43]:
```

```
a      0.777084
b     -0.352422
```

```
c    1.550307
d   -0.097925
```

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 [44]: ts_stand = (df - df.mean()) / df.std()
```

```
In [45]: ts_stand.std()
```

```
Out[45]:
one      1
three    1
two      1
```

```
In [46]: xs_stand = df.sub(df.mean(1), axis=0).div(df.std(1), axis=0)
```

```
In [47]: xs_stand.std(1)
```

```
Out[47]:
a      1
b      1
c      1
d      1
```

Note that methods like **cumsum** and **cumprod** preserve the location of NA values:

```
In [48]: df.cumsum()
```

```
Out[48]:
      one      three      two
a  2.213700      NaN -1.436616
b  2.328701  0.640476 -2.544516
c  2.337164  1.338183 -1.700378
d      NaN  1.669993 -2.130113
```

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-null observations
sum	Sum of values
mean	Mean of values
mad	Mean absolute deviation
median	Arithmetic median of values
min	Minimum
max	Maximum
abs	Absolute Value
prod	Product of values
std	Unbiased standard deviation
var	Unbiased variance
skew	Unbiased skewness (3rd moment)
kurt	Unbiased 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 [49]: np.mean(df['one'])
Out[49]: 0.77905464404599012
```

```
In [50]: np.mean(df['one'].values)
Out[50]: nan
```

Series also has a method `nunique` which will return the number of unique non-null values:

```
In [51]: series = Series(randn(500))
```

```
In [52]: series[20:500] = np.nan
```

```
In [53]: series[10:20] = 5
```

```
In [54]: series.nunique()
Out[54]: 11
```

6.4.1 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 [55]: series = Series(randn(1000))
```

```
In [56]: series[::2] = np.nan
```

```
In [57]: series.describe()
```

```
Out[57]:
count    500.000000
mean      -0.010875
std        1.033202
min       -3.015178
25%       -0.729688
50%       -0.041839
75%        0.701645
max        2.686126
```

```
In [58]: frame = DataFrame(randn(1000, 5), columns=['a', 'b', 'c', 'd', 'e'])
```

```
In [59]: frame.ix[::2] = np.nan
```

```
In [60]: frame.describe()
```

```
Out[60]:
              a              b              c              d              e
count  500.000000  500.000000  500.000000  500.000000  500.000000
mean      0.048326   0.001411   0.061736  -0.062294   0.052831
std      0.989883   1.018237   0.991874   0.983692   1.011472
min     -2.563234  -2.971278  -2.953256  -2.946366  -3.316963
25%     -0.622266  -0.695913  -0.621856  -0.707424  -0.623557
50%      0.078843  -0.038262   0.056343  -0.088981   0.049430
75%      0.651475   0.703472   0.767252   0.632733   0.727674
max      2.672789   3.633045   2.739115   2.681035   3.262320
```

For a non-numerical Series object, `describe` will give a simple summary of the number of unique values and most frequently occurring values:

```
In [61]: s = Series(['a', 'a', 'b', 'b', 'a', 'a', np.nan, 'c', 'd', 'a'])
```

```
In [62]: s.describe()
```

```
Out [62]:
count      9
unique      4
top         a
freq       5
```

There also is a utility function, `value_range` which takes a `DataFrame` and returns a series with the minimum/maximum values in the `DataFrame`.

6.4.2 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 [63]: s1 = Series(randn(5))
```

```
In [64]: s1
```

```
Out [64]:
0    2.424459
1   -1.578985
2    0.847794
3    0.408470
4   -0.232376
```

```
In [65]: s1.idxmin(), s1.idxmax()
```

```
Out [65]: (1, 0)
```

```
In [66]: df1 = DataFrame(randn(5,3), columns=['A','B','C'])
```

```
In [67]: df1
```

```
Out [67]:
      A         B         C
0  0.435132  0.328093 -0.804216
1 -0.546864 -0.966290 -1.306235
2 -0.738659 -0.077397 -0.120734
3 -0.516059 -0.706262  0.338961
4  0.477220  0.240676  0.844725
```

```
In [68]: df1.idxmin(axis=0)
```

```
Out [68]:
A    2
B    1
C    1
```

```
In [69]: df1.idxmax(axis=1)
```

```
Out [69]:
0    A
1    A
2    B
3    C
4    C
```

When there are multiple rows (or columns) matching the minimum or maximum value, `idxmin` and `idxmax` return the first matching index:

```
In [70]: df3 = DataFrame([2, 1, 1, 3, np.nan], columns=['A'], index=list('edcba'))
```

```
In [71]: df3
```

```
Out[71]:
```

```
   A
e   2
d   1
c   1
b   3
a  NaN
```

```
In [72]: df3['A'].idxmin()
```

```
Out[72]: 'd'
```

6.4.3 Value counts (histogramming)

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 [73]: data = np.random.randint(0, 7, size=50)
```

```
In [74]: data
```

```
Out[74]:
```

```
array([2, 4, 4, 0, 3, 0, 6, 1, 0, 0, 5, 2, 2, 2, 1, 6, 2, 5, 3, 4, 4, 1, 0,
       1, 5, 5, 6, 5, 1, 5, 1, 4, 5, 5, 5, 4, 5, 4, 2, 3, 0, 6, 3, 3, 5, 2,
       3, 1, 3, 0])
```

```
In [75]: s = Series(data)
```

```
In [76]: s.value_counts()
```

```
Out[76]:
```

```
5    11
4     7
3     7
2     7
1     7
0     7
6     4
```

```
In [77]: value_counts(data)
```

```
Out[77]:
```

```
5    11
4     7
3     7
2     7
1     7
0     7
6     4
```

6.4.4 Discretization and quantiling

Continuous values can be discretized using the `cut` (bins based on values) and `qcut` (bins based on sample quantiles) functions:

```
In [78]: arr = np.random.randn(20)
```

```
In [79]: factor = cut(arr, 4)
```

```
In [80]: factor
```

```
Out[80]:
```

```
Categorical:
```

```
array([(0.706, 1.689], (-0.278, 0.706], (-0.278, 0.706], (-1.265, -0.278],  
      (-0.278, 0.706], (-1.265, -0.278], (-1.265, -0.278], (0.706, 1.689],  
      (-1.265, -0.278], (-1.265, -0.278], (-0.278, 0.706], (0.706, 1.689],  
      (-0.278, 0.706], (-0.278, 0.706], (0.706, 1.689], (-1.265, -0.278],  
      (-1.265, -0.278], (1.689, 2.672], (-1.265, -0.278], (-1.265, -0.278]], dtype=object)  
Levels (4): Index([(-1.265, -0.278], (-0.278, 0.706], (0.706, 1.689],  
                  (1.689, 2.672]], dtype=object)
```

```
In [81]: factor = cut(arr, [-5, -1, 0, 1, 5])
```

```
In [82]: factor
```

```
Out[82]:
```

```
Categorical:
```

```
array([(1, 5], (0, 1], (-1, 0], (-5, -1], (0, 1], (-1, 0], (-1, 0], (0, 1],  
      (-5, -1], (-5, -1], (-1, 0], (1, 5], (0, 1], (0, 1], (0, 1],  
      (-1, 0], (-5, -1], (1, 5], (-1, 0], (-1, 0]], dtype=object)  
Levels (4): Index([(-5, -1], (-1, 0], (0, 1], (1, 5]], dtype=object)
```

`qcut` computes sample quantiles. For example, we could slice up some normally distributed data into equal-size quartiles like so:

```
In [83]: arr = np.random.randn(30)
```

```
In [84]: factor = qcut(arr, [0, .25, .5, .75, 1])
```

```
In [85]: factor
```

```
Out[85]:
```

```
Categorical:
```

```
array([(-0.933, 0.0435], (0.246, 2.958], [-2.0591, -0.933], (0.246, 2.958],  
      (-0.933, 0.0435], (0.0435, 0.246], (0.0435, 0.246],  
      (-0.933, 0.0435], [-2.0591, -0.933], [-2.0591, -0.933],  
      [-2.0591, -0.933], (0.246, 2.958], (-0.933, 0.0435],  
      [-2.0591, -0.933], (0.0435, 0.246], (0.246, 2.958], (0.0435, 0.246],  
      [-2.0591, -0.933], (0.0435, 0.246], [-2.0591, -0.933],  
      (-0.933, 0.0435], (0.246, 2.958], (0.0435, 0.246], (0.0435, 0.246],  
      (0.246, 2.958], (-0.933, 0.0435], [-2.0591, -0.933], (0.246, 2.958],  
      (0.246, 2.958], (-0.933, 0.0435]], dtype=object)  
Levels (4): Index([[-2.0591, -0.933], (-0.933, 0.0435], (0.0435, 0.246],  
                  (0.246, 2.958]], dtype=object)
```

```
In [86]: value_counts(factor)
```

```
Out[86]:
```

```
[-2.0591, -0.933]      8  
(0.246, 2.958]         8  
(-0.933, 0.0435]       7  
(0.0435, 0.246]        7
```

6.5 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 [87]: df.apply(np.mean)
```

```
Out[87]:
one      0.779055
three    0.556664
two      -0.532528
```

```
In [88]: df.apply(np.mean, axis=1)
```

```
Out[88]:
a      0.388542
b     -0.117474
c      0.516769
d     -0.048963
```

```
In [89]: df.apply(lambda x: x.max() - x.min())
```

```
Out[89]:
one      2.205237
three    0.365897
two      2.280754
```

```
In [90]: df.apply(np.cumsum)
```

```
Out[90]:
      one      three      two
a  2.213700      NaN -1.436616
b  2.328701  0.640476 -2.544516
c  2.337164  1.338183 -1.700378
d      NaN  1.669993 -2.130113
```

```
In [91]: df.apply(np.exp)
```

```
Out[91]:
      one      three      two
a  9.149506      NaN  0.237731
b  1.121875  1.897384  0.330252
c  1.008498  2.009140  2.325971
d      NaN  1.393488  0.650682
```

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 [92]: tsdf = DataFrame(randn(1000, 3), columns=['A', 'B', 'C'],
.....:                      index=date_range('1/1/2000', periods=1000))
.....:
```

```
In [93]: tsdf.apply(lambda x: x.index[x.dropna().argmax()])
```

```
Out[93]:
A    2001-03-27 00:00:00
B    2000-07-11 00:00:00
C    2001-04-15 00:00:00
```

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 [94]: tsdf
```

```
Out [94]:
```

	A	B	C
2000-01-01	0.661645	0.637430	-0.816471
2000-01-02	1.288712	0.004936	-0.552797
2000-01-03	-0.266739	-0.128079	-1.385320
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	1.242274	0.193226	0.084258
2000-01-09	-1.299143	-0.006538	-0.695202
2000-01-10	0.339066	0.421859	0.651384

```
In [95]: tsdf.apply(Series.interpolate)
```

```
Out [95]:
```

	A	B	C
2000-01-01	0.661645	0.637430	-0.816471
2000-01-02	1.288712	0.004936	-0.552797
2000-01-03	-0.266739	-0.128079	-1.385320
2000-01-04	0.035064	-0.063818	-1.091405
2000-01-05	0.336866	0.000443	-0.797489
2000-01-06	0.638669	0.064704	-0.503574
2000-01-07	0.940472	0.128965	-0.209658
2000-01-08	1.242274	0.193226	0.084258
2000-01-09	-1.299143	-0.006538	-0.695202
2000-01-10	0.339066	0.421859	0.651384

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.

See Also:

The section on [GroupBy](#) demonstrates related, flexible functionality for grouping by some criterion, applying, and combining the results into a `Series`, `DataFrame`, etc.

6.5.1 Applying elementwise Python 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 [96]: f = lambda x: len(str(x))
```

```
In [97]: df['one'].map(f)
```

```
Out [97]:
```

a	13
b	14


```
c    16
d     3
Name: one
```

```
In [98]: df.applymap(f)
```

```
Out[98]:
      one  three  two
a     13     3   14
b     14    14   14
c     16    14   14
d      3    14   15
```

`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 [99]: s = Series(['six', 'seven', 'six', 'seven', 'six'],
....:               index=['a', 'b', 'c', 'd', 'e'])
....:
```

```
In [100]: t = Series({'six' : 6., 'seven' : 7.})
```

```
In [101]: s
```

```
Out[101]:
a      six
b     seven
c      six
d     seven
e      six
```

```
In [102]: s.map(t)
```

```
Out[102]:
a      6
b      7
c      6
d      7
e      6
```

6.6 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 [103]: s = Series(randn(5), index=['a', 'b', 'c', 'd', 'e'])
```

```
In [104]: s
```

```
Out[104]:
a    -0.922948
b    -0.463414
c     0.451078
```

```
d    -0.354940
e     0.887440
```

```
In [105]: s.reindex(['e', 'b', 'f', 'd'])
Out[105]:
e     0.887440
b    -0.463414
f         NaN
d    -0.354940
```

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 [106]: df
Out[106]:
```

	one	three	two
a	2.213700	NaN	-1.436616
b	0.115002	0.640476	-1.107900
c	0.008462	0.697707	0.844137
d	NaN	0.331810	-0.429735

```
In [107]: df.reindex(index=['c', 'f', 'b'], columns=['three', 'two', 'one'])
Out[107]:
```

	three	two	one
c	0.697707	0.844137	0.008462
f	NaN	NaN	NaN
b	0.640476	-1.107900	0.115002

For convenience, you may utilize the `reindex_axis` method, which takes the labels and a keyword `axis` parameter.

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 [108]: rs = s.reindex(df.index)

In [109]: rs
Out[109]:
a    -0.922948
b    -0.463414
c     0.451078
d    -0.354940

In [110]: rs.index is df.index
Out[110]: True
```

This means that the reindexed Series's index is the same Python object as the DataFrame's index.

See Also:

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.

6.6.1 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 [111]: df
Out[111]:
```

	one	three	two
a	2.213700	NaN	-1.436616
b	0.115002	0.640476	-1.107900
c	0.008462	0.697707	0.844137
d	NaN	0.331810	-0.429735

```
In [112]: df2
Out[112]:
```

	one	two
a	1.434645	-0.869823
b	-0.664053	-0.541107
c	-0.770592	1.410930

```
In [113]: df.reindex_like(df2)
Out[113]:
```

	one	two
a	2.213700	-1.436616
b	0.115002	-1.107900
c	0.008462	0.844137

6.6.2 Reindexing with `reindex_axis`

6.6.3 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
- `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 [114]: s = Series(randn(5), index=['a', 'b', 'c', 'd', 'e'])
In [115]: s1 = s[:4]
In [116]: s2 = s[1:]
In [117]: s1.align(s2)
Out[117]:
```

(a	0.417351
b	-0.264586
c	0.643011
d	-0.232477
e	NaN,

```
a      NaN
b  -0.264586
c   0.643011
d  -0.232477
e  -0.997911)
```

```
In [118]: s1.align(s2, join='inner')
```

```
Out[118]:
(b  -0.264586
c   0.643011
d  -0.232477,
 b  -0.264586
c   0.643011
d  -0.232477)
```

```
In [119]: s1.align(s2, join='left')
```

```
Out[119]:
(a   0.417351
b  -0.264586
c   0.643011
d  -0.232477,
 a      NaN
b  -0.264586
c   0.643011
d  -0.232477)
```

For DataFrames, the join method will be applied to both the index and the columns by default:

```
In [120]: df.align(df2, join='inner')
```

```
Out[120]:
(      one      two
a  2.213700 -1.436616
b  0.115002 -1.107900
c  0.008462  0.844137,
      one      two
a  1.434645 -0.869823
b -0.664053 -0.541107
c -0.770592  1.410930)
```

You can also pass an axis option to only align on the specified axis:

```
In [121]: df.align(df2, join='inner', axis=0)
```

```
Out[121]:
(      one      three      two
a  2.213700      NaN -1.436616
b  0.115002  0.640476 -1.107900
c  0.008462  0.697707  0.844137,
      one      two
a  1.434645 -0.869823
b -0.664053 -0.541107
c -0.770592  1.410930)
```

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 [122]: df.align(df2.ix[0], axis=1)
```

```
Out[122]:
(      one      three      two
a  2.213700      NaN -1.436616)
```

```

b    0.115002    0.640476 -1.107900
c    0.008462    0.697707    0.844137
d         NaN    0.331810 -0.429735,
  one         1.434645
three         NaN
two         -0.869823
Name: a)

```

6.6.4 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

Other fill methods could be added, of course, but these are the two most commonly used for time series data. In a way they only make sense for time series or otherwise ordered data, but you may have an application on non-time series data where this sort of “interpolation” logic is the correct thing to do. More sophisticated interpolation of missing values would be an obvious extension.

We illustrate these fill methods on a simple `TimeSeries`:

```
In [123]: rng = date_range('1/3/2000', periods=8)
```

```
In [124]: ts = Series(randn(8), index=rng)
```

```
In [125]: ts2 = ts[[0, 3, 6]]
```

```
In [126]: ts
```

```

Out[126]:
2000-01-03    0.546822
2000-01-04   -1.356091
2000-01-05    0.760772
2000-01-06    0.276903
2000-01-07   -0.491488
2000-01-08   -1.163549
2000-01-09    1.247296
2000-01-10   -0.471701
Freq: D

```

```
In [127]: ts2
```

```

Out[127]:
2000-01-03    0.546822
2000-01-06    0.276903
2000-01-09    1.247296

```

```
In [128]: ts2.reindex(ts.index)
```

```

Out[128]:
2000-01-03    0.546822
2000-01-04         NaN
2000-01-05         NaN
2000-01-06    0.276903
2000-01-07         NaN
2000-01-08         NaN
2000-01-09    1.247296
2000-01-10         NaN

```

Freq: D

```
In [129]: ts2.reindex(ts.index, method='ffill')
```

```
Out [129]:
2000-01-03    0.546822
2000-01-04    0.546822
2000-01-05    0.546822
2000-01-06    0.276903
2000-01-07    0.276903
2000-01-08    0.276903
2000-01-09    1.247296
2000-01-10    1.247296
```

Freq: D

```
In [130]: ts2.reindex(ts.index, method='bfill')
```

```
Out [130]:
2000-01-03    0.546822
2000-01-04    0.276903
2000-01-05    0.276903
2000-01-06    0.276903
2000-01-07    1.247296
2000-01-08    1.247296
2000-01-09    1.247296
2000-01-10         NaN
```

Freq: D

Note the same result could have been achieved using *fillna*:

```
In [131]: ts2.reindex(ts.index).fillna(method='ffill')
```

```
Out [131]:
2000-01-03    0.546822
2000-01-04    0.546822
2000-01-05    0.546822
2000-01-06    0.276903
2000-01-07    0.276903
2000-01-08    0.276903
2000-01-09    1.247296
2000-01-10    1.247296
```

Freq: D

Note these methods generally assume that the indexes are **sorted**. They may be modified in the future to be a bit more flexible but as time series data is ordered most of the time anyway, this has not been a major priority.

6.6.5 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 [132]: df
```

```
Out [132]:
      one    three    two
a  2.213700      NaN -1.436616
b  0.115002  0.640476 -1.107900
c  0.008462  0.697707  0.844137
d      NaN  0.331810 -0.429735
```

```
In [133]: df.drop(['a', 'd'], axis=0)
```

```
Out [133]:
```

```

      one      three      two
b  0.115002  0.640476 -1.107900
c  0.008462  0.697707  0.844137

```

```
In [134]: df.drop(['one'], axis=1)
```

```
Out[134]:
      three      two
a      NaN -1.436616
b  0.640476 -1.107900
c  0.697707  0.844137
d  0.331810 -0.429735

```

Note that the following also works, but is a bit less obvious / clean:

```
In [135]: df.reindex(df.index - ['a', 'd'])
```

```
Out[135]:
      one      three      two
b  0.115002  0.640476 -1.107900
c  0.008462  0.697707  0.844137

```

6.6.6 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 [136]: s
```

```
Out[136]:
a    0.417351
b   -0.264586
c    0.643011
d   -0.232477
e   -0.997911

```

```
In [137]: s.rename(str.upper)
```

```
Out[137]:
A    0.417351
B   -0.264586
C    0.643011
D   -0.232477
E   -0.997911

```

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). But if you pass a dict or Series, it need only contain a subset of the labels as keys:

```
In [138]: df.rename(columns={'one' : 'foo', 'two' : 'bar'},
.....:               index={'a' : 'apple', 'b' : 'banana', 'd' : 'durian'})
.....:
```

```
Out[138]:
      foo      three      bar
apple  2.213700      NaN -1.436616
banana  0.115002  0.640476 -1.107900
c        0.008462  0.697707  0.844137
durian   NaN    0.331810 -0.429735

```

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. The `Panel` class has a related `rename_axis` class which can rename any of its three axes.

6.7 Iteration

Because Series is array-like, basic iteration produces the values. Other data structures follow the dict-like convention of iterating over the “keys” of the objects. In short:

- **Series:** values
- **DataFrame:** column labels
- **Panel:** item labels

Thus, for example:

```
In [139]: for col in df:
.....:     print col
.....:
one
three
two
```

6.7.1 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 [140]: for item, frame in wp.iteritems():
.....:     print item
.....:     print frame
.....:
```

Item1

	A	B	C	D
2000-01-01	0.897769	0.451532	-1.650227	-0.700537
2000-01-02	0.067512	0.415011	0.561719	1.280366
2000-01-03	0.462956	-0.524449	0.021485	-1.038221
2000-01-04	0.356336	-0.032454	0.469940	-1.102054
2000-01-05	1.512179	1.356619	0.603337	1.298637

Item2

	A	B	C	D
2000-01-01	0.487997	-1.334250	0.949361	0.698282
2000-01-02	0.418248	-2.565956	0.107096	-1.796398
2000-01-03	0.965673	0.163076	1.157179	-1.152413
2000-01-04	0.520805	0.749052	1.444896	0.619208
2000-01-05	-1.160919	-0.022246	-1.147511	1.600307

6.7.2 iterrows

New in v0.7 is the ability to iterate efficiently through rows of a DataFrame. It returns an iterator yielding each index value along with a Series containing the data in each row:


```
In [141]: for row_index, row in df2.iterrows():
.....:     print '%s\n%s' % (row_index, row)
.....:
a
one    1.434645
two   -0.869823
Name: a
b
one   -0.664053
two   -0.541107
Name: b
c
one   -0.770592
two    1.410930
Name: c
```

For instance, a contrived way to transpose the dataframe would be:

```
In [142]: df2 = DataFrame({'x': [1, 2, 3], 'y': [4, 5, 6]})

In [143]: print df2
   x  y
0  1  4
1  2  5
2  3  6

In [144]: print df2.T
   0  1  2
x  1  2  3
y  4  5  6

In [145]: df2_t = DataFrame(dict((idx, values) for idx, values in df2.iterrows()))

In [146]: print df2_t
   0  1  2
x  1  2  3
y  4  5  6
```

6.7.3 itertuples

This method will return an iterator yielding a tuple 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 proper.

For instance,

```
In [147]: for r in df2.itertuples(): print r
(0, 1, 4)
(1, 2, 5)
(2, 3, 6)
```

6.8 Vectorized string methods

Series is equipped (as of pandas 0.8.1) 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) build-in string methods:

```
In [148]: s = Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog', 'cat'])
```

```
In [149]: s.str.lower()
```

```
Out[149]:
```

```
0      a
1      b
2      c
3    aaba
4    baca
5     NaN
6    caba
7    dog
8    cat
```

```
In [150]: s.str.upper()
```

```
Out[150]:
```

```
0      A
1      B
2      C
3    AABA
4    BACA
5     NaN
6    CABA
7    DOG
8    CAT
```

```
In [151]: s.str.len()
```

```
Out[151]:
```

```
0      1
1      1
2      1
3      4
4      4
5     NaN
6      4
7      3
8      3
```

Methods like `split` return a Series of lists:

```
In [152]: s2 = Series(['a_b_c', 'c_d_e', np.nan, 'f_g_h'])
```

```
In [153]: s2.str.split('_')
```

```
Out[153]:
```

```
0    [a, b, c]
1    [c, d, e]
2         NaN
3    [f, g, h]
```

Elements in the split lists can be accessed using `get` or `[]` notation:

```
In [154]: s2.str.split('_').str.get(1)
```

```
Out[154]:
```

```
0      b
1      d
2     NaN
3      g
```

```
In [155]: s2.str.split('_').str[1]
Out[155]:
0      b
1      d
2     NaN
3      g
```

Methods like `replace` and `findall` take regular expressions, too:

```
In [156]: s3 = Series(['A', 'B', 'C', 'Aaba', 'Baca',
.....:               '', np.nan, 'CABA', 'dog', 'cat'])
.....:
```

```
In [157]: s3
Out[157]:
0      A
1      B
2      C
3    Aaba
4    Baca
5
6     NaN
7    CABA
8     dog
9     cat
```

```
In [158]: s3.str.replace('^.a|dog', 'XX-XX ', case=False)
Out[158]:
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
```

Methods like `contains`, `startswith`, and `endswith` takes an extra `na` argument so missing values can be considered `True` or `False`:

```
In [159]: s4 = Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog', 'cat'])

In [160]: s4.str.contains('A', na=False)
Out[160]:
0     True
1    False
2    False
3     True
4    False
5     NaN
6     True
7    False
8    False
```

Method	Description
cat	Concatenate strings
split	Split strings on delimiter
get	Index into each element (retrieve i-th element)
join	Join strings in each element of the Series with passed separator
contains	Return boolean array if each string contains pattern/regex
replace	Replace occurrences of pattern/regex with some other string
repeat	Duplicate values (<code>s.str.repeat(3)</code> equivalent to <code>x * 3</code>)
pad	Add whitespace to left, right, or both sides of strings
center	Equivalent to <code>pad(side='both')</code>
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 <code>str.startswith(pat)</code> for each element
endswith	Equivalent to <code>str.endswith(pat)</code> for each element
findall	Compute list of all occurrences of pattern/regex for each string
match	Call <code>re.match</code> on each element, returning matched groups as list
len	Compute string lengths
strip	Equivalent to <code>str.strip</code>
rstrip	Equivalent to <code>str.rstrip</code>
lstrip	Equivalent to <code>str.lstrip</code>
lower	Equivalent to <code>str.lower</code>
upper	Equivalent to <code>str.upper</code>

6.9 Sorting by index and value

There are two obvious kinds of sorting that you may be interested in: sorting by label and sorting by actual values. The primary method for sorting axis labels (indexes) across data structures is the `sort_index` method.

```
In [161]: unsorted_df = df.reindex(index=['a', 'd', 'c', 'b'],
.....:                               columns=['three', 'two', 'one'])
.....:
```

```
In [162]: unsorted_df.sort_index()
```

```
Out[162]:
```

	three	two	one
a	NaN	-1.436616	2.213700
b	0.640476	-1.107900	0.115002
c	0.697707	0.844137	0.008462
d	0.331810	-0.429735	NaN

```
In [163]: unsorted_df.sort_index(ascending=False)
```

```
Out[163]:
```

	three	two	one
d	0.331810	-0.429735	NaN
c	0.697707	0.844137	0.008462
b	0.640476	-1.107900	0.115002
a	NaN	-1.436616	2.213700

```
In [164]: unsorted_df.sort_index(axis=1)
```

```
Out[164]:
```

	one	three	two
a	2.213700	NaN	-1.436616
d	NaN	0.331810	-0.429735

```
c 0.008462 0.697707 0.844137
b 0.115002 0.640476 -1.107900
```

`DataFrame.sort_index` 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 [165]: df.sort_index(by='two')
Out[165]:
```

	one	three	two
a	2.213700	NaN	-1.436616
b	0.115002	0.640476	-1.107900
d	NaN	0.331810	-0.429735
c	0.008462	0.697707	0.844137

The `by` argument can take a list of column names, e.g.:

```
In [166]: df = DataFrame({'one': [2, 1, 1, 1], 'two': [1, 3, 2, 4], 'three': [5, 4, 3, 2]})
In [167]: df[['one', 'two', 'three']].sort_index(by=['one', 'two'])
Out[167]:
```

	one	two	three
2	1	2	3
1	1	3	4
3	1	4	2
0	2	1	5

`Series` has the method `order` (analogous to R's `order` function) which sorts by value, with special treatment of NA values via the `na_last` argument:

```
In [168]: s[2] = np.nan
In [169]: s.order()
Out[169]:
```

0	A
3	Aaba
1	B
4	Baca
6	CABA
8	cat
7	dog
2	NaN
5	NaN

```
In [170]: s.order(na_last=False)
Out[170]:
```

2	NaN
5	NaN
0	A
3	Aaba
1	B
4	Baca
6	CABA
8	cat
7	dog

Some other sorting notes / nuances:

- `Series.sort` sorts a `Series` by value in-place. This is to provide compatibility with NumPy methods which expect the `ndarray.sort` behavior.

- `DataFrame.sort` takes a `column` argument instead of `by`. This method will likely be deprecated in a future release in favor of just using `sort_index`.

6.10 Copying, type casting

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.

Data can be explicitly cast to a NumPy dtype by using the `astype` method or alternately passing the `dtype` keyword argument to the object constructor.

```
In [171]: df = DataFrame(np.arange(12).reshape((4, 3)))

In [172]: df[0].dtype
Out[172]: dtype('int64')

In [173]: df.astype(float)[0].dtype
Out[173]: dtype('float64')

In [174]: df = DataFrame(np.arange(12).reshape((4, 3)), dtype=float)

In [175]: df[0].dtype
Out[175]: dtype('float64')
```

6.10.1 Inferring better types for object columns

The `convert_objects` `DataFrame` method will attempt to convert `dtype=object` columns to a better NumPy dtype. Occasionally (after transposing multiple times, for example), a mixed-type `DataFrame` will end up with everything as `dtype=object`. This method attempts to fix that:

```
In [176]: df = DataFrame(randn(6, 3), columns=['a', 'b', 'c'])

In [177]: df['d'] = 'foo'

In [178]: df
Out[178]:
```

	a	b	c	d
0	0.395592	-1.270444	0.640682	foo
1	2.217917	-0.850118	0.518373	foo
2	0.485539	0.959880	0.146047	foo
3	-1.944420	0.818298	0.880439	foo
4	0.430850	-0.053682	-0.281954	foo
5	-0.910794	-0.104207	-1.376930	foo

```
In [179]: df = df.T.T
```

```
In [180]: df.dtypes
```

```
Out[180]:
```

```
a    object
b    object
c    object
d    object
```

```
In [181]: converted = df.convert_objects()
```

```
In [182]: converted.dtypes
```

```
Out[182]:
```

```
a    float64
b    float64
c    float64
d    object
```

6.11 Pickling and serialization

All pandas objects are equipped with save methods which use Python's `cPickle` module to save data structures to disk using the pickle format.

```
In [183]: df
```

```
Out[183]:
```

```
      a          b          c    d
0  0.3955917  -1.270444  0.6406821  foo
1  2.217917  -0.8501181  0.5183729  foo
2  0.4855388  0.9598796  0.1460468  foo
3  -1.94442   0.8182979  0.8804393  foo
4  0.4308498 -0.05368197 -0.2819535  foo
5 -0.9107941 -0.1042069  -1.37693   foo
```

```
In [184]: df.save('foo.pickle')
```

The load function in the pandas namespace can be used to load any pickled pandas object (or any other pickled object) from file:

```
In [185]: load('foo.pickle')
```

```
Out[185]:
```

```
      a          b          c    d
0  0.3955917  -1.270444  0.6406821  foo
1  2.217917  -0.8501181  0.5183729  foo
2  0.4855388  0.9598796  0.1460468  foo
3  -1.94442   0.8182979  0.8804393  foo
4  0.4308498 -0.05368197 -0.2819535  foo
5 -0.9107941 -0.1042069  -1.37693   foo
```

There is also a save function which takes any object as its first argument:

```
In [186]: save(df, 'foo.pickle')
```

```
In [187]: load('foo.pickle')
```

```
Out[187]:
```

```
      a          b          c    d
0  0.3955917  -1.270444  0.6406821  foo
1  2.217917  -0.8501181  0.5183729  foo
2  0.4855388  0.9598796  0.1460468  foo
```

```
3  -1.94442    0.8182979  0.8804393  foo
4   0.4308498 -0.05368197 -0.2819535  foo
5  -0.9107941 -0.1042069  -1.37693   foo
```

6.12 Working with package options

Introduced in 0.10.0, pandas supports a new system for working with options. 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 [188]: import pandas as pd

In [189]: pd.options.display.max_rows
Out[189]: 100

In [190]: pd.options.display.max_rows = 999

In [191]: pd.options.display.max_rows
Out[191]: 999
```

There is also an API composed of 4 relevant functions, available directly from the pandas namespace, and they are:

- `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.

Note: developers can check out `pandas/core/config.py` for more info.

but all of the functions above accept a regexp pattern (`re.search` style) as argument, so passing in a substring will work - as long as it is unambiguous :

```
In [192]: get_option("display.max_rows")
Out[192]: 999

In [193]: set_option("display.max_rows", 101)

In [194]: get_option("display.max_rows")
Out[194]: 101

In [195]: set_option("max_r", 102)

In [196]: get_option("display.max_rows")
Out[196]: 102
```

However, the following will **not work** because it matches multiple option names, e.g. “`display.max_colwidth`”, `display.max_rows`, `display.max_columns`:

```
In [197]: try:
.....:     get_option("display.max_")
.....: except KeyError as e:
.....:     print(e)
.....:
File "<ipython-input-197-633ae52b0297>", line 3
      except KeyError as e:
            ^
IndentationError: unindent does not match any outer indentation level
```


Note: Using this form of convenient shorthand may make your code break if new options with similar names are added in future versions.

The docstrings of all the functions document the available options, but you can also get a list of available options and their descriptions with `describe_option`. When called with no argument `describe_option` will print out descriptions for all available options.

```
In [198]: describe_option()
display.colheader_justify:
: 'left'/'right'
    Controls the justification of column headers. used by DataFrameFormatter.
display.column_space: No description available.
display.date_dayfirst:
: boolean
    When True, prints and parses dates with the day first, eg 20/01/2005
display.date_yearfirst:
: boolean
    When True, prints and parses dates with the year first, eg 2005/01/20
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.
display.expand_frame_repr:
: boolean
    Default False
    Whether to print out the full DataFrame repr for wide DataFrames
    across multiple lines.
    If False, the summary representation is shown.
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 core.format.EngFormatter for an example.
display.line_width:
: int
    Default 80
    When printing wide DataFrames, this is the width of each line.
display.max_columns:
: int
    max_rows and max_columns are used in __repr__() methods to decide if
    to_string() or info() is used to render an object to a string.
    Either one, or both can be set to 0 (experimental). Pandas will figure
    out how big the terminal is and will not display more rows or/and
    columns that can fit on it.
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.
display.max_info_columns:
: int
    max_info_columns is used in DataFrame.info method to decide if
    per column information will be printed.
display.max_rows:
: int
    This sets the maximum number of rows pandas should output when printing
    out various output. For example, this value determines whether the repr()
```

```
    for a dataframe prints out fully or just an summary repr.
display.multi_sparse:
: boolean
    Default True, "sparsify" MultiIndex display (don't display repeated
    elements in outer levels within groups)
display.notebook_repr_html:
: boolean
    When True (default), IPython notebook will use html representation for
    pandas objects (if it is available).
display.pprint_nest_depth:
: int
    Defaults to 3.
    Controls the number of nested levels to process when pretty-printing
display.precision:
: int
    Floating point output precision (number of significant digits). This is
    only a suggestion
mode.sim_interactive:
: boolean
    Default False
    Whether to simulate interactive mode for purposes of testing
mode.use_inf_as_null:
: boolean
    True means treat None, NaN, INF, -INF as null (old way),
    False means None and NaN are null, but INF, -INF are not null
    (new way).
```

or you can get the description for just the options that match the regexp you pass in:

```
In [199]: describe_option("date")
display.date_dayfirst:
: boolean
    When True, prints and parses dates with the day first, eg 20/01/2005
display.date_yearfirst:
: boolean
    When True, prints and parses dates with the year first, eg 2005/01/20
```

All options also have a default value, and you can use the `reset_option` to do just that:

```
In [200]: get_option("display.max_rows")
Out[200]: 100

In [201]: set_option("display.max_rows", 999)

In [202]: get_option("display.max_rows")
Out[202]: 999

In [203]: reset_option("display.max_rows")

In [204]: get_option("display.max_rows")
Out[204]: 100
```

and you also set multiple options at once:

```
In [205]: reset_option("^display\\.")
```

6.13 Console Output Formatting

Note: `set_printoptions/ reset_printoptions` are now deprecated (but functioning), and both, as well as `set_eng_float_format`, use the options API behind the scenes. The corresponding options now live under “`print.XYZ`”, and you can set them directly with `get/set_option`.

Use the `set_eng_float_format` function in the `pandas.core.common` module to alter the floating-point formatting of pandas objects to produce a particular format.

For instance:

```
In [206]: set_eng_float_format(accuracy=3, use_eng_prefix=True)
```

```
In [207]: df['a']/1.e3
```

```
Out[207]:
0      395.592u
1       2.218m
2      485.539u
3      -1.944m
4      430.850u
5     -910.794u
Name: a
```

```
In [208]: df['a']/1.e6
```

```
Out[208]:
0      395.592n
1       2.218u
2      485.539n
3      -1.944u
4      430.850n
5     -910.794n
Name: a
```

The `set_printoptions` function has a number of options for controlling how floating point numbers are formatted (using the `precision` argument) in the console and `.`. The `max_rows` and `max_columns` control how many rows and columns of DataFrame objects are shown by default. If `max_columns` is set to 0 (the default, in fact), the library will attempt to fit the DataFrame’s string representation into the current terminal width, and defaulting to the summary view otherwise.

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 / chapter, 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 higher-dimensional data structures (including Panel) in the future, especially in label-based advanced indexing.

7.1 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,

- **Series:** `series[label]` returns a scalar value
- **DataFrame:** `frame[colname]` returns a Series corresponding to the passed column name
- **Panel:** `panel[itemname]` returns a DataFrame corresponding to the passed item name

Here we construct a simple time series data set to use for illustrating the indexing functionality:

```
In [620]: dates = np.asarray(date_range('1/1/2000', periods=8))
```

```
In [621]: df = DataFrame(randn(8, 4), index=dates, columns=['A', 'B', 'C', 'D'])
```

```
In [622]: df
```

```
Out [622]:
```

	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 [623]: panel = Panel({'one' : df, 'two' : df - df.mean()})
```

```
In [624]: panel
```

```
Out [624]:  
<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 [625]: s = df['A']
```

```
In [626]: s[dates[5]]
```

```
Out [626]: -0.67368970808837059
```

```
In [627]: panel['two']
```

```
Out [627]:
```

	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

7.1.1 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 `get_value` method, which is implemented on all of the data structures:

```
In [628]: s.get_value(dates[5])
```

```
Out [628]: -0.67368970808837059
```

```
In [629]: df.get_value(dates[5], 'A')
```

```
Out [629]: -0.67368970808837059
```

There is an analogous `set_value` method which has the additional capability of enlarging an object. This method *always* returns a reference to the object it modified, which in the case of enlargement, will be a **new object**:

```
In [630]: df.set_value(dates[5], 'E', 7)
```

```
Out [630]:
```

	A	B	C	D	E
2000-01-01	0.469112	-0.282863	-1.509059	-1.135632	NaN
2000-01-02	1.212112	-0.173215	0.119209	-1.044236	NaN
2000-01-03	-0.861849	-2.104569	-0.494929	1.071804	NaN
2000-01-04	0.721555	-0.706771	-1.039575	0.271860	NaN
2000-01-05	-0.424972	0.567020	0.276232	-1.087401	NaN
2000-01-06	-0.673690	0.113648	-1.478427	0.524988	7

```
2000-01-07    0.404705    0.577046 -1.715002 -1.039268 NaN
2000-01-08   -0.370647   -1.157892 -1.344312    0.844885 NaN
```

7.1.2 Additional Column Access

You may access a column on a dataframe directly as an attribute:

```
In [631]: df.A
Out[631]:
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
Name: A
```

If you are using the IPython environment, you may also use tab-completion to see the accessible columns of a DataFrame.

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 [632]: df
Out[632]:
```

	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 [633]: df[['B', 'A']] = df[['A', 'B']]
```

```
In [634]: df
Out[634]:
```

	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.

7.1.3 Data slices on other axes

It's certainly possible to retrieve data slices along the other axes of a DataFrame or Panel. We tend to refer to these slices as *cross-sections*. DataFrame has the `xs` function for retrieving rows as Series and Panel has the analogous

`major_xs` and `minor_xs` functions for retrieving slices as DataFrames for a given `major_axis` or `minor_axis` label, respectively.

```
In [635]: date = dates[5]
```

```
In [636]: df.xs(date)
```

```
Out [636]:  
A    0.113648  
B   -0.673690  
C   -1.478427  
D    0.524988  
Name: 2000-01-06 00:00:00
```

```
In [637]: panel.major_xs(date)
```

```
Out [637]:  
      one      two  
A -0.673690 -0.733231  
B  0.113648  0.509598  
C -1.478427 -0.580194  
D  0.524988  0.724113
```

```
In [638]: panel.minor_xs('A')
```

```
Out [638]:  
      one      two  
2000-01-01  0.469112  0.409571  
2000-01-02  1.212112  1.152571  
2000-01-03 -0.861849 -0.921390  
2000-01-04  0.721555  0.662014  
2000-01-05 -0.424972 -0.484513  
2000-01-06 -0.673690 -0.733231  
2000-01-07  0.404705  0.345164  
2000-01-08 -0.370647 -0.430188
```

7.1.4 Slicing ranges

The most robust and consistent way of slicing ranges along arbitrary axes is described in the [Advanced indexing](#) section detailing the `.ix` 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 [639]: s[:5]
```

```
Out [639]:  
2000-01-01    -0.282863  
2000-01-02    -0.173215  
2000-01-03    -2.104569  
2000-01-04    -0.706771  
2000-01-05     0.567020  
Name: A
```

```
In [640]: s[::2]
```

```
Out [640]:  
2000-01-01    -0.282863  
2000-01-03    -2.104569  
2000-01-05     0.567020  
2000-01-07     0.577046  
Name: A
```

```
In [641]: s[::-1]
```



```
Out [641]:
2000-01-08    -1.157892
2000-01-07     0.577046
2000-01-06     0.113648
2000-01-05     0.567020
2000-01-04    -0.706771
2000-01-03    -2.104569
2000-01-02    -0.173215
2000-01-01    -0.282863
Name: A
```

Note that setting works as well:

```
In [642]: s2 = s.copy()
```

```
In [643]: s2[:5] = 0
```

```
In [644]: s2
Out [644]:
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     0.113648
2000-01-07     0.577046
2000-01-08    -1.157892
Name: A
```

With DataFrame, slicing inside of `[]` **slices the rows**. This is provided largely as a convenience since it is such a common operation.

```
In [645]: df[:3]
Out [645]:
```

	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

```
In [646]: df[::-1]
Out [646]:
```

	A	B	C	D
2000-01-08	-1.157892	-0.370647	-1.344312	0.844885
2000-01-07	0.577046	0.404705	-1.715002	-1.039268
2000-01-06	0.113648	-0.673690	-1.478427	0.524988
2000-01-05	0.567020	-0.424972	0.276232	-1.087401
2000-01-04	-0.706771	0.721555	-1.039575	0.271860
2000-01-03	-2.104569	-0.861849	-0.494929	1.071804
2000-01-02	-0.173215	1.212112	0.119209	-1.044236
2000-01-01	-0.282863	0.469112	-1.509059	-1.135632

7.1.5 Boolean indexing

Another common operation is the use of boolean vectors to filter the data.

Using a boolean vector to index a Series works exactly as in a numpy ndarray:

```
In [647]: s[s > 0]
Out[647]:
2000-01-05    0.567020
2000-01-06    0.113648
2000-01-07    0.577046
Name: A
```

```
In [648]: s[(s < 0) & (s > -0.5)]
Out[648]:
2000-01-01   -0.282863
2000-01-02   -0.173215
Name: A
```

```
In [649]: s[(s < -1) | (s > 1)]
Out[649]:
2000-01-03   -2.104569
2000-01-08   -1.157892
Name: A
```

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 [650]: df[df['A'] > 0]
Out[650]:
           A         B         C         D
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
```

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 [651]: df2 = DataFrame({'a' : ['one', 'one', 'two', 'three', 'two', 'one', 'six'],
.....:                  'b' : ['x', 'y', 'y', 'x', 'y', 'x', 'x'],
.....:                  'c' : randn(7)})
.....:
```

```
In [652]: df2[df2['a'].isin(['one', 'two'])]
Out[652]:
   a  b         c
0 one x  1.075770
1 one y -0.109050
2 two y  1.643563
4 two y  0.357021
5 one x -0.674600
```

List comprehensions and `map` method of `Series` can also be used to produce more complex criteria:

```
# only want 'two' or 'three'
In [653]: criterion = df2['a'].map(lambda x: x.startswith('t'))
```

```
In [654]: df2[criterion]
Out[654]:
   a  b         c
2 two y  1.643563
3 three x -1.469388
4 two y  0.357021
```

```
# equivalent but slower
```

```
In [655]: df2[[x.startswith('t') for x in df2['a']]]
```

```
Out[655]:
   a  b      c
2  two y  1.643563
3 three x -1.469388
4  two y  0.357021
```

```
# Multiple criteria
```

```
In [656]: df2[criterion & (df2['b'] == 'x')]
```

```
Out[656]:
   a  b      c
3 three x -1.469388
```

Note, with the *advanced indexing* `ix` method, you may select along more than one axis using boolean vectors combined with other indexing expressions.

7.1.6 Where 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.

```
# return only the selected rows
```

```
In [657]: s[s > 0]
```

```
Out[657]:
2000-01-05    0.567020
2000-01-06    0.113648
2000-01-07    0.577046
Name: A
```

```
# return a Series of the same shape as the original
```

```
In [658]: s.where(s > 0)
```

```
Out[658]:
2000-01-01      NaN
2000-01-02      NaN
2000-01-03      NaN
2000-01-04      NaN
2000-01-05    0.567020
2000-01-06    0.113648
2000-01-07    0.577046
2000-01-08      NaN
Name: A
```

Selecting values from a DataFrame with a boolean criterion now also preserves input data shape. `where` is used under the hood as the implementation.

```
# return a DataFrame of the same shape as the original
```

```
# this is equivalent to 'df.where(df < 0)'
```

```
In [659]: df[df < 0]
```

```
Out[659]:
   A      B      C      D
2000-01-01 -0.282863  NaN -1.509059 -1.135632
2000-01-02 -0.173215  NaN      NaN -1.044236
2000-01-03 -2.104569 -0.861849 -0.494929      NaN
2000-01-04 -0.706771  NaN -1.039575      NaN
2000-01-05  NaN -0.424972      NaN -1.087401
2000-01-06  NaN -0.673690 -1.478427      NaN
2000-01-07  NaN      NaN -1.715002 -1.039268
2000-01-08 -1.157892 -0.370647 -1.344312      NaN
```

In addition, `where` takes an optional `other` argument for replacement of values where the condition is False, in the returned copy.

```
In [660]: df.where(df < 0, -df)
```

```
Out [660]:
```

	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 wish to set values based on some boolean criteria. This can be done intuitively like so:

```
In [661]: s2 = s.copy()
```

```
In [662]: s2[s2 < 0] = 0
```

```
In [663]: s2
```

```
Out [663]:
```

2000-01-01	0.000000
2000-01-02	0.000000
2000-01-03	0.000000
2000-01-04	0.000000
2000-01-05	0.567020
2000-01-06	0.113648
2000-01-07	0.577046
2000-01-08	0.000000

Name: A

```
In [664]: df2 = df.copy()
```

```
In [665]: df2[df2 < 0] = 0
```

```
In [666]: df2
```

```
Out [666]:
```

	A	B	C	D
2000-01-01	0.000000	0.469112	0.000000	0.000000
2000-01-02	0.000000	1.212112	0.119209	0.000000
2000-01-03	0.000000	0.000000	0.000000	1.071804
2000-01-04	0.000000	0.721555	0.000000	0.271860
2000-01-05	0.567020	0.000000	0.276232	0.000000
2000-01-06	0.113648	0.000000	0.000000	0.524988
2000-01-07	0.577046	0.404705	0.000000	0.000000
2000-01-08	0.000000	0.000000	0.000000	0.844885

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 `.ix` (but on the contents rather than the axis labels)

```
In [667]: df2 = df.copy()
```

```
In [668]: df2[ df2[1:4] > 0 ] = 3
```

```
In [669]: df2
```

```
Out [669]:
```

	A	B	C	D
2000-01-01	-0.282863	0.469112	-1.509059	-1.135632
2000-01-02	-0.173215	3.000000	3.000000	-1.044236
2000-01-03	-2.104569	-0.861849	-0.494929	3.000000
2000-01-04	-0.706771	3.000000	-1.039575	3.000000
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

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 [670]: df_orig = df.copy()
```

```
In [671]: df_orig.where(df > 0, -df, inplace=True);
```

```
In [671]: df_orig
```

```
Out [671]:
```

	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

`mask` is the inverse boolean operation of `where`.

```
In [672]: s.mask(s >= 0)
```

```
Out [672]:
```

2000-01-01	-0.282863
2000-01-02	-0.173215
2000-01-03	-2.104569
2000-01-04	-0.706771
2000-01-05	NaN
2000-01-06	NaN
2000-01-07	NaN
2000-01-08	-1.157892

Name: A

```
In [673]: df.mask(df >= 0)
```

```
Out [673]:
```

	A	B	C	D
2000-01-01	-0.282863	NaN	-1.509059	-1.135632
2000-01-02	-0.173215	NaN	NaN	-1.044236
2000-01-03	-2.104569	-0.861849	-0.494929	NaN
2000-01-04	-0.706771	NaN	-1.039575	NaN
2000-01-05	NaN	-0.424972	NaN	-1.087401
2000-01-06	NaN	-0.673690	-1.478427	NaN
2000-01-07	NaN	NaN	-1.715002	-1.039268
2000-01-08	-1.157892	-0.370647	-1.344312	NaN

7.1.7 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.

```
In [674]: index = Index(randint(0, 1000, 10))

In [675]: index
Out[675]: Int64Index([969, 412, 496, 195, 288, 101, 881, 900, 732, 658], dtype=int64)

In [676]: positions = [0, 9, 3]

In [677]: index[positions]
Out[677]: Int64Index([969, 658, 195], dtype=int64)

In [678]: index.take(positions)
Out[678]: Int64Index([969, 658, 195], dtype=int64)

In [679]: ser = Series(randn(10))

In [680]: ser.ix[positions]
Out[680]:
0    -0.968914
9    -1.131345
3     1.247642

In [681]: ser.take(positions)
Out[681]:
0    -0.968914
9    -1.131345
3     1.247642
```

For DataFrames, the given indices should be a 1d list or ndarray that specifies row or column positions.

```
In [682]: frm = DataFrame(randn(5, 3))

In [683]: frm.take([1, 4, 3])
Out[683]:
      0      1      2
1 -0.932132  1.956030  0.017587
4 -0.077118 -0.408530 -0.862495
3 -1.143704  0.215897  1.193555

In [684]: frm.take([0, 2], axis=1)
Out[684]:
      0      2
0 -0.089329 -0.945867
1 -0.932132  0.017587
2 -0.016692  0.254161
3 -1.143704  1.193555
4 -0.077118 -0.862495
```

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 [685]: arr = randn(10)

In [686]: arr.take([False, False, True, True])
Out[686]: array([ 1.3461,  1.3461,  1.5118,  1.5118])

In [687]: arr[[0, 1]]
Out[687]: array([ 1.3461,  1.5118])
```

```
In [688]: ser = Series(randn(10))

In [689]: ser.take([False, False, True, True])
Out[689]:
0    -0.105381
0    -0.105381
1    -0.532532
1    -0.532532

In [690]: ser.ix[[0, 1]]
Out[690]:
0    -0.105381
1    -0.532532
```

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.

7.1.8 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 `take_last` parameter that indicates the last observed row should be taken instead.

```
In [691]: df2 = DataFrame({'a' : ['one', 'one', 'two', 'three', 'two', 'one', 'six'],
.....:                  'b' : ['x', 'y', 'y', 'x', 'y', 'x', 'x'],
.....:                  'c' : np.random.randn(7)})
.....:

In [692]: df2.duplicated(['a', 'b'])
Out[692]:
0    False
1    False
2    False
3    False
4     True
5     True
6    False
```

```
In [693]: df2.drop_duplicates(['a', 'b'])
Out[693]:
   a b      c
0  one x -0.339355
1  one y  0.593616
2  two y  0.884345
3 three x  1.591431
6  six x  0.435589
```

```
In [694]: df2.drop_duplicates(['a', 'b'], take_last=True)
Out[694]:
   a b      c
1  one y  0.593616
```

```
3  three  x  1.591431
4    two  y  0.141809
5     one  x  0.220390
6     six  x  0.435589
```

7.1.9 Dictionary-like get method

Each of Series, DataFrame, and Panel have a `get` method which can return a default value.

```
In [695]: s = Series([1,2,3], index=['a','b','c'])
```

```
In [696]: s.get('a')                                # equivalent to s['a']
Out[696]: 1
```

```
In [697]: s.get('x', default=-1)
Out[697]: -1
```

7.2 Advanced indexing with labels

We have avoided excessively overloading the `[]` / `__getitem__` operator to keep the basic functionality of the pandas objects straightforward and simple. However, there are often times when you may wish get a subset (or analogously set a subset) of the data in a way that is not straightforward using the combination of `reindex` and `[]`. Complicated setting operations are actually quite difficult because `reindex` usually returns a copy.

By *advanced* indexing we are referring to a special `.ix` attribute on pandas objects which enable you to do getting/setting operations on a DataFrame, for example, with matrix/ndarray-like semantics. Thus you can combine the following kinds of indexing:

- An integer or single label, e.g. 5 or 'a'
- A list or array of labels ['a', 'b', 'c'] or integers [4, 3, 0]
- A slice object with ints 1:7 or labels 'a':'f'
- A boolean array

We'll illustrate all of these methods. First, note that this provides a concise way of reindexing on multiple axes at once:

```
In [698]: subindex = dates[[3,4,5]]
```

```
In [699]: df.reindex(index=subindex, columns=['C', 'B'])
Out[699]:
```

	C	B
2000-01-04	-1.039575	0.721555
2000-01-05	0.276232	-0.424972
2000-01-06	-1.478427	-0.673690

```
In [700]: df.ix[subindex, ['C', 'B']]
Out[700]:
```

	C	B
2000-01-04	-1.039575	0.721555
2000-01-05	0.276232	-0.424972
2000-01-06	-1.478427	-0.673690

Assignment / setting values is possible when using `ix`:


```
In [701]: df2 = df.copy()
```

```
In [702]: df2.ix[subindex, ['C', 'B']] = 0
```

```
In [703]: df2
```

```
Out [703]:
```

	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	0.000000	0.000000	0.271860
2000-01-05	0.567020	0.000000	0.000000	-1.087401
2000-01-06	0.113648	0.000000	0.000000	0.524988
2000-01-07	0.577046	0.404705	-1.715002	-1.039268
2000-01-08	-1.157892	-0.370647	-1.344312	0.844885

Indexing with an array of integers can also be done:

```
In [704]: df.ix[[4,3,1]]
```

```
Out [704]:
```

	A	B	C	D
2000-01-05	0.567020	-0.424972	0.276232	-1.087401
2000-01-04	-0.706771	0.721555	-1.039575	0.271860
2000-01-02	-0.173215	1.212112	0.119209	-1.044236

```
In [705]: df.ix[dates[[4,3,1]]]
```

```
Out [705]:
```

	A	B	C	D
2000-01-05	0.567020	-0.424972	0.276232	-1.087401
2000-01-04	-0.706771	0.721555	-1.039575	0.271860
2000-01-02	-0.173215	1.212112	0.119209	-1.044236

Slicing has standard Python semantics for integer slices:

```
In [706]: df.ix[1:7, :2]
```

```
Out [706]:
```

	A	B
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

Slicing with labels is semantically slightly different because the slice start and stop are **inclusive** in the label-based case:

```
In [707]: date1, date2 = dates[[2, 4]]
```

```
In [708]: print date1, date2
```

```
1970-01-11 232:00:00 1970-01-11 24:00:00
```

```
In [709]: df.ix[date1:date2]
```

```
Out [709]:
```

Empty DataFrame
Columns: [A, B, C, D]
Index: []

```
In [710]: df['A'].ix[date1:date2]
```

```
Out[710]: []
```

Getting and setting rows in a DataFrame, especially by their location, is much easier:

```
In [711]: df2 = df[:5].copy()
```

```
In [712]: df2.ix[3]
```

```
Out[712]:
A    -0.706771
B     0.721555
C    -1.039575
D     0.271860
Name: 2000-01-04 00:00:00
```

```
In [713]: df2.ix[3] = np.arange(len(df2.columns))
```

```
In [714]: df2
```

```
Out[714]:
           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  0.000000  1.000000  2.000000  3.000000
2000-01-05  0.567020 -0.424972  0.276232 -1.087401
```

Column or row selection can be combined as you would expect with arrays of labels or even boolean vectors:

```
In [715]: df.ix[df['A'] > 0, 'B']
```

```
Out[715]:
2000-01-05    -0.424972
2000-01-06    -0.673690
2000-01-07     0.404705
Name: B
```

```
In [716]: df.ix[date1:date2, 'B']
```

```
Out[716]: []
```

```
In [717]: df.ix[date1, 'B']
```

```
Out[717]: -0.86184896334779992
```

Slicing with labels is closely related to the `truncate` method which does precisely `.ix[start:stop]` but returns a copy (for legacy reasons).

7.2.1 Returning a view versus a copy

The rules about when a view on the data is returned are entirely dependent on NumPy. Whenever an array of labels or a boolean vector are involved in the indexing operation, the result will be a copy. With single label / scalar indexing and slicing, e.g. `df.ix[3:6]` or `df.ix[:, 'A']`, a view will be returned.

7.2.2 The `select` method

Another way to extract slices from an object is with the `select` method of Series, DataFrame, and Panel. This method should be used only when there is no more direct way. `select` takes a function which operates on labels along `axis` and returns a boolean. For instance:

```
In [718]: df.select(lambda x: x == 'A', axis=1)
Out[718]:
```

```
      A
2000-01-01 -0.282863
2000-01-02 -0.173215
2000-01-03 -2.104569
2000-01-04 -0.706771
2000-01-05  0.567020
2000-01-06  0.113648
2000-01-07  0.577046
2000-01-08 -1.157892
```

7.2.3 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 [719]: dflookup = DataFrame(np.random.rand(20,4), columns = ['A','B','C','D'])

In [720]: dflookup.lookup(xrange(0,10,2), ['B','C','A','B','D'])
Out[720]: array([ 0.0227,  0.4199,  0.529 ,  0.9674,  0.5357])
```

7.2.4 Advanced indexing with integer labels

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 `.ix`. The following code will generate exceptions:

```
s = Series(range(5))
s[-1]
df = DataFrame(np.random.randn(5, 4))
df
df.ix[-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).

7.2.5 Setting values in mixed-type DataFrame

Setting values on a mixed-type DataFrame or Panel is supported when using scalar values, though setting arbitrary vectors is not yet supported:

```
In [721]: df2 = df[:4]

In [722]: df2['foo'] = 'bar'

In [723]: print df2
```

	A	B	C	D	foo
2000-01-01	-0.282863	0.469112	-1.509059	-1.135632	bar
2000-01-02	-0.173215	1.212112	0.119209	-1.044236	bar
2000-01-03	-2.104569	-0.861849	-0.494929	1.071804	bar
2000-01-04	-0.706771	0.721555	-1.039575	0.271860	bar

```
In [724]: df2.ix[2] = np.nan
```

```
In [725]: print df2
           A          B          C          D  foo
2000-01-01 -0.282863  0.469112 -1.509059 -1.135632  bar
2000-01-02 -0.173215  1.212112  0.119209 -1.044236  bar
2000-01-03         NaN         NaN         NaN         NaN  NaN
2000-01-04 -0.706771  0.721555 -1.039575  0.271860  bar
```

```
In [726]: print df2.dtypes
A          float64
B          float64
C          float64
D          float64
foo        object
```

7.3 Index objects

The pandas Index class and its subclasses can be viewed as implementing an *ordered set* in addition to providing the support infrastructure necessary for lookups, data alignment, and reindexing. The easiest way to create one directly is to pass a list or other sequence to Index:

```
In [727]: index = Index(['e', 'd', 'a', 'b'])
```

```
In [728]: index
Out[728]: Index([e, d, a, b], dtype=object)
```

```
In [729]: 'd' in index
Out[729]: True
```

You can also pass a name to be stored in the index:

```
In [730]: index = Index(['e', 'd', 'a', 'b'], name='something')
```

```
In [731]: index.name
Out[731]: 'something'
```

Starting with pandas 0.5, the name, if set, will be shown in the console display:

```
In [732]: index = Index(range(5), name='rows')
```

```
In [733]: columns = Index(['A', 'B', 'C'], name='cols')
```

```
In [734]: df = DataFrame(np.random.randn(5, 3), index=index, columns=columns)
```

```
In [735]: df
Out[735]:
cols          A          B          C
rows
0      0.192451  0.629675 -1.425966
1      1.857704 -1.193545  0.677510
2     -0.153931  0.520091 -1.475051
3      0.722570 -0.322646 -1.601631
4      0.778033 -0.289342  0.233141
```

```
In [736]: df['A']
```

```
Out[736]:
rows
0      0.192451
1      1.857704
2     -0.153931
3      0.722570
4      0.778033
Name: A
```

7.3.1 Set operations on Index objects

The three main operations are union (`|`), intersection (`&`), and diff (`-`). These can be directly called as instance methods or used via overloaded operators:

```
In [737]: a = Index(['c', 'b', 'a'])
In [738]: b = Index(['c', 'e', 'd'])
In [739]: a.union(b)
Out[739]: Index([a, b, c, d, e], dtype=object)
In [740]: a | b
Out[740]: Index([a, b, c, d, e], dtype=object)
In [741]: a & b
Out[741]: Index([c], dtype=object)
In [742]: a - b
Out[742]: Index([a, b], dtype=object)
```

7.3.2 `isin` method of Index objects

One additional operation is the `isin` method that works analogously to the `Series.isin` method found [here](#).

7.4 Hierarchical indexing (MultiIndex)

Hierarchical indexing (also referred to as “multi-level” indexing) is brand new in the pandas 0.4 release. It 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 the 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.

Note: Given that hierarchical indexing is so new to the library, it is definitely “bleeding-edge” functionality but is certainly suitable for production. But, there may inevitably be some minor API changes as more use cases are explored and any weaknesses in the design / implementation are identified. pandas aims to be “eminently usable” so any feedback about new functionality like this is extremely helpful.

7.4.1 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` an array of tuples where each tuple is unique. A `MultiIndex` can be created from a list of arrays (using `MultiIndex.from_arrays`) or an array of tuples (using `MultiIndex.from_tuples`).

```
In [743]: arrays = [['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'],
.....:             ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two']]
.....:
```

```
In [744]: tuples = zip(*arrays)
```

```
In [745]: tuples
```

```
Out[745]:
[('bar', 'one'),
 ('bar', 'two'),
 ('baz', 'one'),
 ('baz', 'two'),
 ('foo', 'one'),
 ('foo', 'two'),
 ('qux', 'one'),
 ('qux', 'two')]
```

```
In [746]: index = MultiIndex.from_tuples(tuples, names=['first', 'second'])
```

```
In [747]: s = Series(randn(8), index=index)
```

```
In [748]: s
```

```
Out[748]:
first second
bar    one   -0.223540
      two    0.542054
baz    one   -0.688585
      two   -0.352676
foo    one   -0.711411
      two   -2.122599
qux    one    1.962935
      two    1.672027
```

As a convenience, you can pass a list of arrays directly into `Series` or `DataFrame` to construct a `MultiIndex` automatically:

```
In [749]: arrays = [np.array(['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux']),
.....:              np.array(['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two'])]
.....:
```

```
In [750]: s = Series(randn(8), index=arrays)
```

```
In [751]: s
```

```
Out[751]:
bar    one   -0.880984
      two    0.997289
baz    one   -1.693316
      two   -0.179129
foo    one   -1.598062
      two    0.936914
qux    one    0.912560
      two   -1.003401
```

```
In [752]: df = DataFrame(randn(8, 4), index=arrays)
```

```
In [753]: df
```

```
Out [753]:
```

		0	1	2	3
bar	one	1.632781	-0.724626	0.178219	0.310610
	two	-0.108002	-0.974226	-1.147708	-2.281374
baz	one	0.760010	-0.742532	1.533318	2.495362
	two	-0.432771	-0.068954	0.043520	0.112246
foo	one	0.871721	-0.816064	-0.784880	1.030659
	two	0.187483	-1.933946	0.377312	0.734122
qux	one	2.141616	-0.011225	0.048869	-1.360687
	two	-0.479010	-0.859661	-0.231595	-0.527750

All of the `MultiIndex` constructors accept a `names` argument which stores string names for the levels themselves. If no names are provided, some arbitrary ones will be assigned:

```
In [754]: index.names
```

```
Out [754]: ['first', 'second']
```

This index can back any axis of a pandas object, and the number of **levels** of the index is up to you:

```
In [755]: df = DataFrame(randn(3, 8), index=['A', 'B', 'C'], columns=index)
```

```
In [756]: df
```

```
Out [756]:
```

	first	bar		baz		foo		qux	
	second	one	two	one	two	one	two	one	two
A		-1.296337	0.150680	0.123836	0.571764	1.555563	-0.823761	0.535420	-1.032853
B		1.469725	1.304124	1.449735	0.203109	-1.032011	0.969818	-0.962723	1.382083
C		-0.938794	0.669142	-0.433567	-0.273610	0.680433	-0.308450	-0.276099	-1.821168

```
In [757]: DataFrame(randn(6, 6), index=index[:6], columns=index[:6])
```

```
Out [757]:
```

	first		bar		baz		foo	
	second		one	two	one	two	one	two
first	second							
		first	second					
bar	one	-1.993606	-1.927385	-2.027924	1.624972	0.551135	3.059267	
	two	0.455264	-0.030740	0.935716	1.061192	-2.107852	0.199905	
baz	one	0.323586	-0.641630	-0.587514	0.053897	0.194889	-0.381994	
	two	0.318587	2.089075	-0.728293	-0.090255	-0.748199	1.318931	
foo	one	-2.029766	0.792652	0.461007	-0.542749	-0.305384	-0.479195	
	two	0.095031	-0.270099	-0.707140	-0.773882	0.229453	0.304418	

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 [758]: Series(randn(8), index=tuples)
```

```
Out [758]:
```

(bar, one)	0.736135
(bar, two)	-0.859631
(baz, one)	-0.424100
(baz, two)	-0.776114
(foo, one)	1.279293
(foo, two)	0.943798
(qux, one)	-1.001859
(qux, two)	0.306546

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_printoptions`:

```
In [759]: pd.set_printoptions(multi_sparse=False)
```

```
In [760]: df
```

```
Out[760]:
```

first	bar	bar	baz	baz	foo	foo	qux	qux
second	one	two	one	two	one	two	one	two
A	-1.296337	0.150680	0.123836	0.571764	1.555563	-0.823761	0.535420	-1.032853
B	1.469725	1.304124	1.449735	0.203109	-1.032011	0.969818	-0.962723	1.382083
C	-0.938794	0.669142	-0.433567	-0.273610	0.680433	-0.308450	-0.276099	-1.821168

```
In [761]: pd.set_printoptions(multi_sparse=True)
```

7.4.2 Reconstructing the level labels

The method `get_level_values` will return a vector of the labels for each location at a particular level:

```
In [762]: index.get_level_values(0)
```

```
Out[762]: Index([bar, bar, baz, baz, foo, foo, qux, qux], dtype=object)
```

```
In [763]: index.get_level_values('second')
```

```
Out[763]: Index([one, two, one, two, one, two, one, two], dtype=object)
```

7.4.3 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 [764]: df['bar']
```

```
Out[764]:
```

second	one	two
A	-1.296337	0.150680
B	1.469725	1.304124
C	-0.938794	0.669142

```
In [765]: df['bar', 'one']
```

```
Out[765]:
```

A	-1.296337
B	1.469725
C	-0.938794

Name: (bar, one)

```
In [766]: df['bar']['one']
```

```
Out[766]:
```

A	-1.296337
B	1.469725
C	-0.938794

Name: one


```
In [767]: s['qux']
Out[767]:
one      0.912560
two     -1.003401
```

7.4.4 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 [768]: s + s[:-2]
Out[768]:
bar one   -1.761968
    two    1.994577
baz one   -3.386631
    two   -0.358257
foo one   -3.196125
    two    1.873828
qux one         NaN
    two         NaN
```

```
In [769]: s + s[:,2]
Out[769]:
bar one   -1.761968
    two         NaN
baz one   -3.386631
    two         NaN
foo one   -3.196125
    two         NaN
qux one    1.825119
    two         NaN
```

`reindex` can be called with another `MultiIndex` or even a list or array of tuples:

```
In [770]: s.reindex(index[:3])
Out[770]:
first second
bar one    -0.880984
    two     0.997289
baz one    -1.693316
```

```
In [771]: s.reindex([('foo', 'two'), ('bar', 'one'), ('qux', 'one'), ('baz', 'one')])
Out[771]:
foo two    0.936914
bar one   -0.880984
qux one    0.912560
baz one   -1.693316
```

7.4.5 Advanced indexing with hierarchical index

Syntactically integrating `MultiIndex` in advanced indexing with `.ix` is a bit challenging, but we've made every effort to do so. for example the following works as you would expect:

```
In [772]: df = df.T
```

```
In [773]: df
```

```
Out[773]:
```

		A	B	C
first	second			
bar	one	-1.296337	1.469725	-0.938794
	two	0.150680	1.304124	0.669142
baz	one	0.123836	1.449735	-0.433567
	two	0.571764	0.203109	-0.273610
foo	one	1.555563	-1.032011	0.680433
	two	-0.823761	0.969818	-0.308450
qux	one	0.535420	-0.962723	-0.276099
	two	-1.032853	1.382083	-1.821168

```
In [774]: df.ix['bar']
```

```
Out[774]:
```

	A	B	C
second			
one	-1.296337	1.469725	-0.938794
two	0.150680	1.304124	0.669142

```
In [775]: df.ix['bar', 'two']
```

```
Out[775]:
```

A	0.150680
B	1.304124
C	0.669142

Name: (bar, two)

“Partial” slicing also works quite nicely:

```
In [776]: df.ix['baz':'foo']
```

```
Out[776]:
```

		A	B	C
first	second			
baz	one	0.123836	1.449735	-0.433567
	two	0.571764	0.203109	-0.273610
foo	one	1.555563	-1.032011	0.680433
	two	-0.823761	0.969818	-0.308450

```
In [777]: df.ix[('baz', 'two'):( 'qux', 'one')]
```

```
Out[777]:
```

		A	B	C
first	second			
baz	two	0.571764	0.203109	-0.273610
foo	one	1.555563	-1.032011	0.680433
	two	-0.823761	0.969818	-0.308450
qux	one	0.535420	-0.962723	-0.276099

```
In [778]: df.ix[('baz', 'two'):'foo']
```

```
Out[778]:
```

		A	B	C
first	second			
baz	two	0.571764	0.203109	-0.273610
foo	one	1.555563	-1.032011	0.680433
	two	-0.823761	0.969818	-0.308450

Passing a list of labels or tuples works similar to reindexing:

```
In [779]: df.ix[(('bar', 'two'), ('qux', 'one'))]
```

```
Out[779]:
```

		A	B	C
first	second			
bar	two	0.15068	1.304124	0.669142
qux	one	0.53542	-0.962723	-0.276099

The following does not work, and it's not clear if it should or not:

```
>>> df.ix[['bar', 'qux']]
```

The code for implementing `.ix` makes every attempt to “do the right thing” but as you use it you may uncover corner cases or unintuitive behavior. If you do find something like this, do not hesitate to report the issue or ask on the mailing list.

7.4.6 Cross-section with hierarchical index

The `xs` method of `DataFrame` additionally takes a `level` argument to make selecting data at a particular level of a `MultiIndex` easier.

```
In [780]: df.xs('one', level='second')
```

```
Out[780]:
```

	A	B	C
first			
bar	-1.296337	1.469725	-0.938794
baz	0.123836	1.449735	-0.433567
foo	1.555563	-1.032011	0.680433
qux	0.535420	-0.962723	-0.276099

7.4.7 Advanced reindexing and alignment with hierarchical index

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 [781]: midx = MultiIndex(levels=[['zero', 'one'], ['x', 'y']],
.....:                      labels=[[1, 1, 0, 0], [1, 0, 1, 0]])
.....:
```

```
In [782]: df = DataFrame(randn(4, 2), index=midx)
```

```
In [783]: print df
```

		0	1
one	y	0.307453	-0.906534
	x	-1.505397	1.392009
zero	y	-0.027793	-0.631023
	x	-0.662357	2.725042

```
In [784]: df2 = df.mean(level=0)
```

```
In [785]: print df2
```

		0	1
zero		-0.345075	1.047010
one		-0.598972	0.242737

```
In [786]: print df2.reindex(df.index, level=0)
```

		0	1
one	y	-0.598972	0.242737
	x	-0.598972	0.242737

```
zero y -0.345075  1.047010
     x -0.345075  1.047010
```

```
In [787]: df_aligned, df2_aligned = df.align(df2, level=0)
```

```
In [788]: print df_aligned
           0      1
one  y  0.307453 -0.906534
     x -1.505397  1.392009
zero y -0.027793 -0.631023
     x -0.662357  2.725042
```

```
In [789]: print df2_aligned
           0      1
one  y -0.598972  0.242737
     x -0.598972  0.242737
zero y -0.345075  1.047010
     x -0.345075  1.047010
```

7.4.8 The need for sortedness

Caveat emptor: the present implementation of `MultiIndex` requires that the labels be sorted for some of the slicing / indexing routines to work correctly. You can think about breaking the axis into unique groups, where at the hierarchical level of interest, each distinct group shares a label, but no two have the same label. However, the `MultiIndex` does not enforce this: **you are responsible for ensuring that things are properly sorted**. There is an important new method `sortlevel` to sort an axis within a `MultiIndex` so that its labels are grouped and sorted by the original ordering of the associated factor at that level. Note that this does not necessarily mean the labels will be sorted lexicographically!

```
In [790]: import random; random.shuffle(tuples)
```

```
In [791]: s = Series(randn(8), index=MultiIndex.from_tuples(tuples))
```

```
In [792]: s
Out[792]:
baz one   -1.847240
     two   -0.529247
qux two    0.614656
foo one   -1.590742
     two   -0.156479
bar one   -1.696377
     two    0.819712
qux one   -2.107728
```

```
In [793]: s.sortlevel(0)
Out[793]:
bar one   -1.696377
     two    0.819712
baz one   -1.847240
     two   -0.529247
foo one   -1.590742
     two   -0.156479
qux one   -2.107728
     two    0.614656
```

```
In [794]: s.sortlevel(1)
```

```
Out [794]:
bar one -1.696377
baz one -1.847240
foo one -1.590742
qux one -2.107728
bar two  0.819712
baz two -0.529247
foo two -0.156479
qux two  0.614656
```

Note, you may also pass a level name to `sortlevel` if the MultiIndex levels are named.

```
In [795]: s.index.names = ['L1', 'L2']
```

```
In [796]: s.sortlevel(level='L1')
```

```
Out [796]:
L1  L2
bar one -1.696377
      two  0.819712
baz one -1.847240
      two -0.529247
foo one -1.590742
      two -0.156479
qux one -2.107728
      two  0.614656
```

```
In [797]: s.sortlevel(level='L2')
```

```
Out [797]:
L1  L2
bar one -1.696377
baz one -1.847240
foo one -1.590742
qux one -2.107728
bar two  0.819712
baz two -0.529247
foo two -0.156479
qux two  0.614656
```

Some indexing will work even if the data are not sorted, but will be rather inefficient and will also return a copy of the data rather than a view:

```
In [798]: s['qux']
```

```
Out [798]:
L2
two  0.614656
one -2.107728
```

```
In [799]: s.sortlevel(1)['qux']
```

```
Out [799]:
L2
one -2.107728
two  0.614656
```

On higher dimensional objects, you can sort any of the other axes by level if they have a MultiIndex:

```
In [800]: df.T.sortlevel(1, axis=1)
```

```
Out [800]:
      zero      one      zero      one
      x        x        y        y
```

```
0 -0.662357 -1.505397 -0.027793  0.307453
1  2.725042  1.392009 -0.631023 -0.906534
```

The `MultiIndex` object has code to **explicitly check the sort depth**. Thus, if you try to index at a depth at which the index is not sorted, it will raise an exception. Here is a concrete example to illustrate this:

```
In [801]: tuples = [('a', 'a'), ('a', 'b'), ('b', 'a'), ('b', 'b')]
```

```
In [802]: idx = MultiIndex.from_tuples(tuples)
```

```
In [803]: idx.lexsort_depth
```

```
Out[803]: 2
```

```
In [804]: reordered = idx[[1, 0, 3, 2]]
```

```
In [805]: reordered.lexsort_depth
```

```
Out[805]: 1
```

```
In [806]: s = Series(randn(4), index=reordered)
```

```
In [807]: s.ix['a':'a']
```

```
Out[807]:
```

```
a b    -0.488326
a    0.851918
```

However:

```
>>> s.ix[('a', 'b'):(('b', 'a'))]
```

```
Exception: MultiIndex lexsort depth 1, key was length 2
```

7.4.9 Swapping levels with `swaplevel`

The `swaplevel` function can switch the order of two levels:

```
In [808]: df[:5]
```

```
Out[808]:
```

		0	1
one	y	0.307453	-0.906534
	x	-1.505397	1.392009
zero	y	-0.027793	-0.631023
	x	-0.662357	2.725042

```
In [809]: df[:5].swaplevel(0, 1, axis=0)
```

```
Out[809]:
```

		0	1
y	one	0.307453	-0.906534
x	one	-1.505397	1.392009
y	zero	-0.027793	-0.631023
x	zero	-0.662357	2.725042

7.4.10 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 [810]: df[:5].reorder_levels([1,0], axis=0)
Out[810]:
```

	0	1
y one	0.307453	-0.906534
x one	-1.505397	1.392009
y zero	-0.027793	-0.631023
x zero	-0.662357	2.725042

7.4.11 Some gory internal details

Internally, the `MultiIndex` consists of a few things: the **levels**, the integer **labels**, and the level **names**:

```
In [811]: index
Out[811]:
MultiIndex
[(bar, one), (bar, two), (baz, one), (baz, two), (foo, one), (foo, two), (qux, one), (qux, two)]

In [812]: index.levels
Out[812]: [Index([bar, baz, foo, qux], dtype=object), Index([one, two], dtype=object)]

In [813]: index.labels
Out[813]: [array([0, 0, 1, 1, 2, 2, 3, 3]), array([0, 1, 0, 1, 0, 1, 0, 1])]

In [814]: index.names
Out[814]: ['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.

7.5 Adding an index to an existing DataFrame

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.

7.5.1 Add an index using `DataFrame` columns

`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 [815]: data
Out[815]:
```

	a	b	c	d
0	bar	one	z	1
1	bar	two	y	2
2	foo	one	x	3
3	foo	two	w	4

```
In [816]: indexed1 = data.set_index('c')

In [817]: indexed1
Out[817]:
```

```
      a      b      d
c
z bar one 1
y bar two 2
x foo one 3
w foo two 4
```

```
In [818]: indexed2 = data.set_index(['a', 'b'])
```

```
In [819]: indexed2
```

```
Out[819]:
```

		c	d
a	b		
bar	one	z	1
	two	y	2
foo	one	x	3
	two	w	4

The append keyword option allow you to keep the existing index and append the given columns to a MultiIndex:

```
In [820]: frame = data.set_index('c', drop=False)
```

```
In [821]: frame = frame.set_index(['a', 'b'], append=True)
```

```
In [822]: frame
```

```
Out[822]:
```

			c	d
c	a	b		
z	bar	one	z	1
y	bar	two	y	2
x	foo	one	x	3
w	foo	two	w	4

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 [823]: data.set_index('c', drop=False)
```

```
Out[823]:
```

		a	b	c	d
c					
z	bar	one	z	1	
y	bar	two	y	2	
x	foo	one	x	3	
w	foo	two	w	4	

```
In [824]: data.set_index(['a', 'b'], inplace=True)
```

```
Out[824]:
```

		c	d
a	b		
bar	one	z	1
	two	y	2
foo	one	x	3
	two	w	4

```
In [825]: data
```

```
Out[825]:
```

		c	d
a	b		
bar	one	z	1


```
two y 2
foo one x 3
two w 4
```

7.5.2 Remove / reset the index, `reset_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 [826]: data
```

```
Out[826]:
```

```
      c d
a  b
bar one z 1
      two y 2
foo one x 3
      two w 4
```

```
In [827]: data.reset_index()
```

```
Out[827]:
```

```
      a  b  c d
0 bar one z 1
1 bar two y 2
2 foo one x 3
3 foo two w 4
```

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 [828]: frame
```

```
Out[828]:
```

```
      c d
c a  b
z bar one z 1
y bar two y 2
x foo one x 3
w foo two w 4
```

```
In [829]: frame.reset_index(level=1)
```

```
Out[829]:
```

```
      a  c d
c b
z one bar z 1
y two bar y 2
x one foo x 3
w two foo w 4
```

`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.

7.5.3 Adding an ad hoc index

If you create an index yourself, you can just assign it to the `index` field:

```
data.index = index
```

7.6 Indexing internal details

Note: The following is largely relevant for those actually working on the pandas codebase. And the source code is still the best place to look at the specifics of how things are implemented.

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
- `MultiIndex`: the standard hierarchical index object
- `date_range`: fixed frequency date range generated from a time rule or `DateOffset`. An ndarray of Python datetime objects

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
- `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`

COMPUTATIONAL TOOLS

8.1 Statistical functions

8.1.1 Percent Change

Both `Series` and `DataFrame` has a method `pct_change` to compute the percent change over a given number of periods (using `fill_method` to fill NA/null values).

```
In [209]: ser = Series(randn(8))
```

```
In [210]: ser.pct_change()
```

```
Out[210]:  
0      NaN  
1   -1.602976  
2    4.334938  
3   -0.247456  
4   -2.067345  
5   -1.142903  
6   -1.688214  
7   -9.759729
```

```
In [211]: df = DataFrame(randn(10, 4))
```

```
In [212]: df.pct_change(periods=3)
```

```
Out[212]:  
      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
```

8.1.2 Covariance

The `Series` object has a method `cov` to compute covariance between series (excluding NA/null values).

```
In [213]: s1 = Series(randn(1000))
```

```
In [214]: s2 = Series(randn(1000))
```

```
In [215]: s1.cov(s2)
```

```
Out[215]: 0.00068010881743109321
```

Analogously, `DataFrame` has a method `cov` to compute pairwise covariances among the series in the `DataFrame`, also excluding NA/null values.

```
In [216]: frame = DataFrame(randn(1000, 5), columns=['a', 'b', 'c', 'd', 'e'])
```

```
In [217]: frame.cov()
```

```
Out[217]:
```

	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 [218]: frame = DataFrame(randn(20, 3), columns=['a', 'b', 'c'])
```

```
In [219]: frame.ix[:5, 'a'] = np.nan
```

```
In [220]: frame.ix[5:10, 'b'] = np.nan
```

```
In [221]: frame.cov()
```

```
Out[221]:
```

	a	b	c
a	1.210090	-0.430629	0.018002
b	-0.430629	1.240960	0.347188
c	0.018002	0.347188	1.301149

```
In [222]: frame.cov(min_periods=12)
```

```
Out[222]:
```

	a	b	c
a	1.210090	NaN	0.018002
b	NaN	1.240960	0.347188
c	0.018002	0.347188	1.301149

8.1.3 Correlation

Several methods for computing correlations are provided. Several kinds of correlation methods 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.

```
In [223]: frame = DataFrame(randn(1000, 5), columns=['a', 'b', 'c', 'd', 'e'])
```

```
In [224]: frame.ix[:,2] = np.nan
```

```
# Series with Series
In [225]: frame['a'].corr(frame['b'])
Out[225]: 0.013479040400098763

In [226]: frame['a'].corr(frame['b'], method='spearman')
Out[226]: -0.0072898851595406388

# Pairwise correlation of DataFrame columns
In [227]: frame.corr()
Out[227]:
```

	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 [228]: frame = DataFrame(randn(20, 3), columns=['a', 'b', 'c'])

In [229]: frame.ix[:5, 'a'] = np.nan

In [230]: frame.ix[5:10, 'b'] = np.nan

In [231]: frame.corr()
Out[231]:
```

	a	b	c
a	1.000000	-0.076520	0.160092
b	-0.076520	1.000000	0.135967
c	0.160092	0.135967	1.000000

```
In [232]: frame.corr(min_periods=12)
Out[232]:
```

	a	b	c
a	1.000000	NaN	0.160092
b	NaN	1.000000	0.135967
c	0.160092	0.135967	1.000000

A related method `corrwith` is implemented on `DataFrame` to compute the correlation between like-labeled `Series` contained in different `DataFrame` objects.

```
In [233]: index = ['a', 'b', 'c', 'd', 'e']

In [234]: columns = ['one', 'two', 'three', 'four']

In [235]: df1 = DataFrame(randn(5, 4), index=index, columns=columns)

In [236]: df2 = DataFrame(randn(4, 4), index=index[:4], columns=columns)

In [237]: df1.corrwith(df2)
Out[237]:
```

	one	two	three	four
a	-0.125501	-0.493244	0.344056	0.004183
b	-0.125501	-0.493244	0.344056	0.004183
c	-0.125501	-0.493244	0.344056	0.004183
d	-0.125501	-0.493244	0.344056	0.004183

```
In [238]: df2.corrwith(df1, axis=1)
Out[238]:
a    -0.675817
b     0.458296
c     0.190809
d    -0.186275
e             NaN
```

8.1.4 Data ranking

The rank method produces a data ranking with ties being assigned the mean of the ranks (by default) for the group:

```
In [239]: s = Series(np.random.randn(5), index=list('abcde'))
```

```
In [240]: s['d'] = s['b'] # so there's a tie
```

```
In [241]: s.rank()
Out[241]:
a    5.0
b    2.5
c    1.0
d    2.5
e    4.0
```

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 [242]: df = DataFrame(np.random.randn(10, 6))
```

```
In [243]: df[4] = df[2][:5] # some ties
```

```
In [244]: df
Out[244]:
```

	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 [245]: df.rank(1)
Out[245]:
```

	0	1	2	3	4	5
0	4	3	1.5	5	1.5	6
1	2	6	4.5	1	4.5	3
2	1	6	3.5	5	3.5	2
3	4	5	1.5	3	1.5	6
4	5	3	1.5	4	1.5	6
5	1	2	5.0	3	NaN	4
6	4	5	3.0	1	NaN	2
7	2	5	3.0	4	NaN	1
8	2	5	3.0	4	NaN	1

```
9  2  3  1.0  4  NaN  5
```

`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

Note: These methods are significantly faster (around 10-20x) than `scipy.stats.rankdata`.

8.2 Moving (rolling) statistics / moments

For working with time series data, a number of functions are provided for computing common *moving* or *rolling* statistics. Among these are count, sum, mean, median, correlation, variance, covariance, standard deviation, skewness, and kurtosis. All of these methods are in the `pandas` namespace, but otherwise they can be found in `pandas.stats.moments`.

Function	Description
<code>rolling_count</code>	Number of non-null observations
<code>rolling_sum</code>	Sum of values
<code>rolling_mean</code>	Mean of values
<code>rolling_median</code>	Arithmetic median of values
<code>rolling_min</code>	Minimum
<code>rolling_max</code>	Maximum
<code>rolling_std</code>	Unbiased standard deviation
<code>rolling_var</code>	Unbiased variance
<code>rolling_skew</code>	Unbiased skewness (3rd moment)
<code>rolling_kurt</code>	Unbiased kurtosis (4th moment)
<code>rolling_quantile</code>	Sample quantile (value at %)
<code>rolling_apply</code>	Generic apply
<code>rolling_cov</code>	Unbiased covariance (binary)
<code>rolling_corr</code>	Correlation (binary)
<code>rolling_corr_pairwise</code>	Pairwise correlation of DataFrame columns
<code>rolling_window</code>	Moving window function

Generally these methods all have the same interface. The binary operators (e.g. `rolling_corr`) take two Series or DataFrames. Otherwise, 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)
- `freq`: optionally specify a *frequency string* or *DateOffset* to pre-conform the data to. Note that prior to pandas v0.8.0, a keyword argument `time_rule` was used instead of `freq` that referred to the legacy time rule constants

These functions can be applied to `ndarrays` or `Series` objects:

```
In [246]: ts = Series(randn(1000), index=date_range('1/1/2000', periods=1000))
```

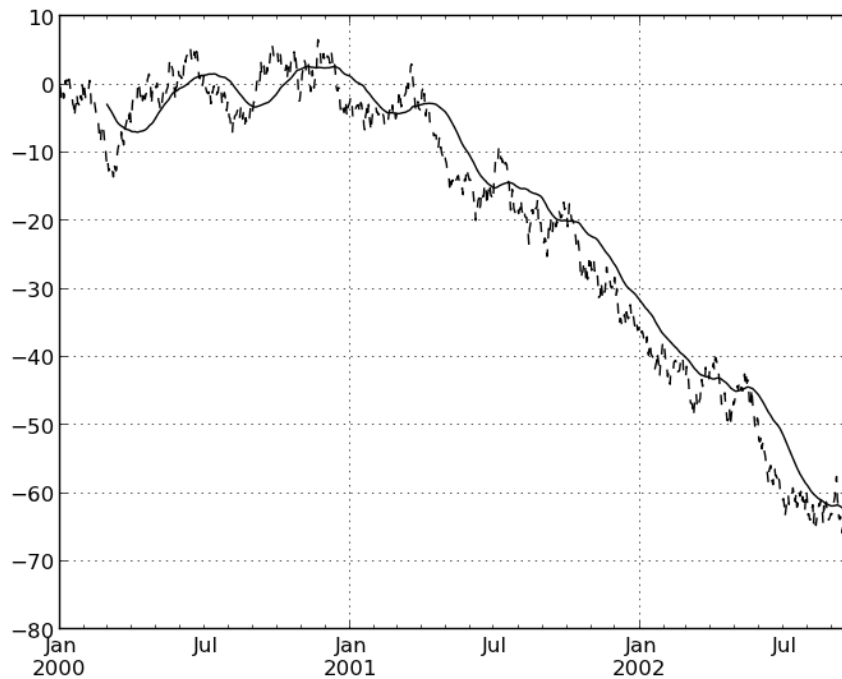
```
In [247]: ts = ts.cumsum()
```

```
In [248]: ts.plot(style='k--')
```

```
Out[248]: <matplotlib.axes.AxesSubplot at 0x48e3210>
```

```
In [249]: rolling_mean(ts, 60).plot(style='k')
```

```
Out[249]: <matplotlib.axes.AxesSubplot at 0x48e3210>
```



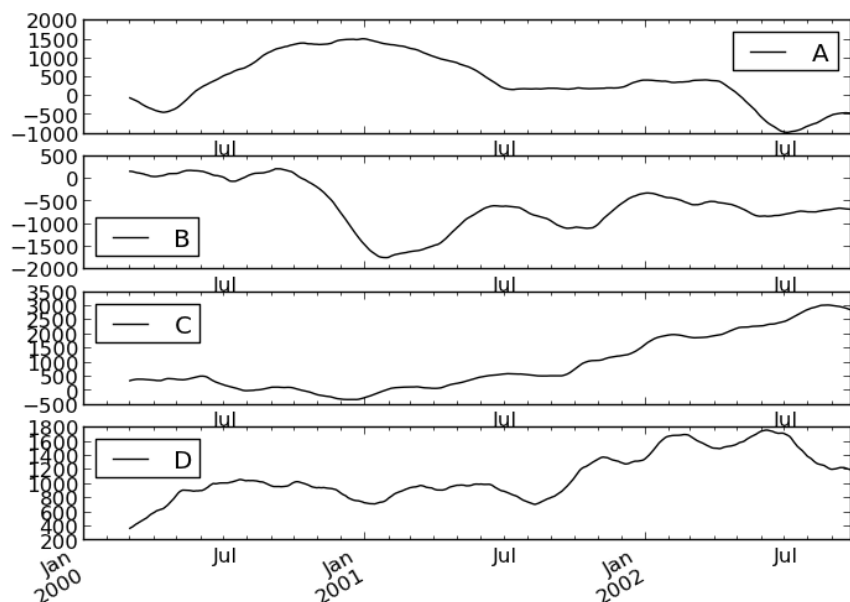
They can also be applied to DataFrame objects. This is really just syntactic sugar for applying the moving window operator to all of the DataFrame's columns:

```
In [250]: df = DataFrame(randn(1000, 4), index=ts.index,
.....:                  columns=['A', 'B', 'C', 'D'])
.....:
```

```
In [251]: df = df.cumsum()
```

```
In [252]: rolling_sum(df, 60).plot(subplots=True)
```

```
Out[252]:
array([Axes(0.125,0.747826;0.775x0.152174),
       Axes(0.125,0.565217;0.775x0.152174),
       Axes(0.125,0.382609;0.775x0.152174)], dtype=object)
```

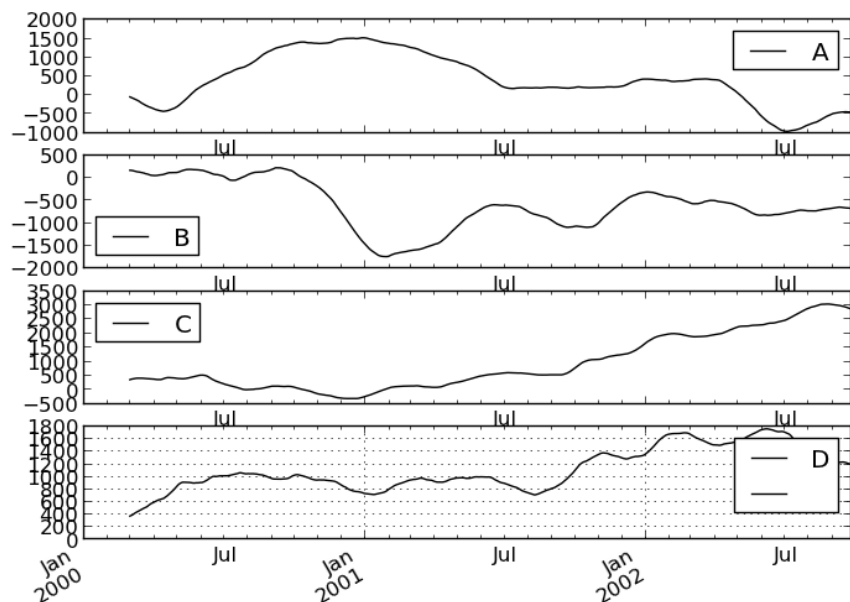



The `rolling_apply` function takes an extra `func` argument and performs generic rolling computations. The `func` argument should be a single function that produces a single value from an ndarray input. Suppose we wanted to compute the mean absolute deviation on a rolling basis:

```
In [253]: mad = lambda x: np.fabs(x - x.mean()).mean()
```

```
In [254]: rolling_apply(ts, 60, mad).plot(style='k')
```

```
Out[254]: <matplotlib.axes.AxesSubplot at 0x4f94290>
```



The `rolling_window` function performs a generic rolling window computation on the input data. 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 [255]: ser = Series(randn(10), index=date_range('1/1/2000', periods=10))
```

```
In [256]: rolling_window(ser, 5, 'triang')
```

```
Out[256]:
2000-01-01      NaN
2000-01-02      NaN
2000-01-03      NaN
2000-01-04      NaN
2000-01-05    -0.622722
2000-01-06    -0.460623
2000-01-07    -0.229918
2000-01-08    -0.237308
2000-01-09    -0.335064
2000-01-10    -0.403449
Freq: D
```

Note that the boxcar window is equivalent to `rolling_mean`:

```
In [257]: rolling_window(ser, 5, 'boxcar')
```

```
Out[257]:
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
```

```
In [258]: rolling_mean(ser, 5)
```

```
Out[258]:
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

```

For some windowing functions, additional parameters must be specified:

```
In [259]: rolling_window(ser, 5, 'gaussian', std=0.1)
```

```

Out[259]:
2000-01-01      NaN
2000-01-02      NaN
2000-01-03      NaN
2000-01-04      NaN
2000-01-05    -0.261998
2000-01-06    -0.230600
2000-01-07     0.121276
2000-01-08    -0.136220
2000-01-09    -0.057945
2000-01-10    -0.199326
Freq: D

```

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. This keyword is available in other rolling functions as well.

```
In [260]: rolling_window(ser, 5, 'boxcar')
```

```

Out[260]:
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

```

```
In [261]: rolling_window(ser, 5, 'boxcar', center=True)
```

```

Out[261]:
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

```

```
In [262]: rolling_mean(ser, 5, center=True)
```

```

Out[262]:
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
```

8.2.1 Binary rolling moments

`rolling_cov` and `rolling_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`: compute statistic for matching column names, returning a `DataFrame`

For example:

```
In [263]: df2 = df[:20]
```

```
In [264]: rolling_corr(df2, df2['B'], window=5)
```

```
Out[264]:
```

	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	-0.262853	1	0.334449	0.193380
2000-01-06	-0.083745	1	-0.521587	-0.556126
2000-01-07	-0.292940	1	-0.658532	-0.458128
2000-01-08	0.840416	1	0.796505	-0.498672
2000-01-09	-0.135275	1	0.753895	-0.634445
2000-01-10	-0.346229	1	-0.682232	-0.645681
2000-01-11	-0.365524	1	-0.775831	-0.561991
2000-01-12	-0.204761	1	-0.855874	-0.382232
2000-01-13	0.575218	1	-0.747531	0.167892
2000-01-14	0.519499	1	-0.687277	0.192822
2000-01-15	0.048982	1	0.167669	-0.061463
2000-01-16	0.217190	1	0.167564	-0.326034
2000-01-17	0.641180	1	-0.164780	-0.111487
2000-01-18	0.130422	1	0.322833	0.632383
2000-01-19	0.317278	1	0.384528	0.813656
2000-01-20	0.293598	1	0.159538	0.742381

8.2.2 Computing rolling pairwise correlations

In financial data analysis and other fields it's common to compute correlation matrices for a collection of time series. More difficult is to compute a moving-window correlation matrix. This can be done using the `rolling_corr_pairwise` function, which yields a `Panel` whose items are the dates in question:

```
In [265]: correls = rolling_corr_pairwise(df, 50)
```

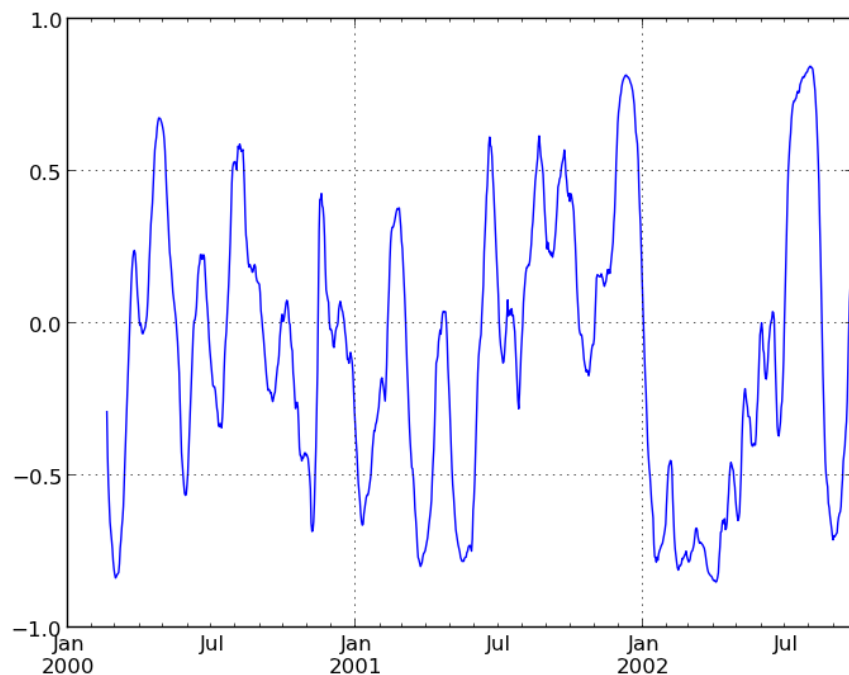
```
In [266]: correls[df.index[-50]]
```

```
Out[266]:
```

	A	B	C	D
A	1.000000	0.604221	0.767429	-0.776170
B	0.604221	1.000000	0.461484	-0.381148
C	0.767429	0.461484	1.000000	-0.748863
D	-0.776170	-0.381148	-0.748863	1.000000

You can efficiently retrieve the time series of correlations between two columns using `ix` indexing:

```
In [267]: correls.ix[:, 'A', 'C'].plot()
Out[267]: <matplotlib.axes.AxesSubplot at 0x51777d0>
```



8.3 Expanding window moment functions

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. As these calculations are a special case of rolling statistics, they are implemented in pandas such that the following two calls are equivalent:

```
In [268]: rolling_mean(df, window=len(df), min_periods=1)[:5]
Out[268]:
```

	A	B	C	D
2000-01-01	-1.388345	3.317290	0.344542	-0.036968
2000-01-02	-1.123132	3.622300	1.675867	0.595300
2000-01-03	-0.628502	3.626503	2.455240	1.060158
2000-01-04	-0.768740	3.888917	2.451354	1.281874
2000-01-05	-0.824034	4.108035	2.556112	1.140723

```
In [269]: expanding_mean(df)[:5]
Out[269]:
```

	A	B	C	D
2000-01-01	-1.388345	3.317290	0.344542	-0.036968
2000-01-02	-1.123132	3.622300	1.675867	0.595300
2000-01-03	-0.628502	3.626503	2.455240	1.060158

```
2000-01-04 -0.768740  3.888917  2.451354  1.281874
2000-01-05 -0.824034  4.108035  2.556112  1.140723
```

Like the `rolling_` functions, the following methods are included in the pandas namespace or can be located in `pandas.stats.moments`.

Function	Description
<code>expanding_count</code>	Number of non-null observations
<code>expanding_sum</code>	Sum of values
<code>expanding_mean</code>	Mean of values
<code>expanding_median</code>	Arithmetic median of values
<code>expanding_min</code>	Minimum
<code>expanding_max</code>	Maximum
<code>expanding_std</code>	Unbiased standard deviation
<code>expanding_var</code>	Unbiased variance
<code>expanding_skew</code>	Unbiased skewness (3rd moment)
<code>expanding_kurt</code>	Unbiased kurtosis (4th moment)
<code>expanding_quantile</code>	Sample quantile (value at %)
<code>expanding_apply</code>	Generic apply
<code>expanding_cov</code>	Unbiased covariance (binary)
<code>expanding_corr</code>	Correlation (binary)
<code>expanding_corr_pairwise</code>	Pairwise correlation of DataFrame columns

Aside from not having a `window` parameter, these functions have the same interfaces as their `rolling_` counterpart. 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.
- `freq`: optionally specify a *frequency string* or *DateOffset* to pre-conform the data to. Note that prior to pandas v0.8.0, a keyword argument `time_rule` was used instead of `freq` that referred to the legacy time rule constants

Note: The output of the `rolling_` and `expanding_` functions do not return a NaN if there are at least `min_periods` non-null values in the current window. This differs from `cumsum`, `cumprod`, `cummax`, and `cummin`, which return NaN in the output wherever a NaN is encountered in the input.

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 `expanding_mean` output for the previous time series dataset:

```
In [270]: ts.plot(style='k--')
Out[270]: <matplotlib.axes.AxesSubplot at 0x5b3d310>

In [271]: expanding_mean(ts).plot(style='k')
Out[271]: <matplotlib.axes.AxesSubplot at 0x5b3d310>
```



8.4 Exponentially weighted moment functions

A related set of functions are exponentially weighted versions of many of the above statistics. A number of EW (exponentially weighted) functions are provided using the blending method. For example, where y_t is the result and x_t the input, we compute an exponentially weighted moving average as

$$y_t = \alpha y_{t-1} + (1 - \alpha)x_t$$

One must have $0 < \alpha \leq 1$, but rather than pass α directly, it's easier to think about either the **span** or **center of mass (com)** of an EW moment:

$$\alpha = \begin{cases} \frac{2}{s+1}, s = \text{span} \\ \frac{1}{c+1}, c = \text{center of mass} \end{cases}$$

You can pass one or the other to these functions but not both. **Span** corresponds to what is commonly called a “20-day EW moving average” for example. **Center of mass** has a more physical interpretation. For example, **span** = 20 corresponds to **com** = 9.5. Here is the list of functions available:

Function	Description
ewma	EW moving average
ewmvar	EW moving variance
ewmstd	EW moving standard deviation
ewmcorr	EW moving correlation
ewmcov	EW moving covariance

Here are an example for a univariate time series:

```
In [272]: plt.close('all')

In [273]: ts.plot(style='k--')
Out[273]: <matplotlib.axes.AxesSubplot at 0x5b49ed0>
```

```
In [274]: ewma(ts, span=20).plot(style='k')
Out[274]: <matplotlib.axes.AxesSubplot at 0x5b49ed0>
```



Note: The EW functions perform a standard adjustment to the initial observations whereby if there are fewer observations than called for in the span, those observations are reweighted accordingly.

8.5 Linear and panel regression

Note: We plan to move this functionality to [statsmodels](#) for the next release. Some of the result attributes may change names in order to foster naming consistency with the rest of statsmodels. We will provide every effort to provide compatibility with older versions of pandas, however.

We have implemented a very fast set of *moving-window linear regression* classes in pandas. Two different types of regressions are supported:

- Standard ordinary least squares (OLS) multiple regression
- Multiple regression (OLS-based) on [panel data](#) including with fixed-effects (also known as entity or individual effects) or time-effects.

Both kinds of linear models are accessed through the `ols` function in the pandas namespace. They all take the following arguments to specify either a static (full sample) or dynamic (moving window) regression:

- `window_type`: 'full sample' (default), 'expanding', or 'rolling'
- `window`: size of the moving window in the `window_type='rolling'` case. If `window` is specified, `window_type` will be automatically set to 'rolling'
- `min_periods`: minimum number of time periods to require to compute the regression coefficients

Generally speaking, the `ols` works by being given a `y` (response) object and an `x` (predictors) object. These can take many forms:

- `y`: a Series, ndarray, or DataFrame (panel model)
- `x`: Series, DataFrame, dict of Series, dict of DataFrame or Panel

Based on the types of `y` and `x`, the model will be inferred to either a panel model or a regular linear model. If the `y` variable is a DataFrame, the result will be a panel model. In this case, the `x` variable must either be a Panel, or a dict of DataFrame (which will be coerced into a Panel).

8.5.1 Standard OLS regression

Let's pull in some sample data:

```
In [275]: from pandas.io.data import DataReader

In [276]: symbols = ['MSFT', 'GOOG', 'AAPL']

In [277]: data = dict((sym, DataReader(sym, "yahoo"))
.....:                 for sym in symbols)
.....:

In [278]: panel = Panel(data).swapaxes('items', 'minor')

In [279]: close_px = panel['Close']

# convert closing prices to returns
In [280]: rets = close_px / close_px.shift(1) - 1

In [281]: rets.info()
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 767 entries, 2010-01-04 00:00:00 to 2013-01-18 00:00:00
Data columns:
AAPL      766  non-null values
GOOG      766  non-null values
MSFT      766  non-null values
dtypes: float64(3)
```

Let's do a static regression of AAPL returns on GOOG returns:

```
In [282]: model = ols(y=rets['AAPL'], x=rets.ix[:, ['GOOG']])
```

```
In [283]: model
```

```
Out[283]:
-----Summary of Regression Analysis-----
Formula: Y ~ <GOOG> + <intercept>
Number of Observations:      766
Number of Degrees of Freedom:  2
R-squared:      0.2761
Adj R-squared:  0.2751
Rmse:          0.0148
F-stat (1, 764): 291.3847, p-value:      0.0000
Degrees of Freedom: model 1, resid 764
-----Summary of Estimated Coefficients-----
```

Variable	Coef	Std Err	t-stat	p-value	CI 2.5%	CI 97.5%
GOOG	0.5434	0.0318	17.07	0.0000	0.4810	0.6058
intercept	0.0011	0.0005	2.05	0.0408	0.0000	0.0022

-----End of Summary-----

```
In [284]: model.beta
Out[284]:
GOOG      0.543388
intercept 0.001100
```

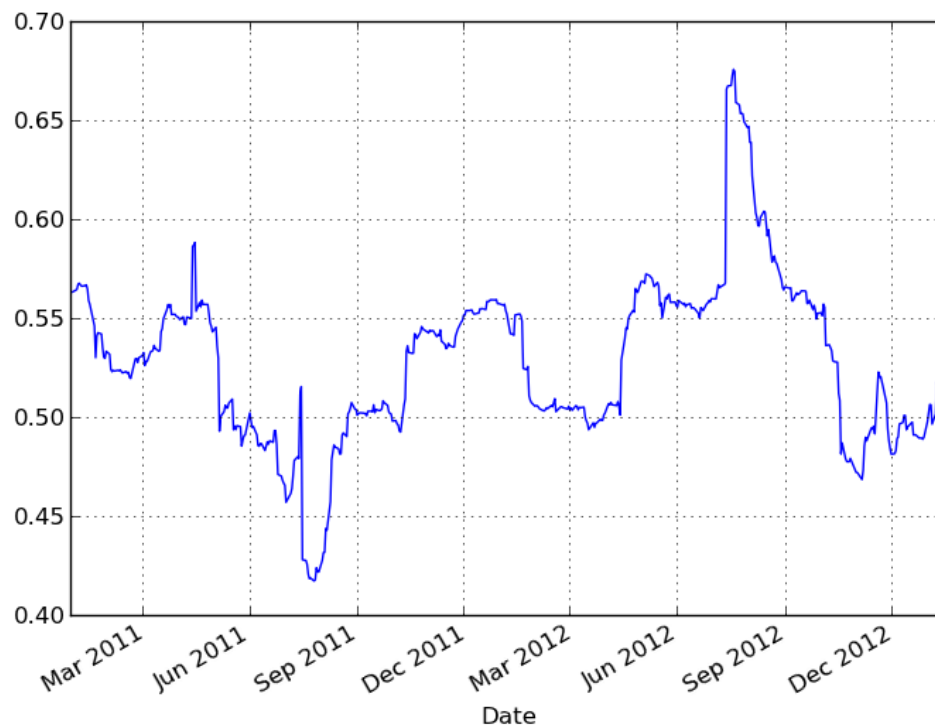
If we had passed a Series instead of a DataFrame with the single GOOG column, the model would have assigned the generic name `x` to the sole right-hand side variable.

We can do a moving window regression to see how the relationship changes over time:

```
In [285]: model = ols(y=rets['AAPL'], x=rets.ix[:, ['GOOG']],
.....:               window=250)
.....:
```

```
# just plot the coefficient for GOOG
```

```
In [286]: model.beta['GOOG'].plot()
Out[286]: <matplotlib.axes.AxesSubplot at 0x63e10d0>
```



It looks like there are some outliers rolling in and out of the window in the above regression, influencing the results. We could perform a simple [winsorization](#) at the 3 STD level to trim the impact of outliers:

```
In [287]: winz = rets.copy()

In [288]: std_1year = rolling_std(rets, 250, min_periods=20)

# cap at 3 * 1 year standard deviation
In [289]: cap_level = 3 * np.sign(winz) * std_1year

In [290]: winz[np.abs(winz) > 3 * std_1year] = cap_level

In [291]: winz_model = ols(y=winz['AAPL'], x=winz.ix[:, ['GOOG']],
```

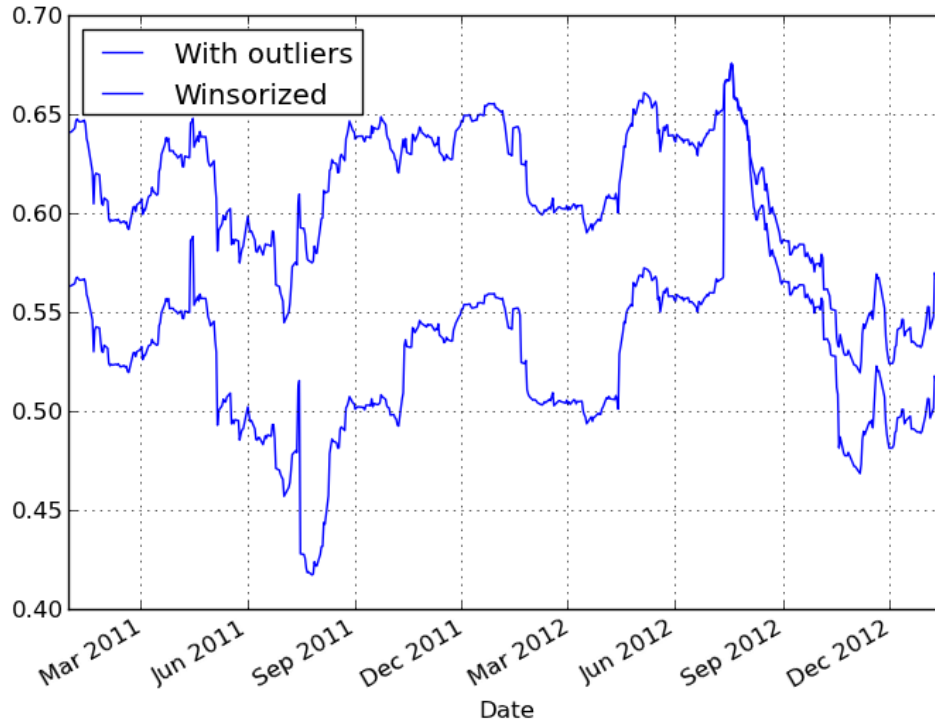
```
.....:         window=250)
.....:
```

```
In [292]: model.beta['GOOG'].plot(label="With outliers")
```

```
Out[292]: <matplotlib.axes.AxesSubplot at 0x63cd3d0>
```

```
In [293]: winz_model.beta['GOOG'].plot(label="Winsorized"); plt.legend(loc='best')
```

```
Out[293]: <matplotlib.legend.Legend at 0x7122550>
```



So in this simple example we see the impact of winsorization is actually quite significant. Note the correlation after winsorization remains high:

```
In [294]: winz.corrwith(rets)
```

```
Out[294]:
AAPL    0.995059
GOOG    0.972578
MSFT    0.998393
```

Multiple regressions can be run by passing a DataFrame with multiple columns for the predictors x :

```
In [295]: ols(y=winz['AAPL'], x=winz.drop(['AAPL'], axis=1))
```

```
Out[295]:
-----Summary of Regression Analysis-----
Formula: Y ~ <GOOG> + <MSFT> + <intercept>
Number of Observations:      766
Number of Degrees of Freedom:  3
R-squared:                    0.3552
Adj R-squared:                 0.3535
Rmse:                         0.0135
F-stat (2, 763):              210.1852, p-value:      0.0000
Degrees of Freedom: model 2, resid 763
-----Summary of Estimated Coefficients-----
Variable      Coef      Std Err    t-stat    p-value    CI 2.5%    CI 97.5%
```

```

-----
      GOOG      0.4746      0.0377      12.60      0.0000      0.4008      0.5484
      MSFT      0.3049      0.0416       7.33      0.0000      0.2234      0.3865
      intercept 0.0010      0.0005       2.13      0.0336      0.0001      0.0020
-----End of Summary-----

```

8.5.2 Panel regression

We’ve implemented moving window panel regression on potentially unbalanced panel data (see [this article](#) if this means nothing to you). Suppose we wanted to model the relationship between the magnitude of the daily return and trading volume among a group of stocks, and we want to pool all the data together to run one big regression. This is actually quite easy:

```

# make the units somewhat comparable
In [296]: volume = panel['Volume'] / 1e8

In [297]: model = ols(y=volume, x={'return' : np.abs(rets)})

In [298]: model
Out[298]:
-----Summary of Regression Analysis-----
Formula: Y ~ <return> + <intercept>
Number of Observations:      2298
Number of Degrees of Freedom:  2
R-squared:      0.0205
Adj R-squared:   0.0200
Rmse:           0.2676
F-stat (1, 2296):  47.9468, p-value:      0.0000
Degrees of Freedom: model 1, resid 2296
-----Summary of Estimated Coefficients-----
      Variable      Coef      Std Err      t-stat      p-value      CI 2.5%      CI 97.5%
-----
      return      3.4365      0.4963       6.92      0.0000      2.4638      4.4092
      intercept  0.2248      0.0080      28.03      0.0000      0.2090      0.2405
-----End of Summary-----

```

In a panel model, we can insert dummy (0-1) variables for the “entities” involved (here, each of the stocks) to account the a entity-specific effect (intercept):

```

In [299]: fe_model = ols(y=volume, x={'return' : np.abs(rets)},
.....:                  entity_effects=True)
.....:

In [300]: fe_model
Out[300]:
-----Summary of Regression Analysis-----
Formula: Y ~ <return> + <FE_GOOG> + <FE_MSFT> + <intercept>
Number of Observations:      2298
Number of Degrees of Freedom:  4
R-squared:      0.7411
Adj R-squared:   0.7407
Rmse:           0.1376
F-stat (3, 2294): 2188.6924, p-value:      0.0000
Degrees of Freedom: model 3, resid 2294
-----Summary of Estimated Coefficients-----
      Variable      Coef      Std Err      t-stat      p-value      CI 2.5%      CI 97.5%
-----

```

```

      return      4.5121      0.2563      17.60      0.0000      4.0098      5.0145
FE_GOOG      -0.1565      0.0070     -22.22      0.0000     -0.1703     -0.1427
FE_MSFT       0.3898      0.0071      55.21      0.0000      0.3760      0.4037
intercept     0.1345      0.0060      22.51      0.0000      0.1228      0.1462

```

```
-----End of Summary-----
```

Because we ran the regression with an intercept, one of the dummy variables must be dropped or the design matrix will not be full rank. If we do not use an intercept, all of the dummy variables will be included:

```

In [301]: fe_model = ols(y=volume, x={'return' : np.abs(rets)},
.....:                  entity_effects=True, intercept=False)
.....:

```

```
In [302]: fe_model
```

```
Out[302]:
```

```

-----Summary of Regression Analysis-----
Formula: Y ~ <return> + <FE_AAPL> + <FE_GOOG> + <FE_MSFT>
Number of Observations:      2298
Number of Degrees of Freedom:  4
R-squared:      0.7411
Adj R-squared:   0.7407
Rmse:           0.1376
F-stat (4, 2294): 2188.6924, p-value:      0.0000
Degrees of Freedom: model 3, resid 2294
-----Summary of Estimated Coefficients-----

```

Variable	Coef	Std Err	t-stat	p-value	CI 2.5%	CI 97.5%
return	4.5121	0.2563	17.60	0.0000	4.0098	5.0145
FE_AAPL	0.1345	0.0060	22.51	0.0000	0.1228	0.1462
FE_GOOG	-0.0220	0.0058	-3.81	0.0001	-0.0333	-0.0107
FE_MSFT	0.5243	0.0057	92.78	0.0000	0.5133	0.5354

```

-----End of Summary-----

```

We can also include *time effects*, which demeans the data cross-sectionally at each point in time (equivalent to including dummy variables for each date). More mathematical care must be taken to properly compute the standard errors in this case:

```

In [303]: te_model = ols(y=volume, x={'return' : np.abs(rets)},
.....:                  time_effects=True, entity_effects=True)
.....:

```

```
In [304]: te_model
```

```
Out[304]:
```

```

-----Summary of Regression Analysis-----
Formula: Y ~ <return> + <FE_GOOG> + <FE_MSFT>
Number of Observations:      2298
Number of Degrees of Freedom: 769
R-squared:      0.8176
Adj R-squared:   0.7259
Rmse:           0.1325
F-stat (3, 1529):  8.9212, p-value:      0.0000
Degrees of Freedom: model 768, resid 1529
-----Summary of Estimated Coefficients-----

```

Variable	Coef	Std Err	t-stat	p-value	CI 2.5%	CI 97.5%
return	3.7339	0.3694	10.11	0.0000	3.0098	4.4580
FE_GOOG	-0.1577	0.0068	-23.21	0.0000	-0.1710	-0.1444
FE_MSFT	0.3879	0.0068	56.79	0.0000	0.3745	0.4013

```

-----End of Summary-----

```

Here the intercept (the mean term) is dropped by default because it will be 0 according to the model assumptions, having subtracted off the group means.

8.5.3 Result fields and tests

We'll leave it to the user to explore the docstrings and source, especially as we'll be moving this code into statsmodels in the near future.

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.

9.1 Missing data basics

9.1.1 When / why does data become missing?

Some might quibble over our usage of *missing*. By “missing” we simply mean **null** 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 [1159]: df = DataFrame(randn(5, 3), index=['a', 'c', 'e', 'f', 'h'],
.....:                  columns=['one', 'two', 'three'])
.....:
```

```
In [1160]: df['four'] = 'bar'
```

```
In [1161]: df['five'] = df['one'] > 0
```

```
In [1162]: df
```

```
Out[1162]:
```

	one	two	three	four	five
a	0.059117	1.138469	-2.400634	bar	True
c	-0.280853	0.025653	-1.386071	bar	False
e	0.863937	0.252462	1.500571	bar	True
f	1.053202	-2.338595	-0.374279	bar	True
h	-2.359958	-1.157886	-0.551865	bar	False

```
In [1163]: df2 = df.reindex(['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h'])
```

```
In [1164]: df2
```

```
Out[1164]:
```

	one	two	three	four	five
--	-----	-----	-------	------	------

```
a  0.059117  1.138469 -2.400634  bar  True
b         NaN         NaN         NaN  NaN  NaN
c -0.280853  0.025653 -1.386071  bar False
d         NaN         NaN         NaN  NaN  NaN
e  0.863937  0.252462  1.500571  bar  True
f  1.053202 -2.338595 -0.374279  bar  True
g         NaN         NaN         NaN  NaN  NaN
h -2.359958 -1.157886 -0.551865  bar False
```

9.1.2 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 “null”.

Until recently, for legacy reasons `inf` and `-inf` were also considered to be “null” in computations. This is no longer the case by default; use the `mode.use_inf_as_null` option to recover it. To make detecting missing values easier (and across different array dtypes), pandas provides the `isnull()` and `notnull()` functions, which are also methods on Series objects:

```
In [1165]: df2['one']
```

```
Out[1165]:
```

```
a    0.059117
b         NaN
c   -0.280853
d         NaN
e    0.863937
f    1.053202
g         NaN
h   -2.359958
Name: one
```

```
In [1166]: isnull(df2['one'])
```

```
Out[1166]:
```

```
a    False
b     True
c    False
d     True
e    False
f    False
g     True
h    False
Name: one
```

```
In [1167]: df2['four'].notnull()
```

```
Out[1167]:
```

```
a     True
b    False
c     True
d    False
e     True
f     True
g    False
h     True
```

Summary: NaN and None (in object arrays) are considered missing by the `isnull` and `notnull` functions. `inf`

and `-inf` are no longer considered missing by default.

9.2 Calculations with missing data

Missing values propagate naturally through arithmetic operations between pandas objects.

```
In [1168]: a
```

```
Out[1168]:
```

	one	two
a	0.059117	1.138469
b	0.059117	1.138469
c	-0.280853	0.025653
d	-0.280853	0.025653
e	0.863937	0.252462

```
In [1169]: b
```

```
Out[1169]:
```

	one	two	three
a	0.059117	1.138469	-2.400634
b	NaN	NaN	NaN
c	-0.280853	0.025653	-1.386071
d	NaN	NaN	NaN
e	0.863937	0.252462	1.500571

```
In [1170]: a + b
```

```
Out[1170]:
```

	one	three	two
a	0.118234	NaN	2.276938
b	NaN	NaN	NaN
c	-0.561707	NaN	0.051306
d	NaN	NaN	NaN
e	1.727874	NaN	0.504923

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 [1171]: df
```

```
Out[1171]:
```

	one	two	three
a	0.059117	1.138469	-2.400634
b	NaN	NaN	NaN
c	-0.280853	0.025653	-1.386071
d	NaN	NaN	NaN
e	0.863937	0.252462	1.500571
f	1.053202	-2.338595	-0.374279
g	NaN	NaN	NaN
h	-2.359958	-1.157886	-0.551865

```
In [1172]: df['one'].sum()
```

```
Out[1172]: -0.66455558290247652
```

```
In [1173]: df.mean(1)
```

```
Out [1173]:
a    -0.401016
b         NaN
c    -0.547090
d         NaN
e     0.872323
f    -0.553224
g         NaN
h    -1.356570
```

```
In [1174]: df.cumsum()
```

```
Out [1174]:
      one      two      three
a  0.059117  1.138469 -2.400634
b         NaN         NaN         NaN
c -0.221736  1.164122 -3.786705
d         NaN         NaN         NaN
e  0.642200  1.416584 -2.286134
f  1.695403 -0.922011 -2.660413
g         NaN         NaN         NaN
h -0.664556 -2.079897 -3.212278
```

9.2.1 NA values in GroupBy

NA groups in GroupBy are automatically excluded. This behavior is consistent with R, for example.

9.3 Cleaning / filling missing data

pandas objects are equipped with various data manipulation methods for dealing with missing data.

9.3.1 Filling missing values: fillna

The `fillna` function can “fill in” NA values with non-null data in a couple of ways, which we illustrate:

Replace NA with a scalar value

```
In [1175]: df2
```

```
Out [1175]:
      one      two      three four  five
a  0.059117  1.138469 -2.400634  bar  True
b         NaN         NaN         NaN  NaN  NaN
c -0.280853  0.025653 -1.386071  bar  False
d         NaN         NaN         NaN  NaN  NaN
e  0.863937  0.252462  1.500571  bar  True
f  1.053202 -2.338595 -0.374279  bar  True
g         NaN         NaN         NaN  NaN  NaN
h -2.359958 -1.157886 -0.551865  bar  False
```

```
In [1176]: df2.fillna(0)
```

```
Out [1176]:
      one      two      three four  five
a  0.059117  1.138469 -2.400634  bar  True
b  0.000000  0.000000  0.000000    0    0
c -0.280853  0.025653 -1.386071  bar  False
```

```

d  0.000000  0.000000  0.000000    0    0
e  0.863937  0.252462  1.500571  bar  True
f  1.053202 -2.338595 -0.374279  bar  True
g  0.000000  0.000000  0.000000    0    0
h -2.359958 -1.157886 -0.551865  bar  False

```

```
In [1177]: df2['four'].fillna('missing')
```

```
Out[1177]:
```

```

a      bar
b  missing
c      bar
d  missing
e      bar
f      bar
g  missing
h      bar

```

```
Name: four
```

Fill gaps forward or backward

Using the same filling arguments as *reindexing*, we can propagate non-null values forward or backward:

```
In [1178]: df
```

```
Out[1178]:
```

```

      one      two      three
a  0.059117  1.138469 -2.400634
b      NaN      NaN      NaN
c -0.280853  0.025653 -1.386071
d      NaN      NaN      NaN
e  0.863937  0.252462  1.500571
f  1.053202 -2.338595 -0.374279
g      NaN      NaN      NaN
h -2.359958 -1.157886 -0.551865

```

```
In [1179]: df.fillna(method='pad')
```

```
Out[1179]:
```

```

      one      two      three
a  0.059117  1.138469 -2.400634
b  0.059117  1.138469 -2.400634
c -0.280853  0.025653 -1.386071
d -0.280853  0.025653 -1.386071
e  0.863937  0.252462  1.500571
f  1.053202 -2.338595 -0.374279
g  1.053202 -2.338595 -0.374279
h -2.359958 -1.157886 -0.551865

```

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 [1180]: df
```

```
Out[1180]:
```

```

      one      two      three
a  0.059117  1.138469 -2.400634
b      NaN      NaN      NaN
c      NaN      NaN      NaN
d      NaN      NaN      NaN
e  0.863937  0.252462  1.500571
f  1.053202 -2.338595 -0.374279
g      NaN      NaN      NaN

```

```
h -2.359958 -1.157886 -0.551865
```

```
In [1181]: df.fillna(method='pad', limit=1)
```

```
Out[1181]:
```

	one	two	three
a	0.059117	1.138469	-2.400634
b	0.059117	1.138469	-2.400634
c	NaN	NaN	NaN
d	NaN	NaN	NaN
e	0.863937	0.252462	1.500571
f	1.053202	-2.338595	-0.374279
g	1.053202	-2.338595	-0.374279
h	-2.359958	-1.157886	-0.551865

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.

9.3.2 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 [1182]: df
```

```
Out[1182]:
```

	one	two	three
a	0.059117	1.138469	-2.400634
b	NaN	0.000000	0.000000
c	NaN	0.000000	0.000000
d	NaN	0.000000	0.000000
e	0.863937	0.252462	1.500571
f	1.053202	-2.338595	-0.374279
g	NaN	0.000000	0.000000
h	-2.359958	-1.157886	-0.551865

```
In [1183]: df.dropna(axis=0)
```

```
Out[1183]:
```

	one	two	three
a	0.059117	1.138469	-2.400634
e	0.863937	0.252462	1.500571
f	1.053202	-2.338595	-0.374279
h	-2.359958	-1.157886	-0.551865

```
In [1184]: df.dropna(axis=1)
```

```
Out[1184]:
```

	two	three
a	1.138469	-2.400634
b	0.000000	0.000000
c	0.000000	0.000000
d	0.000000	0.000000
e	0.252462	1.500571
f	-2.338595	-0.374279
g	0.000000	0.000000
h	-1.157886	-0.551865

```
In [1185]: df['one'].dropna()
Out[1185]:
a    0.059117
e    0.863937
f    1.053202
h   -2.359958
Name: one
```

dropna is presently only implemented for Series and DataFrame, but will be eventually added to Panel. Series.dropna is a simpler method as it only has one axis to consider. DataFrame.dropna has considerably more options, which can be examined *in the API*.

9.3.3 Interpolation

A linear **interpolate** method has been implemented on Series. The default interpolation assumes equally spaced points.

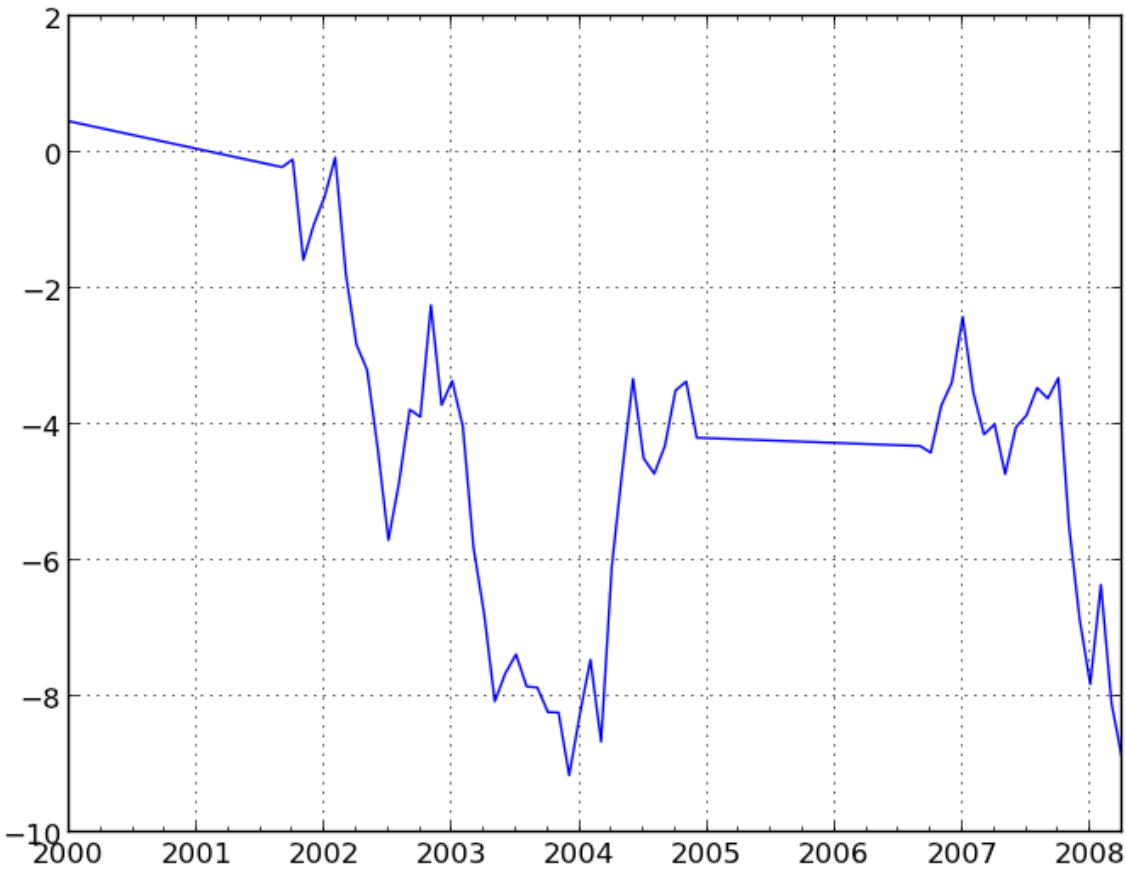
```
In [1186]: ts.count()
Out[1186]: 61

In [1187]: ts.head()
Out[1187]:
2000-01-31    0.469112
2000-02-29         NaN
2000-03-31         NaN
2000-04-28         NaN
2000-05-31         NaN
Freq: BM

In [1188]: ts.interpolate().count()
Out[1188]: 100

In [1189]: ts.interpolate().head()
Out[1189]:
2000-01-31    0.469112
2000-02-29    0.435428
2000-03-31    0.401743
2000-04-28    0.368059
2000-05-31    0.334374
Freq: BM

In [1190]: ts.interpolate().plot()
Out[1190]: <matplotlib.axes.AxesSubplot at 0xb9e46d0>
```



Index aware interpolation is available via the `method` keyword:

```
In [1191]: ts
```

```
Out[1191]:
```

```
2000-01-31    0.469112
2000-02-29         NaN
2002-07-31   -5.689738
2005-01-31         NaN
2008-04-30   -8.916232
```

```
In [1192]: ts.interpolate()
```

```
Out[1192]:
```

```
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
```

```
In [1193]: ts.interpolate(method='time')
```

```
Out[1193]:
```

```
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
```

For a floating-point index, use `method='values'`:

```
In [1194]: ser
```

```
Out[1194]:
```

```
0      0
1     NaN
10     10
```

```
In [1195]: ser.interpolate()
```

```
Out[1195]:
```

```
0      0
1      5
10     10
```

```
In [1196]: ser.interpolate(method='values')
```

```
Out[1196]:
```

```
0      0
1      1
10     10
```

9.3.4 Replacing Generic Values

Often times we want to replace arbitrary values with other values. New in v0.8 is the `replace` method in `Series/DataFrame` that 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 [1197]: ser = Series([0., 1., 2., 3., 4.])
```

```
In [1198]: ser.replace(0, 5)
```

```
Out[1198]:
```

```
0      5
1      1
2      2
3      3
4      4
```

You can replace a list of values by a list of other values:

```
In [1199]: ser.replace([0, 1, 2, 3, 4], [4, 3, 2, 1, 0])
```

```
Out[1199]:
```

```
0      4
1      3
2      2
3      1
4      0
```

You can also specify a mapping dict:

```
In [1200]: ser.replace({0: 10, 1: 100})
```

```
Out[1200]:
```

```
0      10
1     100
2      2
3      3
4      4
```

For a `DataFrame`, you can specify individual values by column:

```
In [1201]: df = DataFrame({'a': [0, 1, 2, 3, 4], 'b': [5, 6, 7, 8, 9]})
```

```
In [1202]: df.replace({'a': 0, 'b': 5}, 100)
```

```
Out[1202]:
```

```
   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 [1203]: ser.replace([1, 2, 3], method='pad')
```

```
Out[1203]:
```

```
0    0
1    0
2    0
3    0
4    4
```

9.4 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 [1204]: s = Series(randn(5), index=[0, 2, 4, 6, 7])
```

```
In [1205]: s > 0
```

```
Out[1205]:
```

```
0    False
2     True
4     True
6     True
7     True
```

```
In [1206]: (s > 0).dtype
```

```
Out[1206]: dtype('bool')
```

```
In [1207]: crit = (s > 0).reindex(range(8))
```

```
In [1208]: crit
```

```
Out[1208]:
```

```
0    False
1     NaN
2     True
3     NaN
4     True
```



```

5      NaN
6      True
7      True

```

```

In [1209]: crit.dtype
Out[1209]: dtype('object')

```

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 [1210]: reindexed = s.reindex(range(8)).fillna(0)
```

```
In [1211]: reindexed[crit]
```

```

-----
ValueError                                Traceback (most recent call last)
<ipython-input-1211-2da204ed1ac7> in <module>()
----> 1 reindexed[crit]
/home/wesm/code/pandas/pandas/core/series.pyc in __getitem__(self, key)
    521         # special handling of boolean data with NAs stored in object
    522         # arrays. Since we can't represent NA with dtype=bool
--> 523         if _is_bool_indexer(key):
    524             key = self._check_bool_indexer(key)
    525             key = np.asarray(key, dtype=bool)
/home/wesm/code/pandas/pandas/core/common.pyc in _is_bool_indexer(key)
    685         if not lib.is_bool_array(key):
    686             if isnull(key).any():
--> 687                 raise ValueError('cannot index with vector containing '
    688                                 'NA / NaN values')
    689         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 [1212]: reindexed[crit.fillna(False)]
Out[1212]:

```

```

2      1.314232
4      0.690579
6      0.995761
7      2.396780

```

```
In [1213]: reindexed[crit.fillna(True)]
```

```

Out[1213]:
1      0.000000
2      1.314232
3      0.000000
4      0.690579
5      0.000000
6      0.995761
7      2.396780

```


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
- 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 method 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.

10.1 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:

```
>>> 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
- A list of any of the above things

Collectively we refer to the grouping objects as the **keys**. For example, consider the following DataFrame:

```
In [518]: df = DataFrame({'A' : ['foo', 'bar', 'foo', 'bar',  
.....:                        'foo', 'bar', 'foo', 'foo'],  
.....:                  'B' : ['one', 'one', 'two', 'three',  
.....:                        'two', 'two', 'one', 'three'],  
.....:                  'C' : randn(8), 'D' : randn(8)})  
.....:
```

```
In [519]: df  
Out[519]:
```

	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 [520]: grouped = df.groupby('A')
```

```
In [521]: grouped = df.groupby(['A', 'B'])
```

These will split the DataFrame on its index (rows). We could also split by the columns:

```
In [522]: def get_letter_type(letter):  
.....:     if letter.lower() in 'aeiou':  
.....:         return 'vowel'  
.....:     else:  
.....:         return 'consonant'  
.....:
```

```
In [523]: grouped = df.groupby(get_letter_type, axis=1)
```

Starting with 0.8, pandas Index objects now supports 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 [524]: lst = [1, 2, 3, 1, 2, 3]
```

```
In [525]: s = Series([1, 2, 3, 10, 20, 30], lst)
```

```
In [526]: grouped = s.groupby(level=0)
```

```
In [527]: grouped.first()
```

```
Out [527]:
```

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

```
In [528]: grouped.last()
```

```
Out [528]:
```

```
1    10
2    20
3    30
```

```
In [529]: grouped.sum()
```

```
Out [529]:
```

```
1    11
2    22
3    33
```

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.

10.1.1 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 [530]: df.groupby('A').groups
```

```
Out [530]: {'bar': [1, 3, 5], 'foo': [0, 2, 4, 6, 7]}
```

```
In [531]: df.groupby(get_letter_type, axis=1).groups
```

```
Out [531]: {'consonant': ['B', 'C', 'D'], 'vowel': ['A']}
```

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 [532]: grouped = df.groupby(['A', 'B'])
```

```
In [533]: grouped.groups
```

```
Out [533]:
```

```
{('bar', 'one'): [1],
 ('bar', 'three'): [3],
 ('bar', 'two'): [5],
 ('foo', 'one'): [0, 6],
 ('foo', 'three'): [7],
 ('foo', 'two'): [2, 4]}
```

```
In [534]: len(grouped)
```

```
Out [534]: 6
```

By default the group keys are sorted during the groupby operation. You may however pass `sort=False` for potential speedups:

```
In [535]: df2 = DataFrame({'X' : ['B', 'B', 'A', 'A'], 'Y' : [1, 2, 3, 4]})
```

```
In [536]: df2.groupby(['X'], sort=True).sum()
```

```
Out[536]:
```

```
      Y
X
A     7
B     3
```

```
In [537]: df2.groupby(['X'], sort=False).sum()
```

```
Out[537]:
```

```
      Y
X
B     3
A     7
```

10.1.2 GroupBy with MultiIndex

With *hierarchically-indexed data*, it's quite natural to group by one of the levels of the hierarchy.

```
In [538]: s
```

```
Out[538]:
```

```
first second
bar    one   -0.424972
      two    0.567020
baz    one    0.276232
      two   -1.087401
foo    one   -0.673690
      two    0.113648
qux    one   -1.478427
      two    0.524988
```

```
In [539]: grouped = s.groupby(level=0)
```

```
In [540]: grouped.sum()
```

```
Out[540]:
```

```
first
bar    0.142048
baz   -0.811169
foo   -0.560041
qux   -0.953439
```

If the MultiIndex has names specified, these can be passed instead of the level number:

```
In [541]: s.groupby(level='second').sum()
```

```
Out[541]:
```

```
second
one   -2.300857
two    0.118256
```

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 [542]: s.sum(level='second')
```

```
Out[542]:
```

```
second
one   -2.300857
two    0.118256
```

Also as of v0.6, grouping with multiple levels is supported.

```
In [543]: s
Out[543]:
first  second  third
bar    doo     one    0.404705
        two    0.577046
baz    bee     one   -1.715002
        two   -1.039268
foo    bop     one   -0.370647
        two   -1.157892
qux    bop     one   -1.344312
        two    0.844885

In [544]: s.groupby(level=['first', 'second']).sum()
Out[544]:
first  second
bar    doo      0.981751
baz    bee     -2.754270
foo    bop     -1.528539
qux    bop     -0.499427
```

More on the `sum` function and aggregation later.

10.1.3 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 [545]: grouped = df.groupby(['A'])

In [546]: grouped_C = grouped['C']

In [547]: grouped_D = grouped['D']
```

This is mainly syntactic sugar for the alternative and much more verbose:

```
In [548]: df['C'].groupby(df['A'])
Out[548]: <pandas.core.groupby.SeriesGroupBy at 0xc5b27d0>
```

Additionally this method avoids recomputing the internal grouping information derived from the passed key.

10.2 Iterating through groups

With the `GroupBy` object in hand, iterating through the grouped data is very natural and functions similarly to `itertools.groupby`:

```
In [549]: grouped = df.groupby('A')

In [550]: for name, group in grouped:
.....:     print name
.....:     print group
.....:
bar
   A      B      C      D
1 bar  one -0.282863 -2.104569
3 bar three -1.135632  1.071804
```

```
5 bar    two -0.173215 -0.706771
foo
   A      B      C      D
0 foo  one  0.469112 -0.861849
2 foo  two -1.509059 -0.494929
4 foo  two  1.212112  0.721555
6 foo  one  0.119209 -1.039575
7 foo three -1.044236  0.271860
```

In the case of grouping by multiple keys, the group name will be a tuple:

```
In [551]: for name, group in df.groupby(['A', 'B']):
.....:     print name
.....:     print group
.....:
('bar', 'one')
   A      B      C      D
1 bar  one -0.282863 -2.104569
('bar', 'three')
   A      B      C      D
3 bar three -1.135632  1.071804
('bar', 'two')
   A      B      C      D
5 bar  two -0.173215 -0.706771
('foo', 'one')
   A      B      C      D
0 foo  one  0.469112 -0.861849
6 foo  one  0.119209 -1.039575
('foo', 'three')
   A      B      C      D
7 foo three -1.044236  0.27186
('foo', 'two')
   A      B      C      D
2 foo  two -1.509059 -0.494929
4 foo  two  1.212112  0.721555
```

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:`.

10.3 Aggregation

Once the `GroupBy` object has been created, several methods are available to perform a computation on the grouped data. An obvious one is aggregation via the `aggregate` or equivalently `agg` method:

```
In [552]: grouped = df.groupby('A')
```

```
In [553]: grouped.agg(np.sum)
```

```
Out[553]:
           C      D
A
bar -1.591710 -1.739537
foo -0.752861 -1.402938
```

```
In [554]: grouped = df.groupby(['A', 'B'])
```

```
In [555]: grouped.agg(np.sum)
```

```
Out[555]:
```


	A	B	C	D
bar	one		-0.282863	-2.104569
	three		-1.135632	1.071804
	two		-0.173215	-0.706771
foo	one		0.588321	-1.901424
	three		-1.044236	0.271860
	two		-0.296946	0.226626

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 [556]: grouped = df.groupby(['A', 'B'], as_index=False)
```

```
In [557]: grouped.aggregate(np.sum)
```

```
Out[557]:
```

	A	B	C	D
0	bar	one	-0.282863	-2.104569
1	bar	three	-1.135632	1.071804
2	bar	two	-0.173215	-0.706771
3	foo	one	0.588321	-1.901424
4	foo	three	-1.044236	0.271860
5	foo	two	-0.296946	0.226626

```
In [558]: df.groupby('A', as_index=False).sum()
```

```
Out[558]:
```

	A	C	D
0	bar	-1.591710	-1.739537
1	foo	-0.752861	-1.402938

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 [559]: df.groupby(['A', 'B']).sum().reset_index()
```

```
Out[559]:
```

	A	B	C	D
0	bar	one	-0.282863	-2.104569
1	bar	three	-1.135632	1.071804
2	bar	two	-0.173215	-0.706771
3	foo	one	0.588321	-1.901424
4	foo	three	-1.044236	0.271860
5	foo	two	-0.296946	0.226626

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 [560]: grouped.size()
```

```
Out[560]:
```

	A	B
bar	one	1
	three	1
	two	1
foo	one	2
	three	1
	two	2

10.3.1 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 [561]: grouped = df.groupby('A')

In [562]: grouped['C'].agg([np.sum, np.mean, np.std])
Out[562]:
```

	sum	mean	std
A			
bar	-1.591710	-0.530570	0.526860
foo	-0.752861	-0.150572	1.113308

If a dict is passed, the keys will be used to name the columns. Otherwise the function's name (stored in the function object) will be used.

```
In [563]: grouped['D'].agg({'result1' : np.sum,
.....:                    'result2' : np.mean})
.....:
Out[563]:
```

	result2	result1
A		
bar	-0.579846	-1.739537
foo	-0.280588	-1.402938

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 [564]: grouped.agg([np.sum, np.mean, np.std])
Out[564]:
```

	C			D		
	sum	mean	std	sum	mean	std
A						
bar	-1.591710	-0.530570	0.526860	-1.739537	-0.579846	1.591986
foo	-0.752861	-0.150572	1.113308	-1.402938	-0.280588	0.753219

Passing a dict of functions has different behavior by default, see the next section.

10.3.2 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 [565]: grouped.agg({'C' : np.sum,
.....:                'D' : lambda x: np.std(x, ddof=1)})
.....:
Out[565]:
```

	C	D
A		
bar	-1.591710	1.591986
foo	-0.752861	0.753219

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 [566]: grouped.agg({'C' : 'sum', 'D' : 'std'})
Out[566]:
```

	C	D
A		

```
bar -1.591710  1.591986
foo -0.752861  0.753219
```

10.3.3 Cython-optimized aggregation functions

Some common aggregations, currently only `sum`, `mean`, and `std`, have optimized Cython implementations:

```
In [567]: df.groupby('A').sum()
Out[567]:
```

```
      C      D
A
bar -1.591710 -1.739537
foo -0.752861 -1.402938
```

```
In [568]: df.groupby(['A', 'B']).mean()
Out[568]:
```

```
      C      D
A  B
bar one  -0.282863 -2.104569
     three -1.135632  1.071804
     two   -0.173215 -0.706771
foo one   0.294161 -0.950712
     three -1.044236  0.271860
     two   -0.148473  0.113313
```

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).

10.4 Transformation

The `transform` method returns an object that is indexed the same (same size) as the one being grouped. Thus, the passed transform function should return a result that is the same size as the group chunk. For example, suppose we wished to standardize the data within each group:

```
In [569]: index = date_range('10/1/1999', periods=1100)
```

```
In [570]: ts = Series(np.random.normal(0.5, 2, 1100), index)
```

```
In [571]: ts = rolling_mean(ts, 100, 100).dropna()
```

```
In [572]: ts.head()
```

```
Out[572]:
2000-01-08    0.536925
2000-01-09    0.494448
2000-01-10    0.496114
2000-01-11    0.443475
2000-01-12    0.474744
Freq: D
```

```
In [573]: ts.tail()
```

```
Out[573]:
2002-09-30    0.978859
2002-10-01    0.994704
2002-10-02    0.953789
2002-10-03    0.932345
```

```
2002-10-04    0.915581
Freq: D
```

```
In [574]: key = lambda x: x.year
```

```
In [575]: zscore = lambda x: (x - x.mean()) / x.std()
```

```
In [576]: 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 [577]: grouped = ts.groupby(key)
```

```
In [578]: grouped.mean()
```

```
Out[578]:
2000    0.416344
2001    0.416987
2002    0.599380
```

```
In [579]: grouped.std()
```

```
Out[579]:
2000    0.174755
2001    0.309640
2002    0.266172
```

```
# Transformed Data
```

```
In [580]: grouped_trans = transformed.groupby(key)
```

```
In [581]: grouped_trans.mean()
```

```
Out[581]:
2000   -3.122696e-16
2001   -2.688869e-16
2002   -1.499001e-16
```

```
In [582]: grouped_trans.std()
```

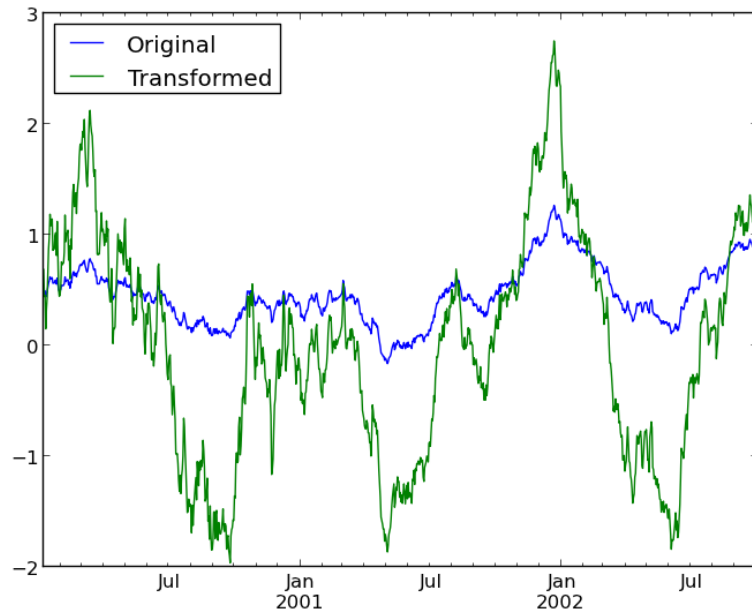
```
Out[582]:
2000    1
2001    1
2002    1
```

We can also visually compare the original and transformed data sets.

```
In [583]: compare = DataFrame({'Original': ts, 'Transformed': transformed})
```

```
In [584]: compare.plot()
```

```
Out[584]: <matplotlib.axes.AxesSubplot at 0x9d176d0>
```



Another common data transform is to replace missing data with the group mean.

```
In [585]: data_df
Out[585]:
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1000 entries, 0 to 999
Data columns:
A    908 non-null values
B    953 non-null values
C    820 non-null values
dtypes: float64(3)

In [586]: countries = np.array(['US', 'UK', 'GR', 'JP'])

In [587]: key = countries[np.random.randint(0, 4, 1000)]

In [588]: grouped = data_df.groupby(key)

# Non-NA count in each group
In [589]: grouped.count()
Out[589]:
      A    B    C
GR  219  223  194
JP  238  250  211
UK  228  239  213
US  223  241  202
```

```
In [590]: f = lambda x: x.fillna(x.mean())

In [591]: 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 [592]: grouped_trans = transformed.groupby(key)

In [593]: grouped.mean() # original group means
```

Out[593]:

	A	B	C
GR	0.093655	-0.004978	-0.049883
JP	-0.067605	0.025828	0.006752
UK	-0.054246	0.031742	0.068974
US	0.084334	-0.013433	0.056589

In [594]: grouped_trans.mean() # *transformation did not change group means*

Out[594]:

	A	B	C
GR	0.093655	-0.004978	-0.049883
JP	-0.067605	0.025828	0.006752
UK	-0.054246	0.031742	0.068974
US	0.084334	-0.013433	0.056589

In [595]: grouped.count() # *original has some missing data points*

Out[595]:

	A	B	C
GR	219	223	194
JP	238	250	211
UK	228	239	213
US	223	241	202

In [596]: grouped_trans.count() # *counts after transformation*

Out[596]:

	A	B	C
GR	234	234	234
JP	264	264	264
UK	251	251	251
US	251	251	251

In [597]: grouped_trans.size() # *Verify non-NA count equals group size*

Out[597]:

GR	234
JP	264
UK	251
US	251

10.5 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 [598]: grouped = df.groupby('A')

In [599]: grouped.agg(lambda x: x.std())

Out[599]:

	B	C	D
A			
bar	NaN	0.526860	1.591986
foo	NaN	1.113308	0.753219

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 [600]: grouped.std()
```

```
Out[600]:
```

	C	D
A		
bar	0.526860	1.591986
foo	1.113308	0.753219

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 grouping, documented next). This enables some operations to be carried out rather succinctly:

```
In [601]: tsdf = DataFrame(randn(1000, 3),
.....:                    index=date_range('1/1/2000', periods=1000),
.....:                    columns=['A', 'B', 'C'])
.....:
```

```
In [602]: tsdf.ix[:,2] = np.nan
```

```
In [603]: grouped = tsdf.groupby(lambda x: x.year)
```

```
In [604]: grouped.fillna(method='pad')
```

```
Out[604]:
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 1000 entries, 2000-01-01 00:00:00 to 2002-09-26 00:00:00
Freq: D
Data columns:
A      998 non-null values
B      998 non-null values
C      998 non-null values
dtypes: float64(3)
```

In this example, we chopped the collection of time series into yearly chunks then independently called *fillna* on the groups.

10.6 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 [605]: df
```

```
Out[605]:
```

	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

```
In [606]: grouped = df.groupby('A')
```

```
# could also just call .describe()
In [607]: grouped['C'].apply(lambda x: x.describe())
Out[607]:
A
bar  count      3.000000
     mean     -0.530570
     std       0.526860
     min     -1.135632
     25%     -0.709248
     50%     -0.282863
     75%     -0.228039
     max     -0.173215
foo  count      5.000000
     mean     -0.150572
     std       1.113308
     min     -1.509059
     25%     -1.044236
     50%       0.119209
     75%       0.469112
     max       1.212112
```

The dimension of the returned result can also change:

```
In [608]: grouped = df.groupby('A')['C']

In [609]: def f(group):
.....:     return DataFrame({'original' : group,
.....:                       'demeaned' : group - group.mean()})
.....:

In [610]: grouped.apply(f)
Out[610]:
   demeaned  original
0    0.619685    0.469112
1    0.247707   -0.282863
2   -1.358486   -1.509059
3   -0.605062   -1.135632
4    1.362684    1.212112
5    0.357355   -0.173215
6    0.269781    0.119209
7   -0.893664   -1.044236
```

`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 [611]: def f(x):
.....:     return Series([ x, x**2 ], index = ['x', 'x^s'])
.....:

In [612]: s = Series(np.random.rand(5))

In [613]: s
Out[613]:
0    0.785887
1    0.498525
2    0.933703
3    0.154106
4    0.271779
```



```
In [614]: s.apply(f)
Out[614]:
```

	x	x ^s
0	0.785887	0.617619
1	0.498525	0.248528
2	0.933703	0.871801
3	0.154106	0.023749
4	0.271779	0.073864

10.7 Other useful features

10.7.1 Automatic exclusion of “nuisance” columns

Again consider the example DataFrame we’ve been looking at:

```
In [615]: df
Out[615]:
```

	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

Supposed we wished 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 [616]: df.groupby('A').std()
Out[616]:
```

		C	D
A			
bar		0.526860	1.591986
foo		1.113308	0.753219

10.7.2 NA group handling

If there are any NaN values in the grouping key, these will be automatically excluded. So there will never be an “NA 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).

10.7.3 Grouping with ordered factors

Categorical variables represented as instance of pandas’s `Factor` class can be used as group keys. If so, the order of the levels will be preserved:

```
In [617]: data = Series(np.random.randn(100))
In [618]: factor = qcut(data, [0, .25, .5, .75, 1.])
```

```
In [619]: data.groupby(factor).mean()
```

```
Out[619]:
```

```
[-3.469, -0.737]    -1.269581  
[-0.737,  0.214]    -0.216269  
[ 0.214,  1.0572]     0.680402  
[ 1.0572,  3.0762]     1.629338
```

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.

11.1 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 [1055]: df = DataFrame(np.random.randn(10, 4))
```

```
In [1056]: df
```

```
Out[1056]:
```

	0	1	2	3
0	0.469112	-0.282863	-1.509059	-1.135632
1	1.212112	-0.173215	0.119209	-1.044236
2	-0.861849	-2.104569	-0.494929	1.071804
3	0.721555	-0.706771	-1.039575	0.271860
4	-0.424972	0.567020	0.276232	-1.087401
5	-0.673690	0.113648	-1.478427	0.524988
6	0.404705	0.577046	-1.715002	-1.039268
7	-0.370647	-1.157892	-1.344312	0.844885
8	1.075770	-0.109050	1.643563	-1.469388
9	0.357021	-0.674600	-1.776904	-0.968914

```
# break it into pieces
```

```
In [1057]: pieces = [df[:3], df[3:7], df[7:]]
```

```
In [1058]: concatenated = concat(pieces)
```

```
In [1059]: concatenated
```

```
Out[1059]:
```

	0	1	2	3
0	0.469112	-0.282863	-1.509059	-1.135632
1	1.212112	-0.173215	0.119209	-1.044236
2	-0.861849	-2.104569	-0.494929	1.071804
3	0.721555	-0.706771	-1.039575	0.271860
4	-0.424972	0.567020	0.276232	-1.087401
5	-0.673690	0.113648	-1.478427	0.524988
6	0.404705	0.577046	-1.715002	-1.039268

```
7 -0.370647 -1.157892 -1.344312  0.844885
8  1.075770 -0.109050  1.643563 -1.469388
9  0.357021 -0.674600 -1.776904 -0.968914
```

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”:

```
concat(objs, axis=0, join='outer', join_axes=None, ignore_index=False,
       keys=None, levels=None, names=None, verify_integrity=False)
```

- `objs`: list or dict 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)
- `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
- `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. If keys passed, specific levels to use for the resulting 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
- `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.

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 [1060]: concatenated = concat(pieces, keys=['first', 'second', 'third'])
```

```
In [1061]: concatenated
```

```
Out[1061]:
```

```
          0          1          2          3
first 0  0.469112 -0.282863 -1.509059 -1.135632
      1  1.212112 -0.173215  0.119209 -1.044236
      2 -0.861849 -2.104569 -0.494929  1.071804
second 3  0.721555 -0.706771 -1.039575  0.271860
      4 -0.424972  0.567020  0.276232 -1.087401
      5 -0.673690  0.113648 -1.478427  0.524988
      6  0.404705  0.577046 -1.715002 -1.039268
third  7 -0.370647 -1.157892 -1.344312  0.844885
      8  1.075770 -0.109050  1.643563 -1.469388
      9  0.357021 -0.674600 -1.776904 -0.968914
```

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 [1062]: concatenated.ix['second']
Out[1062]:
```

	0	1	2	3
3	0.721555	-0.706771	-1.039575	0.271860
4	-0.424972	0.567020	0.276232	-1.087401
5	-0.673690	0.113648	-1.478427	0.524988
6	0.404705	0.577046	-1.715002	-1.039268

It's not a stretch to see how this can be very useful. More detail on this functionality below.

11.1.1 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 [1063]: from pandas.util.testing import randn

In [1064]: df = DataFrame(np.random.randn(10, 4), columns=['a', 'b', 'c', 'd'],
.....:                    index=[randn(5) for _ in xrange(10)])
.....:

In [1065]: df
Out[1065]:
```

	a	b	c	d
WA4ew	-1.294524	0.413738	0.276662	-0.472035
zYqRP	-0.013960	-0.362543	-0.006154	-0.923061
gbVku	0.895717	0.805244	-1.206412	2.565646
uTXd3	1.431256	1.340309	-1.170299	-0.226169
j1kL5	0.410835	0.813850	0.132003	-0.827317
ATfJx	-0.076467	-1.187678	1.130127	-1.436737
4J0k1	-1.413681	1.607920	1.024180	0.569605
O0NnD	0.875906	-2.211372	0.974466	-2.006747
PYjP5	-0.410001	-0.078638	0.545952	-1.219217
k4uLB	-1.226825	0.769804	-1.281247	-0.727707

```
In [1066]: concat([df.ix[:7, ['a', 'b']], df.ix[2:-2, ['c']],
.....:             df.ix[-7:, ['d']], axis=1)
.....:
Out[1066]:
```

	a	b	c	d
4J0k1	-1.413681	1.607920	1.024180	0.569605
ATfJx	-0.076467	-1.187678	1.130127	-1.436737
O0NnD	NaN	NaN	0.974466	-2.006747
PYjP5	NaN	NaN	NaN	-1.219217
WA4ew	-1.294524	0.413738	NaN	NaN
gbVku	0.895717	0.805244	-1.206412	NaN
j1kL5	0.410835	0.813850	0.132003	-0.827317
k4uLB	NaN	NaN	NaN	-0.727707

```
uTXd3  1.431256  1.340309 -1.170299 -0.226169
zYqRP  -0.013960 -0.362543      NaN      NaN
```

Note that the row indexes have been unioned and sorted. Here is the same thing with `join='inner'`:

```
In [1067]: concat([df.ix[:7, ['a', 'b']], df.ix[2:-2, ['c']],
.....:           df.ix[-7:, ['d']]], axis=1, join='inner')
.....:
Out[1067]:
```

	a	b	c	d
uTXd3	1.431256	1.340309	-1.170299	-0.226169
j1kL5	0.410835	0.813850	0.132003	-0.827317
ATfJx	-0.076467	-1.187678	1.130127	-1.436737
4J0k1	-1.413681	1.607920	1.024180	0.569605

Lastly, suppose we just wanted to reuse the *exact index* from the original DataFrame:

```
In [1068]: concat([df.ix[:7, ['a', 'b']], df.ix[2:-2, ['c']],
.....:           df.ix[-7:, ['d']]], axis=1, join_axes=[df.index])
.....:
Out[1068]:
```

	a	b	c	d
WA4ew	-1.294524	0.413738	NaN	NaN
zYqRP	-0.013960	-0.362543	NaN	NaN
gbVku	0.895717	0.805244	-1.206412	NaN
uTXd3	1.431256	1.340309	-1.170299	-0.226169
j1kL5	0.410835	0.813850	0.132003	-0.827317
ATfJx	-0.076467	-1.187678	1.130127	-1.436737
4J0k1	-1.413681	1.607920	1.024180	0.569605
OONnD	NaN	NaN	0.974466	-2.006747
PYjP5	NaN	NaN	NaN	-1.219217
k4uLB	NaN	NaN	NaN	-0.727707

11.1.2 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 [1069]: s = Series(randn(10), index=np.arange(10))
```

```
In [1070]: s1 = s[:5] # note we're slicing with labels here, so 5 is included
```

```
In [1071]: s2 = s[6:]
```

```
In [1072]: s1.append(s2)
```

```
Out[1072]:
0    -0.121306
1    -0.097883
2     0.695775
3     0.341734
4     0.959726
6    -0.619976
7     0.149748
8    -0.732339
9     0.687738
```

In the case of `DataFrame`, the indexes must be disjoint but the columns do not need to be:

```
In [1073]: df = DataFrame(randn(6, 4), index=date_range('1/1/2000', periods=6),
.....:                  columns=['A', 'B', 'C', 'D'])
.....:
```

```
In [1074]: df1 = df.ix[:3]
```

```
In [1075]: df2 = df.ix[3:, :3]
```

```
In [1076]: df1
```

```
Out [1076]:
```

	A	B	C	D
2000-01-01	0.176444	0.403310	-0.154951	0.301624
2000-01-02	-2.179861	-1.369849	-0.954208	1.462696
2000-01-03	-1.743161	-0.826591	-0.345352	1.314232

```
In [1077]: df2
```

```
Out [1077]:
```

	A	B	C
2000-01-04	0.690579	0.995761	2.396780
2000-01-05	3.357427	-0.317441	-1.236269
2000-01-06	-0.487602	-0.082240	-2.182937

```
In [1078]: df1.append(df2)
```

```
Out [1078]:
```

	A	B	C	D
2000-01-01	0.176444	0.403310	-0.154951	0.301624
2000-01-02	-2.179861	-1.369849	-0.954208	1.462696
2000-01-03	-1.743161	-0.826591	-0.345352	1.314232
2000-01-04	0.690579	0.995761	2.396780	NaN
2000-01-05	3.357427	-0.317441	-1.236269	NaN
2000-01-06	-0.487602	-0.082240	-2.182937	NaN

append may take multiple objects to concatenate:

```
In [1079]: df1 = df.ix[:2]
```

```
In [1080]: df2 = df.ix[2:4]
```

```
In [1081]: df3 = df.ix[4:]
```

```
In [1082]: df1.append([df2, df3])
```

```
Out [1082]:
```

	A	B	C	D
2000-01-01	0.176444	0.403310	-0.154951	0.301624
2000-01-02	-2.179861	-1.369849	-0.954208	1.462696
2000-01-03	-1.743161	-0.826591	-0.345352	1.314232
2000-01-04	0.690579	0.995761	2.396780	0.014871
2000-01-05	3.357427	-0.317441	-1.236269	0.896171
2000-01-06	-0.487602	-0.082240	-2.182937	0.380396

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.

11.1.3 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:

```
In [1083]: df1 = DataFrame(randn(6, 4), columns=['A', 'B', 'C', 'D'])
```

```
In [1084]: df2 = DataFrame(randn(3, 4), columns=['A', 'B', 'C', 'D'])
```

```
In [1085]: df1
```

```
Out[1085]:
```

	A	B	C	D
0	0.084844	0.432390	1.519970	-0.493662
1	0.600178	0.274230	0.132885	-0.023688
2	2.410179	1.450520	0.206053	-0.251905
3	-2.213588	1.063327	1.266143	0.299368
4	-0.863838	0.408204	-1.048089	-0.025747
5	-0.988387	0.094055	1.262731	1.289997

```
In [1086]: df2
```

```
Out[1086]:
```

	A	B	C	D
0	0.082423	-0.055758	0.536580	-0.489682
1	0.369374	-0.034571	-2.484478	-0.281461
2	0.030711	0.109121	1.126203	-0.977349

To do this, use the `ignore_index` argument:

```
In [1087]: concat([df1, df2], ignore_index=True)
```

```
Out[1087]:
```

	A	B	C	D
0	0.084844	0.432390	1.519970	-0.493662
1	0.600178	0.274230	0.132885	-0.023688
2	2.410179	1.450520	0.206053	-0.251905
3	-2.213588	1.063327	1.266143	0.299368
4	-0.863838	0.408204	-1.048089	-0.025747
5	-0.988387	0.094055	1.262731	1.289997
6	0.082423	-0.055758	0.536580	-0.489682
7	0.369374	-0.034571	-2.484478	-0.281461
8	0.030711	0.109121	1.126203	-0.977349

This is also a valid argument to `DataFrame.append`:

```
In [1088]: df1.append(df2, ignore_index=True)
```

```
Out[1088]:
```

	A	B	C	D
0	0.084844	0.432390	1.519970	-0.493662
1	0.600178	0.274230	0.132885	-0.023688
2	2.410179	1.450520	0.206053	-0.251905
3	-2.213588	1.063327	1.266143	0.299368
4	-0.863838	0.408204	-1.048089	-0.025747
5	-0.988387	0.094055	1.262731	1.289997
6	0.082423	-0.055758	0.536580	-0.489682
7	0.369374	-0.034571	-2.484478	-0.281461
8	0.030711	0.109121	1.126203	-0.977349

11.1.4 More concatenating with group keys

Let's consider a variation on the first example presented:

```
In [1089]: df = DataFrame(np.random.randn(10, 4))
```

```
In [1090]: df
```

```
Out[1090]:
```

	0	1	2	3
0	1.474071	-0.064034	-1.282782	0.781836
1	-1.071357	0.441153	2.353925	0.583787
2	0.221471	-0.744471	0.758527	1.729689
3	-0.964980	-0.845696	-1.340896	1.846883
4	-1.328865	1.682706	-1.717693	0.888782
5	0.228440	0.901805	1.171216	0.520260
6	-1.197071	-1.066969	-0.303421	-0.858447
7	0.306996	-0.028665	0.384316	1.574159
8	1.588931	0.476720	0.473424	-0.242861
9	-0.014805	-0.284319	0.650776	-1.461665

```
# break it into pieces
```

```
In [1091]: pieces = [df.ix[:, [0, 1]], df.ix[:, [2]], df.ix[:, [3]]]
```

```
In [1092]: result = concat(pieces, axis=1, keys=['one', 'two', 'three'])
```

```
In [1093]: result
```

```
Out[1093]:
```

	one		two		three
	0	1	2	3	
0	1.474071	-0.064034	-1.282782	0.781836	
1	-1.071357	0.441153	2.353925	0.583787	
2	0.221471	-0.744471	0.758527	1.729689	
3	-0.964980	-0.845696	-1.340896	1.846883	
4	-1.328865	1.682706	-1.717693	0.888782	
5	0.228440	0.901805	1.171216	0.520260	
6	-1.197071	-1.066969	-0.303421	-0.858447	
7	0.306996	-0.028665	0.384316	1.574159	
8	1.588931	0.476720	0.473424	-0.242861	
9	-0.014805	-0.284319	0.650776	-1.461665	

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 [1094]: pieces = {'one': df.ix[:, [0, 1]],
.....:               'two': df.ix[:, [2]],
.....:               'three': df.ix[:, [3]]}
.....:
```

```
In [1095]: concat(pieces, axis=1)
```

```
Out[1095]:
```

	one		three	two
	0	1	3	2
0	1.474071	-0.064034	0.781836	-1.282782
1	-1.071357	0.441153	0.583787	2.353925
2	0.221471	-0.744471	1.729689	0.758527
3	-0.964980	-0.845696	1.846883	-1.340896
4	-1.328865	1.682706	0.888782	-1.717693
5	0.228440	0.901805	0.520260	1.171216
6	-1.197071	-1.066969	-0.858447	-0.303421

```
7  0.306996 -0.028665  1.574159  0.384316
8  1.588931  0.476720 -0.242861  0.473424
9 -0.014805 -0.284319 -1.461665  0.650776
```

```
In [1096]: concat(pieces, keys=['three', 'two'])
```

```
Out[1096]:
```

		2	3
three	0	NaN	0.781836
	1	NaN	0.583787
	2	NaN	1.729689
	3	NaN	1.846883
	4	NaN	0.888782
	5	NaN	0.520260
	6	NaN	-0.858447
	7	NaN	1.574159
	8	NaN	-0.242861
	9	NaN	-1.461665
two	0	-1.282782	NaN
	1	2.353925	NaN
	2	0.758527	NaN
	3	-1.340896	NaN
	4	-1.717693	NaN
	5	1.171216	NaN
	6	-0.303421	NaN
	7	0.384316	NaN
	8	0.473424	NaN
	9	0.650776	NaN

The MultiIndex created has levels that are constructed from the passed keys and the columns of the DataFrame pieces:

```
In [1097]: result.columns.levels
```

```
Out[1097]: [Index([one, two, three], dtype=object), Int64Index([0, 1, 2, 3], dtype=int64)]
```

If you wish to specify other levels (as will occasionally be the case), you can do so using the levels argument:

```
In [1098]: result = concat(pieces, axis=1, keys=['one', 'two', 'three'],
.....:                      levels=[['three', 'two', 'one', 'zero']],
.....:                      names=['group_key'])
.....:
```

```
In [1099]: result
```

```
Out[1099]:
```

group_key	one		two	three
	0	1	2	3
0	1.474071	-0.064034	-1.282782	0.781836
1	-1.071357	0.441153	2.353925	0.583787
2	0.221471	-0.744471	0.758527	1.729689
3	-0.964980	-0.845696	-1.340896	1.846883
4	-1.328865	1.682706	-1.717693	0.888782
5	0.228440	0.901805	1.171216	0.520260
6	-1.197071	-1.066969	-0.303421	-0.858447
7	0.306996	-0.028665	0.384316	1.574159
8	1.588931	0.476720	0.473424	-0.242861
9	-0.014805	-0.284319	0.650776	-1.461665

```
In [1100]: result.columns.levels
```

```
Out[1100]: [Index([three, two, one, zero], dtype=object),
Int64Index([0, 1, 2, 3], dtype=int64)]
```

Yes, this is fairly esoteric, but is actually necessary for implementing things like GroupBy where the order of a categorical variable is meaningful.

11.1.5 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 [1101]: df = DataFrame(np.random.randn(8, 4), columns=['A', 'B', 'C', 'D'])
```

```
In [1102]: df
```

```
Out[1102]:
```

	A	B	C	D
0	-1.137707	-0.891060	-0.693921	1.613616
1	0.464000	0.227371	-0.496922	0.306389
2	-2.290613	-1.134623	-1.561819	-0.260838
3	0.281957	1.523962	-0.902937	0.068159
4	-0.057873	-0.368204	-1.144073	0.861209
5	0.800193	0.782098	-1.069094	-1.099248
6	0.255269	0.009750	0.661084	0.379319
7	-0.008434	1.952541	-1.056652	0.533946

```
In [1103]: s = df.xs(3)
```

```
In [1104]: df.append(s, ignore_index=True)
```

```
Out[1104]:
```

	A	B	C	D
0	-1.137707	-0.891060	-0.693921	1.613616
1	0.464000	0.227371	-0.496922	0.306389
2	-2.290613	-1.134623	-1.561819	-0.260838
3	0.281957	1.523962	-0.902937	0.068159
4	-0.057873	-0.368204	-1.144073	0.861209
5	0.800193	0.782098	-1.069094	-1.099248
6	0.255269	0.009750	0.661084	0.379319
7	-0.008434	1.952541	-1.056652	0.533946
8	0.281957	1.523962	-0.902937	0.068159

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 [1105]: df = DataFrame(np.random.randn(5, 4),
.....:                    columns=['foo', 'bar', 'baz', 'qux'])
.....:
```

```
In [1106]: dicts = [{'foo': 1, 'bar': 2, 'baz': 3, 'peekaboo': 4},
.....:               {'foo': 5, 'bar': 6, 'baz': 7, 'peekaboo': 8}]
.....:
```

```
In [1107]: result = df.append(dicts, ignore_index=True)
```

```
In [1108]: result
```

```
Out[1108]:
```

	bar	baz	foo	peekaboo	qux
0	0.040403	-0.507516	-1.226970	NaN	-0.230096
1	-1.934370	-1.652499	0.394500	NaN	1.488753
2	0.576897	1.146000	-0.896484	NaN	1.487349

```
3  2.121453  0.597701  0.604603      NaN  0.563700
4 -1.057909  1.375020  0.967661      NaN -0.928797
5  2.000000  3.000000  1.000000         4      NaN
6  6.000000  7.000000  5.000000         8      NaN
```

11.2 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.

pandas provides a single function, `merge`, as the entry point for all standard database join operations between DataFrame objects:

```
merge(left, right, how='left', on=None, left_on=None, right_on=None,
      left_index=False, right_index=False, sort=True,
      suffixes=('_x', '_y'), copy=True)
```

Here's a description of what each argument is for:

- `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.

`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 and index-on-column(s) joins, but *joins on indexes* by default rather than trying to join on common columns (the default behavior for `merge`). If you are joining on index, you may wish to use `DataFrame.join` to save yourself some typing.

11.2.1 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 [1109]: left = DataFrame({'key': ['foo', 'foo'], 'lval': [1, 2]})

In [1110]: right = DataFrame({'key': ['foo', 'foo'], 'rval': [4, 5]})

In [1111]: left
Out[1111]:
   key  lval
0  foo     1
1  foo     2

In [1112]: right
Out[1112]:
   key  rval
0  foo     4
1  foo     5

In [1113]: merge(left, right, on='key')
Out[1113]:
   key  lval  rval
0  foo     1     4
1  foo     1     5
2  foo     2     4
3  foo     2     5
```

Here is a more complicated example with multiple join keys:

```
In [1114]: left = DataFrame({'key1': ['foo', 'foo', 'bar'],
.....:                      'key2': ['one', 'two', 'one'],
.....:                      'lval': [1, 2, 3]})
.....:

In [1115]: right = DataFrame({'key1': ['foo', 'foo', 'bar', 'bar'],
.....:                        'key2': ['one', 'one', 'one', 'two'],
.....:                        'rval': [4, 5, 6, 7]})
.....:

In [1116]: merge(left, right, how='outer')
Out[1116]:
   key1 key2  lval  rval
0  foo  one     1     4
1  foo  one     2     5
2  foo  two     2     6
3  bar  one     3     6
4  bar  two     3     7
```

```
0  foo  one    1    4
1  foo  one    1    5
2  foo  two    2   NaN
3  bar  one    3    6
4  bar  two   NaN    7
```

```
In [1117]: merge(left, right, how='inner')
```

```
Out[1117]:
   key1 key2  lval  rval
0  foo  one    1    4
1  foo  one    1    5
2  bar  one    3    6
```

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

11.2.2 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 [1118]: df = DataFrame(np.random.randn(8, 4), columns=['A', 'B', 'C', 'D'])
```

```
In [1119]: df1 = df.ix[1:, ['A', 'B']]
```

```
In [1120]: df2 = df.ix[:5, ['C', 'D']]
```

```
In [1121]: df1
```

```
Out[1121]:
      A      B
1 -2.461467 -1.553902
2  1.771740 -0.670027
3 -3.201750  0.792716
4 -0.747169 -0.309038
5  0.936527  1.255746
6  0.062297 -0.110388
7  0.077849  0.629498
```

```
In [1122]: df2
```

```
Out[1122]:
      C      D
0  0.377953  0.493672
1  2.015523 -1.833722
2  0.049307 -0.521493
3  0.146111  1.903247
4  0.393876  1.861468
5 -2.655452  1.219492
```

```
In [1123]: df1.join(df2)
```

```
Out[1123]:
```

	A	B	C	D
1	-2.461467	-1.553902	2.015523	-1.833722
2	1.771740	-0.670027	0.049307	-0.521493
3	-3.201750	0.792716	0.146111	1.903247
4	-0.747169	-0.309038	0.393876	1.861468
5	0.936527	1.255746	-2.655452	1.219492
6	0.062297	-0.110388	NaN	NaN
7	0.077849	0.629498	NaN	NaN

```
In [1124]: df1.join(df2, how='outer')
```

```
Out [1124]:
```

	A	B	C	D
0	NaN	NaN	0.377953	0.493672
1	-2.461467	-1.553902	2.015523	-1.833722
2	1.771740	-0.670027	0.049307	-0.521493
3	-3.201750	0.792716	0.146111	1.903247
4	-0.747169	-0.309038	0.393876	1.861468
5	0.936527	1.255746	-2.655452	1.219492
6	0.062297	-0.110388	NaN	NaN
7	0.077849	0.629498	NaN	NaN

```
In [1125]: df1.join(df2, how='inner')
```

```
Out [1125]:
```

	A	B	C	D
1	-2.461467	-1.553902	2.015523	-1.833722
2	1.771740	-0.670027	0.049307	-0.521493
3	-3.201750	0.792716	0.146111	1.903247
4	-0.747169	-0.309038	0.393876	1.861468
5	0.936527	1.255746	-2.655452	1.219492

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 [1126]: merge(df1, df2, left_index=True, right_index=True, how='outer')
```

```
Out [1126]:
```

	A	B	C	D
0	NaN	NaN	0.377953	0.493672
1	-2.461467	-1.553902	2.015523	-1.833722
2	1.771740	-0.670027	0.049307	-0.521493
3	-3.201750	0.792716	0.146111	1.903247
4	-0.747169	-0.309038	0.393876	1.861468
5	0.936527	1.255746	-2.655452	1.219492
6	0.062297	-0.110388	NaN	NaN
7	0.077849	0.629498	NaN	NaN

11.2.3 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)
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 [1127]: df['key'] = ['foo', 'bar'] * 4
```

```
In [1128]: to_join = DataFrame(randn(2, 2), index=['bar', 'foo'],
.....:                          columns=['j1', 'j2'])
.....:
```

```
In [1129]: df
```

```
Out[1129]:
```

	A	B	C	D	key
0	-0.308853	-0.681087	0.377953	0.493672	foo
1	-2.461467	-1.553902	2.015523	-1.833722	bar
2	1.771740	-0.670027	0.049307	-0.521493	foo
3	-3.201750	0.792716	0.146111	1.903247	bar
4	-0.747169	-0.309038	0.393876	1.861468	foo
5	0.936527	1.255746	-2.655452	1.219492	bar
6	0.062297	-0.110388	-1.184357	-0.558081	foo
7	0.077849	0.629498	-1.035260	-0.438229	bar

```
In [1130]: to_join
```

```
Out[1130]:
```

	j1	j2
bar	0.503703	0.413086
foo	-1.139050	0.660342

```
In [1131]: df.join(to_join, on='key')
```

```
Out[1131]:
```

	A	B	C	D	key	j1	j2
0	-0.308853	-0.681087	0.377953	0.493672	foo	-1.139050	0.660342
1	-2.461467	-1.553902	2.015523	-1.833722	bar	0.503703	0.413086
2	1.771740	-0.670027	0.049307	-0.521493	foo	-1.139050	0.660342
3	-3.201750	0.792716	0.146111	1.903247	bar	0.503703	0.413086
4	-0.747169	-0.309038	0.393876	1.861468	foo	-1.139050	0.660342
5	0.936527	1.255746	-2.655452	1.219492	bar	0.503703	0.413086
6	0.062297	-0.110388	-1.184357	-0.558081	foo	-1.139050	0.660342
7	0.077849	0.629498	-1.035260	-0.438229	bar	0.503703	0.413086

```
In [1132]: merge(df, to_join, left_on='key', right_index=True,
.....:           how='left', sort=False)
.....:
```

```
Out[1132]:
```

	A	B	C	D	key	j1	j2
0	-0.308853	-0.681087	0.377953	0.493672	foo	-1.139050	0.660342
1	-2.461467	-1.553902	2.015523	-1.833722	bar	0.503703	0.413086
2	1.771740	-0.670027	0.049307	-0.521493	foo	-1.139050	0.660342
3	-3.201750	0.792716	0.146111	1.903247	bar	0.503703	0.413086
4	-0.747169	-0.309038	0.393876	1.861468	foo	-1.139050	0.660342
5	0.936527	1.255746	-2.655452	1.219492	bar	0.503703	0.413086
6	0.062297	-0.110388	-1.184357	-0.558081	foo	-1.139050	0.660342
7	0.077849	0.629498	-1.035260	-0.438229	bar	0.503703	0.413086

To join on multiple keys, the passed DataFrame must have a MultiIndex:

```
In [1133]: 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=['first', 'second'])
.....:
```



```

In [1134]: to_join = DataFrame(np.random.randn(10, 3), index=index,
.....:                        columns=['j_one', 'j_two', 'j_three'])
.....:

# a little relevant example with NAs
In [1135]: key1 = ['bar', 'bar', 'bar', 'foo', 'foo', 'baz', 'baz', 'qux',
.....:             'qux', 'snap']
.....:

In [1136]: key2 = ['two', 'one', 'three', 'one', 'two', 'one', 'two', 'two',
.....:             'three', 'one']
.....:

In [1137]: data = np.random.randn(len(key1))

In [1138]: data = DataFrame({'key1' : key1, 'key2' : key2,
.....:                     'data' : data})
.....:

In [1139]: data
Out[1139]:
   data  key1  key2
0 -1.004168  bar   two
1 -1.377627  bar   one
2  0.499281  bar three
3 -1.405256  foo   one
4  0.162565  foo   two
5 -0.067785  baz   one
6 -1.260006  baz   two
7 -1.132896  qux   two
8 -2.006481  qux three
9  0.301016  snap  one

In [1140]: to_join
Out[1140]:
           j_one    j_two    j_three
first second
foo   one    0.464794 -0.309337 -0.649593
      two    0.683758 -0.643834  0.421287
      three  1.032814 -1.290493  0.787872
bar   one    1.515707 -0.276487 -0.223762
      two    1.397431  1.503874 -0.478905
baz   two   -0.135950 -0.730327 -0.033277
      three  0.281151 -1.298915 -2.819487
qux   one   -0.851985 -1.106952 -0.937731
      two   -1.537770  0.555759 -2.277282
      three -0.390201  1.207122  0.178690

```

Now this can be joined by passing the two key column names:

```

In [1141]: data.join(to_join, on=['key1', 'key2'])
Out[1141]:
   data  key1  key2    j_one    j_two    j_three
0 -1.004168  bar   two  1.397431  1.503874 -0.478905
1 -1.377627  bar   one  1.515707 -0.276487 -0.223762
2  0.499281  bar three      NaN      NaN      NaN
3 -1.405256  foo   one  0.464794 -0.309337 -0.649593
4  0.162565  foo   two  0.683758 -0.643834  0.421287
5 -0.067785  baz   one      NaN      NaN      NaN

```

```
6 -1.260006    baz      two -0.135950 -0.730327 -0.033277
7 -1.132896    qux      two -1.537770  0.555759 -2.277282
8 -2.006481    qux    three -0.390201  1.207122  0.178690
9  0.301016    snap     one         NaN         NaN         NaN
```

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 [1142]: data.join(to_join, on=['key1', 'key2'], how='inner')
```

```
Out[1142]:
```

	data	key1	key2	j_one	j_two	j_three
0	-1.004168	bar	two	1.397431	1.503874	-0.478905
1	-1.377627	bar	one	1.515707	-0.276487	-0.223762
3	-1.405256	foo	one	0.464794	-0.309337	-0.649593
4	0.162565	foo	two	0.683758	-0.643834	0.421287
6	-1.260006	baz	two	-0.135950	-0.730327	-0.033277
7	-1.132896	qux	two	-1.537770	0.555759	-2.277282
8	-2.006481	qux	three	-0.390201	1.207122	0.178690

As you can see, this drops any rows where there was no match.

11.2.4 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 [1143]: left = DataFrame({'key': ['foo', 'foo'], 'value': [1, 2]})
```

```
In [1144]: right = DataFrame({'key': ['foo', 'foo'], 'value': [4, 5]})
```

```
In [1145]: merge(left, right, on='key', suffixes=['_left', '_right'])
```

```
Out[1145]:
```

	key	value_left	value_right
0	foo	1	4
1	foo	1	5
2	foo	2	4
3	foo	2	5

`DataFrame.join` has `lsuffix` and `rsuffix` arguments which behave similarly.

11.2.5 Merging Ordered Data

New in v0.8.0 is the `ordered_merge` function for combining time series and other ordered data. In particular it has an optional `fill_method` keyword to fill/interpolate missing data:

```
In [1146]: A
```

```
Out[1146]:
```

	group	key	lvalue
0	a	a	1
1	a	c	2
2	a	e	3
3	b	a	1
4	b	c	2
5	b	e	3

```
In [1147]: B
```

```
Out[1147]:
   key  rvalue
0    b       1
1    c       2
2    d       3
```

```
In [1148]: ordered_merge(A, B, fill_method='ffill', left_by='group')
```

```
Out[1148]:
   group key  lvalue  rvalue
0      a  a       1     NaN
1      a  b       1       1
2      a  c       2       2
3      a  d       2       3
4      a  e       3       3
5      b  a       1     NaN
6      b  b       1       1
7      b  c       2       2
8      b  d       2       3
9      b  e       3       3
```

11.2.6 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 [1149]: df1 = df.ix[:, ['A', 'B']]
```

```
In [1150]: df2 = df.ix[:, ['C', 'D']]
```

```
In [1151]: df3 = df.ix[:, ['key']]
```

```
In [1152]: df1
```

```
Out[1152]:
      A      B
0 -0.308853 -0.681087
1 -2.461467 -1.553902
2  1.771740 -0.670027
3 -3.201750  0.792716
4 -0.747169 -0.309038
5  0.936527  1.255746
6  0.062297 -0.110388
7  0.077849  0.629498
```

```
In [1153]: df1.join([df2, df3])
```

```
Out[1153]:
      A      B      C      D  key
0 -0.308853 -0.681087  0.377953  0.493672  foo
1 -2.461467 -1.553902  2.015523 -1.833722  bar
2  1.771740 -0.670027  0.049307 -0.521493  foo
3 -3.201750  0.792716  0.146111  1.903247  bar
4 -0.747169 -0.309038  0.393876  1.861468  foo
5  0.936527  1.255746 -2.655452  1.219492  bar
6  0.062297 -0.110388 -1.184357 -0.558081  foo
7  0.077849  0.629498 -1.035260 -0.438229  bar
```

11.2.7 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 [1154]: df1 = DataFrame([[nan, 3., 5.], [-4.6, np.nan, nan],
.....:                    [nan, 7., nan]])
.....:

In [1155]: df2 = DataFrame([[-42.6, np.nan, -8.2], [-5., 1.6, 4]],
.....:                    index=[1, 2])
.....:
```

For this, use the `combine_first` method:

```
In [1156]: df1.combine_first(df2)
Out[1156]:
   0    1    2
0  NaN    3  5.0
1 -4.6  NaN -8.2
2 -5.0    7  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 [1157]: df1.update(df2)

In [1158]: df1
Out[1158]:
   0    1    2
0  NaN  3.0  5.0
1 -42.6  NaN -8.2
2 -5.0  1.6  4.0
```

RESHAPING AND PIVOT TABLES

12.1 Reshaping by pivoting DataFrame objects

Data is often stored in CSV files or databases in so-called “stacked” or “record” format:

```
In [1225]: df
Out[1225]:
```

	date	variable	value
0	2000-01-03 00:00:00	A	0.469112
1	2000-01-04 00:00:00	A	-0.282863
2	2000-01-05 00:00:00	A	-1.509059
3	2000-01-03 00:00:00	B	-1.135632
4	2000-01-04 00:00:00	B	1.212112
5	2000-01-05 00:00:00	B	-0.173215
6	2000-01-03 00:00:00	C	0.119209
7	2000-01-04 00:00:00	C	-1.044236
8	2000-01-05 00:00:00	C	-0.861849
9	2000-01-03 00:00:00	D	-2.104569
10	2000-01-04 00:00:00	D	-0.494929
11	2000-01-05 00:00:00	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 DataFrame(data, columns=['date', 'variable', 'value'])
df = unpivot(tm.makeTimeDataFrame())
```

To select out everything for variable A we could do:

```
In [1226]: df[df['variable'] == 'A']
Out[1226]:
```

	date	variable	value
0	2000-01-03 00:00:00	A	0.469112
1	2000-01-04 00:00:00	A	-0.282863
2	2000-01-05 00:00:00	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 [1227]: df.pivot(index='date', columns='variable', values='value')
Out[1227]:
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 toplevel level indicates the respective value column:

```
In [1228]: df['value2'] = df['value'] * 2
```

```
In [1229]: pivoted = df.pivot('date', 'variable')
```

```
In [1230]: pivoted
```

```
Out[1230]:
variable          value          B          C          D          value2          B          C \
date
2000-01-03  0.469112 -1.135632  0.119209 -2.104569  0.938225 -2.271265  0.238417
2000-01-04 -0.282863  1.212112 -1.044236 -0.494929 -0.565727  2.424224 -2.088472
2000-01-05 -1.509059 -0.173215 -0.861849  1.071804 -3.018117 -0.346429 -1.723698

variable          D
date
2000-01-03 -4.209138
2000-01-04 -0.989859
2000-01-05  2.143608
```

You of course can then select subsets from the pivoted `DataFrame`:

```
In [1231]: pivoted['value2']
```

```
Out[1231]:
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.

12.2 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 [1232]: tuples = zip(*[['bar', 'bar', 'baz', 'baz',
.....:                    'foo', 'foo', 'qux', 'qux'],
.....:                    ['one', 'two', 'one', 'two',
.....:                    'one', 'two', 'one', 'two']])
.....:

In [1233]: index = MultiIndex.from_tuples(tuples, names=['first', 'second'])

In [1234]: df = DataFrame(randn(8, 2), index=index, columns=['A', 'B'])

In [1235]: df2 = df[:4]

In [1236]: df2
Out[1236]:
```

		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 [1237]: stacked = df2.stack()

In [1238]: stacked
Out[1238]:
```

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

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 [1239]: stacked.unstack()
Out[1239]:
```

		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 [1240]: stacked.unstack(1)
Out[1240]:
```

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 [1241]: stacked.unstack(0)
```

```
Out[1241]:
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 [1242]: stacked.unstack('second')
```

```
Out[1242]:
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
```

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.

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 `sortlevel`, of course). Here is a more complex example:

```
In [1243]: columns = MultiIndex.from_tuples([('A', 'cat'), ('B', 'dog'),
.....:                                     ('B', 'cat'), ('A', 'dog')],
.....:                                     names=['exp', 'animal'])
.....:
```

```
In [1244]: df = DataFrame(randn(8, 4), index=index, columns=columns)
```

```
In [1245]: df2 = df.ix[[0, 1, 2, 4, 5, 7]]
```

```
In [1246]: df2
```

```
Out[1246]:
exp      A      B      A
animal   cat   dog   cat   dog
first second
bar   one  -0.370647 -1.157892 -1.344312  0.844885
      two   1.075770 -0.109050  1.643563 -1.469388
baz   one   0.357021 -0.674600 -1.776904 -0.968914
foo   one  -0.013960 -0.362543 -0.006154 -0.923061
      two   0.895717  0.805244 -1.206412  2.565646
qux   two   0.410835  0.813850  0.132003 -0.827317
```

As mentioned above, `stack` can be called with a `level` argument to select which level in the columns to stack:

```
In [1247]: df2.stack('exp')
```

```
Out[1247]:
animal      cat      dog
first second exp
```



```

bar  one  A  -0.370647  0.844885
      B  -1.344312 -1.157892
      two A   1.075770 -1.469388
      B   1.643563 -0.109050
baz  one  A   0.357021 -0.968914
      B  -1.776904 -0.674600
foo  one  A  -0.013960 -0.923061
      B  -0.006154 -0.362543
      two A   0.895717  2.565646
      B  -1.206412  0.805244
qux  two  A   0.410835 -0.827317
      B   0.132003  0.813850

```

```
In [1248]: df2.stack('animal')
```

```
Out[1248]:
```

```

exp          A          B
first second animal
bar  one  cat  -0.370647 -1.344312
      dog    0.844885 -1.157892
      two  cat    1.075770  1.643563
      dog  -1.469388 -0.109050
baz  one  cat    0.357021 -1.776904
      dog  -0.968914 -0.674600
foo  one  cat  -0.013960 -0.006154
      dog  -0.923061 -0.362543
      two  cat    0.895717 -1.206412
      dog    2.565646  0.805244
qux  two  cat    0.410835  0.132003
      dog  -0.827317  0.813850

```

Unstacking when the columns are a MultiIndex is also careful about doing the right thing:

```
In [1249]: df[:3].unstack(0)
```

```
Out[1249]:
```

```

exp          A          B
animal      cat      dog
first      bar      baz      bar      baz
second
one  -0.370647  0.357021 -1.157892 -0.6746 -1.344312 -1.776904  0.844885 -0.968914
two    1.075770      NaN -0.109050      NaN  1.643563      NaN -1.469388      NaN

```

```
In [1250]: df2.unstack(1)
```

```
Out[1250]:
```

```

exp          A          B
animal      cat      dog
second      one      two      one      two
first
bar  -0.370647  1.075770 -1.157892 -0.109050 -1.344312  1.643563  0.844885 -1.469388
baz    0.357021      NaN -0.674600      NaN -1.776904      NaN -0.968914      NaN
foo  -0.013960  0.895717 -0.362543  0.805244 -0.006154 -1.206412 -0.923061  2.565646
qux      NaN  0.410835      NaN  0.813850      NaN  0.132003      NaN -0.827317

```

12.3 Reshaping by Melt

The `melt` function found in `pandas.core.reshape` is useful to massage a `DataFrame` into a format where one or more columns are identifier variables, while all other columns, considered measured variables, are “pivoted” to the

row axis, leaving just two non-identifier columns, “variable” and “value”.

For instance,

```
In [1251]: cheese = DataFrame({'first' : ['John', 'Mary'],
.....:                        'last'  : ['Doe', 'Bo'],
.....:                        'height' : [5.5, 6.0],
.....:                        'weight' : [130, 150]})
.....:
```

```
In [1252]: cheese
```

```
Out[1252]:
   first  height last  weight
0  John    5.5  Doe    130
1  Mary    6.0   Bo    150
```

```
In [1253]: melt(cheese, id_vars=['first', 'last'])
```

```
Out[1253]:
   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
```

12.4 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 [1254]: df
```

```
Out[1254]:
exp      A      B      A
animal   cat   dog   cat   dog
first second
bar   one  -0.370647 -1.157892 -1.344312  0.844885
      two   1.075770 -0.109050  1.643563 -1.469388
baz   one   0.357021 -0.674600 -1.776904 -0.968914
      two  -1.294524  0.413738  0.276662 -0.472035
foo   one  -0.013960 -0.362543 -0.006154 -0.923061
      two   0.895717  0.805244 -1.206412  2.565646
qux   one   1.431256  1.340309 -1.170299 -0.226169
      two   0.410835  0.813850  0.132003 -0.827317
```

```
In [1255]: df.stack().mean(1).unstack()
```

```
Out[1255]:
animal   cat      dog
first second
bar   one  -0.857479 -0.156504
      two   1.359666 -0.789219
baz   one  -0.709942 -0.821757
      two  -0.508931 -0.029148
foo   one  -0.010057 -0.642802
      two  -0.155347  1.685445
qux   one   0.130479  0.557070
      two   0.271419 -0.006733
```

```
# same result, another way
```

```
In [1256]: df.groupby(level=1, axis=1).mean()
```

```
Out[1256]:
animal      cat      dog
first second
bar   one   -0.857479 -0.156504
      two    1.359666 -0.789219
baz   one   -0.709942 -0.821757
      two   -0.508931 -0.029148
foo   one   -0.010057 -0.642802
      two   -0.155347  1.685445
qux   one    0.130479  0.557070
      two    0.271419 -0.006733
```

```
In [1257]: df.stack().groupby(level=1).mean()
```

```
Out[1257]:
exp      A      B
second
one      0.016301 -0.644049
two      0.110588  0.346200
```

```
In [1258]: df.mean().unstack(0)
```

```
Out[1258]:
exp      A      B
animal
cat      0.311433 -0.431481
dog     -0.184544  0.133632
```

12.5 Pivot tables and cross-tabulations

The function `pandas.pivot_table` can be used to create spreadsheet-style pivot tables. It takes a number of arguments

- `data`: A `DataFrame` object
- `values`: a column or a list of columns to aggregate
- `rows`: list of columns to group by on the table rows
- `cols`: list of columns to group by on the table columns
- `aggfunc`: function to use for aggregation, defaulting to `numpy.mean`

Consider a data set like this:

```
In [1259]: df = 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)})
.....:
```

```
In [1260]: df
```

```
Out[1260]:
   A  B  C      D      E
0  one A  foo -0.076467  0.959726
1  one B  foo -1.187678 -1.110336
2  two C  foo  1.130127 -0.619976
3 three A  bar -1.436737  0.149748
```

```
4    one  B  bar -1.413681 -0.732339
5    one  C  bar  1.607920  0.687738
6    two  A  foo  1.024180  0.176444
7   three  B  foo  0.569605  0.403310
8    one  C  foo  0.875906 -0.154951
9    one  A  bar -2.211372  0.301624
10   two  B  bar  0.974466 -2.179861
11  three  C  bar -2.006747 -1.369849
12   one  A  foo -0.410001 -0.954208
13   one  B  foo -0.078638  1.462696
14   two  C  foo  0.545952 -1.743161
15  three  A  bar -1.219217 -0.826591
16   one  B  bar -1.226825 -0.345352
17   one  C  bar  0.769804  1.314232
18   two  A  foo -1.281247  0.690579
19  three  B  foo -0.727707  0.995761
20   one  C  foo -0.121306  2.396780
21   one  A  bar -0.097883  0.014871
22   two  B  bar  0.695775  3.357427
23  three  C  bar  0.341734 -0.317441
```

We can produce pivot tables from this data very easily:

```
In [1261]: pivot_table(df, values='D', rows=['A', 'B'], cols=['C'])
```

```
Out[1261]:
```

		bar	foo
A	B		
one	A	-1.154627	-0.243234
	B	-1.320253	-0.633158
	C	1.188862	0.377300
three	A	-1.327977	NaN
	B	NaN	-0.079051
	C	-0.832506	NaN
two	A	NaN	-0.128534
	B	0.835120	NaN
	C	NaN	0.838040

```
In [1262]: pivot_table(df, values='D', rows=['B'], cols=['A', 'C'], aggfunc=np.sum)
```

```
Out[1262]:
```

A	one		three		two	
C	bar	foo	bar	foo	bar	foo
B						
A	-2.309255	-0.486468	-2.655954	NaN	NaN	-0.257067
B	-2.640506	-1.266315	NaN	-0.158102	1.670241	NaN
C	2.377724	0.754600	-1.665013	NaN	NaN	1.676079

```
In [1263]: pivot_table(df, values=['D', 'E'], rows=['B'], cols=['A', 'C'], aggfunc=np.sum)
```

```
Out[1263]:
```

		D				E		
A	one		three		two		one	\
C	bar	foo	bar	foo	bar	foo	bar	foo
B								
A	-2.309255	-0.486468	-2.655954	NaN	NaN	-0.257067	0.316495	0.005518
B	-2.640506	-1.266315	NaN	-0.158102	1.670241	NaN	-1.077692	0.352360
C	2.377724	0.754600	-1.665013	NaN	NaN	1.676079	2.001971	2.241830
A	three		two					
C	bar	foo	bar	foo				
B								

```
A -0.676843      NaN      NaN  0.867024
B      NaN  1.39907  1.177566      NaN
C -1.687290      NaN      NaN -2.363137
```

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 [1264]: pivot_table(df, rows=['A', 'B'], cols=['C'])
Out[1264]:
```

C		D		E	
		bar	foo	bar	foo
one	A	-1.154627	-0.243234	0.158248	0.002759
	B	-1.320253	-0.633158	-0.538846	0.176180
	C	1.188862	0.377300	1.000985	1.120915
three	A	-1.327977	NaN	-0.338421	NaN
	B	NaN	-0.079051	NaN	0.699535
	C	-0.832506	NaN	-0.843645	NaN
two	A	NaN	-0.128534	NaN	0.433512
	B	0.835120	NaN	0.588783	NaN
	C	NaN	0.838040	NaN	-1.181568

You can render a nice output of the table omitting the missing values by calling `to_string` if you wish:

```
In [1265]: table = pivot_table(df, rows=['A', 'B'], cols=['C'])
```

```
In [1266]: print table.to_string(na_rep='')
```

C		D		E	
		bar	foo	bar	foo
one	A	-1.154627	-0.243234	0.158248	0.002759
	B	-1.320253	-0.633158	-0.538846	0.176180
	C	1.188862	0.377300	1.000985	1.120915
three	A	-1.327977		-0.338421	
	B		-0.079051		0.699535
	C	-0.832506		-0.843645	
two	A		-0.128534		0.433512
	B	0.835120		0.588783	
	C		0.838040		-1.181568

Note that `pivot_table` is also available as an instance method on `DataFrame`.

12.5.1 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

- `rows`: array-like, values to group by in the rows
- `cols`: 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)

Any Series passed will have their name attributes used unless row or column names for the cross-tabulation are specified

For example:

```
In [1267]: foo, bar, dull, shiny, one, two = 'foo', 'bar', 'dull', 'shiny', 'one', 'two'
```

```
In [1268]: a = np.array([foo, foo, bar, bar, foo, foo], dtype=object)
```

```
In [1269]: b = np.array([one, one, two, one, two, one], dtype=object)
```

```
In [1270]: c = np.array([dull, dull, shiny, dull, dull, shiny], dtype=object)
```

```
In [1271]: crosstab(a, [b, c], rownames=['a'], colnames=['b', 'c'])
```

```
Out[1271]:
```

b	one		two	
	dull	shiny	dull	shiny
a				
bar	1	0	0	1
foo	2	1	1	0

12.5.2 Adding margins (partial aggregates)

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 [1272]: df.pivot_table(rows=['A', 'B'], cols='C', margins=True, aggfunc=np.std)
```

```
Out[1272]:
```

C		D			E			
		bar	foo	All	bar	foo	All	
A	B							
	one	A	1.494463	0.235844	1.019752	0.202765	1.353355	0.795165
		B	0.132127	0.784210	0.606779	0.273641	1.819408	1.139647
three		C	0.592638	0.705136	0.708771	0.442998	1.804346	1.074910
	A		0.153810	NaN	0.153810	0.690376	NaN	0.690376
		B	NaN	0.917338	0.917338	NaN	0.418926	0.418926
two		C	1.660627	NaN	1.660627	0.744165	NaN	0.744165
	A		NaN	1.630183	1.630183	NaN	0.363548	0.363548
		B	0.197065	NaN	0.197065	3.915454	NaN	3.915454
All		C	NaN	0.413074	0.413074	NaN	0.794212	0.794212
			1.294620	0.824989	1.064129	1.403041	1.188419	1.248988

12.6 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 [1273]: ages = np.array([10, 15, 13, 12, 23, 25, 28, 59, 60])
```

```
In [1274]: cut(ages, bins=3)
```

```
Out[1274]:
```

```
Categorical:
```

```
array([(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],
      (43.333, 60]], dtype=object)
Levels (3): Index([(9.95, 26.667], (26.667, 43.333], (43.333, 60]], dtype=object)
```

If the `bins` keyword is an integer, then equal-width bins are formed. Alternatively we can specify custom bin-edges:

```
In [1275]: cut(ages, bins=[0, 18, 35, 70])
Out[1275]:
Categorical:
array([(0, 18], (0, 18], (0, 18], (0, 18], (18, 35], (18, 35], (18, 35],
      (35, 70], (35, 70]], dtype=object)
Levels (3): Index([(0, 18], (18, 35], (35, 70]], dtype=object)
```


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. With the 0.8 release, we have further improved the time series API in pandas by leaps and bounds. Using the new NumPy `datetime64` dtype, 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 [1299]: rng = date_range('1/1/2011', periods=72, freq='H')

In [1300]: rng[:5]
Out[1300]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-01 00:00:00, ..., 2011-01-01 04:00:00]
Length: 5, Freq: H, Timezone: None
```

Index pandas objects with dates:

```
In [1301]: ts = Series(randn(len(rng)), index=rng)

In [1302]: ts.head()
Out[1302]:
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
```

Change frequency and fill gaps:

```
# to 45 minute frequency and forward fill
In [1303]: converted = ts.asfreq('45Min', method='pad')
```

```
In [1304]: converted.head()
Out[1304]:
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
```

Resample:

```
# Daily means
In [1305]: ts.resample('D', how='mean')
Out[1305]:
2011-01-01   -0.319569
2011-01-02   -0.337703
2011-01-03    0.117258
Freq: D
```

13.1 Time Stamps vs. Time Spans

Time-stamped data is the most basic type of timeseries data that associates values with points in time. For pandas objects it means using the points in time to create the index

```
In [1306]: dates = [datetime(2012, 5, 1), datetime(2012, 5, 2), datetime(2012, 5, 3)]
In [1307]: ts = Series(np.random.randn(3), dates)

In [1308]: type(ts.index)
Out[1308]: pandas.tseries.index.DatetimeIndex

In [1309]: ts
Out[1309]:
2012-05-01   -0.410001
2012-05-02   -0.078638
2012-05-03    0.545952
```

However, in many cases it is more natural to associate things like change variables with a time span instead.

For example:

```
In [1310]: periods = PeriodIndex([Period('2012-01'), Period('2012-02'),
.....:                           Period('2012-03')])
.....:

In [1311]: ts = Series(np.random.randn(3), periods)

In [1312]: type(ts.index)
Out[1312]: pandas.tseries.period.PeriodIndex

In [1313]: ts
Out[1313]:
2012-01   -1.219217
2012-02   -1.226825
2012-03    0.769804
Freq: M
```

Starting with 0.8, 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.

13.2 Generating Ranges of Timestamps

To generate an index with time stamps, you can use either the `DatetimeIndex` or `Index` constructor and pass in a list of datetime objects:

```
In [1314]: dates = [datetime(2012, 5, 1), datetime(2012, 5, 2), datetime(2012, 5, 3)]
```

```
In [1315]: index = DatetimeIndex(dates)
```

```
In [1316]: index # Note the frequency information
```

```
Out[1316]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2012-05-01 00:00:00, ..., 2012-05-03 00:00:00]
Length: 3, Freq: None, Timezone: None
```

```
In [1317]: index = Index(dates)
```

```
In [1318]: index # Automatically converted to DatetimeIndex
```

```
Out[1318]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2012-05-01 00:00:00, ..., 2012-05-03 00:00:00]
Length: 3, Freq: None, Timezone: None
```

Practically, 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 pandas functions `date_range` and `bdate_range` to create timestamp indexes.

```
In [1319]: index = date_range('2000-1-1', periods=1000, freq='M')
```

```
In [1320]: index
```

```
Out[1320]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2000-01-31 00:00:00, ..., 2083-04-30 00:00:00]
Length: 1000, Freq: M, Timezone: None
```

```
In [1321]: index = bdate_range('2012-1-1', periods=250)
```

```
In [1322]: index
```

```
Out[1322]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2012-01-02 00:00:00, ..., 2012-12-14 00:00:00]
Length: 250, Freq: B, Timezone: None
```

Convenience functions like `date_range` and `bdate_range` utilize a variety of frequency aliases. The default frequency for `date_range` is a **calendar day** while the default for `bdate_range` is a **business day**.

```
In [1323]: start = datetime(2011, 1, 1)
```

```
In [1324]: end = datetime(2012, 1, 1)
```

```
In [1325]: rng = date_range(start, end)
```

```
In [1326]: rng
Out[1326]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-01 00:00:00, ..., 2012-01-01 00:00:00]
Length: 366, Freq: D, Timezone: None
```

```
In [1327]: rng = bdate_range(start, end)
```

```
In [1328]: rng
Out[1328]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-03 00:00:00, ..., 2011-12-30 00:00:00]
Length: 260, Freq: B, Timezone: None
```

`date_range` and `bdate_range` makes it easy to generate a range of dates using various combinations of parameters like `start`, `end`, `periods`, and `freq`:

```
In [1329]: date_range(start, end, freq='BM')
Out[1329]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-31 00:00:00, ..., 2011-12-30 00:00:00]
Length: 12, Freq: BM, Timezone: None
```

```
In [1330]: date_range(start, end, freq='W')
Out[1330]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-02 00:00:00, ..., 2012-01-01 00:00:00]
Length: 53, Freq: W-SUN, Timezone: None
```

```
In [1331]: bdate_range(end=end, periods=20)
Out[1331]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-12-05 00:00:00, ..., 2011-12-30 00:00:00]
Length: 20, Freq: B, Timezone: None
```

```
In [1332]: bdate_range(start=start, periods=20)
Out[1332]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-03 00:00:00, ..., 2011-01-28 00:00:00]
Length: 20, Freq: B, Timezone: None
```

The start and end dates are strictly inclusive. So it will not generate any dates outside of those dates if specified.

13.2.1 DatetimeIndex

One of the main uses for `DatetimeIndex` is as an index for pandas objects. The `DatetimeIndex` class contains many timeseries 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` can be used like a regular index and offers all of its intelligent functionality like selection, slicing, etc.

```
In [1333]: rng = date_range(start, end, freq='BM')
```

```
In [1334]: ts = Series(randn(len(rng)), index=rng)
```

```
In [1335]: ts.index
```

```
Out[1335]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-31 00:00:00, ..., 2011-12-30 00:00:00]
Length: 12, Freq: BM, Timezone: None
```

```
In [1336]: ts[:5].index
```

```
Out[1336]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-31 00:00:00, ..., 2011-05-31 00:00:00]
Length: 5, Freq: BM, Timezone: None
```

```
In [1337]: ts[::2].index
```

```
Out[1337]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-31 00:00:00, ..., 2011-11-30 00:00:00]
Length: 6, Freq: 2BM, Timezone: None
```

You can pass in dates and strings that parses to dates as indexing parameters:

```
In [1338]: ts['1/31/2011']
```

```
Out[1338]: -1.2812473076599531
```

```
In [1339]: ts[datetime(2011, 12, 25):]
```

```
Out[1339]:
2011-12-30    0.687738
Freq: BM
```

```
In [1340]: ts['10/31/2011':'12/31/2011']
```

```
Out[1340]:
2011-10-31    0.149748
2011-11-30   -0.732339
2011-12-30    0.687738
Freq: BM
```

A truncate convenience function is provided that is equivalent to slicing:

```
In [1341]: ts.truncate(before='10/31/2011', after='12/31/2011')
```

```
Out[1341]:
2011-10-31    0.149748
2011-11-30   -0.732339
2011-12-30    0.687738
Freq: BM
```

To provide convenience for accessing longer time series, you can also pass in the year or year and month as strings:

```
In [1342]: ts['2011']
```

```
Out[1342]:
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
```

```
In [1343]: ts['2011-6']
Out[1343]:
2011-06-30     0.341734
Freq: BM
```

Even complicated fancy indexing that breaks the `DatetimeIndex`'s frequency regularity will result in a `DatetimeIndex` (but frequency is lost):

```
In [1344]: ts[[0, 2, 6]].index
Out[1344]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-31 00:00:00, ..., 2011-07-29 00:00:00]
Length: 3, Freq: None, Timezone: None
```

`DatetimeIndex` objects has all the basic functionality of regular `Index` objects and a smorgasbord of advanced timeseries-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. So please be careful.

13.3 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)
Week	one week, optionally anchored on a day of the week
WeekOfMonth	the x-th day of the y-th week of each month
MonthEnd	calendar month end
MonthBegin	calendar month begin
BMonthEnd	business month end
BMonthBegin	business month begin
QuarterEnd	calendar quarter end
QuarterBegin	calendar quarter begin
BQuarterEnd	business quarter end
BQuarterBegin	business quarter begin
YearEnd	calendar year end
YearBegin	calendar year begin
BYearEnd	business year end
BYearBegin	business year begin
Hour	one hour
Minute	one minute
Second	one second
Milli	one millisecond
Micro	one microsecond

The basic `DateOffset` takes the same arguments as `datetime.timedelta`, which works like:

```
In [1345]: d = datetime(2008, 8, 18)

In [1346]: d + relativedelta(months=4, days=5)
Out[1346]: datetime.datetime(2008, 12, 23, 0, 0)
```

We could have done the same thing with `DateOffset`:

```
In [1347]: from pandas.tseries.offsets import *

In [1348]: d + DateOffset(months=4, days=5)
Out[1348]: datetime.datetime(2008, 12, 23, 0, 0)
```

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 [1349]: d - 5 * BDay()
Out[1349]: datetime.datetime(2008, 8, 11, 0, 0)

In [1350]: d + BMonthEnd()
Out[1350]: datetime.datetime(2008, 8, 29, 0, 0)
```

The `rollforward` and `rollback` methods do exactly what you would expect:

```
In [1351]: d
Out[1351]: datetime.datetime(2008, 8, 18, 0, 0)

In [1352]: offset = BMonthEnd()

In [1353]: offset.rollforward(d)
Out[1353]: datetime.datetime(2008, 8, 29, 0, 0)

In [1354]: offset.rollback(d)
Out[1354]: datetime.datetime(2008, 7, 31, 0, 0)
```

It's definitely worth exploring the `pandas.tseries.offsets` module and the various docstrings for the classes.

13.3.1 Parametric offsets

Some of the offsets can be “parameterized” when created to result in different behavior. 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 [1355]: d + Week()
Out[1355]: datetime.datetime(2008, 8, 25, 0, 0)

In [1356]: d + Week(weekday=4)
Out[1356]: datetime.datetime(2008, 8, 22, 0, 0)

In [1357]: (d + Week(weekday=4)).weekday()
Out[1357]: 4
```

Another example is parameterizing `YearEnd` with the specific ending month:

```
In [1358]: d + YearEnd()
Out[1358]: datetime.datetime(2008, 12, 31, 0, 0)

In [1359]: d + YearEnd(month=6)
Out[1359]: datetime.datetime(2009, 6, 30, 0, 0)
```

13.3.2 Offset Aliases

A number of string aliases are given to useful common time series frequencies. We will refer to these aliases as *offset aliases* (referred to as *time rules* prior to v0.8.0).

Alias	Description
B	business day frequency
D	calendar day frequency
W	weekly frequency
M	month end frequency
BM	business month end frequency
MS	month start frequency
BMS	business month start frequency
Q	quarter end frequency
BQ	business quarter end frequency
QS	quarter start frequency
BQS	business quarter start frequency
A	year end frequency
BA	business year end frequency
AS	year start frequency
BAS	business year start frequency
H	hourly frequency
T	minutely frequency
S	secondly frequency
L	milliseconds
U	microseconds

13.3.3 Combining Aliases

As we have seen previously, the alias and the offset instance are fungible in most functions:

```
In [1360]: date_range(start, periods=5, freq='B')
Out[1360]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-03 00:00:00, ..., 2011-01-07 00:00:00]
Length: 5, Freq: B, Timezone: None
```

```
In [1361]: date_range(start, periods=5, freq=BDay())
Out[1361]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-03 00:00:00, ..., 2011-01-07 00:00:00]
Length: 5, Freq: B, Timezone: None
```

You can combine together day and intraday offsets:

```
In [1362]: date_range(start, periods=10, freq='2h20min')
Out[1362]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-01 00:00:00, ..., 2011-01-01 21:00:00]
Length: 10, Freq: 140T, Timezone: None
```

```
In [1363]: date_range(start, periods=10, freq='1D10U')
Out[1363]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2011-01-01 00:00:00, ..., 2011-01-10 00:00:00.000090]
Length: 10, Freq: 86400000010U, Timezone: None
```

13.3.4 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
(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.

13.3.5 Legacy Aliases

Note that prior to v0.8.0, time rules had a slightly different look. Pandas will continue to support the legacy time rules for the time being but it is strongly recommended that you switch to using the new offset aliases.

Legacy Time Rule	Offset Alias
WEEKDAY	B
EOM	BM
W@MON	W-MON
W@TUE	W-TUE
W@WED	W-WED
W@THU	W-THU
W@FRI	W-FRI
W@SAT	W-SAT
W@SUN	W-SUN
Q@JAN	BQ-JAN
Q@FEB	BQ-FEB
Q@MAR	BQ-MAR
A@JAN	BA-JAN
A@FEB	BA-FEB
A@MAR	BA-MAR
A@APR	BA-APR
A@MAY	BA-MAY
A@JUN	BA-JUN
A@JUL	BA-JUL
A@AUG	BA-AUG
A@SEP	BA-SEP
A@OCT	BA-OCT
A@NOV	BA-NOV
A@DEC	BA-DEC
min	T
ms	L
us: "U"	

As you can see, legacy quarterly and annual frequencies are business quarter and business year ends. Please also note the legacy time rule for milliseconds `ms` versus the new offset alias for month start `MS`. This means that offset alias parsing is case sensitive.

13.4 Time series-related instance methods

13.4.1 Shifting / lagging

One may want to *shift* or *lag* the values in a `TimeSeries` back and forward in time. The method for this is `shift`, which is available on all of the pandas objects. In `DataFrame`, `shift` will currently only shift along the `index` and in `Panel` along the `major_axis`.

```
In [1364]: ts = ts[:5]
```

```
In [1365]: ts.shift(1)
```

```
Out[1365]:
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
```

The `shift` method accepts an `freq` argument which can accept a `DateOffset` class or other `timedelta`-like object

or also a *offset alias*:

```
In [1366]: ts.shift(5, freq=datetools.bday)
Out[1366]:
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

In [1367]: ts.shift(5, freq='BM')
Out[1367]:
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
```

Rather than changing the alignment of the data and the index, `DataFrame` and `TimeSeries` objects also have a `tshift` convenience method that changes all the dates in the index by a specified number of offsets:

```
In [1368]: ts.tshift(5, freq='D')
Out[1368]:
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
```

Note that with `tshift`, the leading entry is no longer `NaN` because the data is not being realigned.

13.4.2 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 [1369]: dr = date_range('1/1/2010', periods=3, freq=3 * datetools.bday)
```

```
In [1370]: ts = Series(randn(3), index=dr)
```

```
In [1371]: ts
Out[1371]:
2010-01-01    0.176444
2010-01-06    0.403310
2010-01-11   -0.154951
Freq: 3B
```

```
In [1372]: ts.asfreq(BDay())
Out[1372]:
2010-01-01    0.176444
2010-01-04         NaN
2010-01-05         NaN
2010-01-06    0.403310
2010-01-07         NaN
2010-01-08         NaN
2010-01-11   -0.154951
Freq: B
```

`asfreq` provides a further convenience so you can specify an interpolation method for any gaps that may appear after the frequency conversion

```
In [1373]: ts.asfreq(BDay(), method='pad')
Out[1373]:
2010-01-01    0.176444
2010-01-04    0.176444
2010-01-05    0.176444
2010-01-06    0.403310
2010-01-07    0.403310
2010-01-08    0.403310
2010-01-11   -0.154951
Freq: B
```

13.4.3 Filling forward / backward

Related to `asfreq` and `reindex` is the `fillna` function documented in the [missing data section](#).

13.5 Up- and downsampling

With 0.8, pandas introduces 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.

```
In [1374]: rng = date_range('1/1/2012', periods=100, freq='S')
In [1375]: ts = Series(randint(0, 500, len(rng)), index=rng)
In [1376]: ts.resample('5Min', how='sum')
Out[1376]:
2012-01-01    25792
Freq: 5T
```

The `resample` function is very flexible and allows you to specify many different parameters to control the frequency conversion and resampling operation.

The `how` parameter can be a function name or numpy array function that takes an array and produces aggregated values:

```
In [1377]: ts.resample('5Min') # default is mean
Out[1377]:
2012-01-01    257.92
Freq: 5T

In [1378]: ts.resample('5Min', how='ohlc')
Out[1378]:
          open  high  low  close
2012-01-01   230   492    0   214

In [1379]: ts.resample('5Min', how=np.max)
Out[1379]:
2012-01-01    NaN
Freq: 5T
```

Any function available via [dispatching](#) can be given to the `how` parameter by name, including `sum`, `mean`, `std`, `max`, `min`, `median`, `first`, `last`, `ohlc`.

For downsampling, `closed` can be set to 'left' or 'right' to specify which end of the interval is closed:

```
In [1380]: ts.resample('5Min', closed='right')
Out[1380]:
2011-12-31 23:55:00    230.00000
2012-01-01 00:00:00    258.20202
Freq: 5T
```

```
In [1381]: ts.resample('5Min', closed='left')
Out[1381]:
2012-01-01    257.92
Freq: 5T
```

For upsampling, the `fill_method` and `limit` parameters can be specified to interpolate over the gaps that are created:

```
# from secondly to every 250 milliseconds
```

```
In [1382]: ts[:2].resample('250L')
Out[1382]:
2012-01-01 00:00:00.250000    NaN
2012-01-01 00:00:00.500000    NaN
2012-01-01 00:00:00.750000    NaN
2012-01-01 00:00:01        202
2012-01-01 00:00:01.250000    NaN
Freq: 250L
```

```
In [1383]: ts[:2].resample('250L', fill_method='pad')
Out[1383]:
2012-01-01 00:00:00.250000    230
2012-01-01 00:00:00.500000    230
2012-01-01 00:00:00.750000    230
2012-01-01 00:00:01        202
2012-01-01 00:00:01.250000    202
Freq: 250L
```

```
In [1384]: ts[:2].resample('250L', fill_method='pad', limit=2)
Out[1384]:
2012-01-01 00:00:00.250000    230
2012-01-01 00:00:00.500000    230
2012-01-01 00:00:00.750000    NaN
2012-01-01 00:00:01        202
2012-01-01 00:00:01.250000    202
Freq: 250L
```

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 [1385]: ts.resample('5Min') # by default label='right'
Out[1385]:
2012-01-01    257.92
Freq: 5T
```

```
In [1386]: ts.resample('5Min', label='left')
Out[1386]:
2012-01-01    257.92
Freq: 5T
```

```
In [1387]: ts.resample('5Min', label='left', loffset='1s')
Out[1387]: 2012-01-01 00:00:01    257.92
```

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 time-stamp 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.

Note that 0.8 marks a watershed in the timeseries functionality in pandas. In previous versions, resampling had to be done using a combination of `date_range`, `groupby` with `asof`, and then calling an aggregation function on the grouped object. This was not nearly convenient or performant as the new pandas timeseries API.

13.6 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`.

13.6.1 Period

A `Period` represents a span of time (e.g., a day, a month, a quarter, etc). It can be created using a frequency alias:

```
In [1388]: Period('2012', freq='A-DEC')
Out[1388]: Period('2012', 'A-DEC')

In [1389]: Period('2012-1-1', freq='D')
Out[1389]: Period('2012-01-01', 'D')

In [1390]: Period('2012-1-1 19:00', freq='H')
Out[1390]: Period('2012-01-01 19:00', 'H')
```

Unlike time stamped data, pandas does not support frequencies at multiples of `DateOffsets` (e.g., '3Min') for periods.

Adding and subtracting integers from periods shifts the period by its own frequency.

```
In [1391]: p = Period('2012', freq='A-DEC')

In [1392]: p + 1
Out[1392]: Period('2013', 'A-DEC')

In [1393]: p - 3
Out[1393]: Period('2009', 'A-DEC')
```

Taking the difference of `Period` instances with the same frequency will return the number of frequency units between them:

```
In [1394]: Period('2012', freq='A-DEC') - Period('2002', freq='A-DEC')
Out[1394]: 10
```

13.6.2 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 [1395]: prng = period_range('1/1/2011', '1/1/2012', freq='M')
```

```
In [1396]: prng
```

```
Out[1396]:  
<class 'pandas.tseries.period.PeriodIndex'>  
freq: M  
[2011-01, ..., 2012-01]  
length: 13
```

The PeriodIndex constructor can also be used directly:

```
In [1397]: PeriodIndex(['2011-1', '2011-2', '2011-3'], freq='M')
```

```
Out[1397]:  
<class 'pandas.tseries.period.PeriodIndex'>  
freq: M  
[2011-01, ..., 2011-03]  
length: 3
```

Just like DatetimeIndex, a PeriodIndex can also be used to index pandas objects:

```
In [1398]: Series(randn(len(prng)), prng)
```

```
Out[1398]:  
2011-01    0.301624  
2011-02   -1.460489  
2011-03    0.610679  
2011-04    1.195856  
2011-05   -0.008820  
2011-06   -0.045729  
2011-07   -1.051015  
2011-08   -0.422924  
2011-09   -0.028361  
2011-10   -0.782386  
2011-11    0.861980  
2011-12    1.438604  
2012-01   -0.525492  
Freq: M
```

13.6.3 Frequency Conversion and Resampling with PeriodIndex

The frequency of Periods and PeriodIndex can be converted via the `asfreq` method. Let's start with the fiscal year 2011, ending in December:

```
In [1399]: p = Period('2011', freq='A-DEC')
```

```
In [1400]: p
```

```
Out[1400]: 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 [1401]: p.asfreq('M', how='start')
```

```
Out[1401]: Period('2011-01', 'M')
```

```
In [1402]: p.asfreq('M', how='end')
```

```
Out[1402]: Period('2011-12', 'M')
```

The shorthands 's' and 'e' are provided for convenience:


```
In [1403]: p.asfreq('M', 's')
Out[1403]: Period('2011-01', 'M')
```

```
In [1404]: p.asfreq('M', 'e')
Out[1404]: 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 [1405]: p = Period('2011-12', freq='M')
```

```
In [1406]: p.asfreq('A-NOV')
Out[1406]: 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 start and ends. Thus, first quarter of 2011 could start in 2010 or a few months into 2011. Via anchored frequencies, pandas works all quarterly frequencies Q-JAN through Q-DEC.

Q-DEC define regular calendar quarters:

```
In [1407]: p = Period('2012Q1', freq='Q-DEC')
```

```
In [1408]: p.asfreq('D', 's')
Out[1408]: Period('2012-01-01', 'D')
```

```
In [1409]: p.asfreq('D', 'e')
Out[1409]: Period('2012-03-31', 'D')
```

Q-MAR defines fiscal year end in March:

```
In [1410]: p = Period('2011Q4', freq='Q-MAR')
```

```
In [1411]: p.asfreq('D', 's')
Out[1411]: Period('2011-01-01', 'D')
```

```
In [1412]: p.asfreq('D', 'e')
Out[1412]: Period('2011-03-31', 'D')
```

13.7 Converting between Representations

Timestamped data can be converted to PeriodIndex-ed data using `to_period` and vice-versa using `to_timestamp`:

```
In [1413]: rng = date_range('1/1/2012', periods=5, freq='M')
```

```
In [1414]: ts = Series(randn(len(rng)), index=rng)
```

```
In [1415]: ts
Out[1415]:
2012-01-31    -1.684469
2012-02-29     0.550605
2012-03-31     0.091955
2012-04-30     0.891713
2012-05-31     0.807078
Freq: M
```

```
In [1416]: ps = ts.to_period()
```

```
In [1417]: ps
```

```
Out[1417]:
2012-01    -1.684469
2012-02     0.550605
2012-03     0.091955
2012-04     0.891713
2012-05     0.807078
Freq: M
```

```
In [1418]: ps.to_timestamp()
```

```
Out[1418]:
2012-01-01    -1.684469
2012-02-01     0.550605
2012-03-01     0.091955
2012-04-01     0.891713
2012-05-01     0.807078
Freq: MS
```

Remember that 's' and 'e' can be used to return the timestamps at the start or end of the period:

```
In [1419]: ps.to_timestamp('D', how='s')
```

```
Out[1419]:
2012-01-01    -1.684469
2012-02-01     0.550605
2012-03-01     0.091955
2012-04-01     0.891713
2012-05-01     0.807078
Freq: MS
```

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 [1420]: prng = period_range('1990Q1', '2000Q4', freq='Q-NOV')
```

```
In [1421]: ts = Series(randn(len(prng)), prng)
```

```
In [1422]: ts.index = (prng.asfreq('M', 'e') + 1).asfreq('H', 's') + 9
```

```
In [1423]: ts.head()
```

```
Out[1423]:
1990-03-01 09:00    0.221441
1990-06-01 09:00   -0.113139
1990-09-01 09:00   -1.812900
1990-12-01 09:00   -0.053708
1991-03-01 09:00   -0.114574
Freq: H
```

13.8 Time Zone Handling

Using `pytz`, pandas provides rich support for working with timestamps in different time zones. By default, pandas objects are time zone unaware:

```
In [1424]: rng = date_range('3/6/2012 00:00', periods=15, freq='D')
```

```
In [1425]: print(rng.tz)
None
```

To supply the time zone, you can use the `tz` keyword to `date_range` and other functions:

```
In [1426]: rng_utc = date_range('3/6/2012 00:00', periods=10, freq='D', tz='UTC')
```

```
In [1427]: print(rng_utc.tz)
UTC
```

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 [1428]: ts = Series(randn(len(rng)), rng)
```

```
In [1429]: ts_utc = ts.tz_localize('UTC')
```

```
In [1430]: ts_utc
```

```
Out[1430]:
2012-03-06 00:00:00+00:00    -0.114722
2012-03-07 00:00:00+00:00     0.168904
2012-03-08 00:00:00+00:00    -0.048048
2012-03-09 00:00:00+00:00     0.801196
2012-03-10 00:00:00+00:00     1.392071
2012-03-11 00:00:00+00:00    -0.048788
2012-03-12 00:00:00+00:00    -0.808838
2012-03-13 00:00:00+00:00    -1.003677
2012-03-14 00:00:00+00:00    -0.160766
2012-03-15 00:00:00+00:00     1.758853
2012-03-16 00:00:00+00:00     0.729195
2012-03-17 00:00:00+00:00     1.359732
2012-03-18 00:00:00+00:00     2.006296
2012-03-19 00:00:00+00:00     0.870210
2012-03-20 00:00:00+00:00     0.043464
Freq: D
```

You can use the `tz_convert` method to convert pandas objects to convert tz-aware data to another time zone:

```
In [1431]: ts_utc.tz_convert('US/Eastern')
```

```
Out[1431]:
2012-03-05 19:00:00-05:00    -0.114722
2012-03-06 19:00:00-05:00     0.168904
2012-03-07 19:00:00-05:00    -0.048048
2012-03-08 19:00:00-05:00     0.801196
2012-03-09 19:00:00-05:00     1.392071
2012-03-10 19:00:00-05:00    -0.048788
2012-03-11 20:00:00-04:00    -0.808838
2012-03-12 20:00:00-04:00    -1.003677
2012-03-13 20:00:00-04:00    -0.160766
2012-03-14 20:00:00-04:00     1.758853
2012-03-15 20:00:00-04:00     0.729195
2012-03-16 20:00:00-04:00     1.359732
2012-03-17 20:00:00-04:00     2.006296
2012-03-18 20:00:00-04:00     0.870210
2012-03-19 20:00:00-04:00     0.043464
Freq: D
```

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 [1432]: rng_eastern = rng_utc.tz_convert('US/Eastern')

In [1433]: rng_berlin = rng_utc.tz_convert('Europe/Berlin')

In [1434]: rng_eastern[5]
Out[1434]: <Timestamp: 2012-03-10 19:00:00-0500 EST, tz=US/Eastern>

In [1435]: rng_berlin[5]
Out[1435]: <Timestamp: 2012-03-11 01:00:00+0100 CET, tz=Europe/Berlin>

In [1436]: rng_eastern[5] == rng_berlin[5]
Out[1436]: True
```

Like Series, DataFrame, and DatetimeIndex, Timestamps can be converted to other time zones using `tz_convert`:

```
In [1437]: rng_eastern[5]
Out[1437]: <Timestamp: 2012-03-10 19:00:00-0500 EST, tz=US/Eastern>

In [1438]: rng_berlin[5]
Out[1438]: <Timestamp: 2012-03-11 01:00:00+0100 CET, tz=Europe/Berlin>

In [1439]: rng_eastern[5].tz_convert('Europe/Berlin')
Out[1439]: <Timestamp: 2012-03-11 01:00:00+0100 CET, tz=Europe/Berlin>
```

Localization of Timestamps functions just like DatetimeIndex and TimeSeries:

```
In [1440]: rng[5]
Out[1440]: <Timestamp: 2012-03-11 00:00:00>

In [1441]: rng[5].tz_localize('Asia/Shanghai')
Out[1441]: <Timestamp: 2012-03-11 00:00:00+0800 CST, tz=Asia/Shanghai>
```

Operations between TimeSeries in difficult time zones will yield UTC TimeSeries, aligning the data on the UTC timestamps:

```
In [1442]: eastern = ts_utc.tz_convert('US/Eastern')

In [1443]: berlin = ts_utc.tz_convert('Europe/Berlin')

In [1444]: result = eastern + berlin

In [1445]: result
Out[1445]:
2012-03-06 00:00:00+00:00    -0.229443
2012-03-07 00:00:00+00:00     0.337809
2012-03-08 00:00:00+00:00    -0.096096
2012-03-09 00:00:00+00:00     1.602392
2012-03-10 00:00:00+00:00     2.784142
2012-03-11 00:00:00+00:00    -0.097575
2012-03-12 00:00:00+00:00    -1.617677
2012-03-13 00:00:00+00:00    -2.007353
2012-03-14 00:00:00+00:00    -0.321532
2012-03-15 00:00:00+00:00     3.517706
2012-03-16 00:00:00+00:00     1.458389
2012-03-17 00:00:00+00:00     2.719465
2012-03-18 00:00:00+00:00     4.012592
2012-03-19 00:00:00+00:00     1.740419
```

```
2012-03-20 00:00:00+00:00    0.086928
Freq: D
```

```
In [1446]: result.index
```

```
Out[1446]:
```

```
<class 'pandas.tseries.index.DatetimeIndex'>
[2012-03-06 00:00:00, ..., 2012-03-20 00:00:00]
Length: 15, Freq: D, Timezone: UTC
```


PLOTTING WITH MATPLOTLIB

Note: We intend to build more plotting integration with `matplotlib` as time goes on.

We use the standard convention for referencing the matplotlib API:

```
In [1447]: import matplotlib.pyplot as plt
```

14.1 Basic plotting: `plot`

The `plot` method on `Series` and `DataFrame` is just a simple wrapper around `plt.plot`:

```
In [1448]: ts = Series(randn(1000), index=date_range('1/1/2000', periods=1000))
```

```
In [1449]: ts = ts.cumsum()
```

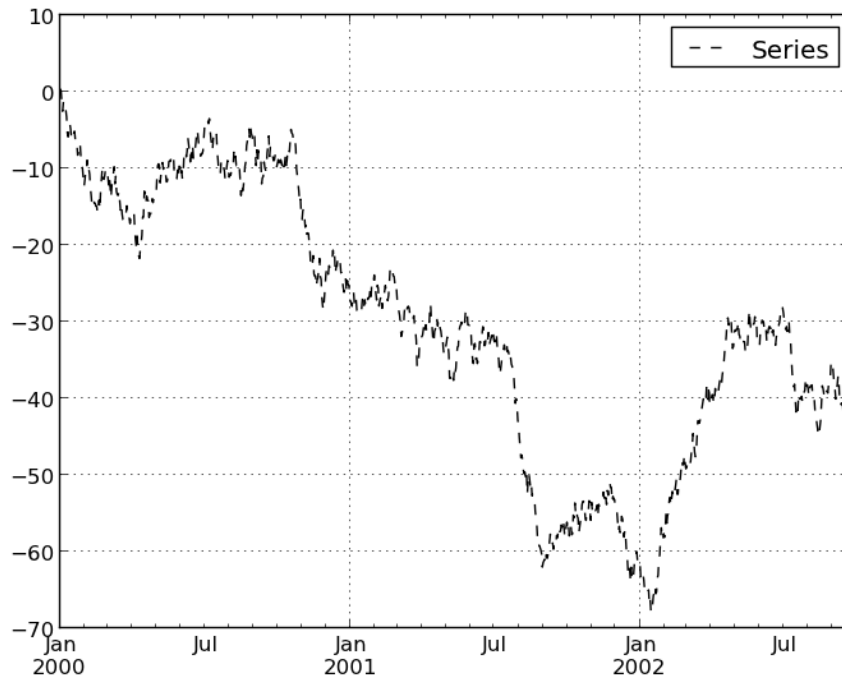
```
In [1450]: ts.plot()
```

```
Out[1450]: <matplotlib.axes.AxesSubplot at 0xc416d50>
```



If the index consists of dates, it calls `gcf().autofmt_xdate()` to try to format the x-axis nicely as per above. The method takes a number of arguments for controlling the look of the plot:

```
In [1451]: plt.figure(); ts.plot(style='k--', label='Series'); plt.legend()
Out[1451]: <matplotlib.legend.Legend at 0xc34bcd0>
```

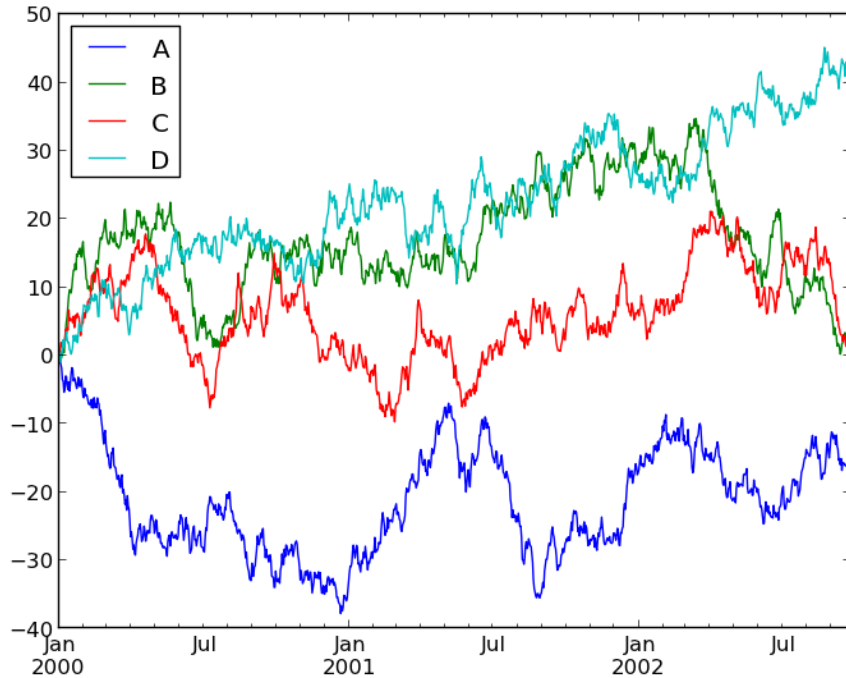


On `DataFrame`, `plot` is a convenience to plot all of the columns with labels:

```
In [1452]: df = DataFrame(randn(1000, 4), index=ts.index,
.....:                  columns=['A', 'B', 'C', 'D'])
.....:

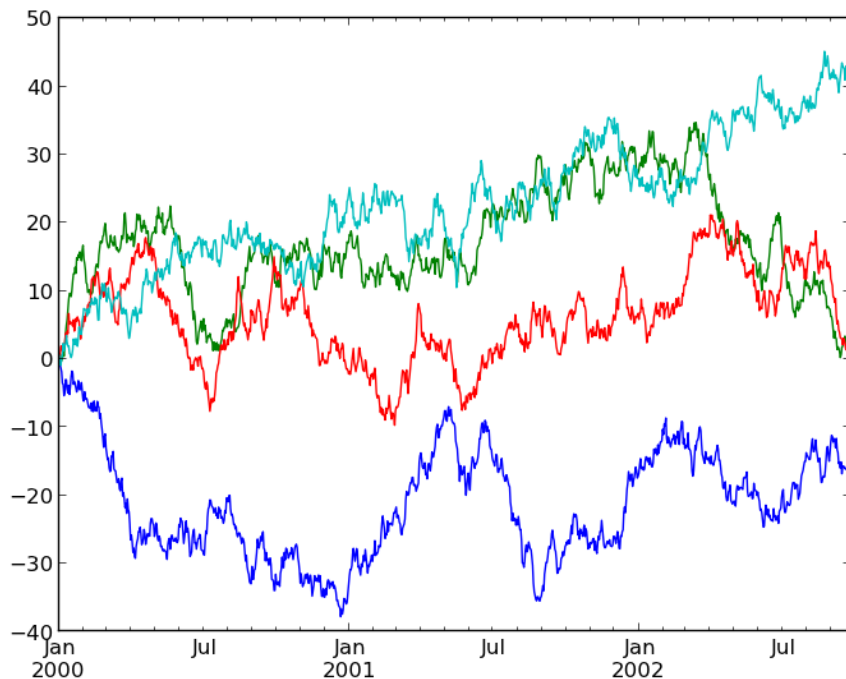
In [1453]: df = df.cumsum()

In [1454]: plt.figure(); df.plot(); plt.legend(loc='best')
Out[1454]: <matplotlib.legend.Legend at 0xe8c2090>
```

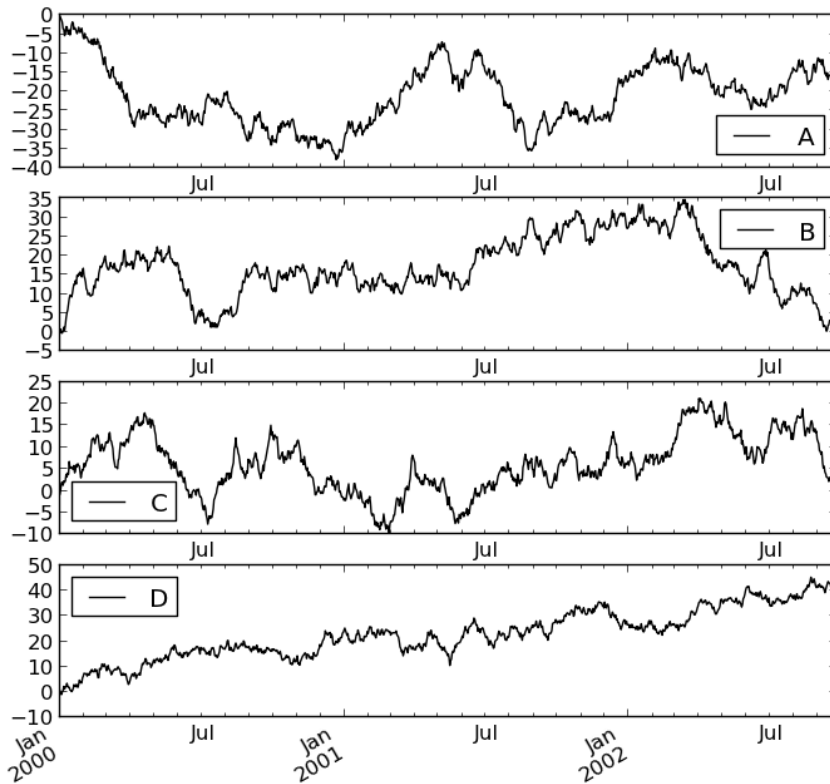
You may set the `legend` argument to `False` to hide the legend, which is shown by default.

```
In [1455]: df.plot(legend=False)
Out[1455]: <matplotlib.axes.AxesSubplot at 0xeddeed0>
```



Some other options are available, like plotting each Series on a different axis:

```
In [1456]: df.plot(subplots=True, figsize=(8, 8)); plt.legend(loc='best')
Out[1456]: <matplotlib.legend.Legend at 0xf235d90>
```



You may pass `logy` to get a log-scale Y axis.

```
In [1457]: plt.figure();
In [1457]: ts = Series(randn(1000), index=date_range('1/1/2000', periods=1000))

In [1458]: ts = np.exp(ts.cumsum())

In [1459]: ts.plot(logy=True)
Out[1459]: <matplotlib.axes.AxesSubplot at 0x103f5dd0>
```



You can plot one column versus another using the *x* and *y* keywords in *DataFrame.plot*:

```
In [1460]: plt.figure()
```

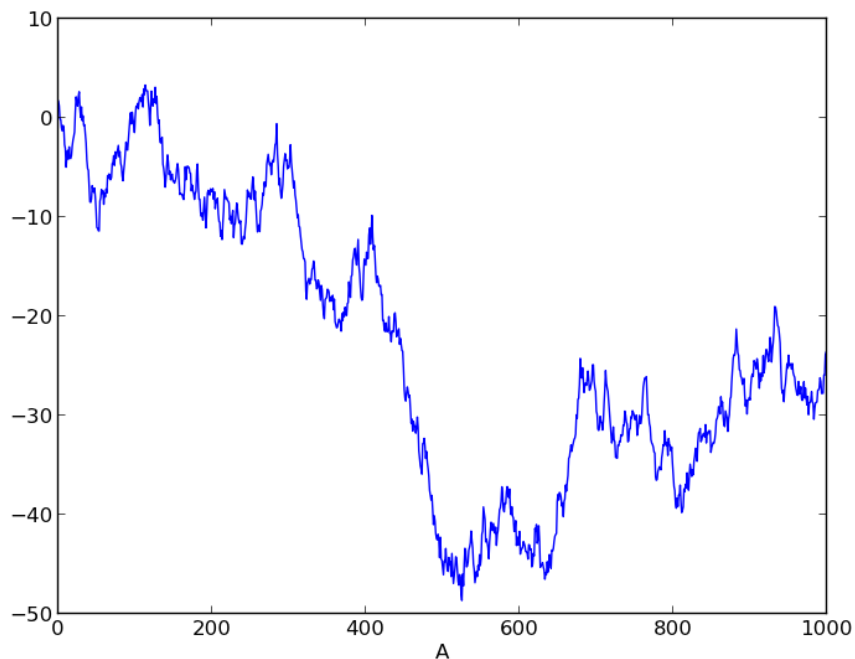
```
Out[1460]: <matplotlib.figure.Figure at 0xfdda2d0>
```

```
In [1461]: df3 = DataFrame(np.random.randn(1000, 2), columns=['B', 'C']).cumsum()
```

```
In [1462]: df3['A'] = Series(range(len(df)))
```

```
In [1463]: df3.plot(x='A', y='B')
```

```
Out[1463]: <matplotlib.axes.AxesSubplot at 0xfdda290>
```



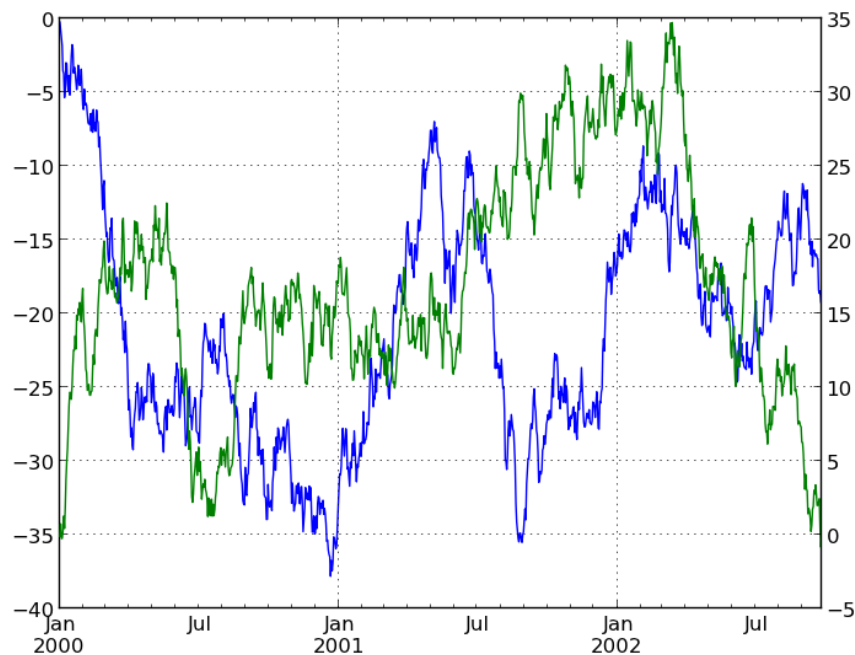
14.1.1 Plotting on a Secondary Y-axis

To plot data on a secondary y-axis, use the `secondary_y` keyword:

```
In [1464]: plt.figure()
Out[1464]: <matplotlib.figure.Figure at 0x10c42650>

In [1465]: df.A.plot()
Out[1465]: <matplotlib.axes.AxesSubplot at 0x10d4d0d0>

In [1466]: df.B.plot(secondary_y=True, style='g')
Out[1466]: <matplotlib.axes.AxesSubplot at 0x10d4d0d0>
```

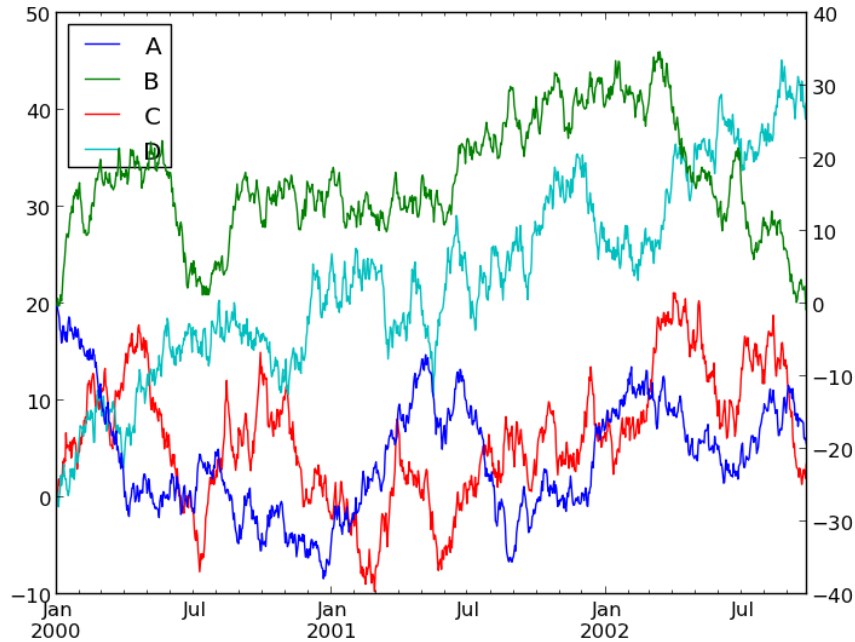


14.1.2 Selective Plotting on Secondary Y-axis

To plot some columns in a DataFrame, give the column names to the `secondary_y` keyword:

```
In [1467]: plt.figure()
Out[1467]: <matplotlib.figure.Figure at 0x10c42510>

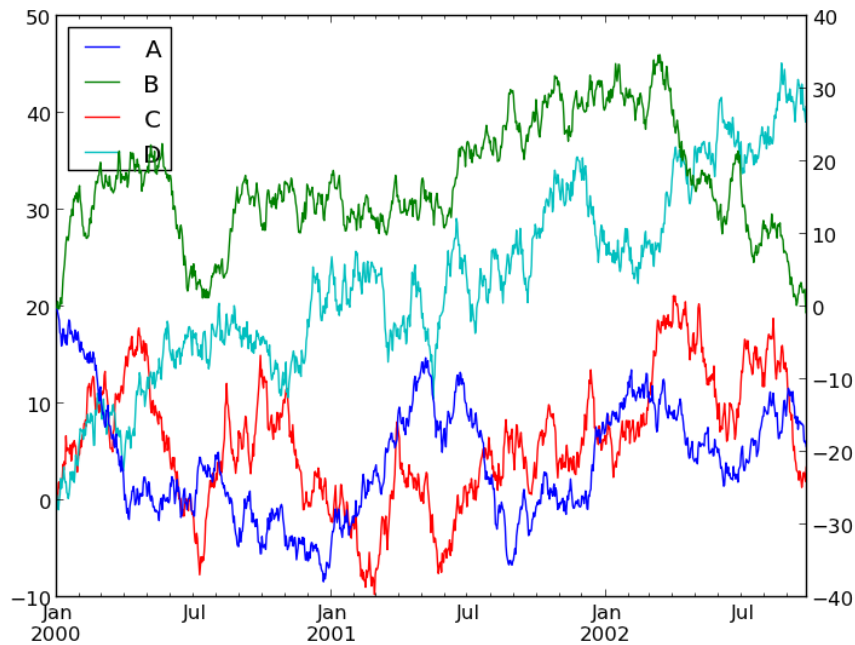
In [1468]: df.plot(secondary_y=['A', 'B'])
Out[1468]: <matplotlib.axes.AxesSubplot at 0x10b95350>
```



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 [1469]: plt.figure()
Out[1469]: <matplotlib.figure.Figure at 0x115ff4d0>

In [1470]: df.plot(secondary_y=['A', 'B'], mark_right=False)
Out[1470]: <matplotlib.axes.AxesSubplot at 0x1145e2d0>
```

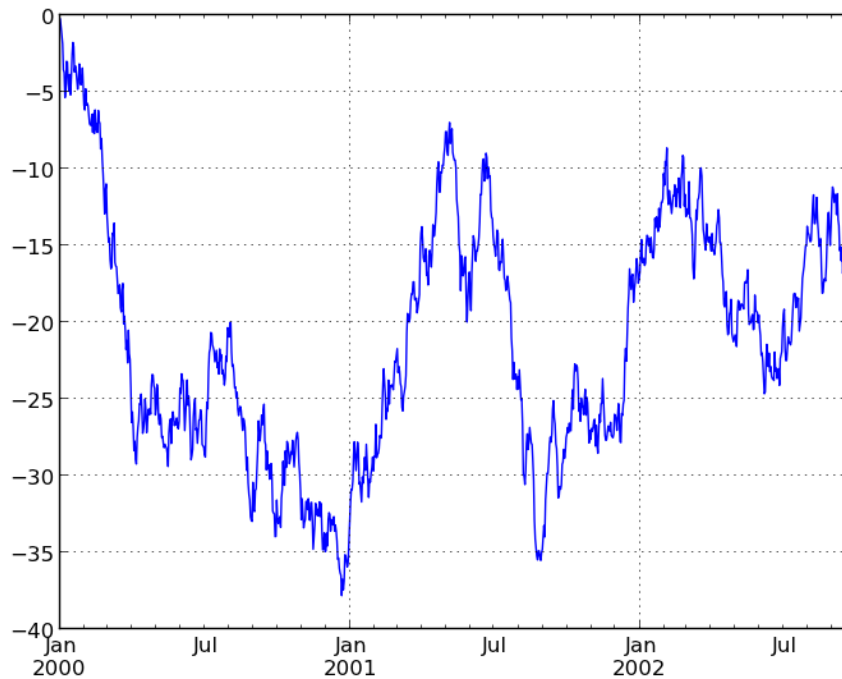


14.1.3 Suppressing tick resolution adjustment

Pandas includes automatically 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.

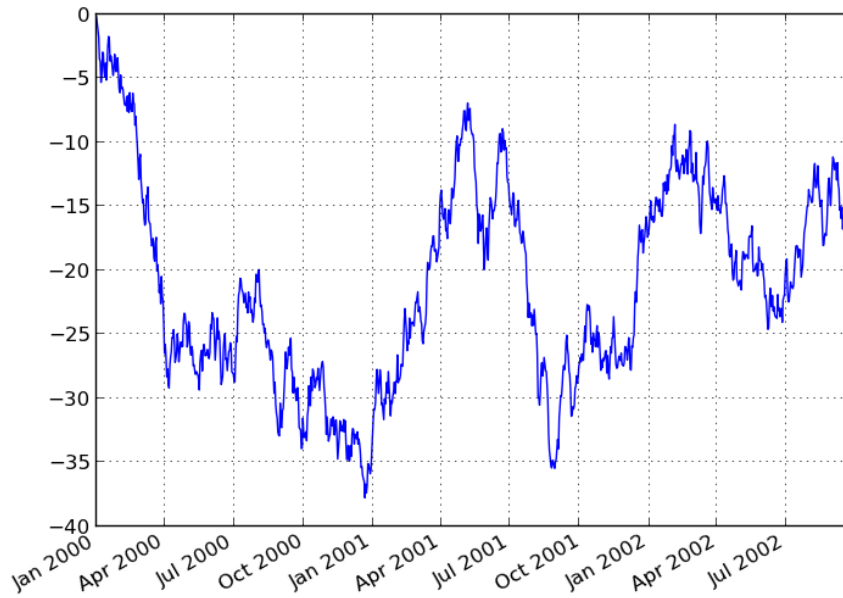
Here is the default behavior, notice how the x-axis tick labelling is performed:

```
In [1471]: plt.figure()  
Out[1471]: <matplotlib.figure.Figure at 0x11ac9f10>  
  
In [1472]: df.A.plot()  
Out[1472]: <matplotlib.axes.AxesSubplot at 0x11ae0350>
```



Using the `x_compat` parameter, you can suppress this behavior:

```
In [1473]: plt.figure()  
Out[1473]: <matplotlib.figure.Figure at 0x123d4110>  
  
In [1474]: df.A.plot(x_compat=True)  
Out[1474]: <matplotlib.axes.AxesSubplot at 0x123d5b10>
```



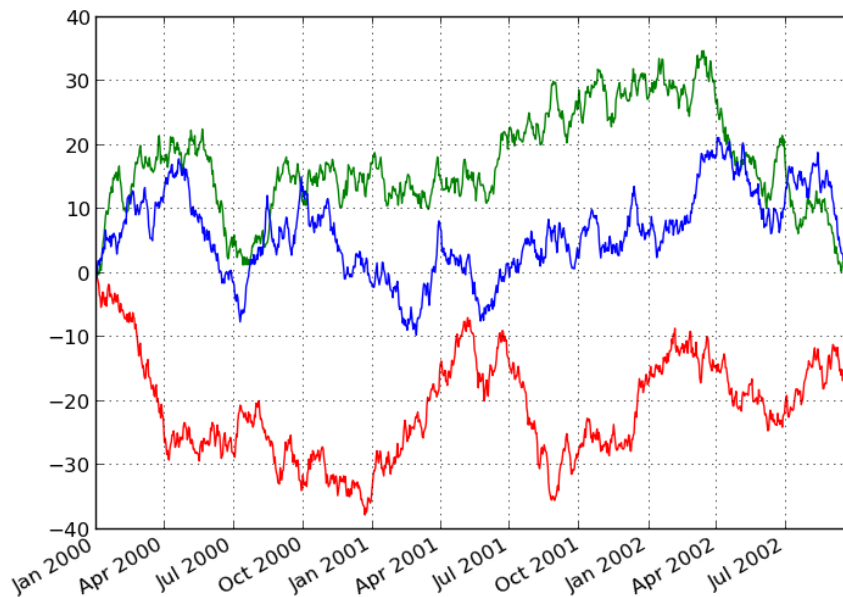
If you have more than one plot that needs to be suppressed, the use method in `pandas.plot_params` can be used in a *with* statement:

```
In [1475]: import pandas as pd
```

```
In [1476]: plt.figure()
```

```
Out[1476]: <matplotlib.figure.Figure at 0x11ada1d0>
```

```
In [1477]: with pd.plot_params.use('x_compat', True):
.....:     df.A.plot(color='r')
.....:     df.B.plot(color='g')
.....:     df.C.plot(color='b')
.....:
```



14.1.4 Targeting different subplots

You can pass an `ax` argument to `Series.plot` to plot on a particular axis:

```
In [1478]: fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(8, 5))
```

```
In [1479]: df['A'].plot(ax=axes[0,0]); axes[0,0].set_title('A')
```

```
Out[1479]: <matplotlib.text.Text at 0x130d4a10>
```

```
In [1480]: df['B'].plot(ax=axes[0,1]); axes[0,1].set_title('B')
```

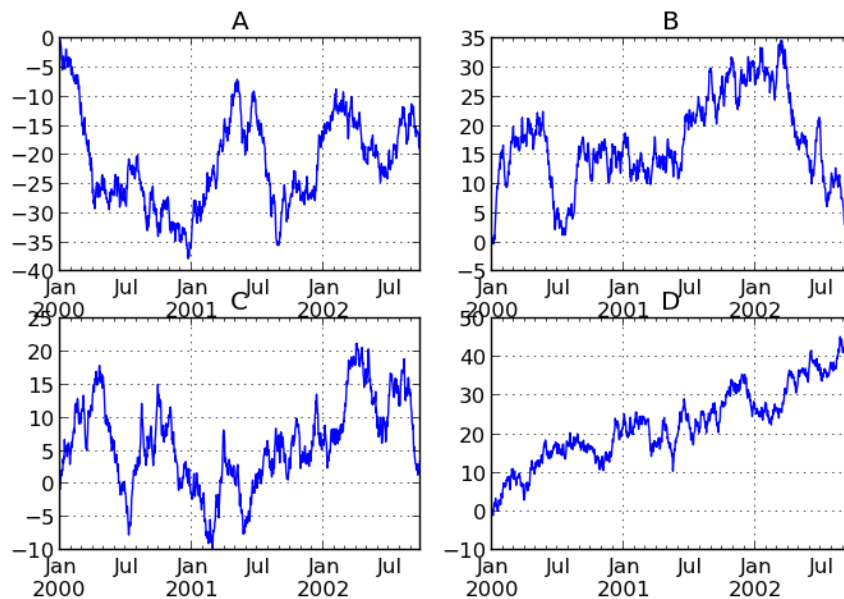
```
Out[1480]: <matplotlib.text.Text at 0x12fff0d0>
```

```
In [1481]: df['C'].plot(ax=axes[1,0]); axes[1,0].set_title('C')
```

```
Out[1481]: <matplotlib.text.Text at 0x1302ca90>
```

```
In [1482]: df['D'].plot(ax=axes[1,1]); axes[1,1].set_title('D')
```

```
Out[1482]: <matplotlib.text.Text at 0x133a4a50>
```



14.2 Other plotting features

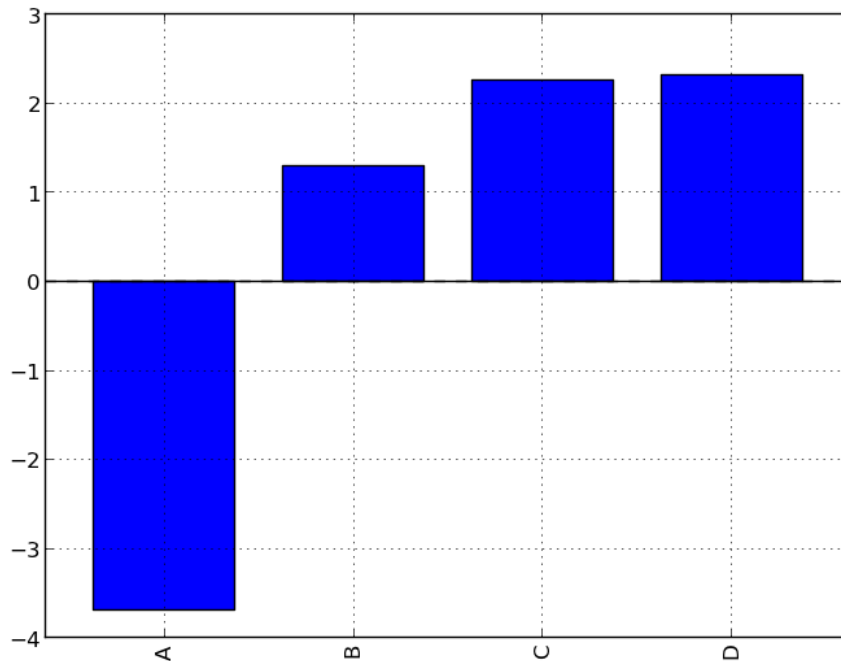
14.2.1 Bar plots

For labeled, non-time series data, you may wish to produce a bar plot:

```
In [1483]: plt.figure();
```

```
In [1483]: df.ix[5].plot(kind='bar'); plt.axhline(0, color='k')
```

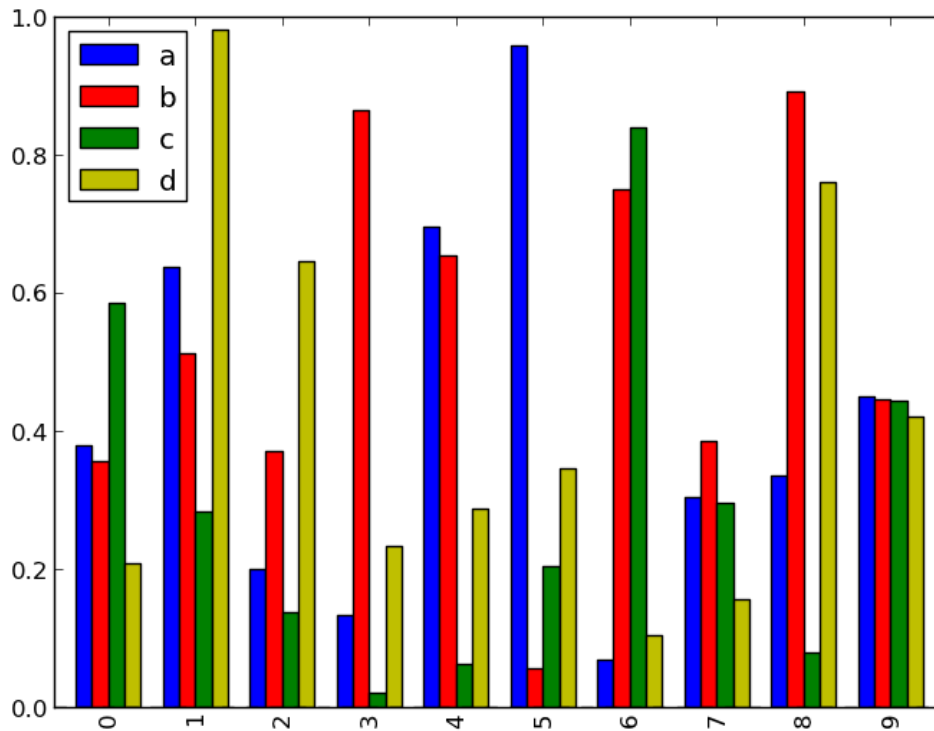
```
Out[1483]: <matplotlib.lines.Line2D at 0x135c0a50>
```

Calling a DataFrame's `plot` method with `kind='bar'` produces a multiple bar plot:

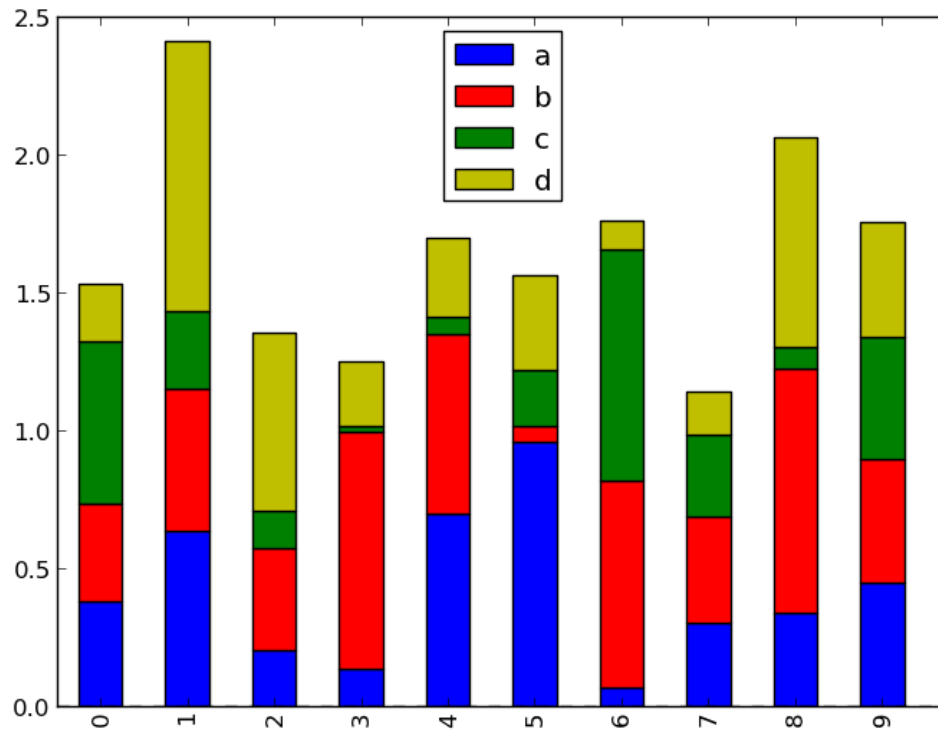
```
In [1484]: df2 = DataFrame(np.random.rand(10, 4), columns=['a', 'b', 'c', 'd'])
```

```
In [1485]: df2.plot(kind='bar');
```



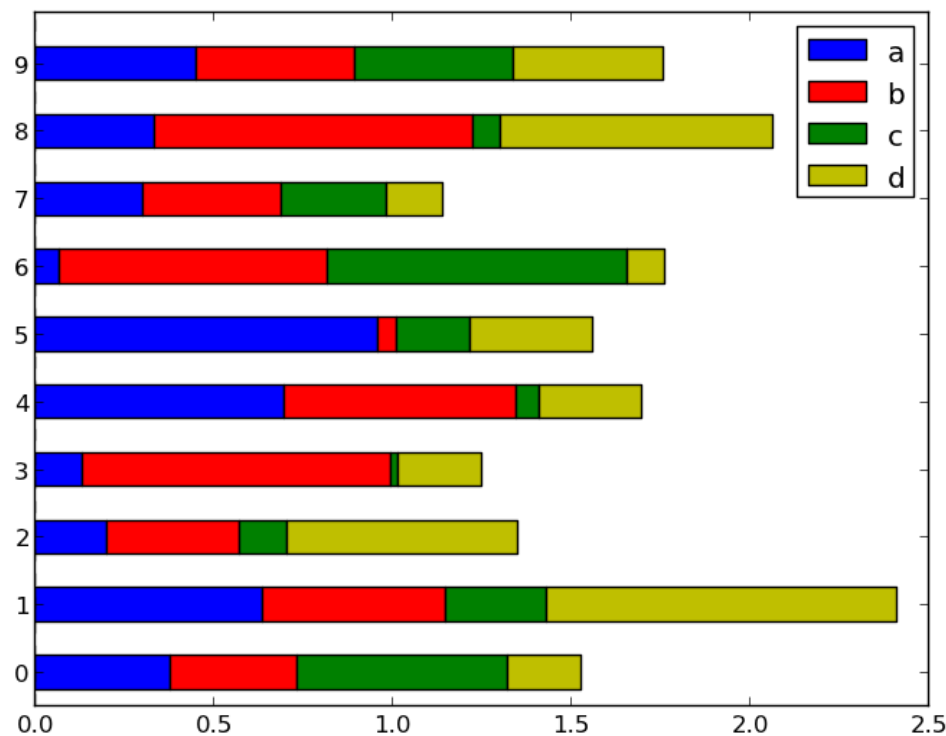
To produce a stacked bar plot, pass `stacked=True`:

```
In [1485]: df2.plot(kind='bar', stacked=True);
```



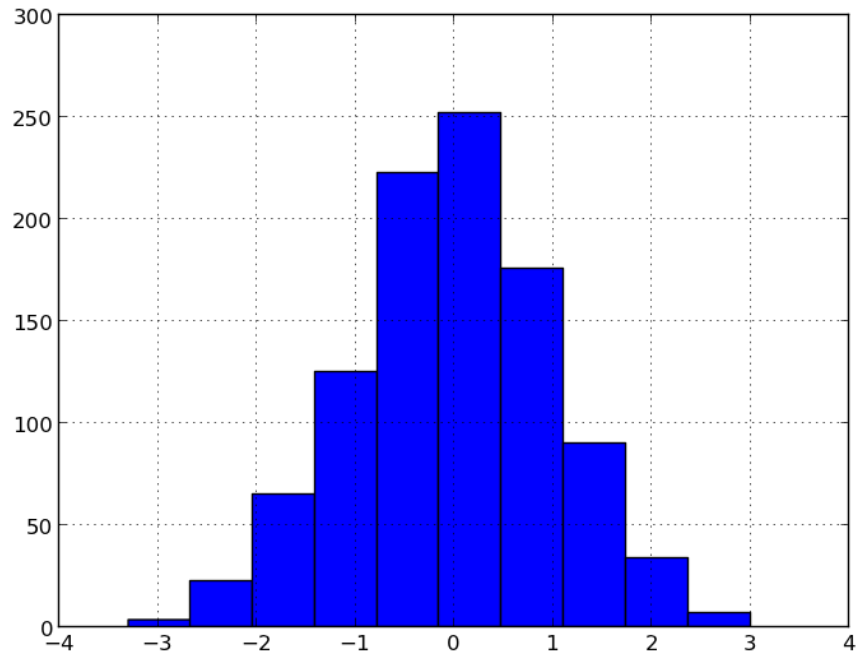
To get horizontal bar plots, pass `kind='barh'`:

```
In [1485]: df2.plot(kind='barh', stacked=True);
```



14.2.2 Histograms

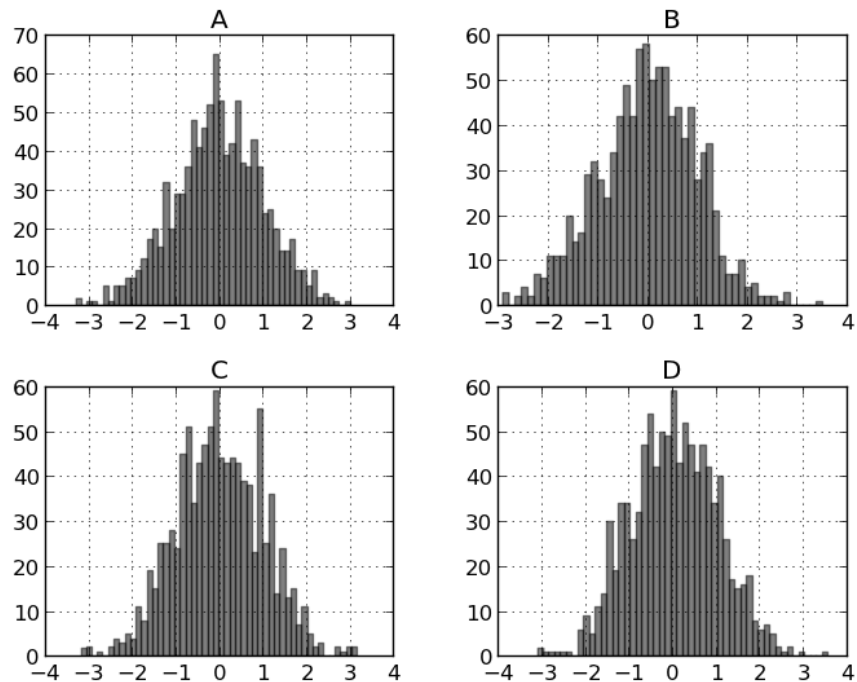
```
In [1485]: plt.figure();
In [1485]: df['A'].diff().hist()
Out[1485]: <matplotlib.axes.AxesSubplot at 0x14811c10>
```



For a DataFrame, hist plots the histograms of the columns on multiple subplots:

```
In [1486]: plt.figure()
Out[1486]: <matplotlib.figure.Figure at 0x14afd490>

In [1487]: df.diff().hist(color='k', alpha=0.5, bins=50)
Out[1487]:
array([[Axes(0.125,0.552174;0.336957x0.347826),
        Axes(0.563043,0.552174;0.336957x0.347826)],
       [Axes(0.125,0.1;0.336957x0.347826),
        Axes(0.563043,0.1;0.336957x0.347826)]], dtype=object)
```



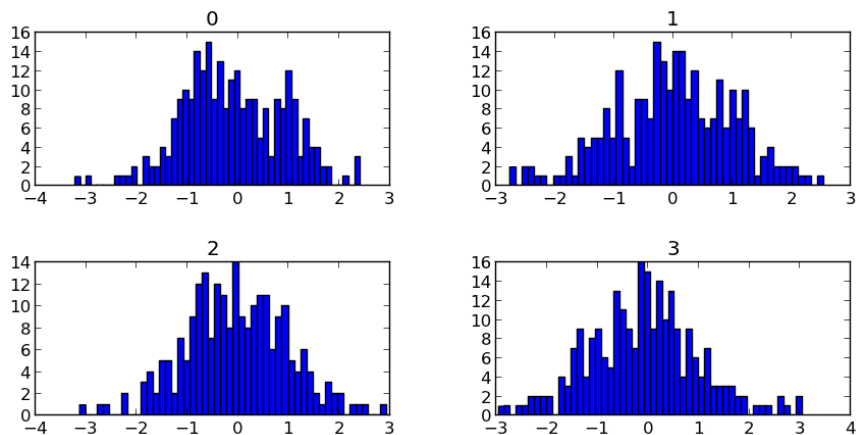
New since 0.10.0, the `by` keyword can be specified to plot grouped histograms:

```
In [1488]: data = Series(np.random.randn(1000))
```

```
In [1489]: data.hist(by=np.random.randint(0, 4, 1000))
```

```
Out[1489]:
```

```
array([[Axes(0.1,0.6;0.347826x0.3), Axes(0.552174,0.6;0.347826x0.3)],
       [Axes(0.1,0.15;0.347826x0.3), Axes(0.552174,0.15;0.347826x0.3)]], dtype=object)
```



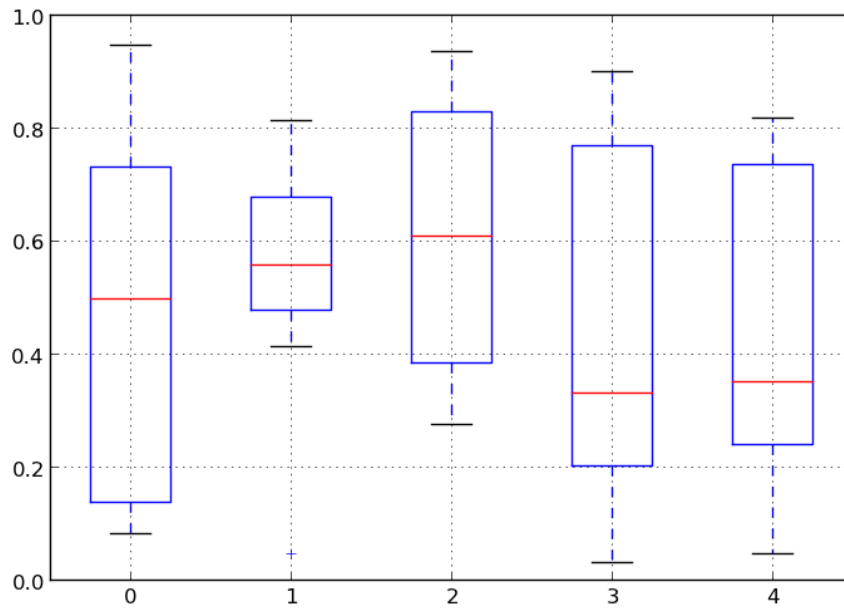
14.2.3 Box-Plotting

`DataFrame` has a `boxplot` method which allows you 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 $[0,1)$.

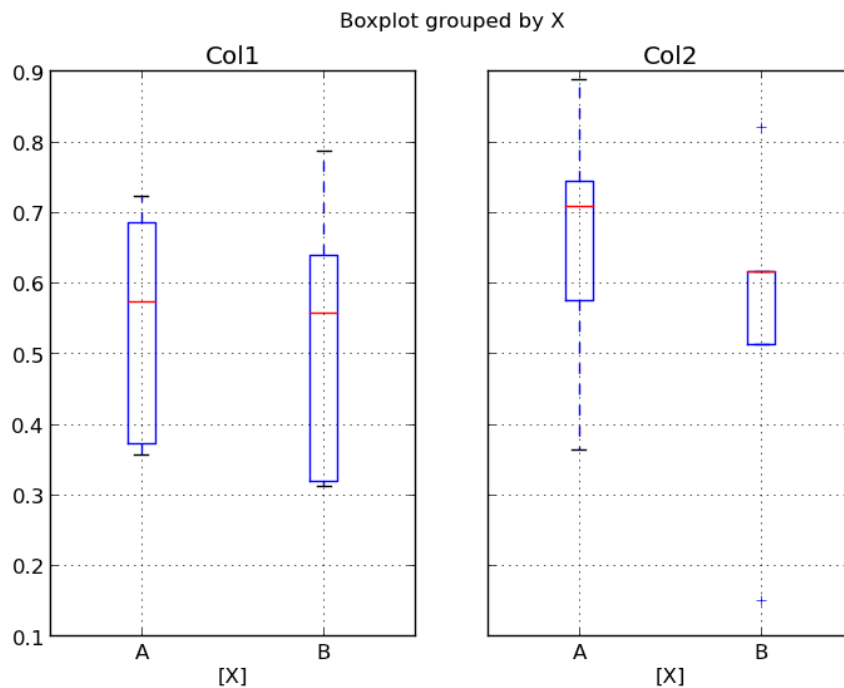
```
In [1490]: df = DataFrame(np.random.rand(10,5))
```

```
In [1491]: plt.figure();
In [1491]: bp = df.boxplot()
```



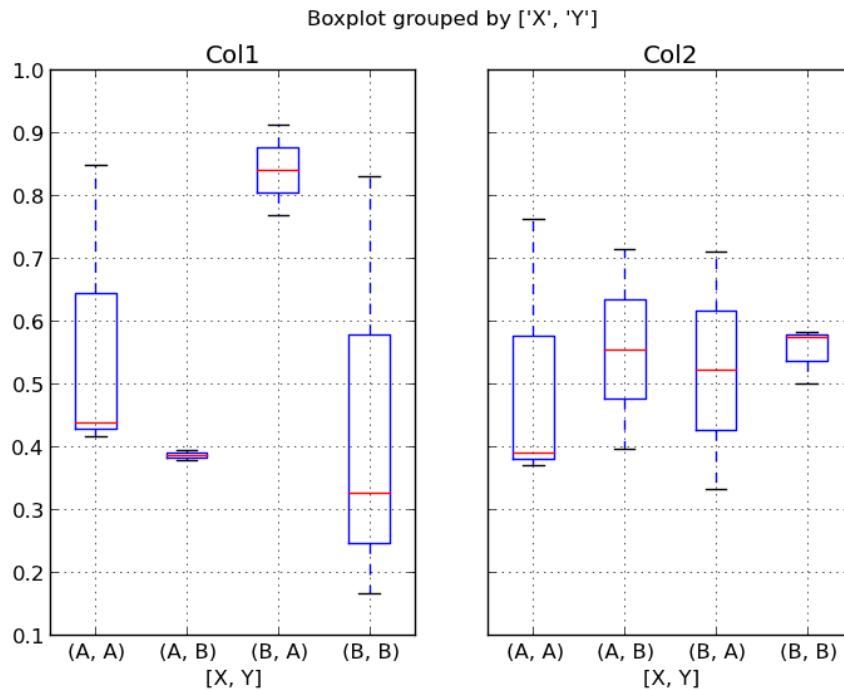
You can create a stratified boxplot using the `by` keyword argument to create groupings. For instance,

```
In [1492]: df = DataFrame(np.random.rand(10,2), columns=['Col1', 'Col2'])
In [1493]: df['X'] = Series(['A','A','A','A','A','B','B','B','B','B'])
In [1494]: plt.figure();
In [1494]: bp = df.boxplot(by='X')
```



You can also pass a subset of columns to plot, as well as group by multiple columns:

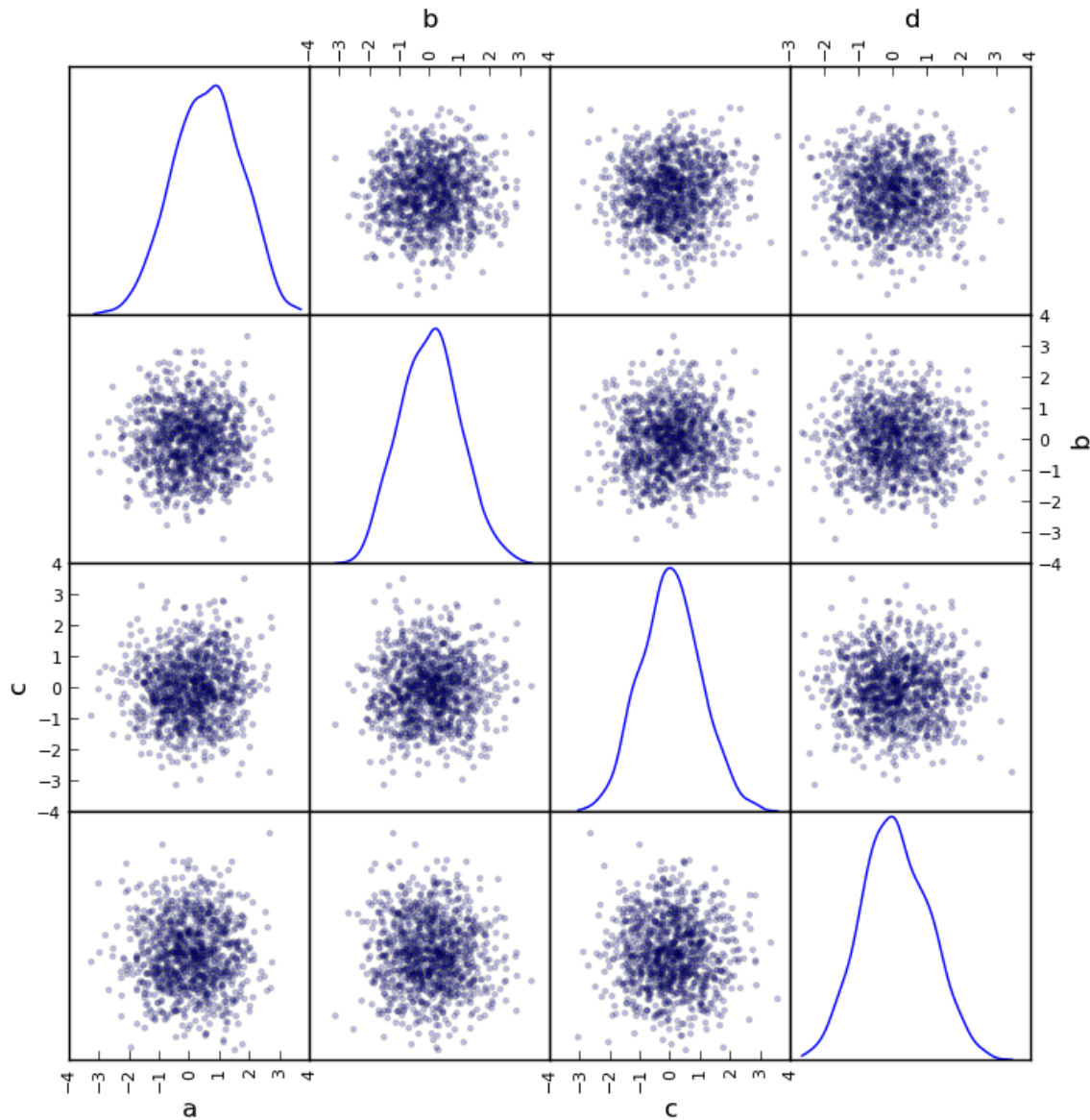
```
In [1495]: df = DataFrame(np.random.rand(10,3), columns=['Col1', 'Col2', 'Col3'])
In [1496]: df['X'] = Series(['A','A','A','A','A','B','B','B','B','B'])
In [1497]: df['Y'] = Series(['A','B','A','B','A','B','A','B','A','B'])
In [1498]: plt.figure();
In [1498]: bp = df.boxplot(column=['Col1','Col2'], by=['X','Y'])
```



14.2.4 Scatter plot matrix

New in 0.7.3. You can create a scatter plot matrix using the `scatter_matrix` method in `pandas.tools.plotting`:

```
In [1499]: from pandas.tools.plotting import scatter_matrix
In [1500]: df = DataFrame(np.random.randn(1000, 4), columns=['a', 'b', 'c', 'd'])
In [1501]: scatter_matrix(df, alpha=0.2, figsize=(8, 8), diagonal='kde')
Out[1501]:
array([[Axes(0.125,0.7;0.19375x0.2), Axes(0.31875,0.7;0.19375x0.2),
       Axes(0.5125,0.7;0.19375x0.2), Axes(0.70625,0.7;0.19375x0.2)],
       [Axes(0.125,0.5;0.19375x0.2), Axes(0.31875,0.5;0.19375x0.2),
       Axes(0.5125,0.5;0.19375x0.2), Axes(0.70625,0.5;0.19375x0.2)],
       [Axes(0.125,0.3;0.19375x0.2), Axes(0.31875,0.3;0.19375x0.2),
       Axes(0.5125,0.3;0.19375x0.2), Axes(0.70625,0.3;0.19375x0.2)],
       [Axes(0.125,0.1;0.19375x0.2), Axes(0.31875,0.1;0.19375x0.2),
       Axes(0.5125,0.1;0.19375x0.2), Axes(0.70625,0.1;0.19375x0.2)]] , dtype=object)
```

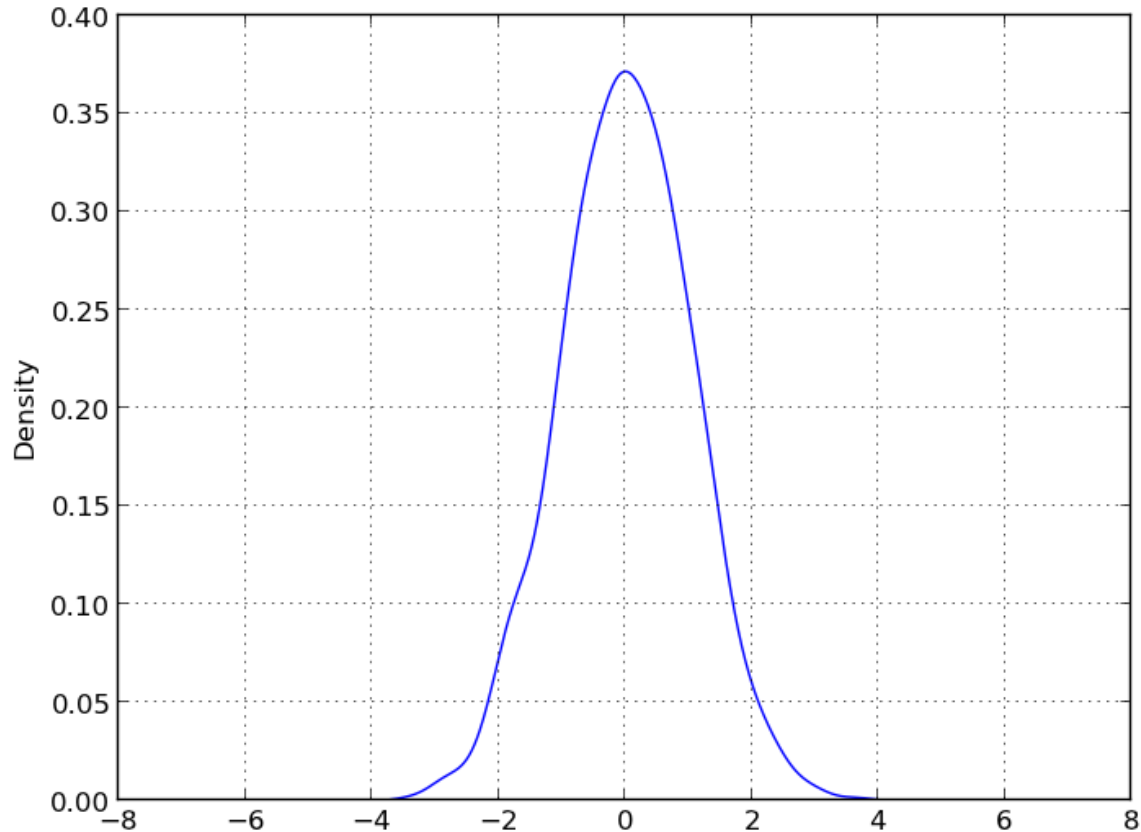


New in

0.8.0 You can create density plots using the Series/DataFrame.plot and setting `kind='kde'`:

```
In [1502]: ser = Series(np.random.randn(1000))

In [1503]: ser.plot(kind='kde')
Out[1503]: <matplotlib.axes.AxesSubplot at 0x1765ed50>
```



14.2.5 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](#).

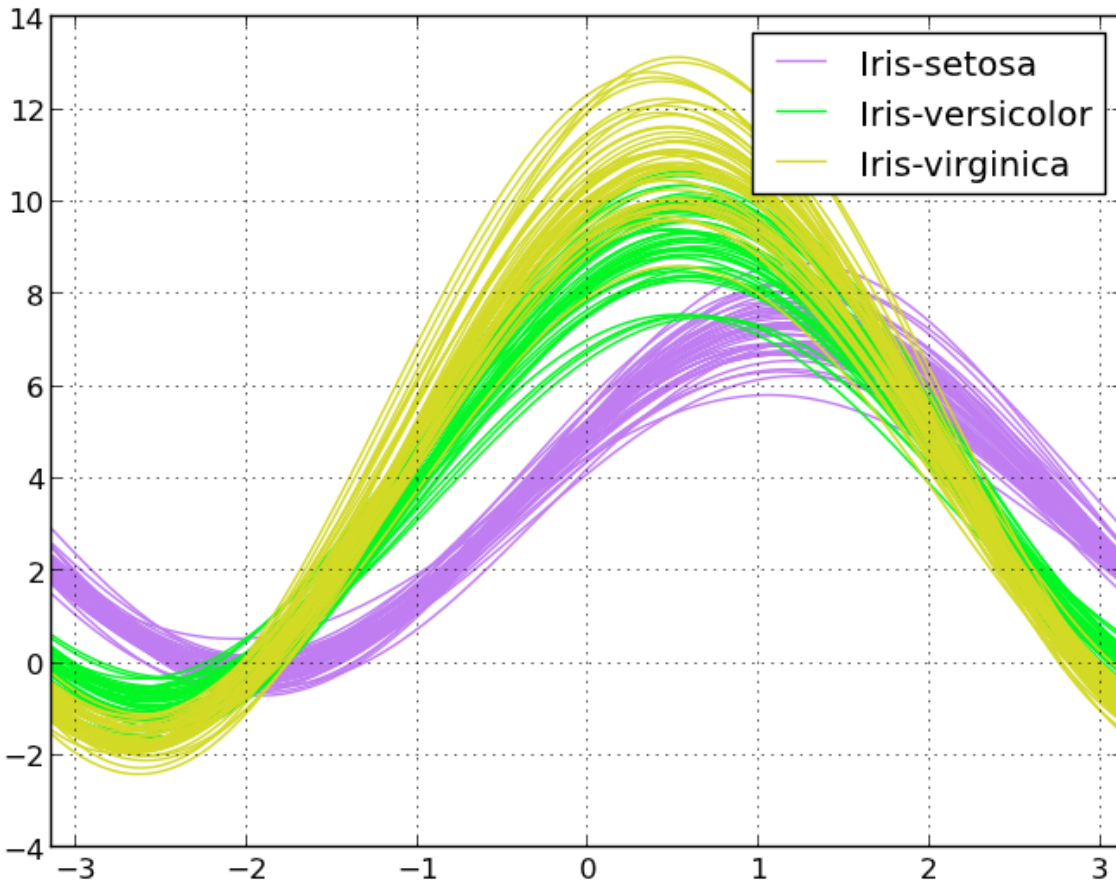
```
In [1504]: from pandas import read_csv

In [1505]: from pandas.tools.plotting import andrews_curves

In [1506]: data = read_csv('data/iris.data')

In [1507]: plt.figure()
Out[1507]: <matplotlib.figure.Figure at 0x18df0050>

In [1508]: andrews_curves(data, 'Name')
Out[1508]: <matplotlib.axes.AxesSubplot at 0x18dfd090>
```

14.2.6 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.

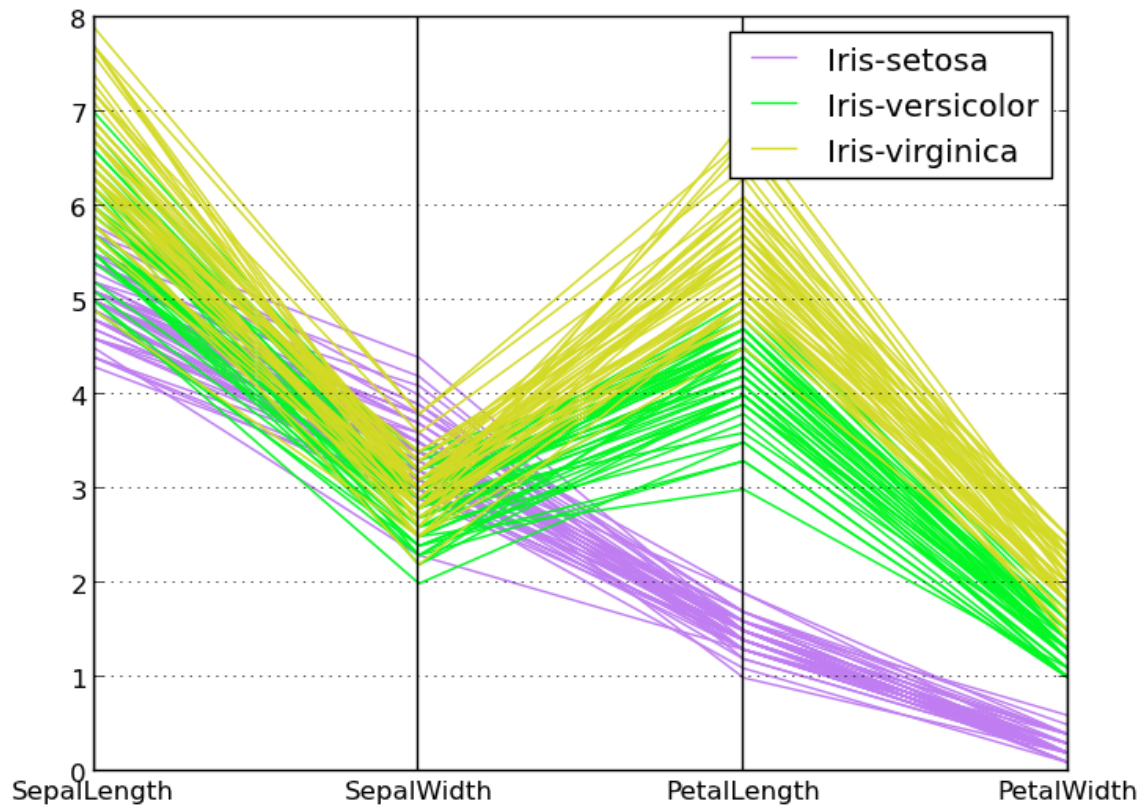
```
In [1509]: from pandas import read_csv

In [1510]: from pandas.tools.plotting import parallel_coordinates

In [1511]: data = read_csv('data/iris.data')

In [1512]: plt.figure()
Out[1512]: <matplotlib.figure.Figure at 0x195f7dd0>

In [1513]: parallel_coordinates(data, 'Name')
Out[1513]: <matplotlib.axes.AxesSubplot at 0x19a586d0>
```



14.2.7 Lag Plot

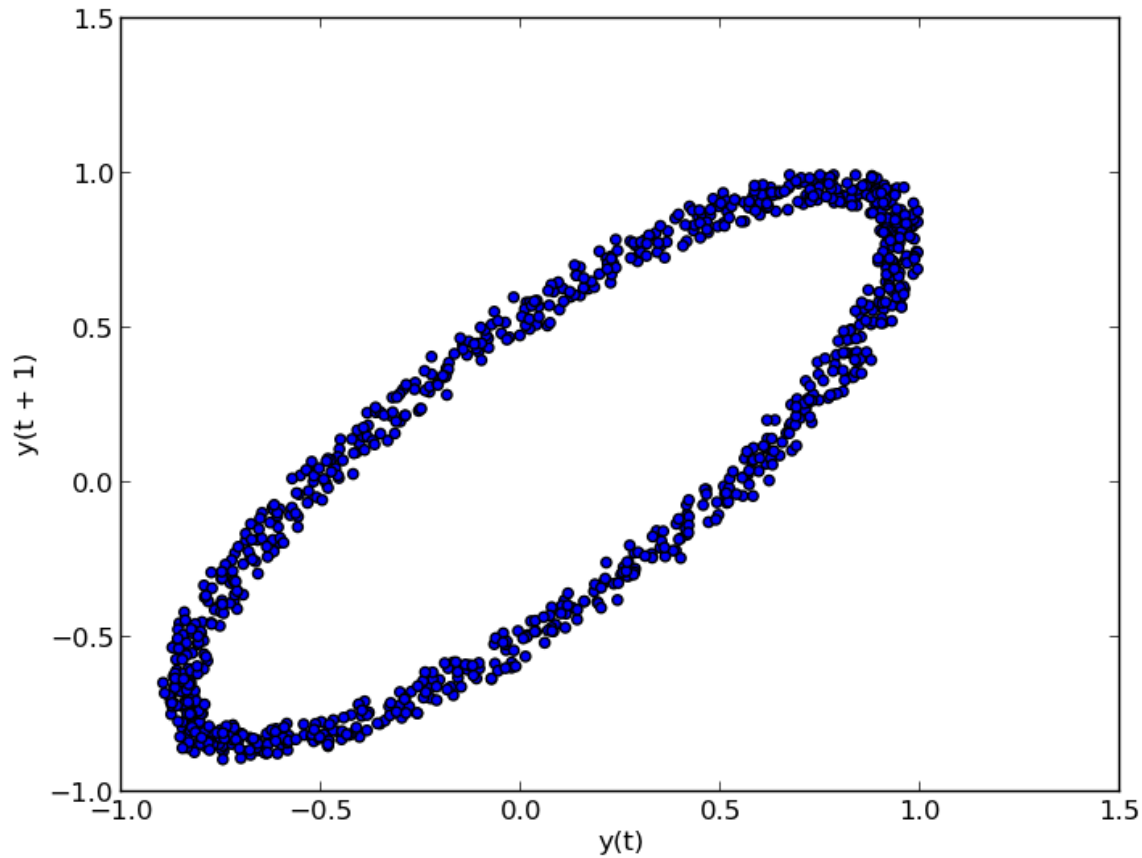
Lag plots are used to check if a data set or time series is random. Random data should not exhibit any structure in the lag plot. Non-random structure implies that the underlying data are not random.

```
In [1514]: from pandas.tools.plotting import lag_plot

In [1515]: plt.figure()
Out[1515]: <matplotlib.figure.Figure at 0x18df2c50>

In [1516]: data = Series(0.1 * np.random.random(1000) +
.....:     0.9 * np.sin(np.linspace(-99 * np.pi, 99 * np.pi, num=1000)))
.....:

In [1517]: lag_plot(data)
Out[1517]: <matplotlib.axes.AxesSubplot at 0x1a0ab6d0>
```



14.2.8 Autocorrelation Plot

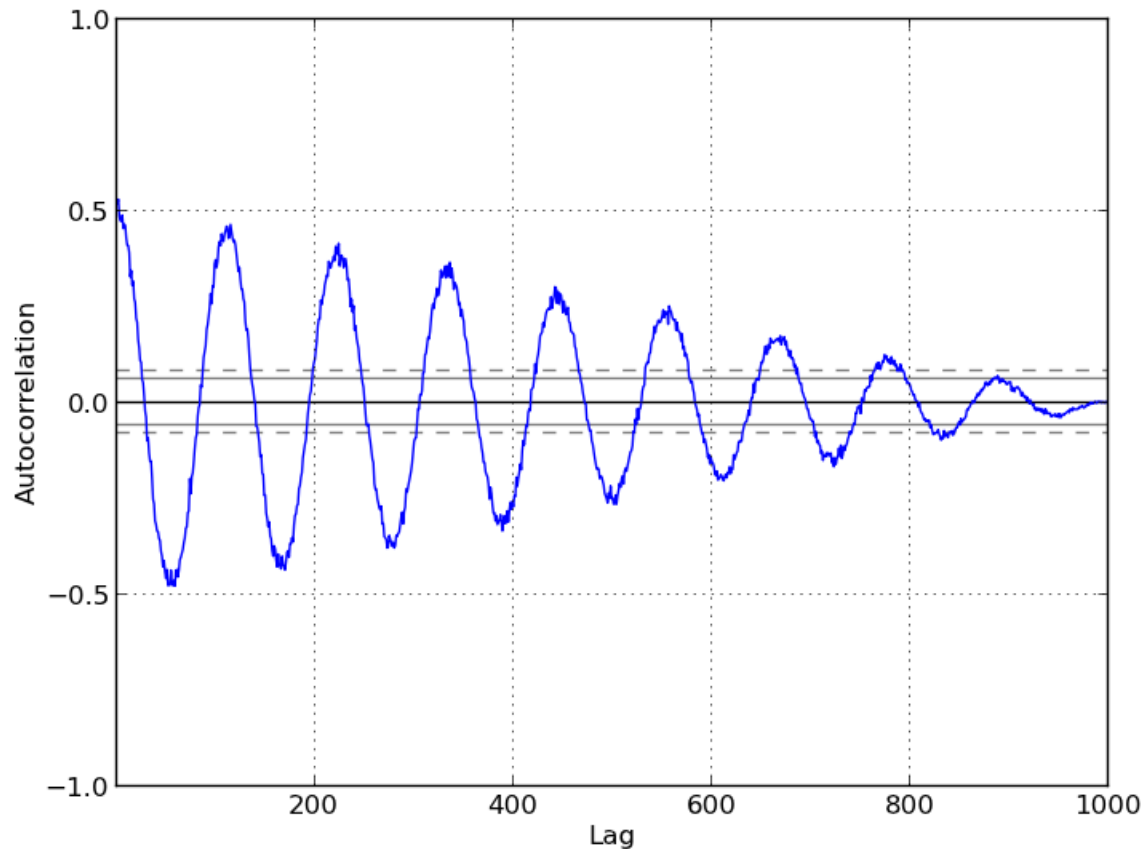
Autocorrelation plots are often used for checking randomness in time series. This is done by computing autocorrelations for data values at varying time lags. If time series is random, such autocorrelations should be near zero for any and all time-lag separations. If time series is non-random then one 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 [1518]: from pandas.tools.plotting import autocorrelation_plot

In [1519]: plt.figure()
Out[1519]: <matplotlib.figure.Figure at 0x1a183c50>

In [1520]: data = Series(0.7 * np.random.random(1000) +
.....:     0.3 * np.sin(np.linspace(-9 * np.pi, 9 * np.pi, num=1000)))
.....:

In [1521]: autocorrelation_plot(data)
Out[1521]: <matplotlib.axes.AxesSubplot at 0x1a183f50>
```



14.2.9 Bootstrap Plot

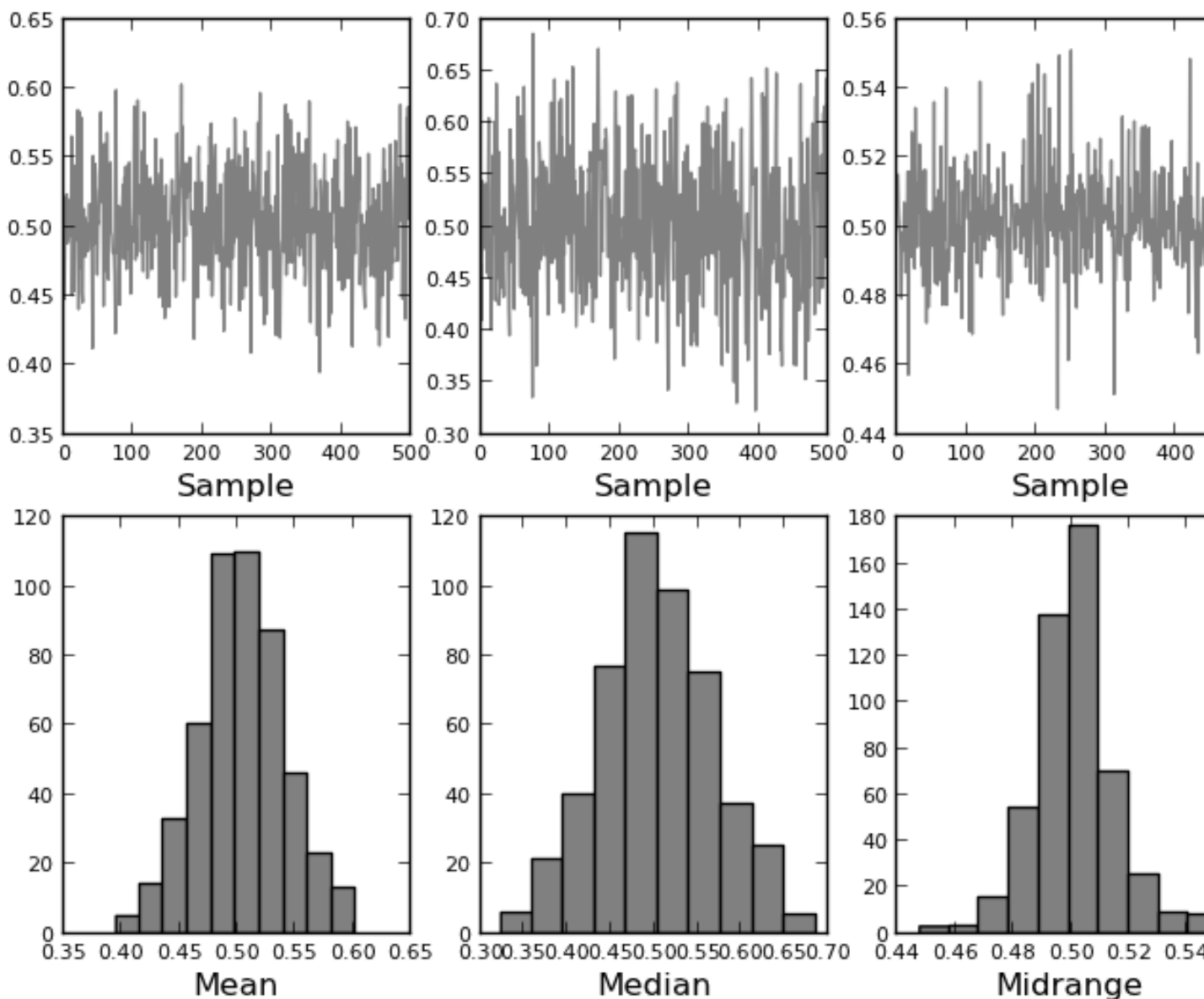
Bootstrap plots are used to visually assess the uncertainty of a statistic, such as mean, median, midrange, etc. A random subset of a specified size is selected from a data set, the statistic in question is computed for this subset and the process is repeated a specified number of times. Resulting plots and histograms are what constitutes the bootstrap plot.

```
In [1522]: from pandas.tools.plotting import bootstrap_plot
```

```
In [1523]: data = Series(np.random.random(1000))
```

```
In [1524]: bootstrap_plot(data, size=50, samples=500, color='grey')
```

```
Out[1524]: <matplotlib.figure.Figure at 0x19a53790>
```



14.2.10 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 to it will be colored differently.

Note: The “Iris” dataset is available [here](#).

```
In [1525]: from pandas import read_csv
```

```
In [1526]: from pandas.tools.plotting import radviz
```

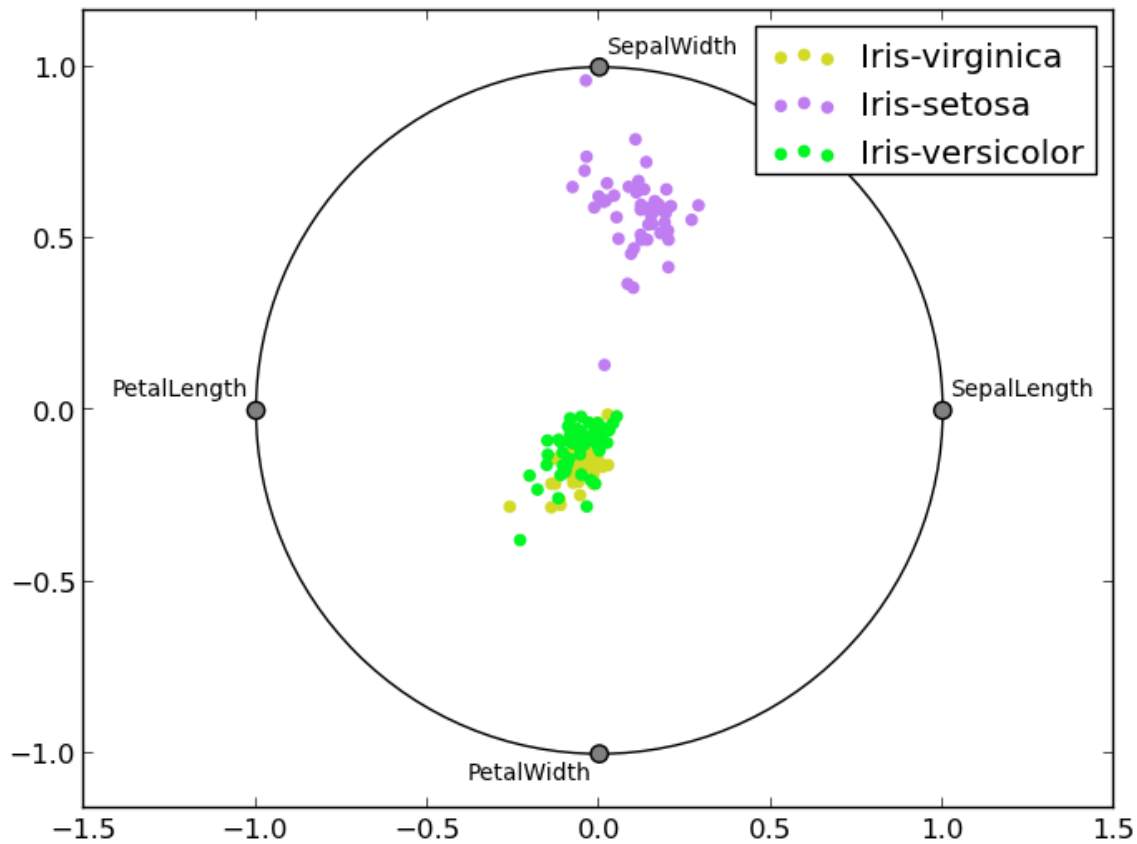
```
In [1527]: data = read_csv('data/iris.data')
```

```
In [1528]: plt.figure()
```

```
Out[1528]: <matplotlib.figure.Figure at 0x1a0d2450>
```

```
In [1529]: radviz(data, 'Name')
```

```
Out[1529]: <matplotlib.axes.AxesSubplot at 0x1b618390>
```



IO TOOLS (TEXT, CSV, HDF5, ...)

15.1 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. They can take a number of arguments:

- `filepath_or_buffer`: Either a string path to a file, or any object with a `read` method (such as an open file or `StringIO`).
- `sep` or `delimiter`: A delimiter / separator to split fields on. `read_csv` is capable of inferring the delimiter automatically in some cases by “sniffing.” The separator may be specified as a regular expression; for instance you may use `'\s*'` to indicate a pipe plus arbitrary whitespace.
- `delim_whitespace`: Parse whitespace-delimited (spaces or tabs) file (much faster than using a regular expression)
- `compression`: decompress `'gzip'` and `'bz2'` formats on the fly.
- `dialect`: string or `csv.Dialect` instance to expose more ways to specify the file format
- `dtype`: A data type name or a dict of column name to data type. If not specified, data types will be inferred.
- `header`: row number to use as the column names, and the start of the data. Defaults to 0 if no `names` passed, otherwise `None`. Explicitly pass `header=0` to be able to replace existing names.
- `skiprows`: A collection of numbers for rows in the file to skip. Can also be an integer to skip the first `n` rows
- `index_col`: column number, column name, or list of column numbers/names, to use as the `index` (row labels) of the resulting `DataFrame`. By default, it will number the rows without using any column, unless there is one more data column than there are headers, in which case the first column is taken as the index.
- `names`: List of column names to use as column names. To replace header existing in file, explicitly pass `header=0`.
- `na_values`: optional list of strings to recognize as `NaN` (missing values), either in addition to or in lieu of the default set.
- `true_values`: list of strings to recognize as `True`
- `false_values`: list of strings to recognize as `False`
- `keep_default_na`: whether to include the default set of missing values in addition to the ones specified in `na_values`
- `parse_dates`: if `True` then index will be parsed as dates (`False` by default). You can specify more complicated options to parse a subset of columns or a combination of columns into a single date column (list of ints or names, list of lists, or dict) `[1, 2, 3]` -> try parsing columns 1, 2, 3 each as a separate date column `[[1, 3]]` -> combine

columns 1 and 3 and parse as a single date column { 'foo' : [1, 3]} -> parse columns 1, 3 as date and call result 'foo'

- `keep_date_col`: if True, then date component columns passed into `parse_dates` will be retained in the output (False by default).
- `date_parser`: function to use to parse strings into datetime objects. If `parse_dates` is True, it defaults to the very robust `dateutil.parser`. Specifying this implicitly sets `parse_dates` as True. You can also use functions from community supported date converters from `date_converters.py`
- `dayfirst`: if True then uses the DD/MM international/European date format (This is False by default)
- `thousands`: specifies the thousands separator. If not None, then parser will try to look for it in the output and parse relevant data to integers. Because it has to essentially scan through the data again, this causes a significant performance hit so only use if necessary.
- `comment`: denotes the start of a comment and ignores the rest of the line. Currently line commenting is not supported.
- `nrows`: Number of rows to read out of the file. Useful to only read a small portion of a large file
- `iterator`: If True, return a `TextParser` to enable reading a file into memory piece by piece
- `chunksize`: An number of rows to be used to “chunk” a file into pieces. Will cause an `TextParser` object to be returned. More on this below in the section on *iterating and chunking*
- `skip_footer`: number of lines to skip at bottom of file (default 0)
- `converters`: a dictionary of functions for converting values in certain columns, where keys are either integers or column labels
- `encoding`: a string representing the encoding to use for decoding unicode data, e.g. `'utf-8'` or `'latin-1'`.
- `verbose`: show number of NA values inserted in non-numeric columns
- `squeeze`: if True then output with only one column is turned into Series

Consider a typical CSV file containing, in this case, some time series data:

```
In [830]: print open('foo.csv').read()
date,A,B,C
20090101,a,1,2
20090102,b,3,4
20090103,c,4,5
```

The default for `read_csv` is to create a `DataFrame` with simple numbered rows:

```
In [831]: pd.read_csv('foo.csv')
Out[831]:
```

	date	A	B	C
0	20090101	a	1	2
1	20090102	b	3	4
2	20090103	c	4	5

In the case of indexed data, you can pass the column number or column name you wish to use as the index:

```
In [832]: pd.read_csv('foo.csv', index_col=0)
Out[832]:
```

	A	B	C
date			
20090101	a	1	2
20090102	b	3	4
20090103	c	4	5


```
In [833]: pd.read_csv('foo.csv', index_col='date')
Out[833]:
```

	A	B	C
date			
20090101	a	1	2
20090102	b	3	4
20090103	c	4	5

You can also use a list of columns to create a hierarchical index:

```
In [834]: pd.read_csv('foo.csv', index_col=[0, 'A'])
Out[834]:
```

		B	C
date	A		
20090101	a	1	2
20090102	b	3	4
20090103	c	4	5

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 [835]: 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 [836]: dia = csv.excel()

In [837]: dia.quoting = csv.QUOTE_NONE

In [838]: pd.read_csv(StringIO(data), dialect=dia)
Out[838]:
```

	label1	label2	label3
index1	"a	c	e
index2	b	d	f

All of the dialect options can be specified separately by keyword arguments:

```
In [839]: data = 'a,b,c~1,2,3~4,5,6'

In [840]: pd.read_csv(StringIO(data), lineterminator='~')
Out[840]:
```

	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 [841]: data = 'a, b, c\n1, 2, 3\n4, 5, 6'

In [842]: print data
a, b, c
1, 2, 3
4, 5, 6
```

```
In [843]: pd.read_csv(StringIO(data), skipinitialspace=True)
Out[843]:
```

	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.

15.1.1 Specifying column data types

Starting with v0.10, you can indicate the data type for the whole DataFrame or individual columns:

```
In [844]: data = 'a,b,c\n1,2,3\n4,5,6\n7,8,9'
```

```
In [845]: print data
a,b,c
1,2,3
4,5,6
7,8,9
```

```
In [846]: df = pd.read_csv(StringIO(data), dtype=object)
```

```
In [847]: df
Out[847]:
```

	a	b	c
0	1	2	3
1	4	5	6
2	7	8	9

```
In [848]: df['a'][0]
Out[848]: '1'
```

```
In [849]: df = pd.read_csv(StringIO(data), dtype={'b': object, 'c': np.float64})
```

```
In [850]: df.dtypes
Out[850]:
```

	a	b	c
	int64	object	float64

15.1.2 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 [851]: from StringIO import StringIO
```

```
In [852]: data = 'a,b,c\n1,2,3\n4,5,6\n7,8,9'
```

```
In [853]: print data
a,b,c
1,2,3
4,5,6
7,8,9
```

```
In [854]: pd.read_csv(StringIO(data))
Out[854]:
   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 [855]: print data
a,b,c
1,2,3
4,5,6
7,8,9
```

```
In [856]: pd.read_csv(StringIO(data), names=['foo', 'bar', 'baz'], header=0)
Out[856]:
   foo  bar  baz
0    1    2    3
1    4    5    6
2    7    8    9
```

```
In [857]: pd.read_csv(StringIO(data), names=['foo', 'bar', 'baz'], header=None)
Out[857]:
   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 [858]: data = 'skip this skip it\na,b,c\n1,2,3\n4,5,6\n7,8,9'

In [859]: pd.read_csv(StringIO(data), header=1)
Out[859]:
   a  b  c
0  1  2  3
1  4  5  6
2  7  8  9
```

15.1.3 Filtering columns (`usecols`)

The `usecols` argument allows you to select any subset of the columns in a file, either using the column names or position numbers:

```
In [860]: data = 'a,b,c,d\n1,2,3,foo\n4,5,6,bar\n7,8,9,baz'

In [861]: pd.read_csv(StringIO(data))
Out[861]:
   a  b  c  d
0  1  2  3  foo
1  4  5  6  bar
2  7  8  9  baz
```

```
In [862]: pd.read_csv(StringIO(data), usecols=['b', 'd'])
```

```
Out[862]:
   b    d
0  2  foo
1  5  bar
2  8  baz

In [863]: pd.read_csv(StringIO(data), usecols=[0, 2, 3])
Out[863]:
   a    c    d
0  1    3  foo
1  4    6  bar
2  7    9  baz
```

15.1.4 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 [864]: data = 'word,length\nTr\xe4umen,7\nGr\xfc\xdf\xfe,5'

In [865]: df = pd.read_csv(StringIO(data), encoding='latin-1')

In [866]: df
Out[866]:
   word  length
0  Träumen      7
1   Grüße      5

In [867]: df['word'][1]
Out[867]: u'Gr\xfc\xdf\xfe'
```

Some formats which encode all characters as multiple bytes, like UTF-16, won't parse correctly at all without specifying the encoding.

15.1.5 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 [868]: data = 'a,b,c\n4,apple,bat,5.7\n8,orange,cow,10'

In [869]: pd.read_csv(StringIO(data))
Out[869]:
   a    b    c
4  apple bat  5.7
8  orange cow 10.0

In [870]: data = 'index,a,b,c\n4,apple,bat,5.7\n8,orange,cow,10'

In [871]: pd.read_csv(StringIO(data), index_col=0)
Out[871]:
   index    a    b    c
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 [872]: data = 'a,b,c\n4,apple,bat,\n8,orange,cow,'
```

```
In [873]: print data
```

```
a,b,c
4,apple,bat,
8,orange,cow,
```

```
In [874]: pd.read_csv(StringIO(data))
```

```
Out[874]:
```

	a	b	c
4	apple	bat	NaN
8	orange	cow	NaN

```
In [875]: pd.read_csv(StringIO(data), index_col=False)
```

```
Out[875]:
```

	a	b	c
0	4	apple	bat
1	8	orange	cow

15.1.6 Specifying Date Columns

To better facilitate working with datetime data, `read_csv()` and `read_table()` uses 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 [876]: df = pd.read_csv('foo.csv', index_col=0, parse_dates=True)
```

```
In [877]: df
```

```
Out[877]:
```

	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 [878]: df.index
```

```
Out[878]:
```

```
<class 'pandas.tseries.index.DatetimeIndex'>
[2009-01-01 00:00:00, ..., 2009-01-03 00:00:00]
Length: 3, Freq: None, Timezone: 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 [879]: 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 [880]: df = pd.read_csv('tmp.csv', header=None, parse_dates=[[1, 2], [1, 3]])
```

```
In [881]: df
Out[881]:
```

	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 [882]: df = pd.read_csv('tmp.csv', header=None, parse_dates=[[1, 2], [1, 3]],
.....:                  keep_date_col=True)
.....:
```

```
In [883]: df
Out[883]:
```

	1_2	1_3	0	1	2	3	4
0	1999-01-27 19:00:00	1999-01-27 18:56:00	KORD	19990127	19:00:00	18:56:00	0.81
1	1999-01-27 20:00:00	1999-01-27 19:56:00	KORD	19990127	20:00:00	19:56:00	0.01
2	1999-01-27 21:00:00	1999-01-27 20:56:00	KORD	19990127	21:00:00	20:56:00	-0.59
3	1999-01-27 21:00:00	1999-01-27 21:18:00	KORD	19990127	21:00:00	21:18:00	-0.99
4	1999-01-27 22:00:00	1999-01-27 21:56:00	KORD	19990127	22:00:00	21:56:00	-0.59
5	1999-01-27 23:00:00	1999-01-27 22:56:00	KORD	19990127	23:00:00	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 [884]: date_spec = {'nominal': [1, 2], 'actual': [1, 3]}
```

```
In [885]: df = pd.read_csv('tmp.csv', header=None, parse_dates=date_spec)
```

```
In [886]: df
Out[886]:
```

	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 [887]: date_spec = {'nominal': [1, 2], 'actual': [1, 3]}

In [888]: df = pd.read_csv('tmp.csv', header=None, parse_dates=date_spec,
.....:                    index_col=0) #index is the nominal column
.....:

In [889]: df
Out[889]:
```

			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: 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 than as an index on the resulting frame.

15.1.7 Date Parsing Functions

Finally, the parser allows you can specify a custom *date_parser* function to take full advantage of the flexibility of the date parsing API:

```
In [890]: import pandas.io.date_converters as conv

In [891]: df = pd.read_csv('tmp.csv', header=None, parse_dates=date_spec,
.....:                    date_parser=conv.parse_date_time)
.....:

In [892]: df
Out[892]:
```

	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

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.

15.1.8 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 [893]: print open('tmp.csv').read()
date,value,cat
1/6/2000,5,a
2/6/2000,10,b
3/6/2000,15,c
```

```
In [894]: pd.read_csv('tmp.csv', parse_dates=[0])
Out[894]:
```

	date	value	cat
0	2000-01-06 00:00:00	5	a
1	2000-02-06 00:00:00	10	b
2	2000-03-06 00:00:00	15	c

```
In [895]: pd.read_csv('tmp.csv', dayfirst=True, parse_dates=[0])
Out[895]:
```

	date	value	cat
0	2000-06-01 00:00:00	5	a
1	2000-06-02 00:00:00	10	b
2	2000-06-03 00:00:00	15	c

15.1.9 Thousand Separators

For large integers that have been written with a thousands separator, you can set the `thousands` keyword to `True` so that integers will be parsed correctly:

By default, integers with a thousands separator will be parsed as strings

```
In [896]: print open('tmp.csv').read()
ID|level|category
Patient1|123,000|x
Patient2|23,000|y
Patient3|1,234,018|z
```

```
In [897]: df = pd.read_csv('tmp.csv', sep='|')
```

```
In [898]: df
Out[898]:
```

	ID	level	category
0	Patient1	123,000	x
1	Patient2	23,000	y
2	Patient3	1,234,018	z

```
In [899]: df.level.dtype
Out[899]: dtype('object')
```

The `thousands` keyword allows integers to be parsed correctly

```
In [900]: print open('tmp.csv').read()
ID|level|category
Patient1|123,000|x
Patient2|23,000|y
Patient3|1,234,018|z
```

```
In [901]: df = pd.read_csv('tmp.csv', sep='|', thousands=',')
```

```
In [902]: df
Out[902]:
```



```

      ID    level category
0 Patient1  123000      x
1 Patient2   23000      y
2 Patient3 1234018      z

```

```

In [903]: df.level.dtype
Out[903]: dtype('int64')

```

15.1.10 Comments

Sometimes comments or meta data may be included in a file:

```

In [904]: 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 parse includes the comments in the output:

```

In [905]: df = pd.read_csv('tmp.csv')

In [906]: df
Out[906]:
      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 [907]: df = pd.read_csv('tmp.csv', comment='#')

In [908]: df
Out[908]:
      ID    level category
0 Patient1  123000      x
1 Patient2   23000      y
2 Patient3 1234018      z

```

15.1.11 Returning Series

Using the `squeeze` keyword, the parser will return output with a single column as a `Series`:

```

In [909]: print open('tmp.csv').read()
level
Patient1,123000
Patient2,23000
Patient3,1234018

In [910]: output = pd.read_csv('tmp.csv', squeeze=True)

In [911]: output
Out[911]:
Patient1    123000
Patient2     23000

```

```
Patient3    1234018
Name: level
```

```
In [912]: type(output)
Out[912]: pandas.core.series.Series
```

15.1.12 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 [913]: data= 'a,b,c\n1,Yes,2\n3,No,4'
```

```
In [914]: print data
a,b,c
1,Yes,2
3,No,4
```

```
In [915]: pd.read_csv(StringIO(data))
Out[915]:
   a  b  c
0  1  Yes  2
1  3  No  4
```

```
In [916]: pd.read_csv(StringIO(data), true_values=['Yes'], false_values=['No'])
Out[916]:
   a  b  c
0  1  True  2
1  3  False  4
```

15.1.13 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))
-----
CParserError                                Traceback (most recent call last)
CParserError: 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
```

15.1.14 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 [917]: data = 'a,b\n"hello, \\"Bob\\", nice to see you",5'
```

```
In [918]: print data
a,b
"hello, \"Bob\\", nice to see you",5
```

```
In [919]: pd.read_csv(StringIO(data), escapechar='\\')
Out[919]:
```

```

              a  b
0  hello, "Bob", nice to see you  5
```

15.1.15 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:

- `colspecs`: a list of pairs (tuples), giving the extents of the fixed-width fields of each line as half-open intervals [from, to[
- `widths`: a list of field widths, which can be used instead of `colspecs` if the intervals are contiguous

Consider a typical fixed-width data file:

```
In [920]: 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 [921]: colspecs = [(0, 6), (8, 20), (21, 33), (34, 43)]
```

```
In [922]: df = pd.read_fwf('bar.csv', colspecs=colspecs, header=None, index_col=0)
```

```
In [923]: df
```

```
Out[923]:
              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 [924]: widths = [6, 14, 13, 10]
```

```
In [925]: df = pd.read_fwf('bar.csv', widths=widths, header=None)
```

```
In [926]: df
```

```
Out[926]:
```

	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.

15.1.16 Files with an “implicit” index column

Consider a file with one less entry in the header than the number of data column:

```
In [927]: 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 [928]: pd.read_csv('foo.csv')
```

```
Out[928]:
```

	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 [929]: df = pd.read_csv('foo.csv', parse_dates=True)
```

```
In [930]: df.index
```

```
Out[930]:
```

```
<class 'pandas.tseries.index.DatetimeIndex'>
[2009-01-01 00:00:00, ..., 2009-01-03 00:00:00]
Length: 3, Freq: None, Timezone: None
```

15.1.17 Reading DataFrame objects with MultiIndex

Suppose you have data indexed by two columns:

```
In [931]: print open('data/minindex_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`:

```
In [932]: df = pd.read_csv("data/minindex_ex.csv", index_col=[0,1])
```

```
In [933]: df
```

```
Out[933]:
```

		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 [934]: df.ix[1978]
```

```
Out[934]:
```

	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

15.1.18 Automatically “sniffing” the delimiter

`read_csv` is capable of inferring delimited (not necessarily comma-separated) files. YMMV, as pandas uses the `csv.Sniffer` class of the `csv` module.

```
In [935]: print open('tmp2.csv').read()
:0:1:2:3
0:0.469112299907:-0.282863344329:-1.50905850317:-1.13563237102
1:1.21211202502:-0.173214649053:0.119208711297:-1.04423596628
2:-0.861848963348:-2.10456921889:-0.494929274069:1.07180380704
3:0.721555162244:-0.70677113363:-1.03957498511:0.271859885543
4:-0.424972329789:0.567020349794:0.276232019278:-1.08740069129
5:-0.673689708088:0.113648409689:-1.47842655244:0.524987667115
6:0.40470521868:0.57704598592:-1.71500201611:-1.03926848351
```

7:-0.370646858236:-1.15789225064:-1.34431181273:0.844885141425
8:1.07576978372:-0.10904997528:1.64356307036:-1.46938795954
9:0.357020564133:-0.67460010373:-1.77690371697:-0.968913812447

```
In [936]: pd.read_csv('tmp2.csv')
```

[illegible]

15.1.19 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 [937]: print open('tmp.sv').read()
```

|0|1|2|3
 0|0.469112299907|-0.282863344329|-1.50905850317|-1.13563237102
 1|1.21211202502|-0.173214649053|0.119208711297|-1.04423596628
 2|-0.861848963348|-2.10456921889|-0.494929274069|1.07180380704
 3|0.721555162244|-0.70677113363|-1.03957498511|0.271859885543
 4|-0.424972329789|0.567020349794|0.276232019278|-1.08740069129
 5|-0.673689708088|0.113648409689|-1.47842655244|0.524987667115
 6|0.40470521868|0.57704598592|-1.71500201611|-1.03926848351
 7|-0.370646858236|-1.15789225064|-1.34431181273|0.84488514125
 8|1.07576978372|-0.10904997528|1.64356307036|-1.46938795954
 9|0.357020564133|-0.67460010373|-1.77690371697|-0.968913812447

```
In [938]: table = pd.read_table('tmp.csv', sep='|')
```

In [939]: table

```
Out[939]:
```

	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 `TextParser`:

```
In [940]: reader = pd.read_table('tmp.csv', sep='|', chunksize=4)
```

```
In [941]: reader
```

```
Out[941]: <pandas.io.parsers.TextFileReader at 0xae02d0>
```

```
In [942]: 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
0      4 -0.424972  0.567020  0.276232 -1.087401
1      5 -0.673690  0.113648 -1.478427  0.524988
2      6  0.404705  0.577046 -1.715002 -1.039268
3      7 -0.370647 -1.157892 -1.344312  0.844885
   Unnamed: 0      0      1      2      3
0      8  1.075770 -0.10905  1.643563 -1.469388
1      9  0.357021 -0.67460 -1.776904 -0.968914
```

Specifying `iterator=True` will also return the `TextParser` object:

```
In [943]: reader = pd.read_table('tmp.csv', sep='|', iterator=True)
```

```
In [944]: reader.get_chunk(5)
```

```
Out[944]:
   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
```

15.1.20 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`: A string path to the file to write
- `nanRep`: A string representation of a missing value (default `''`)
- `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'`
- `sep`: Field delimiter for the output file (default `','`)
- `encoding`: a string representing the encoding to use if the contents are non-ascii, for python versions prior to 3

15.1.21 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.

15.1.22 Writing to HTML format

DataFrame object has 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.

15.2 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 described in the next section. 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(delim_whitespace=True)
```

```
In [945]: clipdf
```

```
Out[945]:
```

```
   A  B  C
x  1  4  p
y  2  5  q
z  3  6  r
```


15.3 Excel files

The `ExcelFile` class can read an Excel 2003 file using the `xlrd` Python module and use the same parsing code as the above to convert tabular data into a `DataFrame`. To use it, create the `ExcelFile` object:

```
xls = ExcelFile('path_to_file.xls')
```

Then use the `parse` instance method with a `sheetname`, then use the same additional arguments as the parsers above:

```
xls.parse('Sheet1', index_col=None, na_values=['NA'])
```

To read sheets from an Excel 2007 file, you can pass a filename with a `.xlsx` extension, in which case the `openpyxl` module will be used to read the file.

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. `ExcelFile.parse` takes a `parse_cols` keyword to allow you to specify a subset of columns to parse.

If `parse_cols` is an integer, then it is assumed to indicate the last column to be parsed.

```
xls.parse('Sheet1', parse_cols=2, index_col=None, na_values=['NA'])
```

If `parse_cols` is a list of integers, then it is assumed to be the file column indices to be parsed.

```
xls.parse('Sheet1', parse_cols=[0, 2, 3], index_col=None, na_values=['NA'])
```

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 `openpyxl`. 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 use the `ExcelWriter` class, as in the following example:

```
writer = ExcelWriter('path_to_file.xlsx')
df1.to_excel(writer, sheet_name='sheet1')
df2.to_excel(writer, sheet_name='sheet2')
writer.save()
```

15.4 HDF5 (PyTables)

`HDFStore` is a dict-like object which reads and writes pandas to the high performance HDF5 format using the excellent `PyTables` library.

```
In [946]: store = HDFStore('store.h5')
```

```
In [947]: print store
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
Empty
```

Objects can be written to the file just like adding key-value pairs to a dict:

```
In [948]: index = date_range('1/1/2000', periods=8)

In [949]: s = Series(randn(5), index=['a', 'b', 'c', 'd', 'e'])

In [950]: df = DataFrame(randn(8, 3), index=index,
.....:                  columns=['A', 'B', 'C'])
.....:

In [951]: wp = Panel(randn(2, 5, 4), items=['Item1', 'Item2'],
.....:               major_axis=date_range('1/1/2000', periods=5),
.....:               minor_axis=['A', 'B', 'C', 'D'])
.....:

# store.put('s', s) is an equivalent method
In [952]: store['s'] = s

In [953]: store['df'] = df

In [954]: store['wp'] = wp

# the type of stored data
In [955]: store.root.wp._v_attrs.pandas_type
Out[955]: 'wide'

In [956]: store
Out[956]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/df          frame          (shape->[8,3])
/s           series         (shape->[5])
/wp          wide           (shape->[2,5,4])
```

In a current or later Python session, you can retrieve stored objects:

```
# store.get('df') is an equivalent method
In [957]: store['df']
Out[957]:
```

	A	B	C
2000-01-01	-0.362543	-0.006154	-0.923061
2000-01-02	0.895717	0.805244	-1.206412
2000-01-03	2.565646	1.431256	1.340309
2000-01-04	-1.170299	-0.226169	0.410835
2000-01-05	0.813850	0.132003	-0.827317
2000-01-06	-0.076467	-1.187678	1.130127
2000-01-07	-1.436737	-1.413681	1.607920
2000-01-08	1.024180	0.569605	0.875906

Deletion of the object specified by the key

```
# store.remove('wp') is an equivalent method
In [958]: del store['wp']

In [959]: store
Out[959]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/df          frame          (shape->[8,3])
/s           series         (shape->[5])
```

Closing a Store

```
# closing a store
In [960]: store.close()

# Working with, and automatically closing the store with the context manager.
In [961]: with get_store('store.h5') as store:
.....:     store.keys()
.....:
```

These 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.

15.4.1 Storing in 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.

```
In [962]: store = HDFStore('store.h5')

In [963]: df1 = df[0:4]

In [964]: df2 = df[4:]

# append data (creates a table automatically)
In [965]: store.append('df', df1)

In [966]: store.append('df', df2)

In [967]: store
Out[967]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/df          frame_table  (typ->appendable,nrows->8,ncols->3,indexers->[index])

# select the entire object
In [968]: store.select('df')
Out[968]:
```

	A	B	C
2000-01-01	-0.362543	-0.006154	-0.923061
2000-01-02	0.895717	0.805244	-1.206412
2000-01-03	2.565646	1.431256	1.340309
2000-01-04	-1.170299	-0.226169	0.410835
2000-01-05	0.813850	0.132003	-0.827317
2000-01-06	-0.076467	-1.187678	1.130127
2000-01-07	-1.436737	-1.413681	1.607920
2000-01-08	1.024180	0.569605	0.875906

```
# the type of stored data
In [969]: store.root.df._v_attrs.pandas_type
Out[969]: 'frame_table'
```

15.4.2 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 [970]: store.put('foo/bar/bah', df)

In [971]: store.append('food/orange', df)

In [972]: store.append('food/apple', df)

In [973]: store
Out[973]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/df                frame_table  (typ->appendable,nrows->8,ncols->3,indexers->[index])
/food/apple        frame_table  (typ->appendable,nrows->8,ncols->3,indexers->[index])
/food/orange       frame_table  (typ->appendable,nrows->8,ncols->3,indexers->[index])
/foo/bar/bah       frame        (shape->[8,3])

# a list of keys are returned
In [974]: store.keys()
Out[974]: ['/df', '/food/apple', '/food/orange', '/foo/bar/bah']

# remove all nodes under this level
In [975]: store.remove('food')

In [976]: store
Out[976]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/df                frame_table  (typ->appendable,nrows->8,ncols->3,indexers->[index])
/foo/bar/bah       frame        (shape->[8,3])
```

15.4.3 Storing Mixed Types in a Table

Storing mixed-dtype data is supported. Strings are store as a fixed-width using the maximum size of the appended column. Subsequent appends will truncate strings at this length. 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 [977]: df_mixed                = df.copy()

In [978]: df_mixed['string']      = 'string'

In [979]: df_mixed['int']         = 1

In [980]: df_mixed['bool']       = True

In [981]: df_mixed['datetime64'] = Timestamp('20010102')

In [982]: df_mixed.ix[3:5,['A','B','string','datetime64']] = np.nan

In [983]: store.append('df_mixed', df_mixed, min_itemsize = { 'values' : 50 })
```

```
In [984]: df_mixed1 = store.select('df_mixed')
```

```
In [985]: df_mixed1
```

```
Out [985]:
```

	A	B	C	string	int	bool	datetime64
2000-01-01	-0.362543	-0.006154	-0.923061	string	1	True	2001-01-02 00:00:00
2000-01-02	0.895717	0.805244	-1.206412	string	1	True	2001-01-02 00:00:00
2000-01-03	2.565646	1.431256	1.340309	string	1	True	2001-01-02 00:00:00
2000-01-04	NaN	NaN	0.410835	NaN	1	True	NaT
2000-01-05	NaN	NaN	-0.827317	NaN	1	True	NaT
2000-01-06	-0.076467	-1.187678	1.130127	string	1	True	2001-01-02 00:00:00
2000-01-07	-1.436737	-1.413681	1.607920	string	1	True	2001-01-02 00:00:00
2000-01-08	1.024180	0.569605	0.875906	string	1	True	2001-01-02 00:00:00

```
In [986]: df_mixed1.get_dtype_counts()
```

```
Out [986]:
```

bool	1
datetime64[ns]	1
float64	3
int64	1
object	1

```
# we have provided a minimum string column size
```

```
In [987]: store.root.df_mixed.table
```

```
Out [987]:
```

```
/df_mixed/table (Table(8,)) ''
description := {
  "index": Int64Col(shape=(), dflt=0, pos=0),
  "values_block_0": Float64Col(shape=(3,), dflt=0.0, pos=1),
  "values_block_1": StringCol(itemsize=50, shape=(1,), dflt='', pos=2),
  "values_block_2": Int64Col(shape=(1,), dflt=0, pos=3),
  "values_block_3": BoolCol(shape=(1,), dflt=False, pos=4),
  "values_block_4": Int64Col(shape=(1,), dflt=0, pos=5)}
byteorder := 'little'
chunkshape := (661,)
autoIndex := True
colindexes := {
  "index": Index(6, medium, shuffle, zlib(1)).is_CSI=False}
```

15.4.4 Storing Multi-Index DataFrames

Storing multi-index dataframes as tables is very similar to storing/selecting from homogenous index DataFrames.

```
In [988]: 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 [989]: df_mi = DataFrame(np.random.randn(10, 3), index=index,
.....:                      columns=['A', 'B', 'C'])
.....:
```

```
In [990]: df_mi
```

```
Out [990]:
```

```
          A          B          C
foo bar
foo one    0.896171 -0.487602 -0.082240
   two    -2.182937  0.380396  0.084844
   three    0.432390  1.519970 -0.493662
bar one    0.600178  0.274230  0.132885
   two    -0.023688  2.410179  1.450520
baz two     0.206053 -0.251905 -2.213588
   three    1.063327  1.266143  0.299368
gux one    -0.863838  0.408204 -1.048089
   two    -0.025747 -0.988387  0.094055
   three    1.262731  1.289997  0.082423
```

```
In [991]: store.append('df_mi', df_mi)
```

```
In [992]: store.select('df_mi')
```

```
Out [992]:
```

```
          A          B          C
foo bar
foo one    0.896171 -0.487602 -0.082240
   two    -2.182937  0.380396  0.084844
   three    0.432390  1.519970 -0.493662
bar one    0.600178  0.274230  0.132885
   two    -0.023688  2.410179  1.450520
baz two     0.206053 -0.251905 -2.213588
   three    1.063327  1.266143  0.299368
gux one    -0.863838  0.408204 -1.048089
   two    -0.025747 -0.988387  0.094055
   three    1.262731  1.289997  0.082423
```

```
# the levels are automatically included as data columns
```

```
In [993]: store.select('df_mi', Term('foo=bar'))
```

```
Out [993]:
```

```
          A          B          C
foo bar
bar one    0.600178  0.274230  0.132885
   two    -0.023688  2.410179  1.450520
```

15.4.5 Querying a Table

`select` and `delete` operations have an optional criteria 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.

- ‘index’ and ‘columns’ are supported indexers of a `DataFrame`
- ‘major_axis’, ‘minor_axis’, and ‘items’ are supported indexers of the `Panel`

Valid terms can be created from `dict`, `list`, `tuple`, or `string`. Objects can be embedded as values. Allowed operations are: `<`, `<=`, `>`, `>=`, `=`. `=` will be inferred as an implicit set operation (e.g. if 2 or more values are provided). The following are all valid terms.

- `dict(field = 'index', op = '>', value = '20121114')`
- `('index', '>', '20121114')`
- `'index > 20121114'`
- `('index', '>', datetime(2012, 11, 14))`

- ('index', ['20121114', '20121115'])
- ('major_axis', '=', Timestamp('2012/11/14'))
- ('minor_axis', ['A', 'B'])

Queries are built up using a list of Terms (currently only **and**ing of terms is supported). An example query for a panel might be specified as follows. ['major_axis>20000102', ('minor_axis', '=', ['A', 'B'])]. This is roughly translated to: *major_axis must be greater than the date 20000102 and the minor_axis must be A or B*

```
In [994]: store.append('wp', wp)
```

```
In [995]: store
```

```
Out[995]:
```

```
<class 'pandas.io.pytables.HDFStore'>
```

```
File path: store.h5
```

```
/df                frame_table    (typ->appendable,nrows->8,ncols->3,indexers->[index])
/df_mi            frame_table    (typ->appendable_multi,nrows->10,ncols->5,indexers->[index],dc->1)
/df_mixed         frame_table    (typ->appendable,nrows->8,ncols->7,indexers->[index])
/wp              wide_table      (typ->appendable,nrows->20,ncols->2,indexers->[major_axis,minor_axis])
/foo/bar/bah      frame          (shape->[8,3])
```

```
In [996]: store.select('wp', [Term('major_axis>20000102'), Term('minor_axis', '=', ['A', 'B'])])
```

```
Out[996]:
```

```
<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 to filter a list of the return columns, this is equivalent to passing a Term('columns', list_of_columns_to_filter)

```
In [997]: store.select('df', columns = ['A', 'B'])
```

```
Out[997]:
```

	A	B
2000-01-01	-0.362543	-0.006154
2000-01-02	0.895717	0.805244
2000-01-03	2.565646	1.431256
2000-01-04	-1.170299	-0.226169
2000-01-05	0.813850	0.132003
2000-01-06	-0.076467	-1.187678
2000-01-07	-1.436737	-1.413681
2000-01-08	1.024180	0.569605

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 [998]: wp.to_frame()
```

```
Out[998]:
```

		Item1	Item2
major	minor		
2000-01-01	A	-2.211372	0.687738
	B	0.974466	0.176444
	C	-2.006747	0.403310
	D	-0.410001	-0.154951
2000-01-02	A	-0.078638	0.301624
	B	0.545952	-2.179861

```
      C      -1.219217 -1.369849
      D      -1.226825 -0.954208
2000-01-03 A      0.769804  1.462696
      B      -1.281247 -1.743161
      C      -0.727707 -0.826591
      D      -0.121306 -0.345352
2000-01-04 A      -0.097883  1.314232
      B      0.695775  0.690579
      C      0.341734  0.995761
      D      0.959726  2.396780
2000-01-05 A      -1.110336  0.014871
      B      -0.619976  3.357427
      C      0.149748 -0.317441
      D      -0.732339 -1.236269
```

```
# limiting the search
```

```
In [999]: store.select('wp', [ Term('major_axis>20000102'), Term('minor_axis', '=', ['A','B']) ], start=
```

```
Out[999]:
```

```
<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
```

15.4.6 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. **Indexes are automatically created (starting 0.10.1)** 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 [1000]: i = store.root.df.table.cols.index.index
```

```
In [1001]: i.optlevel, i.kind
```

```
Out[1001]: (6, 'medium')
```

```
# change an index by passing new parameters
```

```
In [1002]: store.create_table_index('df', optlevel = 9, kind = 'full')
```

```
In [1003]: i = store.root.df.table.cols.index.index
```

```
In [1004]: i.optlevel, i.kind
```

```
Out[1004]: (9, 'full')
```

15.4.7 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 [1005]: df_dc = df.copy()
```



```
In [1006]: df_dc['string'] = 'foo'
```

```
In [1007]: df_dc.ix[4:6,'string'] = np.nan
```

```
In [1008]: df_dc.ix[7:9,'string'] = 'bar'
```

```
In [1009]: df_dc['string2'] = 'cool'
```

```
In [1010]: df_dc
```

```
Out[1010]:
```

	A	B	C	string	string2
2000-01-01	-0.362543	-0.006154	-0.923061	foo	cool
2000-01-02	0.895717	0.805244	-1.206412	foo	cool
2000-01-03	2.565646	1.431256	1.340309	foo	cool
2000-01-04	-1.170299	-0.226169	0.410835	foo	cool
2000-01-05	0.813850	0.132003	-0.827317	NaN	cool
2000-01-06	-0.076467	-1.187678	1.130127	NaN	cool
2000-01-07	-1.436737	-1.413681	1.607920	foo	cool
2000-01-08	1.024180	0.569605	0.875906	bar	cool

```
# on-disk operations
```

```
In [1011]: store.append('df_dc', df_dc, data_columns = ['B','C','string','string2'])
```

```
In [1012]: store.select('df_dc',[ Term('B>0') ])
```

```
Out[1012]:
```

	A	B	C	string	string2
2000-01-02	0.895717	0.805244	-1.206412	foo	cool
2000-01-03	2.565646	1.431256	1.340309	foo	cool
2000-01-05	0.813850	0.132003	-0.827317	NaN	cool
2000-01-08	1.024180	0.569605	0.875906	bar	cool

```
# getting creative
```

```
In [1013]: store.select('df_dc',[ 'B > 0', 'C > 0', 'string == foo' ])
```

```
Out[1013]:
```

	A	B	C	string	string2
2000-01-03	2.565646	1.431256	1.340309	foo	cool

```
# this is in-memory version of this type of selection
```

```
In [1014]: df_dc[(df_dc.B > 0) & (df_dc.C > 0) & (df_dc.string == 'foo')]
```

```
Out[1014]:
```

	A	B	C	string	string2
2000-01-03	2.565646	1.431256	1.340309	foo	cool

```
# we have automagically created this index and that the B/C/string/string2 columns are stored separately
```

```
In [1015]: store.root.df_dc.table
```

```
Out[1015]:
```

```
/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(itemsizes=3, shape=(), dflt='', pos=4),
  "string2": StringCol(itemsizes=4, shape=(), dflt='', pos=5)}
byteorder := 'little'
chunkshape := (1680,)
autoIndex := True
colindexes := {
```

```
"index": Index(6, medium, shuffle, zlib(1)).is_CSI=False,
"C": Index(6, medium, shuffle, zlib(1)).is_CSI=False,
"B": Index(6, medium, shuffle, zlib(1)).is_CSI=False,
"string2": Index(6, medium, shuffle, zlib(1)).is_CSI=False,
"string": 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!)

15.4.8 Advanced Queries

Unique

To retrieve the *unique* values of an indexable or data column, use the method `unique`. This will, for example, enable you to get the index very quickly. Note nan are excluded from the result set.

```
In [1016]: store.unique('df_dc', 'index')
Out[1016]:
<class 'pandas.tseries.index.DatetimeIndex'>
[2000-01-01 00:00:00, ..., 2000-01-08 00:00:00]
Length: 8, Freq: None, Timezone: None
```

```
In [1017]: store.unique('df_dc', 'string')
Out[1017]: Index([bar, foo], dtype=object)
```

Replicating or

not and or conditions are unsupported at this time; however, or operations are easy to replicate, by repeatedly applying the criteria to the table, and then `concat` the results.

```
In [1018]: crit1 = [ Term('B>0'), Term('C>0'), Term('string=foo') ]

In [1019]: crit2 = [ Term('B<0'), Term('C>0'), Term('string=foo') ]

In [1020]: concat([ store.select('df_dc', c) for c in [ crit1, crit2 ] ])
Out[1020]:
```

	A	B	C	string	string2
2000-01-03	2.565646	1.431256	1.340309	foo	cool
2000-01-04	-1.170299	-0.226169	0.410835	foo	cool
2000-01-07	-1.436737	-1.413681	1.607920	foo	cool

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 [1021]: store.get_storer('df_dc').nrows
Out[1021]: 8
```

15.4.9 Multiple Table Queries

New in 0.10.1 are the methods `append_to_multiple` and `select_as_multiple`, that 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 that are indexed the same the selector table. You can then perform a very fast query on the selector table, yet get lots of data back. This method works similar to having a very wide-table, but is more efficient in terms of queries.

Note, **THE USER IS RESPONSIBLE FOR SYNCHRONIZING THE TABLES**. This means, append to the tables in the same order; `append_to_multiple` splits a single object to multiple tables, given a specification (as a dictionary). This dictionary is a mapping of the table names to the ‘columns’ you want included in that table. Pass a `None` for a single table (optional) to let it have the remaining columns. The argument `selector` defines which table is the selector table.

```
In [1022]: df_mt = DataFrame(randn(8, 6), index=date_range('1/1/2000', periods=8),
.....:                      columns=['A', 'B', 'C', 'D', 'E', 'F'])
.....:
```

```
In [1023]: df_mt['foo'] = 'bar'
```

you can also create the tables individually

```
In [1024]: store.append_to_multiple({'df1_mt' : ['A', 'B'], 'df2_mt' : None }, df_mt, selector = 'df1_mt')
```

```
In [1025]: store
```

```
Out[1025]:
```

```
<class 'pandas.io.pytables.HDFStore'>
```

```
File path: store.h5
```

```
/df                                frame_table  (typ->appendable,nrows->8,ncols->3,indexers->[index])
/df1_mt                           frame_table  (typ->appendable,nrows->8,ncols->2,indexers->[index],dc->[A,B])
/df2_mt                           frame_table  (typ->appendable,nrows->8,ncols->5,indexers->[index])
/df_dc                            frame_table  (typ->appendable,nrows->8,ncols->5,indexers->[index],dc->[B,C,stack])
/df_mi                            frame_table  (typ->appendable_multi,nrows->10,ncols->5,indexers->[index],dc->[B,C,stack])
/df_mixed                         frame_table  (typ->appendable,nrows->8,ncols->7,indexers->[index])
/wp                               wide_table  (typ->appendable,nrows->20,ncols->2,indexers->[major_axis,minor_axis])
/foo/bar/bah                      frame      (shape->[8,3])
```

individual tables were created

```
In [1026]: store.select('df1_mt')
```

```
Out[1026]:
```

	A	B
2000-01-01	-0.055758	0.536580
2000-01-02	-0.281461	0.030711
2000-01-03	-0.064034	-1.282782
2000-01-04	0.583787	0.221471
2000-01-05	-0.845696	-1.340896
2000-01-06	0.888782	0.228440
2000-01-07	-1.066969	-0.303421
2000-01-08	1.574159	1.588931

```
In [1027]: store.select('df2_mt')
```

```
Out[1027]:
```

	C	D	E	F	foo
2000-01-01	-0.489682	0.369374	-0.034571	-2.484478	bar
2000-01-02	0.109121	1.126203	-0.977349	1.474071	bar
2000-01-03	0.781836	-1.071357	0.441153	2.353925	bar
2000-01-04	-0.744471	0.758527	1.729689	-0.964980	bar
2000-01-05	1.846883	-1.328865	1.682706	-1.717693	bar
2000-01-06	0.901805	1.171216	0.520260	-1.197071	bar
2000-01-07	-0.858447	0.306996	-0.028665	0.384316	bar
2000-01-08	0.476720	0.473424	-0.242861	-0.014805	bar

as a multiple

```
In [1028]: store.select_as_multiple(['df1_mt','df2_mt'], where = [ 'A>0','B>0' ], selector = 'df1_mt')
```

```
Out[1028]:
```

	A	B	C	D	E	F	foo
2000-01-04	0.583787	0.221471	-0.744471	0.758527	1.729689	-0.964980	bar

```
2000-01-06  0.888782  0.228440  0.901805  1.171216  0.520260 -1.197071  bar
2000-01-08  1.574159  1.588931  0.476720  0.473424 -0.242861 -0.014805  bar
```

15.4.10 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 deletion speed, it pays 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 [1029]: store.remove('wp', 'major_axis>20000102' )
Out[1029]: 12

In [1030]: store.select('wp')
Out[1030]:
<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
```

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 *clean* the file, use `ptrepack` (see below).

15.4.11 Compression

PyTables allows the stored data to be compressed. This applies to all kinds of stores, not just tables.

- Pass `complevel=int` for a compression level (1-9, with 0 being no compression, and the default)
- Pass `complib=lib` where `lib` is any of `zlib`, `bzip2`, `lzo`, `blosc` for whichever compression library you prefer.

HDFStore will use the file based compression scheme if no overriding `complib` or `complevel` options are provided. `blosc` offers very fast compression, and is my most used. Note that `lzo` and `bzip2` may not be installed (by Python) by default.

Compression for all objects within the file

- `store_compressed = HDFStore('store_compressed.h5', complevel=9, complib='blosc')`

Or on-the-fly compression (this only applies to tables). You can turn off file compression for a specific table by passing `complevel=0`

- `store.append('df', df, complib='zlib', complevel=5)`

ptrepack

PyTables offer better write performance when compressed after writing them, 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.

15.4.12 Notes & Caveats

- Once a table is created its items (Panel) / columns (DataFrame) are fixed; only exactly the same columns can be appended
- You can not append/select/delete to a non-table (table creation is determined on the first append, or by passing `table=True` in a put operation)
- 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 issue <https://github.com/pydata/pandas/issues/2397> for more information.
- PyTables only supports fixed-width string columns in tables. The sizes of a string based indexing column (e.g. `columns` or `minor_axis`) are determined as the maximum size of the elements in that axis or by passing the parameter `min_itemsize` on the first table creation (`min_itemsize` can be an integer or a dict of column name to an integer). If subsequent appends introduce elements in the indexing axis that are larger than the supported indexer, an Exception will be raised (otherwise you could have a silent truncation of these indexers, leading to loss of information). Just to be clear, this fixed-width restriction applies to **indexables** (the indexing columns) and **string values** in a `mixed_type` table.

```
In [1031]: store.append('wp_big_strings', wp, min_itemsize = { 'minor_axis' : 30 })
```

```
In [1032]: wp = wp.rename_axis(lambda x: x + '_big_strings', axis=2)
```

```
In [1033]: store.append('wp_big_strings', wp)
```

```
In [1034]: store.select('wp_big_strings')
```

```
Out[1034]:
```

```
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 5 (major_axis) x 8 (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_big_strings
```

```
# we have provided a minimum minor_axis indexable size
In [1035]: store.root.wp_big_strings.table
Out[1035]:
/wp_big_strings/table (Table(40,)) ''
description := {
  "major_axis": Int64Col(shape=(), dflt=0, pos=0),
  "minor_axis": StringCol(itemsize=30, shape=(), dflt='', pos=1),
  "values_block_0": Float64Col(shape=(2,), dflt=0.0, pos=2)}
byteorder := 'little'
chunkshape := (1213,)
autoIndex := True
colindexes := {
  "major_axis": Index(6, medium, shuffle, zlib(1)).is_CSI=False,
  "minor_axis": Index(6, medium, shuffle, zlib(1)).is_CSI=False}
```

15.4.13 External Compatibility

HDFStore write storer objects in specific formats suitable for producing loss-less roundtrips 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. Create a table format store like this:

```
In [1036]: store_export = HDFStore('export.h5')

In [1037]: store_export.append('df_dc', df_dc, data_columns=df_dc.columns)

In [1038]: store_export
Out[1038]:
<class 'pandas.io.pytables.HDFStore'>
File path: export.h5
/df_dc          frame_table   (typ->appendable,nrows->8,ncols->5,indexers->[index],dc->[A,B,C,s
```

15.4.14 Backwards Compatibility

0.10.1 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. HDFStore will issue a warning if you try to use a prior-version format file. You must read in the entire file and write it out using the new format, using the method `copy` to take advantage of the updates. The group attribute `pandas_version` contains the version information. `copy` takes a number of options, please see the docstring.

```
# a legacy store
In [1039]: legacy_store = HDFStore(legacy_file_path, 'r')

In [1040]: legacy_store
Out[1040]:
<class 'pandas.io.pytables.HDFStore'>
File path: /home/wesm/code/pandas/doc/source/_static/legacy_0.10.h5
/a          series      (shape->[30])
/b          frame       (shape->[30,4])
/df1_mixed  frame_table [0.10.0] (typ->appendable,nrows->30,ncols->11,indexers->[index
/pl_mixed   wide_table  [0.10.0] (typ->appendable,nrows->120,ncols->9,indexers->[major
/p4d_mixed  ndim_table  [0.10.0] (typ->appendable,nrows->360,ncols->9,indexers->[items
/foo/bar    wide        (shape->[3,30,4])

# copy (and return the new handle)
```

```
In [1041]: new_store = legacy_store.copy('store_new.h5')

In [1042]: new_store
Out[1042]:
<class 'pandas.io.pytables.HDFStore'>
File path: store_new.h5
/a                series          (shape->[30])
/b                frame           (shape->[30,4])
/df1_mixed        frame_table     (typ->appendable,nrows->30,ncols->11,indexers->[index])
/pl_mixed         wide_table      (typ->appendable,nrows->120,ncols->9,indexers->[major_axis,mi
/p4d_mixed        wide_table      (typ->appendable,nrows->360,ncols->9,indexers->[items,major_a
/foo/bar          wide           (shape->[3,30,4])

In [1043]: new_store.close()
```

15.4.15 Performance

- Tables come with a writing performance penalty as compared to regular 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=an integer` to `append`, to change the writing chunksize (default is 50000). This will significantly lower your memory usage on writing.
- You can pass `expectedrows=an integer` to the first `append`, to set the TOTAL number of expected rows that PyTables will expect. 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 <http://stackoverflow.com/questions/14355151/how-to-make-pandas-hdfstore-put-operation-faster/14370190#14370190> for more information and some solutions.

15.4.16 Experimental

HDFStore supports Panel4D storage.

```
In [1044]: p4d = Panel4D({ 'l1' : wp })

In [1045]: p4d
Out[1045]:
<class 'pandas.core.panelnd.Panel4D'>
Dimensions: 1 (labels) x 2 (items) x 5 (major_axis) x 4 (minor_axis)
Labels axis: l1 to l1
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_big_strings to D_big_strings

In [1046]: store.append('p4d', p4d)

In [1047]: store
Out[1047]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5
/df                frame_table     (typ->appendable,nrows->8,ncols->3,indexers->[index])
```

```

/df1_mt          frame_table  (typ->appendable,nrows->8,ncols->2,indexers->[index],dc->[A,B,C])
/df2_mt          frame_table  (typ->appendable,nrows->8,ncols->5,indexers->[index])
/df_dc           frame_table  (typ->appendable,nrows->8,ncols->5,indexers->[index],dc->[B,C])
/df_mi           frame_table  (typ->appendable_multi,nrows->10,ncols->5,indexers->[index],dc->[A,B,C])
/df_mixed        frame_table  (typ->appendable,nrows->8,ncols->7,indexers->[index])
/p4d             wide_table   (typ->appendable,nrows->40,ncols->1,indexers->[items,major_axis])
/wp             wide_table   (typ->appendable,nrows->8,ncols->2,indexers->[major_axis,minor_axis])
/wp_big_strings  wide_table   (typ->appendable,nrows->40,ncols->2,indexers->[major_axis,minor_axis])
/foo/bar/bah     frame       (shape->[8,3])

```

These, by default, index the three axes items, `major_axis`, `minor_axis`. On an `AppendableTable` it is possible to setup with the first append a different indexing scheme, depending on how you want to store your data. Pass the `axes` keyword with a list of dimension (currently must be exactly 1 less than the total dimensions of the object). This cannot be changed after table creation.

```
In [1048]: store.append('p4d2', p4d, axes = ['labels', 'major_axis', 'minor_axis'])
```

```
In [1049]: store
```

```
Out[1049]:
```

```
<class 'pandas.io.pytables.HDFStore'>
```

```
File path: store.h5
```

```

/df             frame_table  (typ->appendable,nrows->8,ncols->3,indexers->[index])
/df1_mt         frame_table  (typ->appendable,nrows->8,ncols->2,indexers->[index],dc->[A,B,C])
/df2_mt         frame_table  (typ->appendable,nrows->8,ncols->5,indexers->[index])
/df_dc          frame_table  (typ->appendable,nrows->8,ncols->5,indexers->[index],dc->[B,C])
/df_mi          frame_table  (typ->appendable_multi,nrows->10,ncols->5,indexers->[index],dc->[A,B,C])
/df_mixed       frame_table  (typ->appendable,nrows->8,ncols->7,indexers->[index])
/p4d            wide_table   (typ->appendable,nrows->40,ncols->1,indexers->[items,major_axis])
/p4d2           wide_table   (typ->appendable,nrows->20,ncols->2,indexers->[labels,major_axis])
/wp            wide_table   (typ->appendable,nrows->8,ncols->2,indexers->[major_axis,minor_axis])
/wp_big_strings wide_table   (typ->appendable,nrows->40,ncols->2,indexers->[major_axis,minor_axis])
/foo/bar/bah    frame       (shape->[8,3])

```

```
In [1050]: store.select('p4d2', [ Term('labels=l1'), Term('items=Item1'), Term('minor_axis=A_big_strings')])
```

```
Out[1050]:
```

```
<class 'pandas.core.panelnd.Panel4D'>
```

```
Dimensions: 1 (labels) x 1 (items) x 5 (major_axis) x 1 (minor_axis)
```

```
Labels axis: l1 to l1
```

```
Items axis: Item1 to Item1
```

```
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
```

```
Minor_axis axis: A_big_strings to A_big_strings
```

15.5 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. These wrappers only support the Python database adapters which respect the [Python DB-API](#).

Suppose you want to query some data with different types from a table such as:

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

Functions from `pandas.io.sql` can extract some data into a `DataFrame`. In the following example, we use [SQLite](#)

SQL database engine. You can use a temporary SQLite database where data are stored in “memory”. Just do:

```
import sqlite3
from pandas.io import sql
# Create your connection.
cnx = sqlite3.connect(':memory:')
```

Let data be the name of your SQL table. With a query and your database connection, just use the `read_frame()` function to get the query results into a DataFrame:

```
In [1051]: sql.read_frame("SELECT * FROM data;", cnx)
```

```
Out[1051]:
```

	id	date	Col_1	Col_2	Col_3
0	26	2010-10-18 00:00:00	X	27.50	1
1	42	2010-10-19 00:00:00	Y	-12.50	0
2	63	2010-10-20 00:00:00	Z	5.73	1

You can also specify the name of the column as the DataFrame index:

```
In [1052]: sql.read_frame("SELECT * FROM data;", cnx, index_col='id')
```

```
Out[1052]:
```

	date	Col_1	Col_2	Col_3
id				
26	2010-10-18 00:00:00	X	27.50	1
42	2010-10-19 00:00:00	Y	-12.50	0
63	2010-10-20 00:00:00	Z	5.73	1

```
In [1053]: sql.read_frame("SELECT * FROM data;", cnx, index_col='date')
```

```
Out[1053]:
```

	id	Col_1	Col_2	Col_3
date				
2010-10-18 00:00:00	26	X	27.50	1
2010-10-19 00:00:00	42	Y	-12.50	0
2010-10-20 00:00:00	63	Z	5.73	1

Of course, you can specify more “complex” query.

```
In [1054]: sql.read_frame("SELECT id, Col_1, Col_2 FROM data WHERE id = 42;", cnx)
```

```
Out[1054]:
```

	id	Col_1	Col_2
0	42	Y	-12.5

There are a few other available functions:

- `tquery` returns list of tuples corresponding to each row.
- `uquery` does the same thing as `tquery`, but instead of returning results, it returns the number of related rows.
- `write_frame` writes records stored in a DataFrame into the SQL table.
- `has_table` checks if a given SQLite table exists.

Note: For now, writing your DataFrame into a database works only with **SQLite**. Moreover, the **index** will currently be **dropped**.

SPARSE DATA STRUCTURES

We have implemented “sparse” versions of Series, DataFrame, and Panel. These are not sparse in the typical “mostly 0”. You can view these objects as being “compressed” where any data matching a specific value (NaN/missing by default, 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 [1276]: ts = Series(randn(10))
```

```
In [1277]: ts[2:-2] = np.nan
```

```
In [1278]: sts = ts.to_sparse()
```

```
In [1279]: sts
```

```
Out[1279]:
```

```
0    0.469112
1   -0.282863
2         NaN
3         NaN
4         NaN
5         NaN
6         NaN
7         NaN
8   -0.861849
9   -2.104569
```

```
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 [1280]: ts.fillna(0).to_sparse(fill_value=0)
```

```
Out[1280]:
```

```
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
```

```
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 [1281]: df = DataFrame(randn(10000, 4))

In [1282]: df.ix[:9998] = np.nan

In [1283]: sdf = df.to_sparse()

In [1284]: sdf
Out[1284]:
<class 'pandas.sparse.frame.SparseDataFrame'>
Int64Index: 10000 entries, 0 to 9999
Columns: 4 entries, 0 to 3
dtypes: float64(4)
```

```
In [1285]: sdf.density
Out[1285]: 0.0001
```

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 [1286]: sts.to_dense()
Out[1286]:
0    0.469112
1   -0.282863
2         NaN
3         NaN
4         NaN
5         NaN
6         NaN
7         NaN
8   -0.861849
9   -2.104569
```

16.1 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 [1287]: arr = np.random.randn(10)

In [1288]: arr[2:5] = np.nan; arr[7:8] = np.nan

In [1289]: sparr = SparseArray(arr)

In [1290]: sparr
Out[1290]:
SparseArray([-1.9557, -1.6589,      nan,      nan,      nan,  1.1589,  0.1453,
             nan,  0.606 ,  1.3342])
IntIndex
Indices: array([0, 1, 5, 6, 8, 9], dtype=int32)
```

Like the indexed objects (SparseSeries, SparseDataFrame, SparsePanel), a SparseArray can be converted back to a regular ndarray by calling `to_dense`:

```
In [1291]: sparr.to_dense()
Out[1291]:
array([-1.9557, -1.6589,      nan,      nan,      nan,  1.1589,  0.1453,
        nan,  0.606 ,  1.3342])
```

16.2 SparseList

SparseList is a list-like data structure for managing a dynamic collection of SparseArrays. To create one, simply call the SparseList constructor with a `fill_value` (defaulting to NaN):

```
In [1292]: spl = SparseList()

In [1293]: spl
Out[1293]:
<pandas.sparse.list.SparseList object at 0xc34b990>
```

The two important methods are `append` and `to_array`. `append` can accept scalar values or any 1-dimensional sequence:

```
In [1294]: spl.append(np.array([1., nan, nan, 2., 3.]))

In [1295]: spl.append(5)

In [1296]: spl.append(sparr)

In [1297]: spl
Out[1297]:
<pandas.sparse.list.SparseList object at 0xc34b990>
SparseArray([ 1., nan, nan,  2.,  3.])
IntIndex
Indices: array([0, 3, 4], dtype=int32)
SparseArray([ 5.])
IntIndex
Indices: array([0], dtype=int32)
SparseArray([-1.9557, -1.6589,      nan,      nan,      nan,  1.1589,  0.1453,
        nan,  0.606 ,  1.3342])
IntIndex
Indices: array([0, 1, 5, 6, 8, 9], dtype=int32)
```

As you can see, all of the contents are stored internally as a list of memory-efficient SparseArray objects. Once you've accumulated all of the data, you can call `to_array` to get a single SparseArray with all the data:

```
In [1298]: spl.to_array()
Out[1298]:
SparseArray([ 1.      ,      nan,      nan,  2.      ,  3.      ,  5.      , -1.9557,
        -1.6589,      nan,      nan,      nan,  1.1589,  0.1453,      nan,
         0.606 ,  1.3342])
IntIndex
Indices: array([ 0,  3,  4,  5,  6,  7, 11, 12, 14, 15], dtype=int32)
```

16.3 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 array 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.

CAVEATS AND GOTCHAS

17.1 NaN, Integer NA values and NA type promotions

17.1.1 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
- 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 `isnull` and `notnull` 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.

17.1.2 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 [488]: s = Series([1, 2, 3, 4, 5], index=list('abcde'))
```

```
In [489]: s
```

```
Out[489]:
```

```
a    1
b    2
c    3
d    4
e    5
```

```
In [490]: s.dtype
```

```
Out[490]: dtype('int64')
```

```
In [491]: s2 = s.reindex(['a', 'b', 'c', 'f', 'u'])
```

```
In [492]: s2
```

```
Out[492]:
```

```
a    1
b    2
```

```
c      3
f     NaN
u     NaN
```

```
In [493]: s2.dtype
Out[493]: 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.

17.1.3 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, in practice I have found very few cases where this is an issue in practice. Some explanation for the motivation here in the next section.

17.1.4 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
<code>numpy.floating</code>	<code>float16</code> , <code>float32</code> , <code>float64</code> , <code>float128</code>
<code>numpy.integer</code>	<code>int8</code> , <code>int16</code> , <code>int32</code> , <code>int64</code>
<code>numpy.unsignedinteger</code>	<code>uint8</code> , <code>uint16</code> , <code>uint32</code> , <code>uint64</code>
<code>numpy.object_</code>	<code>object_</code>
<code>numpy.bool_</code>	<code>bool_</code>
<code>numpy.character</code>	<code>string_</code> , <code>unicode_</code>

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.

17.2 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 `.ix`. The following code will generate exceptions:

```
s = Series(range(5))
s[-1]
df = DataFrame(np.random.randn(5, 4))
df
df.ix[-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).

17.3 Label-based slicing conventions

17.3.1 Non-monotonic indexes require exact matches

17.3.2 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 [494]: s = Series(randn(6), index=list('abcdef'))
```

```
In [495]: s
Out[495]:
a    1.337122
b   -1.531095
c    1.331458
d   -0.571329
e   -0.026671
f   -1.085663
```

Suppose we wished to slice from `c` to `e`, using integers this would be

```
In [496]: s[2:5]
Out[496]:
c    1.331458
d   -0.571329
e   -0.026671
```

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.ix['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 design to make label-based slicing include both endpoints:

```
In [497]: s.ix['c':'e']
Out[497]:
c    1.331458
```

```
d    -0.571329
e    -0.026671
```

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.

17.4 Miscellaneous indexing gotchas

17.4.1 Reindex versus ix gotchas

Many users will find themselves using the `ix` indexing capabilities as a concise means of selecting data from a pandas object:

```
In [498]: df = DataFrame(randn(6, 4), columns=['one', 'two', 'three', 'four'],
.....:                  index=list('abcdef'))
.....:
```

```
In [499]: df
Out[499]:
```

	one	two	three	four
a	-1.114738	-0.058216	-0.486768	1.685148
b	0.112572	-1.495309	0.898435	-0.148217
c	-1.596070	0.159653	0.262136	0.036220
d	0.184735	-0.255069	-0.271020	1.288393
e	0.294633	-1.165787	0.846974	-0.685597
f	0.609099	-0.303961	0.625555	-0.059268

```
In [500]: df.ix[['b', 'c', 'e']]
Out[500]:
```

	one	two	three	four
b	0.112572	-1.495309	0.898435	-0.148217
c	-1.596070	0.159653	0.262136	0.036220
e	0.294633	-1.165787	0.846974	-0.685597

This is, of course, completely equivalent *in this case* to using the `reindex` method:

```
In [501]: df.reindex(['b', 'c', 'e'])
Out[501]:
```

	one	two	three	four
b	0.112572	-1.495309	0.898435	-0.148217
c	-1.596070	0.159653	0.262136	0.036220
e	0.294633	-1.165787	0.846974	-0.685597

Some might conclude that `ix` and `reindex` are 100% equivalent based on this. This is indeed true **except in the case of integer indexing**. For example, the above operation could alternately have been expressed as:

```
In [502]: df.ix[[1, 2, 4]]
Out[502]:
```

	one	two	three	four
b	0.112572	-1.495309	0.898435	-0.148217
c	-1.596070	0.159653	0.262136	0.036220
e	0.294633	-1.165787	0.846974	-0.685597

If you pass `[1, 2, 4]` to `reindex` you will get another thing entirely:

```
In [503]: df.reindex([1, 2, 4])
Out[503]:
```

	one	two	three	four
1	NaN	NaN	NaN	NaN
2	NaN	NaN	NaN	NaN
4	NaN	NaN	NaN	NaN

So it's important to remember that `reindex` is **strict label indexing only**. This can lead to some potentially surprising results in pathological cases where an index contains, say, both integers and strings:

```
In [504]: s = Series([1, 2, 3], index=['a', 0, 1])
```

```
In [505]: s
```

```
Out[505]:
```

```
a    1
0    2
1    3
```

```
In [506]: s.ix[[0, 1]]
```

```
Out[506]:
```

```
0    2
1    3
```

```
In [507]: s.reindex([0, 1])
```

```
Out[507]:
```

```
0    2
1    3
```

Because the index in this case does not contain solely integers, `ix` falls back on integer indexing. By contrast, `reindex` only looks for the values passed in the index, thus finding the integers 0 and 1. While it would be possible to insert some logic to check whether a passed sequence is all contained in the index, that logic would exact a very high cost in large data sets.

17.4.2 Reindex potentially changes underlying Series dtype

The use of `reindex_like` can potentially change the dtype of a `Series`.

```
series = pandas.Series([1, 2, 3])
x = pandas.Series([True])
x.dtype
x = pandas.Series([True]).reindex_like(series)
x.dtype
```

This is because `reindex_like` 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.

17.5 Timestamp limitations

17.5.1 Minimum and maximum timestamps

Since pandas represents timestamps in nanosecond resolution, the timespan that can be represented using a 64-bit integer is limited to approximately 584 years:

```
In [508]: begin = Timestamp(-9223285636854775809L)
```

```
In [509]: begin
Out[509]: <Timestamp: 1677-09-22 00:12:43.145224191>
```

```
In [510]: end = Timestamp(np.iinfo(np.int64).max)
```

```
In [511]: end
Out[511]: <Timestamp: 2262-04-11 23:47:16.854775807>
```

If you need to represent time series data outside the nanosecond timespan, use `PeriodIndex`:

```
In [512]: span = period_range('1215-01-01', '1381-01-01', freq='D')
```

```
In [513]: span
Out[513]:
<class 'pandas.tseries.period.PeriodIndex'>
freq: D
[1215-01-01, ..., 1381-01-01]
length: 60632
```

17.6 Parsing Dates from Text Files

When parsing multiple text file columns into a single date column, the new date column is prepended to the data and then `index_col` specification is indexed off of the new set of columns rather than the original ones:

```
In [514]: 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 [515]: date_spec = {'nominal': [1, 2], 'actual': [1, 3]}
```

```
In [516]: df = read_csv('tmp.csv', header=None,
.....:                  parse_dates=date_spec,
.....:                  keep_date_col=True,
.....:                  index_col=0)
.....:
```

```
# index_col=0 refers to the combined column "nominal" and not the original
# first column of 'KORD' strings
```

```
In [517]: df
```

```
Out[517]:
```

			actual	0	1	2	3	4
nominal								
1999-01-27	19:00:00	1999-01-27	18:56:00	KORD	19990127	19:00:00	18:56:00	0.81
1999-01-27	20:00:00	1999-01-27	19:56:00	KORD	19990127	20:00:00	19:56:00	0.01
1999-01-27	21:00:00	1999-01-27	20:56:00	KORD	19990127	21:00:00	20:56:00	-0.59
1999-01-27	21:00:00	1999-01-27	21:18:00	KORD	19990127	21:00:00	21:18:00	-0.99
1999-01-27	22:00:00	1999-01-27	21:56:00	KORD	19990127	22:00:00	21:56:00	-0.59
1999-01-27	23:00:00	1999-01-27	22:56:00	KORD	19990127	23:00:00	22:56:00	-0.59

17.7 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.

RPY2 / R INTERFACE

Note: This is all highly experimental. I would like to get more people involved with building a nice RPy2 interface for pandas

If your computer has R and rpy2 (> 2.2) installed (which will be left to the reader), you will be able to leverage the below functionality. On Windows, doing this is quite an ordeal at the moment, but users on Unix-like systems should find it quite easy. rpy2 evolves in time, and is currently reaching its release 2.3, while the current interface is designed for the 2.2.x series. We recommend to use 2.2.x over other series unless you are prepared to fix parts of the code, yet the rpy2-2.3.0 introduces improvements such as a better R-Python bridge memory management layer so I might be a good idea to bite the bullet and submit patches for the few minor differences that need to be fixed.

```
# if installing for the first time
hg clone http://bitbucket.org/lgautier/rpy2

cd rpy2
hg pull
hg update version_2.2.x
sudo python setup.py install
```

Note: To use R packages with this interface, you will need to install them inside R yourself. At the moment it cannot install them for you.

Once you have done installed R and rpy2, you should be able to import `pandas.rpy.common` without a hitch.

18.1 Transferring R data sets into Python

The `load_data` function retrieves an R data set and converts it to the appropriate pandas object (most likely a DataFrame):

```
In [1214]: import pandas.rpy.common as com
```

```
In [1215]: infert = com.load_data('infert')
```

```
In [1216]: infert.head()
```

```
Out[1216]:
```

	education	age	parity	induced	case	spontaneous	stratum	pooled.stratum
1	0-5yrs	26	6	1	1	2	1	3
2	0-5yrs	42	1	1	1	0	2	1
3	0-5yrs	39	6	2	1	0	3	4

4	0-5yrs	34	4	2	1	0	4	2
5	6-11yrs	35	3	1	1	1	5	32

18.2 Converting DataFrames into R objects

New in version 0.8. Starting from pandas 0.8, there is **experimental** support to convert DataFrames into the equivalent R object (that is, **data.frame**):

```
In [1217]: from pandas import DataFrame

In [1218]: df = DataFrame({'A': [1, 2, 3], 'B': [4, 5, 6], 'C': [7, 8, 9]},
.....:                    index=["one", "two", "three"])
.....:

In [1219]: r_dataframe = com.convert_to_r_dataframe(df)

In [1220]: print type(r_dataframe)
<class 'rpy2.robjobjects.vectors.DataFrame'>

In [1221]: 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.

You can also use **convert_to_r_matrix** to obtain a `Matrix` instance, but bear in mind that it will only work with homogeneously-typed DataFrames (as R matrices bear no information on the data type):

```
In [1222]: r_matrix = com.convert_to_r_matrix(df)

In [1223]: print type(r_matrix)
<class 'rpy2.robjobjects.vectors.Matrix'>

In [1224]: print r_matrix
   A B C
one  1 4 7
two  2 5 8
three 3 6 9
```

18.3 Calling R functions with pandas objects

18.4 High-level interface to R estimators

RELATED PYTHON LIBRARIES

19.1 `la` (larry)

Keith Goodman's excellent [labeled array package](#) is very similar to pandas in many regards, though with some key differences. The main philosophical design difference is to be a wrapper around a single NumPy `ndarray` object while adding axis labeling and label-based operations and indexing. Because of this, creating a size-mutable object with heterogeneous columns (e.g. `DataFrame`) is not possible with the `la` package.

- Provide a single n-dimensional object with labeled axes with functionally analogous data alignment semantics to pandas objects
- Advanced / label-based indexing similar to that provided in pandas but setting is not supported
- Stays much closer to NumPy arrays than pandas—`larry` objects must be homogeneously typed
- `GroupBy` support is relatively limited, but a few functions are available: `group_mean`, `group_median`, and `group_ranking`
- It has a collection of analytical functions suited to quantitative portfolio construction for financial applications
- It has a collection of moving window statistics implemented in [Bottleneck](#)

19.2 `statsmodels`

The main [statistics and econometrics library](#) for Python. pandas has become a dependency of this library.

19.3 `scikits.timeseries`

`scikits.timeseries` provides a data structure for fixed frequency time series data based on the `numpy.MaskedArray` class. For time series data, it provides some of the same functionality to the pandas `Series` class. It has many more functions for time series-specific manipulation. Also, it has support for many more frequencies, though less customizable by the user (so 5-minutely data is easier to do with pandas for example).

We are aiming to merge these libraries together in the near future.

Progress:

- It has a collection of moving window statistics implemented in [Bottleneck](#)
- [Outstanding issues](#)

Summarising, Pandas offers superior functionality due to its combination with the `pandas.DataFrame`.
An introduction for former users of `scikits.timeseries` is provided in the [migration guide](#).

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 3rd party libraries as they relate to pandas. In offering 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 or harder to use (you may have to be the judge of this given side-by-side code comparisons)

As I do not have an encyclopedic knowledge of R packages, feel free to suggest additional CRAN packages to add to this list. This is also here to offer a big of a translation guide for users of these R packages.

20.1 data.frame

20.2 zoo

20.3 xts

20.4 plyr

20.5 reshape / reshape2

API REFERENCE

21.1 General functions

21.1.1 Data manipulations

`pivot_table(data[, values, rows, cols, ...])` Create a spreadsheet-style pivot table as a DataFrame. The levels in the

pandas.tools.pivot.pivot_table

`pandas.tools.pivot.pivot_table` (*data*, *values=None*, *rows=None*, *cols=None*, *aggfunc='mean'*,
fill_value=None, *margins=False*)

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

rows : list of column names or arrays to group on

Keys to group on the x-axis of the pivot table

cols : list of column names or arrays to group on

Keys to group on the y-axis of the pivot table

aggfunc : function, default `numpy.mean`, or list of functions

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)

Returns **table** : DataFrame

Examples

```
>>> 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', rows=['A', 'B'],
...                       cols=['C'], aggfunc=np.sum)
>>> table
      small large
foo one    1     4
   two    6    NaN
bar one    5     4
   two    6     7
```

<code>merge(left, right[, how, on, left_on, ...])</code>	Merge DataFrame objects by performing a database-style join operation by
--	--

<code>concat(objs[, axis, join, join_axes, ...])</code>	Concatenate pandas objects along a particular axis with optional set logic along the other a
---	--

pandas.tools.merge.merge

`pandas.tools.merge.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)

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 (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)

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

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

Returns **merged** : DataFrame

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

>>> merge(A, B, left_on='lkey', right_on='rkey', how='outer')
   lkey  value_x  rkey  value_y
0   bar      2    bar      6
1   bar      2    bar      8
2   baz      3   NaN     NaN
3   foo      1    foo      5
4   foo      4    foo      5
5   NaN     NaN   qux      7
```

pandas.tools.merge.concat

`pandas.tools.merge.concat` (*objs*, *axis*=0, *join*='outer', *join_axes*=None, *ignore_index*=False, *keys*=None, *levels*=None, *names*=None, *verify_integrity*=False)

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** : list or dict 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 an Exception 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)

join_axes : list of Index objects

Specific indexes to use for the other $n - 1$ axes instead of performing inner/outer set logic

verify_integrity : boolean, default False

Check whether the new concatenated axis contains duplicates. This can be very expensive relative to the actual data concatenation

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

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 the index values on the other axes are still respected in the join.

Returns concatenated : type of objects

Notes

The keys, levels, and names arguments are all optional

21.1.2 Pickling

<code>load(path)</code>	Load pickled pandas object (or any other pickled object) from the specified
<code>save(obj, path)</code>	Pickle (serialize) object to input file path

pandas.core.common.load

`pandas.core.common.load(path)`

Load pickled pandas object (or any other pickled object) from the specified file path

Parameters path : string

File path

Returns unpickled : type of object stored in file

pandas.core.common.save

`pandas.core.common.save(obj, path)`
 Pickle (serialize) object to input file path

Parameters `obj` : any object

`path` : string

File path

21.1.3 File IO

<code>read_table(filepath_or_buffer[, sep, ...])</code>	Read general delimited file into DataFrame
<code>read_csv(filepath_or_buffer[, sep, dialect, ...])</code>	Read CSV (comma-separated) file into DataFrame
<code>ExcelFile.parse(sheetname[, header, ...])</code>	Read Excel table into DataFrame

pandas.io.parsers.read_table

`pandas.io.parsers.read_table(filepath_or_buffer, sep='\t', dialect=None, compression=None, doublequote=True, escapechar=None, quotechar='"', quoting=0, skipinitialspace=False, lineterminator=None, header='infer', index_col=None, names=None, prefix=None, skiprows=None, skipfooter=None, skip_footer=0, na_values=None, true_values=None, false_values=None, delimiter=None, converters=None, dtype=None, usecols=None, engine='c', delim_whitespace=False, as_rearray=False, na_filter=True, compact_ints=False, use_unsigned=False, low_memory=True, buffer_lines=None, warn_bad_lines=True, error_bad_lines=True, keep_default_na=True, thousands=None, comment=None, decimal='.', parse_dates=False, keep_date_col=False, dayfirst=False, date_parser=None, memory_map=False, nrows=None, iterator=False, chunksize=None, verbose=False, encoding=None, squeeze=False)`

Read general delimited file into DataFrame

Also supports optionally iterating or breaking of the file into chunks.

Parameters `filepath_or_buffer` : string or file handle / StringIO. The string could be

a URL. Valid URL schemes include http, ftp, and file. For file URLs, a host is expected. For instance, a local file could be file://localhost/path/to/table.csv

`sep` : string, default t (tab-stop)

Delimiter to use. Regular expressions are accepted.

`lineterminator` : string (length 1), default None

Character to break file into lines. Only valid with C parser

`quotechar` : string

`quoting` : string

`skipinitialspace` : boolean, default False

Skip spaces after delimiter

escapechar : string

dtype : Type name or dict of column -> type

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32}

compression : {'gzip', 'bz2', None}, default None

For on-the-fly decompression of on-disk data

dialect : string or csv.Dialect instance, default None

If None defaults to Excel dialect. Ignored if sep longer than 1 char See csv.Dialect documentation for more details

header : int, default 0 if names parameter not specified, otherwise None

Row to use for the column labels of the parsed DataFrame. Specify None if there is no header row.

skiprows : list-like or integer

Row numbers to skip (0-indexed) or number of rows to skip (int) at the start of the file

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)

names : array-like

List of column names to use. If file contains no header row, then you should explicitly pass header=None

prefix : string or None (default)

Prefix to add to column numbers when no header, e.g 'X' for X0, X1, ...

na_values : list-like or dict, default None

Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values

true_values : list

Values to consider as True

false_values : list

Values to consider as False

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

parse_dates : boolean, list of ints or names, list of lists, or dict

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. {'foo' : [1, 3]} -> parse columns 1, 3 as date and call result 'foo'

keep_date_col : boolean, default False

If True and parse_dates specifies combining multiple columns then keep the original columns.

date_parser : function

Function to use for converting dates to strings. Defaults to dateutil.parser

dayfirst : boolean, default False

DD/MM format dates, international and European format

thousands : str, default None

Thousands separator

comment : str, default None

Indicates remainder of line should not be parsed Does not support line commenting (will return empty line)

decimal : str, default ‘.’

Character to recognize as decimal point. E.g. use ‘,’ for European data

nrows : int, default None

Number of rows of file to read. Useful for reading pieces of large files

iterator : boolean, default False

Return TextParser object

chunksize : int, default None

Return TextParser object for iteration

skipfooter : int, default 0

Number of line at bottom of file to skip

converters : dict. optional

Dict of functions for converting values in certain columns. Keys can either be integers or column labels

verbose : boolean, default False

Indicate number of NA values placed in non-numeric columns

delimiter : string, default None

Alternative argument name for sep. Regular expressions are accepted.

encoding : string, default None

Encoding to use for UTF when reading/writing (ex. ‘utf-8’)

squeeze : boolean, default False

If the parsed data only contains one column then return a Series

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

Returns result : DataFrame or TextParser

pandas.io.parsers.read_csv

```
pandas.io.parsers.read_csv(filepath_or_buffer, sep=',', dialect=None, compression=None,
doublequote=True, escapechar=None, quotechar='"', quoting=0,
skipinitialspace=False, lineterminator=None, header='infer',
index_col=None, names=None, prefix=None, skiprows=None, skip-
footer=None, skip_footer=0, na_values=None, true_values=None,
false_values=None, delimiter=None, converters=None,
dtype=None, usecols=None, engine='c', delim_whitespace=False,
as_reccarray=False, na_filter=True, compact_ints=False,
use_unsigned=False, low_memory=True, buffer_lines=None,
warn_bad_lines=True, error_bad_lines=True, keep_default_na=True,
thousands=None, comment=None, decimal='.', parse_dates=False,
keep_date_col=False, dayfirst=False, date_parser=None, mem-
ory_map=False, nrows=None, iterator=False, chunksize=None,
verbose=False, encoding=None, squeeze=False)
```

Read CSV (comma-separated) file into DataFrame

Also supports optionally iterating or breaking of the file into chunks.

Parameters **filepath_or_buffer** : string or file handle / StringIO. The string could be

a URL. Valid URL schemes include http, ftp, and file. For file URLs, a host is expected.
For instance, a local file could be file ://localhost/path/to/table.csv

sep : string, default ','

Delimiter to use. If sep is None, will try to automatically determine this. Regular
expressions are accepted.

lineterminator : string (length 1), default None

Character to break file into lines. Only valid with C parser

quotechar : string

quoting : string

skipinitialspace : boolean, default False

Skip spaces after delimiter

escapechar : string

dtype : Type name or dict of column -> type

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32}

compression : {'gzip', 'bz2', None}, default None

For on-the-fly decompression of on-disk data

dialect : string or csv.Dialect instance, default None

If None defaults to Excel dialect. Ignored if sep longer than 1 char See csv.Dialect
documentation for more details

header : int, default 0 if names parameter not specified, otherwise None

Row to use for the column labels of the parsed DataFrame. Specify None if there is no
header row.

skiprows : list-like or integer

Row numbers to skip (0-indexed) or number of rows to skip (int) at the start of the file

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)

names : array-like

List of column names to use. If file contains no header row, then you should explicitly pass header=None

prefix : string or None (default)

Prefix to add to column numbers when no header, e.g 'X' for X0, X1, ...

na_values : list-like or dict, default None

Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values

true_values : list

Values to consider as True

false_values : list

Values to consider as False

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

parse_dates : boolean, list of ints or names, list of lists, or dict

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. {'foo' : [1, 3]} -> parse columns 1, 3 as date and call result 'foo'

keep_date_col : boolean, default False

If True and parse_dates specifies combining multiple columns then keep the original columns.

date_parser : function

Function to use for converting dates to strings. Defaults to dateutil.parser

dayfirst : boolean, default False

DD/MM format dates, international and European format

thousands : str, default None

Thousands separator

comment : str, default None

Indicates remainder of line should not be parsed Does not support line commenting (will return empty line)

decimal : str, default '.'

Character to recognize as decimal point. E.g. use ',' for European data

nrows : int, default None

Number of rows of file to read. Useful for reading pieces of large files

iterator : boolean, default False

Return TextParser object

chunksize : int, default None

Return TextParser object for iteration

skipfooter : int, default 0

Number of line at bottom of file to skip

converters : dict. optional

Dict of functions for converting values in certain columns. Keys can either be integers or column labels

verbose : boolean, default False

Indicate number of NA values placed in non-numeric columns

delimiter : string, default None

Alternative argument name for sep. Regular expressions are accepted.

encoding : string, default None

Encoding to use for UTF when reading/writing (ex. 'utf-8')

squeeze : boolean, default False

If the parsed data only contains one column then return a Series

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

Returns **result** : DataFrame or TextParser

pandas.io.parsers.ExcelFile.parse

ExcelFile.**parse**(*sheetname*, *header=0*, *skiprows=None*, *skip_footer=0*, *index_col=None*, *parse_cols=None*, *parse_dates=False*, *date_parser=None*, *na_values=None*, *thousands=None*, *chunksize=None*, ***kwds*)

Read Excel table into DataFrame

Parameters **sheetname** : string

Name of Excel sheet

header : int, default 0

Row to use for the column labels of the parsed DataFrame

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, default None

Column to use as the row labels of the DataFrame. Pass None if there is no such column

parse_cols : 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 column names and

column ranges (e.g. "A:E" or "A,C,E:F")

na_values : list-like, default None

List of additional strings to recognize as NA/NaN

Returns **parsed** : DataFrame

21.1.4 HDFStore: PyTables (HDF5)

<code>HDFStore.put(key, value[, table, append])</code>	Store object in HDFStore
<code>HDFStore.get(key)</code>	Retrieve pandas object stored in file

pandas.io.pytables.HDFStore.put

`HDFStore.put` (*key, value, table=None, append=False, **kwargs*)

Store object in HDFStore

Parameters **key** : object

value : {Series, DataFrame, Panel}

table : boolean, default False

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 data structures, append the input data to the existing table

pandas.io.pytables.HDFStore.get

`HDFStore.get` (*key*)

Retrieve pandas object stored in file

Parameters **key** : object

Returns **obj** : type of object stored in file

21.1.5 Standard moving window functions

<code>rolling_count</code> (arg, window[, freq, center, ...])	Rolling count of number of non-NaN observations inside provided window.
<code>rolling_sum</code> (arg, window[, min_periods, ...])	Moving sum
<code>rolling_mean</code> (arg, window[, min_periods, ...])	Moving mean
<code>rolling_median</code> (arg, window[, min_periods, ...])	O(N log(window)) implementation using skip list
<code>rolling_var</code> (arg, window[, min_periods, ...])	Unbiased moving variance

Continued on next page

Table 21.6 – continued from previous page

<code>rolling_std</code> (arg, window[, min_periods, ...])	Unbiased moving standard deviation
<code>rolling_corr</code> (arg1, arg2, window[, ...])	Moving sample correlation
<code>rolling_cov</code> (arg1, arg2, window[, ...])	Unbiased moving covariance
<code>rolling_skew</code> (arg, window[, min_periods, ...])	Unbiased moving skewness
<code>rolling_kurt</code> (arg, window[, min_periods, ...])	Unbiased moving kurtosis
<code>rolling_apply</code> (arg, window, func[, ...])	Generic moving function application
<code>rolling_quantile</code> (arg, window, quantile[, ...])	Moving quantile

pandas.stats.moments.rolling_count

`pandas.stats.moments.rolling_count` (arg, window, freq=None, center=False, time_rule=None)

Rolling count of number of non-NaN observations inside provided window.

Parameters **arg** : DataFrame or numpy ndarray-like

window : Number of observations used for calculating statistic

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

center : boolean, default False

Whether the label should correspond with center of window

Returns **rolling_count** : type of caller

pandas.stats.moments.rolling_sum

`pandas.stats.moments.rolling_sum` (arg, window, min_periods=None, freq=None, center=False, time_rule=None, **kwargs)

Moving sum

Parameters **arg** : Series, DataFrame

window : Number of observations used for calculating statistic

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic time_rule is a legacy alias for freq

Returns **y** : type of input argument

pandas.stats.moments.rolling_mean

`pandas.stats.moments.rolling_mean` (arg, window, min_periods=None, freq=None, center=False, time_rule=None, **kwargs)

Moving mean

Parameters **arg** : Series, DataFrame

window : Number of observations used for calculating statistic

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic *time_rule* is a legacy alias for *freq*

Returns *y* : type of input argument

pandas.stats.moments.rolling_median

`pandas.stats.moments.rolling_median` (*arg*, *window*, *min_periods=None*, *freq=None*, *center=False*, *time_rule=None*, ***kwargs*)

$O(N \log(\text{window}))$ implementation using skip list

Moving median

Parameters *arg* : Series, DataFrame

window : Number of observations used for calculating statistic

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic *time_rule* is a legacy alias for *freq*

Returns *y* : type of input argument

pandas.stats.moments.rolling_var

`pandas.stats.moments.rolling_var` (*arg*, *window*, *min_periods=None*, *freq=None*, *center=False*, *time_rule=None*, ***kwargs*)

Unbiased moving variance

Parameters *arg* : Series, DataFrame

window : Number of observations used for calculating statistic

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic *time_rule* is a legacy alias for *freq*

Returns *y* : type of input argument

pandas.stats.moments.rolling_std

`pandas.stats.moments.rolling_std` (*arg*, *window*, *min_periods=None*, *freq=None*, *center=False*, *time_rule=None*, ***kwargs*)

Unbiased moving standard deviation

Parameters *arg* : Series, DataFrame

window : Number of observations used for calculating statistic

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic `time_rule` is a legacy alias for `freq`

Returns `y` : type of input argument

pandas.stats.moments.rolling_corr

`pandas.stats.moments.rolling_corr` (*arg1, arg2, window, min_periods=None, freq=None, center=False, time_rule=None*)

Moving sample correlation

Parameters `arg1` : Series, DataFrame, or ndarray

`arg2` : Series, DataFrame, or ndarray

`window` : Number of observations used for calculating statistic

`min_periods` : int

Minimum number of observations in window required to have a value

`freq` : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic `time_rule` is a legacy alias for `freq`

Returns `y` : type depends on inputs

DataFrame / DataFrame -> DataFrame (matches on columns) DataFrame / Series ->

Computes result for each column Series / Series -> Series

pandas.stats.moments.rolling_cov

`pandas.stats.moments.rolling_cov` (*arg1, arg2, window, min_periods=None, freq=None, center=False, time_rule=None*)

Unbiased moving covariance

Parameters `arg1` : Series, DataFrame, or ndarray

`arg2` : Series, DataFrame, or ndarray

`window` : Number of observations used for calculating statistic

`min_periods` : int

Minimum number of observations in window required to have a value

`freq` : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic `time_rule` is a legacy alias for `freq`

Returns `y` : type depends on inputs

DataFrame / DataFrame -> DataFrame (matches on columns) DataFrame / Series ->

Computes result for each column Series / Series -> Series

pandas.stats.moments.rolling_skew

`pandas.stats.moments.rolling_skew` (*arg, window, min_periods=None, freq=None, center=False, time_rule=None, **kwargs*)

Unbiased moving skewness

Parameters **arg** : Series, DataFrame

window : Number of observations used for calculating statistic

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic *time_rule* is a legacy alias for *freq*

Returns **y** : type of input argument

pandas.stats.moments.rolling_kurt

`pandas.stats.moments.rolling_kurt` (*arg, window, min_periods=None, freq=None, center=False, time_rule=None, **kwargs*)

Unbiased moving kurtosis

Parameters **arg** : Series, DataFrame

window : Number of observations used for calculating statistic

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic *time_rule* is a legacy alias for *freq*

Returns **y** : type of input argument

pandas.stats.moments.rolling_apply

`pandas.stats.moments.rolling_apply` (*arg, window, func, min_periods=None, freq=None, center=False, time_rule=None*)

Generic moving function application

Parameters **arg** : Series, DataFrame

window : Number of observations used for calculating statistic

func : function

Must produce a single value from an ndarray input

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

center : boolean, default False

Whether the label should correspond with center of window

Returns **y** : type of input argument

pandas.stats.moments.rolling_quantile

`pandas.stats.moments.rolling_quantile` (*arg*, *window*, *quantile*, *min_periods=None*,
freq=None, *center=False*, *time_rule=None*)

Moving quantile

Parameters *arg* : Series, DataFrame

window : Number of observations used for calculating statistic

quantile : $0 \leq \text{quantile} \leq 1$

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

center : boolean, default False

Whether the label should correspond with center of window

Returns *y* : type of input argument

21.1.6 Standard expanding window functions

<code>expanding_count</code> (<i>arg</i> [, <i>freq</i> , <i>center</i> , <i>time_rule</i>])	Expanding count of number of non-NaN observations.
<code>expanding_sum</code> (<i>arg</i> [, <i>min_periods</i> , <i>freq</i> , ...])	Expanding sum
<code>expanding_mean</code> (<i>arg</i> [, <i>min_periods</i> , <i>freq</i> , ...])	Expanding mean
<code>expanding_median</code> (<i>arg</i> [, <i>min_periods</i> , <i>freq</i> , ...])	O(N log(window)) implementation using skip list
<code>expanding_var</code> (<i>arg</i> [, <i>min_periods</i> , <i>freq</i> , ...])	Unbiased expanding variance
<code>expanding_std</code> (<i>arg</i> [, <i>min_periods</i> , <i>freq</i> , ...])	Unbiased expanding standard deviation
<code>expanding_corr</code> (<i>arg1</i> , <i>arg2</i> [, <i>min_periods</i> , ...])	Expanding sample correlation
<code>expanding_cov</code> (<i>arg1</i> , <i>arg2</i> [, <i>min_periods</i> , ...])	Unbiased expanding covariance
<code>expanding_skew</code> (<i>arg</i> [, <i>min_periods</i> , <i>freq</i> , ...])	Unbiased expanding skewness
<code>expanding_kurt</code> (<i>arg</i> [, <i>min_periods</i> , <i>freq</i> , ...])	Unbiased expanding kurtosis
<code>expanding_apply</code> (<i>arg</i> , <i>func</i> [, <i>min_periods</i> , ...])	Generic expanding function application
<code>expanding_quantile</code> (<i>arg</i> , <i>quantile</i> [, ...])	Expanding quantile

pandas.stats.moments.expanding_count

`pandas.stats.moments.expanding_count` (*arg*, *freq=None*, *center=False*, *time_rule=None*)

Expanding count of number of non-NaN observations.

Parameters *arg* : DataFrame or numpy ndarray-like

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

center : boolean, default False

Whether the label should correspond with center of window

Returns `expanding_count` : type of caller

pandas.stats.moments.expanding_sum

```
pandas.stats.moments.expanding_sum(arg, min_periods=1, freq=None, center=False,  
                                   time_rule=None, **kwargs)
```

Expanding sum

Parameters **arg** : Series, DataFrame

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

Returns **y** : type of input argument

pandas.stats.moments.expanding_mean

```
pandas.stats.moments.expanding_mean(arg, min_periods=1, freq=None, center=False,  
                                    time_rule=None, **kwargs)
```

Expanding mean

Parameters **arg** : Series, DataFrame

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

Returns **y** : type of input argument

pandas.stats.moments.expanding_median

```
pandas.stats.moments.expanding_median(arg, min_periods=1, freq=None, center=False,  
                                       time_rule=None, **kwargs)
```

O(N log(window)) implementation using skip list

Expanding median

Parameters **arg** : Series, DataFrame

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

Returns **y** : type of input argument

pandas.stats.moments.expanding_var

```
pandas.stats.moments.expanding_var(arg, min_periods=1, freq=None, center=False,  
                                   time_rule=None, **kwargs)
```

Unbiased expanding variance

Parameters **arg** : Series, DataFrame

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

Returns **y** : type of input argument

pandas.stats.moments.expanding_std

`pandas.stats.moments.expanding_std(arg, min_periods=1, freq=None, center=False, time_rule=None, **kwargs)`

Unbiased expanding standard deviation

Parameters **arg** : Series, DataFrame

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

Returns **y** : type of input argument

pandas.stats.moments.expanding_corr

`pandas.stats.moments.expanding_corr(arg1, arg2, min_periods=1, freq=None, center=False, time_rule=None)`

Expanding sample correlation

Parameters **arg1** : Series, DataFrame, or ndarray

arg2 : Series, DataFrame, or ndarray

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

Returns **y** : type depends on inputs

DataFrame / DataFrame -> DataFrame (matches on columns) DataFrame / Series ->

Computes result for each column Series / Series -> Series

pandas.stats.moments.expanding_cov

`pandas.stats.moments.expanding_cov(arg1, arg2, min_periods=1, freq=None, center=False, time_rule=None)`

Unbiased expanding covariance

Parameters **arg1** : Series, DataFrame, or ndarray

arg2 : Series, DataFrame, or ndarray

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

Returns y : type depends on inputs

DataFrame / DataFrame -> DataFrame (matches on columns) DataFrame / Series ->

Computes result for each column Series / Series -> Series

pandas.stats.moments.expanding_skew

pandas.stats.moments.expanding_skew(arg, min_periods=1, freq=None, center=False, time_rule=None, **kwargs)

Unbiased expanding skewness

Parameters arg : Series, DataFrame

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

Returns y : type of input argument

pandas.stats.moments.expanding_kurt

pandas.stats.moments.expanding_kurt(arg, min_periods=1, freq=None, center=False, time_rule=None, **kwargs)

Unbiased expanding kurtosis

Parameters arg : Series, DataFrame

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

Returns y : type of input argument

pandas.stats.moments.expanding_apply

pandas.stats.moments.expanding_apply(arg, func, min_periods=1, freq=None, center=False, time_rule=None)

Generic expanding function application

Parameters arg : Series, DataFrame

func : function

Must produce a single value from an ndarray input

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

center : boolean, default False

Whether the label should correspond with center of window

Returns **y** : type of input argument

pandas.stats.moments.expanding_quantile

pandas.stats.moments.**expanding_quantile**(arg, quantile, min_periods=1, freq=None, center=False, time_rule=None)

Expanding quantile

Parameters **arg** : Series, DataFrame

quantile : $0 \leq \text{quantile} \leq 1$

min_periods : int

Minimum number of observations in window required to have a value

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic

center : boolean, default False

Whether the label should correspond with center of window

Returns **y** : type of input argument

21.1.7 Exponentially-weighted moving window functions

<code>ewma</code> (arg[, com, span, min_periods, freq, ...])	Exponentially-weighted moving average
<code>ewmstd</code> (arg[, com, span, min_periods, bias, ...])	Exponentially-weighted moving std
<code>ewmvar</code> (arg[, com, span, min_periods, bias, ...])	Exponentially-weighted moving variance
<code>ewmcorr</code> (arg1, arg2[, com, span, ...])	Exponentially-weighted moving correlation
<code>ewmcov</code> (arg1, arg2[, com, span, min_periods, ...])	Exponentially-weighted moving covariance

pandas.stats.moments.ewma

pandas.stats.moments.**ewma**(arg, com=None, span=None, min_periods=0, freq=None, time_rule=None, adjust=True)

Exponentially-weighted moving average

Parameters **arg** : Series, DataFrame

com : float, optional

Center of mass: $\alpha = \text{com} / (1 + \text{com})$,

span : float, optional

Specify decay in terms of span, $\alpha = 2 / (\text{span} + 1)$

min_periods : int, default 0

Number of observations in sample to require (only affects beginning)

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic `time_rule` is a legacy alias for `freq`

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)

Returns `y` : type of input argument

Notes

Either center of mass or span must be specified

EWMA is sometimes specified using a “span” parameter s , we have have that the decay parameter α is related to the span as $\alpha = 1 - 2/(s + 1) = c/(1 + c)$

where c is the center of mass. Given a span, the associated center of mass is $c = (s - 1)/2$

So a “20-day EWMA” would have center 9.5.

pandas.stats.moments.ewmstd

`pandas.stats.moments.ewmstd` (*arg*, *com=None*, *span=None*, *min_periods=0*, *bias=False*,
time_rule=None)

Exponentially-weighted moving std

Parameters `arg` : Series, DataFrame

com : float. optional

Center of mass: $\alpha = \text{com} / (1 + \text{com})$,

span : float, optional

Specify decay in terms of span, $\alpha = 2 / (\text{span} + 1)$

min_periods : int, default 0

Number of observations in sample to require (only affects beginning)

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic `time_rule` is a legacy alias for `freq`

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)

bias : boolean, default False

Use a standard estimation bias correction

Returns `y` : type of input argument

Notes

Either center of mass or span must be specified

EWMA is sometimes specified using a “span” parameter s , we have have that the decay parameter α is related to the span as $\alpha = 1 - 2/(s + 1) = c/(1 + c)$

where c is the center of mass. Given a span, the associated center of mass is $c = (s - 1)/2$

So a “20-day EWMA” would have center 9.5.

pandas.stats.moments.ewmvar

`pandas.stats.moments.ewmvar` (*arg*, *com=None*, *span=None*, *min_periods=0*, *bias=False*,
freq=None, *time_rule=None*)

Exponentially-weighted moving variance

Parameters *arg* : Series, DataFrame

com : float. optional

Center of mass: $\alpha = \text{com} / (1 + \text{com})$,

span : float, optional

Specify decay in terms of span, $\alpha = 2 / (\text{span} + 1)$

min_periods : int, default 0

Number of observations in sample to require (only affects beginning)

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic *time_rule* is a legacy alias for *freq*

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)

bias : boolean, default False

Use a standard estimation bias correction

Returns *y* : type of input argument

Notes

Either center of mass or span must be specified

EWMA is sometimes specified using a “span” parameter s , we have have that the decay parameter α is related to the span as $\alpha = 1 - 2/(s + 1) = c/(1 + c)$

where c is the center of mass. Given a span, the associated center of mass is $c = (s - 1)/2$

So a “20-day EWMA” would have center 9.5.

pandas.stats.moments.ewmcorr

`pandas.stats.moments.ewmcorr` (*arg1*, *arg2*, *com=None*, *span=None*, *min_periods=0*, *freq=None*,
time_rule=None)

Exponentially-weighted moving correlation

Parameters *arg1* : Series, DataFrame, or ndarray

arg2 : Series, DataFrame, or ndarray

com : float. optional

Center of mass: $\alpha = \text{com} / (1 + \text{com})$,

span : float, optional

Specify decay in terms of span, $\alpha = 2 / (\text{span} + 1)$

min_periods : int, default 0

Number of observations in sample to require (only affects beginning)

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic `time_rule` is a legacy alias for `freq`

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)

Returns `y` : type of input argument

Notes

Either center of mass or span must be specified

EWMA is sometimes specified using a “span” parameter s , we have that the decay parameter α is related to the span as $\alpha = 1 - 2/(s + 1) = c/(1 + c)$

where c is the center of mass. Given a span, the associated center of mass is $c = (s - 1)/2$

So a “20-day EWMA” would have center 9.5.

pandas.stats.moments.ewmcov

`pandas.stats.moments.ewmcov` (*arg1*, *arg2*, *com=None*, *span=None*, *min_periods=0*, *bias=False*,
freq=None, *time_rule=None*)

Exponentially-weighted moving covariance

Parameters **arg1** : Series, DataFrame, or ndarray

arg2 : Series, DataFrame, or ndarray

com : float, optional

Center of mass: $\alpha = \text{com} / (1 + \text{com})$,

span : float, optional

Specify decay in terms of span, $\alpha = 2 / (\text{span} + 1)$

min_periods : int, default 0

Number of observations in sample to require (only affects beginning)

freq : None or string alias / date offset object, default=None

Frequency to conform to before computing statistic `time_rule` is a legacy alias for `freq`

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)

Returns `y` : type of input argument

Notes

Either center of mass or span must be specified

EWMA is sometimes specified using a “span” parameter s , we have have that the decay parameter α is related to the span as $\alpha = 1 - 2/(s + 1) = c/(1 + c)$

where c is the center of mass. Given a span, the associated center of mass is $c = (s - 1)/2$

So a “20-day EWMA” would have center 9.5.

21.2 Series

21.2.1 Attributes and underlying data

Axes

- **index**: axis labels

<code>Series.values</code>	Return Series as ndarray
<code>Series.dtype</code>	Data-type of the array’s elements.
<code>Series.isnull(obj)</code>	Detect missing values (NaN in numeric arrays, None/NaN in object arrays)
<code>Series.notnull(obj)</code>	Replacement for <code>numpy.isfinite</code> / <code>-numpy.isnan</code> which is suitable for use on object arrays.

pandas.Series.values

`Series.values`

Return Series as ndarray

Returns `arr` : `numpy.ndarray`

pandas.Series.dtype

`Series.dtype`

Data-type of the array’s elements.

Parameters `None` :

Returns `d` : `numpy dtype object`

See Also:

`numpy.dtype`

Examples

```
>>> x
array([[0, 1],
       [2, 3]])
>>> x.dtype
dtype('int32')
>>> type(x.dtype)
<type 'numpy.dtype'>
```

pandas.Series.isnull`Series.isnull (obj)`

Detect missing values (NaN in numeric arrays, None/NaN in object arrays)

Parameters `arr`: ndarray or object value :**Returns** boolean ndarray or boolean :**pandas.Series.notnull**`Series.notnull (obj)`Replacement for `numpy.isfinite` / `-numpy.isnan` which is suitable for use on object arrays.**Parameters** `arr`: ndarray or object value :**Returns** boolean ndarray or boolean :**21.2.2 Conversion / Constructors**

<code>Series.__init__([data, index, dtype, name, copy])</code>	One-dimensional ndarray with axis labels (including time series).
<code>Series.astype(dtype)</code>	See <code>numpy.ndarray.astype</code>
<code>Series.copy([order])</code>	Return new Series with copy of underlying values

pandas.Series.__init__`Series.__init__ (data=None, index=None, dtype=None, name=None, copy=False)`

One-dimensional ndarray with axis labels (including time series). Labels need not be unique but must be any 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 unique and hashable, same length as data. Index object (or other iterable of same length as data) Will default to `np.arange(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 NoneIf None, dtype will be inferred `copy` : boolean, default False Copy input data**copy** : boolean, default False**pandas.Series.astype**`Series.astype (dtype)`See `numpy.ndarray.astype`

pandas.Series.copy

`Series.copy (order='C')`

Return new Series with copy of underlying values

Returns `cp` : Series

21.2.3 Indexing, iteration

<code>Series.get(label[, default])</code>	Returns value occupying requested label, default to specified missing value if not present.
<code>Series.ix</code>	
<code>Series.__iter__()</code>	
<code>Series.iteritems()</code>	Lazily iterate over (index, value) tuples

pandas.Series.get

`Series.get (label, default=None)`

Returns value occupying requested label, default to specified missing value if not present. Analogous to dict.get

Parameters `label` : object

Label value looking for

default : object, optional

Value to return if label not in index

Returns `y` : scalar

pandas.Series.ix

`Series.ix`

pandas.Series.__iter__

`Series.__iter__()`

pandas.Series.iteritems

`Series.iteritems()`

Lazily iterate over (index, value) tuples

21.2.4 Binary operator functions

<code>Series.add(other[, level, fill_value])</code>	Binary operator add with support to substitute a <code>fill_value</code> for missing data
<code>Series.div(other[, level, fill_value])</code>	Binary operator divide with support to substitute a <code>fill_value</code> for missing data
<code>Series.mul(other[, level, fill_value])</code>	Binary operator multiply with support to substitute a <code>fill_value</code> for missing data
<code>Series.sub(other[, level, fill_value])</code>	Binary operator subtract with support to substitute a <code>fill_value</code> for missing data
<code>Series.combine(other, func[, fill_value])</code>	Perform elementwise binary operation on two Series using given function

Continued on next page

Table 21.12 – continued from previous page

<code>Series.combine_first(other)</code>	Combine Series values, choosing the calling Series's values
<code>Series.round([decimals, out])</code>	Return <i>a</i> with each element rounded to the given number of decimals.

pandas.Series.add

`Series.add(other, level=None, fill_value=None)`

Binary operator add 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

pandas.Series.div

`Series.div(other, level=None, fill_value=None)`

Binary operator divide 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

pandas.Series.mul

`Series.mul(other, level=None, fill_value=None)`

Binary operator multiply 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

pandas.Series.sub

`Series.sub(other, level=None, fill_value=None)`

Binary operator subtract 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

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.round

`Series.round(decimals=0, out=None)`

Return *a* with each element rounded to the given number of decimals.

Refer to *numpy.around* for full documentation.

See Also:

numpy.around equivalent function

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Table 21.13 – continued from previous page

21.2.5 Function application, GroupBy

<code>Series.apply(func[, convert_dtype, args])</code>	Invoke function on values of Series. Can be ufunc (a NumPy function
<code>Series.map(arg[, na_action])</code>	Map values of Series using input correspondence (which can be
<code>Series.groupby([by, axis, level, as_index, ...])</code>	Group series using mapper (dict or key function, apply given function

pandas.Series.apply

`Series.apply(func, convert_dtype=True, args=(), **kwargs)`

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

Returns `y` : Series or DataFrame if func returns a Series

See Also:

[`Series.map`](#) For element-wise operations

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

Returns `y` : Series

same index as caller

Examples

```
>>> x
one    1
two    2
three  3
```

```
>>> y
1    foo
2    bar
3    baz
```

```
>>> x.map(y)
one    foo
two    bar
three  baz
```

pandas.Series.groupby

`Series.groupby` (*by=None, axis=0, level=None, as_index=True, sort=True, group_keys=True*)

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 / list of functions, dict, Series, or tuple /

list of column names. Called on each element of the object index to determine the groups. If a dict or Series is passed, the Series or dict VALUES will be used to determine the groups

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

group_keys : boolean, default True

When calling `apply`, add group keys to index to identify pieces

Returns **GroupBy object** :

Examples

```
# DataFrame result >>> data.groupby(func, axis=0).mean()
# DataFrame result >>> data.groupby(['col1', 'col2'])['col3'].mean()
# DataFrame with hierarchical index >>> data.groupby(['col1', 'col2']).mean()
```

21.2.6 Computations / Descriptive Stats

<code>Series.abs()</code>	Return an object with absolute value taken.
<code>Series.any([axis, out])</code>	Returns True if any of the elements of <i>a</i> evaluate to True.
<code>Series.autocorr()</code>	Lag-1 autocorrelation
<code>Series.between(left, right[, inclusive])</code>	Return boolean Series equivalent to <code>left <= series <= right</code> . NA values
<code>Series.clip([lower, upper, out])</code>	Trim values at input threshold(s)
<code>Series.clip_lower(threshold)</code>	Return copy of series with values below given value truncated
<code>Series.clip_upper(threshold)</code>	Return copy of series with values above given value truncated
<code>Series.corr(other[, method, min_periods])</code>	Compute correlation two Series, excluding missing values

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Table 21.14 – continued from previous page

<code>Series.count([level])</code>	Return number of non-NA/null observations in the Series
<code>Series.cov(other[, min_periods])</code>	Compute covariance with Series, excluding missing values
<code>Series.cummax([axis, dtype, out, skipna])</code>	Cumulative max of values.
<code>Series.cummin([axis, dtype, out, skipna])</code>	Cumulative min of values.
<code>Series.cumprod([axis, dtype, out, skipna])</code>	Cumulative product of values.
<code>Series.cumsum([axis, dtype, out, skipna])</code>	Cumulative sum of values.
<code>Series.describe([percentile_width])</code>	Generate various summary statistics of Series, excluding NaN
<code>Series.diff([periods])</code>	1st discrete difference of object
<code>Series.kurt([skipna, level])</code>	Return unbiased kurtosis of values
<code>Series.mad([skipna, level])</code>	Return mean absolute deviation of values
<code>Series.max([axis, out, skipna, level])</code>	Return maximum of values
<code>Series.mean([axis, dtype, out, skipna, level])</code>	Return mean of values
<code>Series.median([axis, dtype, out, skipna, level])</code>	Return median of values
<code>Series.min([axis, out, skipna, level])</code>	Return minimum of values
<code>Series.nunique()</code>	Return count of unique elements in the Series
<code>Series.pct_change([periods, fill_method, ...])</code>	Percent change over given number of periods
<code>Series.prod([axis, dtype, out, skipna, level])</code>	Return product of values
<code>Series.quantile([q])</code>	Return value at the given quantile, a la <code>scoreatpercentile</code> in
<code>Series.rank([method, na_option, ascending])</code>	Compute data ranks (1 through n).
<code>Series.skew([skipna, level])</code>	Return unbiased skewness of values
<code>Series.std([axis, dtype, out, ddof, skipna, ...])</code>	Return standard deviation of values
<code>Series.sum([axis, dtype, out, skipna, level])</code>	Return sum of values
<code>Series.unique()</code>	Return array of unique values in the Series. Significantly faster than
<code>Series.var([axis, dtype, out, ddof, skipna, ...])</code>	Return variance of values
<code>Series.value_counts()</code>	Returns Series containing counts of unique values. The resulting Series

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.any**`Series.any (axis=None, out=None)`Returns True if any of the elements of *a* evaluate to True.Refer to `numpy.any` for full documentation.**See Also:**`numpy.any` equivalent function**pandas.Series.autocorr**`Series.autocorr()`

Lag-1 autocorrelation

Returns `autocorr` : float

pandas.Series.between

`Series.between` (*left, right, inclusive=True*)

Return boolean Series equivalent to $\text{left} \leq \text{series} \leq \text{right}$. NA values will be treated as False

Parameters `left` : scalar

Left boundary

`right` : scalar

Right boundary

Returns `is_between` : Series

pandas.Series.clip

`Series.clip` (*lower=None, upper=None, out=None*)

Trim values at input threshold(s)

Parameters `lower` : float, default None

`upper` : float, default None

Returns `clipped` : Series

pandas.Series.clip_lower

`Series.clip_lower` (*threshold*)

Return copy of series with values below given value truncated

Returns `clipped` : Series

See Also:

`clip`

pandas.Series.clip_upper

`Series.clip_upper` (*threshold*)

Return copy of series with values above given value truncated

Returns `clipped` : Series

See Also:

`clip`

pandas.Series.corr

`Series.corr` (*other, method='pearson', min_periods=None*)

Compute correlation two 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, 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=0, dtype=None, out=None, skipna=True)`

Cumulative max of values. Preserves locations of NaN values

Extra parameters are to preserve ndarray interface.

Parameters **skipna** : boolean, default True

Exclude NA/null values

Returns **cummax** : Series

pandas.Series.cummin

`Series.cummin (axis=0, dtype=None, out=None, skipna=True)`

Cumulative min of values. Preserves locations of NaN values

Extra parameters are to preserve ndarray interface.

Parameters **skipna** : boolean, default True

Exclude NA/null values

Returns **cummin** : Series

pandas.Series.cumprod

`Series.cumprod(axis=0, dtype=None, out=None, skipna=True)`
Cumulative product of values. Preserves locations of NaN values

Extra parameters are to preserve ndarray interface.

Parameters `skipna` : boolean, default True
Exclude NA/null values

Returns `cumprod` : Series

pandas.Series.cumsum

`Series.cumsum(axis=0, dtype=None, out=None, skipna=True)`
Cumulative sum of values. Preserves locations of NaN values

Extra parameters are to preserve ndarray interface.

Parameters `skipna` : boolean, default True
Exclude NA/null values

Returns `cumsum` : Series

pandas.Series.describe

`Series.describe(percentile_width=50)`
Generate various summary statistics of Series, excluding NaN values. These include: count, mean, std, min, max, and lower%/50%/upper% percentiles

Parameters `percentile_width` : float, optional
width of the desired uncertainty interval, default is 50, which corresponds to lower=25, upper=75

Returns `desc` : Series

pandas.Series.diff

`Series.diff(periods=1)`
1st discrete difference of object

Parameters `periods` : int, default 1
Periods to shift for forming difference

Returns `difff` : Series

pandas.Series.kurt

`Series.kurt(skipna=True, level=None)`
Return unbiased kurtosis of values NA/null values are excluded

Parameters `skipna` : boolean, default True
Exclude NA/null values

`level` : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns **kurt** : float (or Series if level specified)

pandas.Series.mad

`Series.mad(skipna=True, level=None)`

Return mean absolute deviation of values NA/null values are excluded

Parameters **skipna** : boolean, default True

Exclude NA/null values

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns **mad** : float (or Series if level specified)

pandas.Series.max

`Series.max(axis=None, out=None, skipna=True, level=None)`

Return maximum of values NA/null values are excluded

Parameters **skipna** : boolean, default True

Exclude NA/null values

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns **max** : float (or Series if level specified)

pandas.Series.mean

`Series.mean(axis=0, dtype=None, out=None, skipna=True, level=None)`

Return mean of values NA/null values are excluded

Parameters **skipna** : boolean, default True

Exclude NA/null values

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Extra parameters are to preserve ndarrayinterface. :

Returns **mean** : float (or Series if level specified)

pandas.Series.median

`Series.median (axis=0, dtype=None, out=None, skipna=True, level=None)`

Return median of values NA/null values are excluded

Parameters `skipna` : boolean, default True

Exclude NA/null values

`level` : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns `median` : float (or Series if level specified)

pandas.Series.min

`Series.min (axis=None, out=None, skipna=True, level=None)`

Return minimum of values NA/null values are excluded

Parameters `skipna` : boolean, default True

Exclude NA/null values

`level` : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns `min` : float (or Series if level specified)

pandas.Series.nunique

`Series.nunique ()`

Return count of unique elements in the Series

Returns `nunique` : int

pandas.Series.pct_change

`Series.pct_change (periods=1, fill_method='pad', limit=None, freq=None, **kwds)`

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` : Series or DataFrame

pandas.Series.prod

`Series.prod` (*axis=0, dtype=None, out=None, skipna=True, level=None*)

Return product of values NA/null values are excluded

Parameters `skipna` : boolean, default True

Exclude NA/null values

`level` : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns `prod` : float (or Series if level specified)

pandas.Series.quantile

`Series.quantile` (*q=0.5*)

Return value at the given quantile, a la `scoreatpercentile` in `scipy.stats`

Parameters `q` : quantile

$0 \leq q \leq 1$

Returns `quantile` : float

pandas.Series.rank

`Series.rank` (*method='average', na_option='keep', ascending=True*)

Compute data ranks (1 through n). Equal values are assigned a rank that is the average of the ranks of those values

Parameters `method` : { 'average', 'min', 'max', 'first' }

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

`na_option` : { 'keep' }

keep: leave NA values where they are

`ascending` : boolean, default True

False for ranks by high (1) to low (N)

Returns `ranks` : Series

pandas.Series.skew

`Series.skew` (*skipna=True, level=None*)

Return unbiased skewness of values NA/null values are excluded

Parameters `skipna` : boolean, default True

Exclude NA/null values

`level` : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns **skew** : float (or Series if level specified)

pandas.Series.std

`Series.std (axis=None, dtype=None, out=None, ddof=1, skipna=True, level=None)`

Return standard deviation of values NA/null values are excluded

Parameters **skipna** : boolean, default True

Exclude NA/null values

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns **stdev** : float (or Series if level specified)

Normalized by N-1 (unbiased estimator).

pandas.Series.sum

`Series.sum (axis=0, dtype=None, out=None, skipna=True, level=None)`

Return sum of values NA/null values are excluded

Parameters **skipna** : boolean, default True

Exclude NA/null values

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Extra parameters are to preserve ndarrayinterface. :

Returns **sum** : float (or Series if level specified)

pandas.Series.unique

`Series.unique ()`

Return array of unique values in the Series. Significantly faster than `numpy.unique`

Returns **uniques** : ndarray

pandas.Series.var

`Series.var (axis=None, dtype=None, out=None, ddof=1, skipna=True, level=None)`

Return variance of values NA/null values are excluded

Parameters **skipna** : boolean, default True

Exclude NA/null values

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

Returns **var** : float (or Series if level specified)

Normalized by N-1 (unbiased estimator).

pandas.Series.value_counts

`Series.value_counts()`

Returns Series containing counts of unique values. The resulting Series will be in descending order so that the first element is the most frequently-occurring element. Excludes NA values

Returns `counts` : Series

21.2.7 Reindexing / Selection / Label manipulation

<code>Series.align(other[, join, level, copy, ...])</code>	Align two Series object with the specified join method
<code>Series.drop(labels[, axis, level])</code>	Return new object with labels in requested axis removed
<code>Series.first(offset)</code>	Convenience method for subsetting initial periods of time series data
<code>Series.head([n])</code>	Returns first n rows of Series
<code>Series.idxmax([axis, out, skipna])</code>	Index of first occurrence of maximum of values.
<code>Series.idxmin([axis, out, skipna])</code>	Index of first occurrence of minimum of values.
<code>Series.isin(values)</code>	Return boolean vector showing whether each element in the Series is
<code>Series.last(offset)</code>	Convenience method for subsetting final periods of time series data
<code>Series.reindex([index, method, level, ...])</code>	Conform Series to new index with optional filling logic, placing
<code>Series.reindex_like(other[, method, limit])</code>	Reindex Series to match index of another Series, optionally with
<code>Series.rename(mapper[, inplace])</code>	Alter Series index using dict or function
<code>Series.reset_index([level, drop, name, inplace])</code>	Analogous to the DataFrame.reset_index function, see docstring there.
<code>Series.select(crit[, axis])</code>	Return data corresponding to axis labels matching criteria
<code>Series.take(indices[, axis])</code>	Analogous to ndarray.take, return Series corresponding to requested
<code>Series.tail([n])</code>	Returns last n rows of Series
<code>Series.truncate([before, after, copy])</code>	Function truncate a sorted DataFrame / Series before and/or after

pandas.Series.align

`Series.align(other, join='outer', level=None, copy=True, fill_value=None, method=None, limit=None)`

Align two Series object with the specified join method

Parameters `other` : Series

join : { 'outer', 'inner', 'left', 'right' }, default 'outer'

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

copy : boolean, default True

Always return new objects. If copy=False and no reindexing is required, the same object will be returned (for better performance)

fill_value : object, default None

method : str, default 'pad'

limit : int, default None

fill_value, method, inplace, limit are passed to fillna

Returns `(left, right)` : (Series, Series)

Aligned Series

pandas.Series.drop

`Series.drop(labels, axis=0, level=None)`

Return new object with labels in requested axis removed

Parameters `labels` : array-like

`axis` : int

`level` : int or name, default None

For MultiIndex

Returns `dropped` : type of caller

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.last('10D')` -> First 10 days

pandas.Series.head

`Series.head(n=5)`

Returns first n rows of Series

pandas.Series.idxmax

`Series.idxmax(axis=None, out=None, skipna=True)`

Index of first occurrence of maximum of values.

Parameters `skipna` : boolean, default True

Exclude NA/null values

Returns `idxmax` : Index of minimum of values

pandas.Series.idxmin

`Series.idxmin(axis=None, out=None, skipna=True)`

Index of first occurrence of minimum of values.

Parameters `skipna` : boolean, default True

Exclude NA/null values

Returns `idxmin` : Index of minimum of values

pandas.Series.isin

`Series.isin(values)`

Return boolean vector showing whether each element in the Series is exactly contained in the passed sequence of values

Parameters `values` : sequence

Returns `isin` : Series (boolean dtype)

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.reindex

`Series.reindex(index=None, method=None, level=None, fill_value=nan, limit=None, copy=True)`

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 or Index

New labels / index to conform to. Preferably an Index object to avoid duplicating data

method : { 'backfill', 'bfill', 'pad', 'ffill', 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

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 size gap to forward or backward fill

Returns `reindexed` : Series

pandas.Series.reindex_like

`Series.reindex_like` (*other*, *method=None*, *limit=None*)

Reindex Series to match index of another Series, optionally with filling logic

Parameters **other** : Series

method : string or None

See Series.reindex docstring

limit : int, default None

Maximum size gap to forward or backward fill

Returns **reindexed** : Series

Notes

Like calling `s.reindex(other.index, method=...)`

pandas.Series.rename

`Series.rename` (*mapper*, *inplace=False*)

Alter Series index using dict or function

Parameters **mapper** : dict-like or function

Transformation to apply to each index

Returns **renamed** : Series (new object)

Notes

Function / dict values must be unique (1-to-1)

Examples

```
>>> x
foo 1
bar 2
baz 3

>>> x.rename(str.upper)
FOO 1
BAR 2
BAZ 3

>>> x.rename({'foo' : 'a', 'bar' : 'b', 'baz' : 'c'})
a 1
b 2
c 3
```

pandas.Series.reset_index

`Series.reset_index` (*level=None, drop=False, name=None, inplace=False*)

Analogous to the `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`

pandas.Series.select

`Series.select` (*crit, axis=0*)

Return data corresponding to axis labels matching criteria

Parameters **crit** : function

To be called on each index (label). Should return True or False

axis : int

Returns **selection** : type of caller

pandas.Series.take

`Series.take` (*indices, axis=0*)

Analogous to `ndarray.take`, return Series corresponding to requested indices

Parameters **indices** : list / array of ints

Returns **taken** : Series

pandas.Series.tail

`Series.tail` (*n=5*)

Returns last n rows of Series

pandas.Series.truncate

`Series.truncate` (*before=None, after=None, copy=True*)

Function truncate a sorted DataFrame / Series before and/or after some particular dates.

Parameters **before** : date

Truncate before date

after : date

Truncate after date

Returns `truncated` : type of caller

21.2.8 Missing data handling

<code>Series.dropna()</code>	Return Series without null values
<code>Series.fillna([value, method, inplace, limit])</code>	Fill NA/NaN values using the specified method
<code>Series.interpolate([method])</code>	Interpolate missing values (after the first valid value)

pandas.Series.dropna

`Series.dropna()`

Return Series without null values

Returns `valid` : Series

pandas.Series.fillna

`Series.fillna(value=None, method=None, inplace=False, limit=None)`

Fill NA/NaN values using the specified method

Parameters `value` : any kind (should be same type as array)

Value to use to fill holes (e.g. 0)

method : { 'backfill', 'bfill', 'pad', 'ffill', None }, default 'pad'

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

inplace : boolean, default False

If True, fill the Series in place. Note: this will modify any other views on this Series, for example a column in a DataFrame. Returns a reference to the filled object, which is self if `inplace=True`

limit : int, default None

Maximum size gap to forward or backward fill

Returns `filled` : Series

See Also:

`reindex`, `asfreq`

pandas.Series.interpolate

`Series.interpolate(method='linear')`

Interpolate missing values (after the first valid value)

Parameters `method` : { 'linear', 'time', 'values' }

Interpolation method. 'time' interpolation works on daily and higher resolution data to interpolate given length of interval 'values' using the actual index numeric values

Returns `interpolated` : Series

21.2.9 Reshaping, sorting

<code>Series.argsort([axis, kind, order])</code>	Overrides ndarray.argsort.
<code>Series.order([na_last, ascending, kind])</code>	Sorts Series object, by value, maintaining index-value link
<code>Series.reorder_levels(order)</code>	Rearrange index levels using input order.
<code>Series.sort([axis, kind, order])</code>	Sort values and index labels by value, in place.
<code>Series.sort_index([ascending])</code>	Sort object by labels (along an axis)
<code>Series.sortlevel([level, ascending])</code>	Sort Series with MultiIndex by chosen level. Data will be
<code>Series.swaplevel(i, j[, copy])</code>	Swap levels i and j in a MultiIndex
<code>Series.unstack([level])</code>	Unstack, a.k.a.

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

pandas.Series.order

`Series.order` (*na_last=True, ascending=True, kind='mergesort'*)

Sorts Series object, by value, maintaining index-value link

Parameters `na_last` : boolean (optional, default=True)

Put NaN's at beginning or end

`ascending` : boolean, default True

Sort ascending. Passing False sorts descending

`kind` : { 'mergesort', 'quicksort', 'heapsort' }, default 'mergesort'

Choice of sorting algorithm. See np.sort for more information. 'mergesort' is the only stable algorithm

Returns `y` : Series

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 not by key)

`axis`: where to reorder levels :

Returns type of caller (new object) :

pandas.Series.sort

`Series.sort` (*axis=0, kind='quicksort', order=None*)

Sort values and index labels by value, in place. For compatibility with ndarray API. No return value

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

pandas.Series.sort_index

`Series.sort_index` (*ascending=True*)

Sort object by labels (along an axis)

Parameters **ascending** : boolean or list, default True

Sort ascending vs. descending. Specify list for multiple sort orders

Returns **sorted_obj** : Series

Examples

```
>>> result1 = s.sort_index(ascending=False)
>>> result2 = s.sort_index(ascending=[1, 0])
```

pandas.Series.sortlevel

`Series.sortlevel` (*level=0, ascending=True*)

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

ascending : bool, default True

Returns **sorted** : Series

pandas.Series.swaplevel

`Series.swaplevel` (*i, j, copy=True*)

Swap levels i and j in a MultiIndex

Returns **swapped** : Series

pandas.Series.unstack`Series.unstack (level=-1)`

Unstack, a.k.a. pivot, Series with MultiIndex to produce DataFrame

Parameters `level` : int, string, or list of these, default last level

Level(s) to unstack, can pass level name

Returns `unstacked` : DataFrame**Examples**

```

>>> s
one  a    1.
one  b    2.
two  a    3.
two  b    4.

>>> s.unstack(level=-1)
      a    b
one  1.  2.
two  3.  4.

>>> s.unstack(level=0)
      one  two
a    1.   2.
b    3.   4.

```

21.2.10 Combining / joining / merging

<code>Series.append(to_append[, verify_integrity])</code>	Concatenate two or more Series. The indexes must not overlap
<code>Series.replace(to_replace[, value, method, ...])</code>	Replace arbitrary values in a Series
<code>Series.update(other)</code>	Modify Series in place using non-NA values from passed

pandas.Series.append`Series.append (to_append, verify_integrity=False)`

Concatenate two or more Series. The indexes must not overlap

Parameters `to_append` : Series or list/tuple of Series`verify_integrity` : boolean, default False

If True, raise Exception on creating index with duplicates

Returns `appended` : Series**pandas.Series.replace**`Series.replace (to_replace, value=None, method='pad', inplace=False, limit=None)`

Replace arbitrary values in a Series

Parameters `to_replace` : list or dict

list of values to be replaced or dict of replacement values

value : anything

if `to_replace` is a list then value is the replacement value

method : { 'backfill', 'bfill', 'pad', 'ffill', None }, default 'pad'

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

inplace : boolean, default False

If True, fill the Series in place. Note: this will modify any other views on this Series, for example a column in a DataFrame. Returns a reference to the filled object, which is self if `inplace=True`

limit : int, default None

Maximum size gap to forward or backward fill

Returns `replaced` : Series

See Also:

`fillna`, `reindex`, `asfreq`

Notes

`replace` does not distinguish between NaN and None

pandas.Series.update

`Series.update` (*other*)

Modify Series in place using non-NA values from passed Series. Aligns on index

Parameters `other` : Series

21.2.11 Time series-related

<code>Series.asfreq(freq[, method, how, normalize])</code>	Convert all TimeSeries inside to specified frequency using DateOffset
<code>Series.asof(where)</code>	Return last good (non-NaN) value in TimeSeries if value is NaN for
<code>Series.shift([periods, freq, copy])</code>	Shift the index of the Series by desired number of periods with an
<code>Series.first_valid_index()</code>	Return label for first non-NA/null value
<code>Series.last_valid_index()</code>	Return label for last non-NA/null value
<code>Series.weekday</code>	
<code>Series.resample(rule[, how, axis, ...])</code>	Convenience method for frequency conversion and resampling of regular time-
<code>Series.tz_convert(tz[, copy])</code>	Convert TimeSeries to target time zone
<code>Series.tz_localize(tz[, copy])</code>	Localize tz-naive TimeSeries to target time zone

pandas.Series.asfreq

`Series.asfreq` (*freq, method=None, how=None, normalize=False*)

Convert all TimeSeries inside to specified frequency using DateOffset objects. Optionally provide fill method to pad/backfill missing values.

Parameters **freq** : DateOffset object, or string

method : { 'backfill', 'bfill', 'pad', 'ffill', 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 methdo

how : { 'start', 'end' }, default end

For PeriodIndex only, see PeriodIndex.asfreq

normalize : bool, default False

Whether to reset output index to midnight

Returns **converted** : type of caller

pandas.Series.asof

`Series.asof (where)`

Return last good (non-NaN) value in TimeSeries if value is NaN for requested date.

If there is no good value, NaN is returned.

Parameters **where** : date or array of dates

Returns **value or NaN** :

Notes

Dates are assumed to be sorted

pandas.Series.shift

`Series.shift (periods=1, freq=None, copy=True, **kws)`

Shift the index of the Series by desired number of periods with an optional time offset

Parameters **periods** : int

Number of periods to move, can be positive or negative

freq : DateOffset, timedelta, or offset alias string, optional

Increment to use from datetools module or time rule (e.g. 'EOM')

Returns **shifted** : Series

pandas.Series.first_valid_index

`Series.first_valid_index()`

Return label for first non-NA/null value

pandas.Series.last_valid_index

`Series.last_valid_index()`

Return label for last non-NA/null value

pandas.Series.weekday

Series.**weekday**

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)

Convenience method for frequency conversion and resampling of regular time-series data.

Parameters rule : the offset string or object representing target conversion

how : string, method for down- or re-sampling, default to 'mean' for
downsampling

fill_method : string, fill_method for upsampling, default None

axis : int, optional, default 0

closed : { 'right', 'left' }, default None

Which side of bin interval is closed

label : { 'right', 'left' }, default None

Which bin edge label to label bucket with

convention : { 'start', 'end', 's', 'e' }

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

pandas.Series.tz_convert

Series.**tz_convert**(tz, copy=True)

Convert TimeSeries to target time zone

Parameters tz : string or pytz.timezone object

copy : boolean, default True

Also make a copy of the underlying data

Returns converted : TimeSeries

pandas.Series.tz_localize

Series.**tz_localize**(tz, copy=True)

Localize tz-naive TimeSeries to target time zone

Parameters tz : string or pytz.timezone object

copy : boolean, default True

Also make a copy of the underlying data

Returns `localized` : TimeSeries

21.2.12 Plotting

<code>Series.hist([by, ax, grid, xlabelsize, ...])</code>	Draw histogram of the input series using matplotlib
<code>Series.plot(series[, label, kind, ...])</code>	Plot the input series with the index on the x-axis using matplotlib

pandas.Series.hist

`Series.hist` (*by=None, ax=None, grid=True, xlabelsize=None, xrot=None, ylabelsize=None, yrot=None, **kws*)

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

`kws` : keywords

To be passed to the actual plotting function

Notes

See matplotlib documentation online for more on this

pandas.Series.plot

`Series.plot` (*series, label=None, kind='line', use_index=True, rot=None, xticks=None, yticks=None, xlim=None, ylim=None, ax=None, style=None, grid=None, legend=False, logx=False, logy=False, secondary_y=False, **kws*)

Plot the input series with the index on the x-axis using matplotlib

Parameters `label` : label argument to provide to plot

`kind` : { 'line', 'bar', 'barh' }

bar : vertical bar plot **barh** : horizontal bar plot
rot : int, default 30
 Rotation for tick labels
use_index : boolean, default True
 Plot index as axis tick labels
ax : matplotlib axis object
 If not passed, uses gca()
style : string, default matplotlib default
 matplotlib line style to use
ax : matplotlib axis object
 If not passed, uses gca()
logx : boolean, default False
 For line plots, use log scaling on x axis
logy : boolean, default False
 For line plots, use log scaling on y axis
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
kws : keywords
 Options to pass to matplotlib plotting method

Notes

See matplotlib documentation online for more on this subject

21.2.13 Serialization / IO / Conversion

<code>Series.from_csv(path[, sep, parse_dates, ...])</code>	Read delimited file into Series
<code>Series.load(path)</code>	
<code>Series.save(path)</code>	
<code>Series.to_csv(path[, index, sep, na_rep, ...])</code>	Write Series to a comma-separated values (csv) file
<code>Series.to_dict()</code>	Convert Series to {label -> value} dict
<code>Series.to_sparse([kind, fill_value])</code>	Convert Series to SparseSeries
Continued on next page	

Table 21.21 – continued from previous page

<code>Series.to_string([buf, na_rep, ...])</code>	Render a string representation of the Series
---	--

pandas.Series.from_csv

classmethod `Series.from_csv` (*path*, *sep*=', ', *parse_dates*=True, *header*=None, *index_col*=0, *encoding*=None)

Read delimited file into Series

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 0

Row to use at 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

Returns **y** : Series

pandas.Series.load

classmethod `Series.load` (*path*)

pandas.Series.save

`Series.save` (*path*)

pandas.Series.to_csv

`Series.to_csv` (*path*, *index*=True, *sep*=', ', *na_rep*='', *float_format*=None, *header*=False, *index_label*=None, *mode*='w', *nanRep*=None, *encoding*=None)

Write Series to a comma-separated values (csv) file

Parameters **path** : string file path or file handle / StringIO

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

pandas.Series.to_dict

`Series.to_dict()`

Convert Series to {label -> value} dict

Returns **value_dict** : dict

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_string

`Series.to_string(buf=None, na_rep='NaN', float_format=None, nanRep=None, length=False, name=False)`

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

length : boolean, default False

Add the Series length

name : boolean, default False

Add the Series name (which may be None)

Returns **formatted** : string (if not buffer passed)

21.3 DataFrame

21.3.1 Attributes and underlying data

Axes

- **index**: row labels
- **columns**: column labels

<code>DataFrame.as_matrix([columns])</code>	Convert the frame to its Numpy-array matrix representation. Columns
<code>DataFrame.dtypes</code>	
<code>DataFrame.get_dtype_counts()</code>	
<code>DataFrame.values</code>	Convert the frame to its Numpy-array matrix representation. Columns
<code>DataFrame.axes</code>	
<code>DataFrame.ndim</code>	
<code>DataFrame.shape</code>	

pandas.DataFrame.as_matrix

`DataFrame.as_matrix` (*columns=None*)

Convert the frame to its Numpy-array matrix representation. Columns are presented in sorted order unless a specific list of columns is provided.

Parameters **columns** : array-like

Specific column order

Returns **values** : ndarray

If the DataFrame is heterogeneous and contains booleans or objects, the result will be of dtype=object

pandas.DataFrame.dtypes

`DataFrame.dtypes`

pandas.DataFrame.get_dtype_counts

`DataFrame.get_dtype_counts` ()

pandas.DataFrame.values

`DataFrame.values`

Convert the frame to its Numpy-array matrix representation. Columns are presented in sorted order unless a specific list of columns is provided.

Parameters **columns** : array-like

Specific column order

Returns **values** : ndarray

If the DataFrame is heterogeneous and contains booleans or objects, the result will be of dtype=object

pandas.DataFrame.axes

DataFrame.**axes**

pandas.DataFrame.ndim

DataFrame.**ndim**

pandas.DataFrame.shape

DataFrame.**shape**

21.3.2 Conversion / Constructors

DataFrame.__init__([data, index, columns, ...])	Two-dimensional size-mutable, potentially heterogeneous tabular data structure
DataFrame.astype(dtype)	Cast object to input numpy.dtype
DataFrame.convert_objects([convert_dates])	Attempt to infer better dtype for object columns
DataFrame.copy([deep])	Make a copy of this object

pandas.DataFrame.__init__

DataFrame.**__init__** (*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

Will default to np.arange(n) if not column labels provided

dtype : dtype, default None

Data type to force, otherwise 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_csv` from CSV files`DataFrame.from_items` from sequence of (key, value) pairs`read_csv`**Examples**

```

>>> d = {'col1': ts1, 'col2': ts2}
>>> df = DataFrame(data=d, index=index)
>>> df2 = DataFrame(np.random.randn(10, 5))
>>> df3 = DataFrame(np.random.randn(10, 5),
...                  columns=['a', 'b', 'c', 'd', 'e'])

```

pandas.DataFrame.astype`DataFrame.astype` (*dtype*)

Cast object to input numpy.dtype

Parameters `dtype` : numpy.dtype or Python type**Returns** `casted` : type of caller**pandas.DataFrame.convert_objects**`DataFrame.convert_objects` (*convert_dates=True*)

Attempt to infer better dtype for object columns

Returns `converted` : DataFrame**pandas.DataFrame.copy**`DataFrame.copy` (*deep=True*)

Make a copy of this object

Parameters `deep` : boolean, default True

Make a deep copy, i.e. also copy data

Returns `copy` : type of caller**21.3.3 Indexing, iteration**

<code>DataFrame.head([n])</code>	Returns first n rows of DataFrame
<code>DataFrame.ix</code>	
<code>DataFrame.insert(loc, column, value)</code>	Insert column into DataFrame at specified location. Raises Exception if
Continued on next page	

Table 21.24 – continued from previous page

<code>DataFrame.__iter__()</code>	Iterate over columns of the frame.
<code>DataFrame.iteritems()</code>	Iterator over (column, series) pairs
<code>DataFrame.iterrows()</code>	Iterate over rows of DataFrame as (index, Series) pairs
<code>DataFrame.itertuples([index])</code>	Iterate over rows of DataFrame as tuples, with index value
<code>DataFrame.lookup(row_labels, col_labels)</code>	Label-based “fancy indexing” function for DataFrame. Given equal-length
<code>DataFrame.pop(item)</code>	Return column and drop from frame.
<code>DataFrame.tail([n])</code>	Returns last n rows of DataFrame
<code>DataFrame.xs(key[, axis, level, copy])</code>	Returns a cross-section (row(s) or column(s)) from the DataFrame.

pandas.DataFrame.head

`DataFrame.head (n=5)`
Returns first n rows of DataFrame

pandas.DataFrame.ix

`DataFrame.ix`

pandas.DataFrame.insert

`DataFrame.insert (loc, column, value)`
Insert column into DataFrame at specified location. Raises Exception if column is already contained in the DataFrame

Parameters `loc` : int

Must have $0 \leq \text{loc} \leq \text{len}(\text{columns})$

column : object

value : int, Series, or array-like

pandas.DataFrame.__iter__

`DataFrame.__iter__()`
Iterate over columns of the frame.

pandas.DataFrame.iteritems

`DataFrame.iteritems()`
Iterator over (column, series) pairs

pandas.DataFrame.iterrows

`DataFrame.iterrows()`
Iterate over rows of DataFrame as (index, Series) pairs

pandas.DataFrame.itertuples

`DataFrame.itertuples(index=True)`

Iterate over rows of DataFrame as tuples, with index value as first element of the tuple

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

`col_labels` : sequence

Notes

Akin to

```
result = []
for row, col in zip(row_labels, col_labels):
```

```
    result.append(df.get_value(row, col))
```

pandas.DataFrame.pop

`DataFrame.pop(item)`

Return column and drop from frame. Raise `KeyError` if not found.

Returns `column` : Series

pandas.DataFrame.tail

`DataFrame.tail(n=5)`

Returns last n rows of DataFrame

pandas.DataFrame.xs

`DataFrame.xs(key, axis=0, level=None, copy=True)`

Returns a cross-section (row(s) or column(s)) from the 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.

`copy` : boolean, default True

Whether to make a copy of the data

Returns `xs` : Series or DataFrame**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
>>> s = df.xs('a', copy=False)
>>> s['A'] = 100
>>> df
   A  B  C
a 100  5  2
b   4  0  9
c   9  7  3

>>> df
      first second third    A  B  C  D
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
```

21.3.4 Binary operator functions

<code>DataFrame.add(other[, axis, level, fill_value])</code>	Binary operator add with support to substitute a <code>fill_value</code> for missing data in
<code>DataFrame.div(other[, axis, level, fill_value])</code>	Binary operator divide with support to substitute a <code>fill_value</code> for missing data in
<code>DataFrame.mul(other[, axis, level, fill_value])</code>	Binary operator multiply with support to substitute a <code>fill_value</code> for missing data in
<code>DataFrame.sub(other[, axis, level, fill_value])</code>	Binary operator subtract with support to substitute a <code>fill_value</code> for missing data in

Continued on next page

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<code>DataFrame.radd(other[, axis, level, fill_value])</code>	Binary operator radd with support to substitute a fill_value for missing data in
<code>DataFrame.rdiv(other[, axis, level, fill_value])</code>	Binary operator rdivide with support to substitute a fill_value for missing data in
<code>DataFrame.rmul(other[, axis, level, fill_value])</code>	Binary operator rmultiply with support to substitute a fill_value for missing data in
<code>DataFrame.rsub(other[, axis, level, fill_value])</code>	Binary operator rsubtract with support to substitute a fill_value for missing data in
<code>DataFrame.combine(other, func[, fill_value])</code>	Add two DataFrame objects and do not propagate NaN values, so if for a
<code>DataFrame.combineAdd(other)</code>	Add two DataFrame objects and do not propagate
<code>DataFrame.combine_first(other)</code>	Combine two DataFrame objects and default to non-null values in frame
<code>DataFrame.combineMult(other)</code>	Multiply two DataFrame objects and do not propagate NaN values, so if

pandas.DataFrame.add

`DataFrame.add(other, axis='columns', level=None, fill_value=None)`

Binary operator add 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

Notes

Mismatched indices will be unioned together

pandas.DataFrame.div

`DataFrame.div(other, axis='columns', level=None, fill_value=None)`

Binary operator divide 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

Notes

Mismatched indices will be unioned together

pandas.DataFrame.mul

`DataFrame.mul` (*other*, *axis*='columns', *level*=None, *fill_value*=None)

Binary operator multiply 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

Notes

Mismatched indices will be unioned together

pandas.DataFrame.sub

`DataFrame.sub` (*other*, *axis*='columns', *level*=None, *fill_value*=None)

Binary operator subtract 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

Notes

Mismatched indices will be unioned together

pandas.DataFrame.radd

`DataFrame.radd` (*other*, *axis*='columns', *level*=None, *fill_value*=None)

Binary operator radd 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

Notes

Mismatched indices will be unioned together

pandas.DataFrame.rdiv

`DataFrame.rdiv` (*other*, *axis*='columns', *level*=None, *fill_value*=None)

Binary operator rdivide 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

Notes

Mismatched indices will be unioned together

pandas.DataFrame.rmul

`DataFrame.rmul` (*other*, *axis*='columns', *level*=None, *fill_value*=None)

Binary operator rmultiply 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

Notes

Mismatched indices will be unioned together

pandas.DataFrame.rsub

`DataFrame.rsub(other, axis='columns', level=None, fill_value=None)`

Binary operator rsubtract 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

Notes

Mismatched indices will be unioned together

pandas.DataFrame.combine

`DataFrame.combine(other, func, fill_value=None)`

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

Returns **result** : DataFrame

pandas.DataFrame.combineAdd`DataFrame.combineAdd(other)`

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

Returns 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.combine_first(b)
a's values prioritized, use values from b to fill holes
```

pandas.DataFrame.combineMult`DataFrame.combineMult(other)`

Multiply 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

Returns DataFrame :

21.3.5 Function application, GroupBy

<code>DataFrame.apply(func[, axis, broadcast, ...])</code>	Applies function along input axis of DataFrame. Objects passed to
<code>DataFrame.applymap(func)</code>	Apply a function to a DataFrame that is intended to operate
<code>DataFrame.groupby([by, axis, level, ...])</code>	Group series using mapper (dict or key function, apply given function

pandas.DataFrame.apply`DataFrame.apply(func, axis=0, broadcast=False, raw=False, args=(), **kwargs)`

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

Parameters `func` : function

Function to apply to each column

`axis` : {0, 1}

0 : apply function to each column 1 : apply function to each row

broadcast : bool, 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

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

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

pandas.DataFrame.groupby

`DataFrame.groupby` (*by=None, axis=0, level=None, as_index=True, sort=True, group_keys=True*)

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 / list of functions, dict, Series, or tuple /

list of column names. Called on each element of the object index to determine the groups. If a dict or Series is passed, the Series or dict VALUES will be used to determine the groups

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

group_keys : boolean, default True

When calling apply, add group keys to index to identify pieces

Returns GroupBy object :

Examples

```
# DataFrame result >>> data.groupby(func, axis=0).mean()
# DataFrame result >>> data.groupby(['col1', 'col2'])['col3'].mean()
# DataFrame with hierarchical index >>> data.groupby(['col1', 'col2']).mean()
```

21.3.6 Computations / Descriptive Stats

<code>DataFrame.abs()</code>	Return an object with absolute value taken.
<code>DataFrame.any([axis, bool_only, skipna, level])</code>	Return whether any element is True over requested axis.
<code>DataFrame.clip([upper, lower])</code>	Trim values at input threshold(s)
<code>DataFrame.clip_lower(threshold)</code>	Trim values below threshold
<code>DataFrame.clip_upper(threshold)</code>	Trim values above threshold
<code>DataFrame.corr([method, min_periods])</code>	Compute pairwise correlation of columns, excluding NA/null values
<code>DataFrame.corrwith(other[, axis, drop])</code>	Compute pairwise correlation between rows or columns of two DataFrame
<code>DataFrame.count([axis, level, numeric_only])</code>	Return Series with number of non-NA/null observations over requested
<code>DataFrame.cov([min_periods])</code>	Compute pairwise covariance of columns, excluding NA/null values
<code>DataFrame.cummax([axis, skipna])</code>	Return DataFrame of cumulative max over requested axis.
<code>DataFrame.cummin([axis, skipna])</code>	Return DataFrame of cumulative min over requested axis.
<code>DataFrame.cumprod([axis, skipna])</code>	Return cumulative product over requested axis as DataFrame
<code>DataFrame.cumsum([axis, skipna])</code>	Return DataFrame of cumulative sums over requested axis.
<code>DataFrame.describe([percentile_width])</code>	Generate various summary statistics of each column, excluding
<code>DataFrame.diff([periods])</code>	1st discrete difference of object
<code>DataFrame.kurt([axis, skipna, level])</code>	Return unbiased kurtosis over requested axis.
<code>DataFrame.mad([axis, skipna, level])</code>	Return mean absolute deviation over requested axis.
<code>DataFrame.max([axis, skipna, level])</code>	Return maximum over requested axis.
<code>DataFrame.mean([axis, skipna, level])</code>	Return mean over requested axis.
<code>DataFrame.median([axis, skipna, level])</code>	Return median over requested axis.
<code>DataFrame.min([axis, skipna, level])</code>	Return minimum over requested axis.
<code>DataFrame.pct_change([periods, fill_method, ...])</code>	Percent change over given number of periods
<code>DataFrame.prod([axis, skipna, level])</code>	Return product over requested axis.
<code>DataFrame.quantile([q, axis, numeric_only])</code>	Return values at the given quantile over requested axis, a la
<code>DataFrame.rank([axis, numeric_only, method, ...])</code>	Compute numerical data ranks (1 through n) along axis.
<code>DataFrame.skew([axis, skipna, level])</code>	Return unbiased skewness over requested axis.
<code>DataFrame.sum([axis, numeric_only, skipna, ...])</code>	Return sum over requested axis.
<code>DataFrame.std([axis, skipna, level, ddof])</code>	Return standard deviation over requested axis.
<code>DataFrame.var([axis, skipna, level, ddof])</code>	Return variance over requested axis.

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.any

`DataFrame.any(axis=0, bool_only=None, skipna=True, level=None)`

Return whether any element is True over requested axis. %(na_action)s

Parameters `axis` : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

bool_only : boolean, default None

Only include boolean data.

Returns `any` : Series (or DataFrame if level specified)

pandas.DataFrame.clip

`DataFrame.clip(upper=None, lower=None)`

Trim values at input threshold(s)

Parameters `lower` : float, default None

`upper` : float, default None

Returns `clipped` : DataFrame

pandas.DataFrame.clip_lower

`DataFrame.clip_lower(threshold)`

Trim values below threshold

Returns `clipped` : DataFrame

pandas.DataFrame.clip_upper

`DataFrame.clip_upper(threshold)`

Trim values above threshold

Returns `clipped` : DataFrame

pandas.DataFrame.corr`DataFrame.corr (method='pearson', min_periods=None)`

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 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, 1}

0 to compute column-wise, 1 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, 1}

0 for row-wise, 1 for column-wise

level : int, 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

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*)

Return DataFrame of cumulative max over requested axis.

Parameters axis : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns y : DataFrame

pandas.DataFrame.cummin

DataFrame.**cummin** (*axis=None, skipna=True*)

Return DataFrame of cumulative min over requested axis.

Parameters axis : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns y : DataFrame

pandas.DataFrame.cumprod

DataFrame.**cumprod** (*axis=None, skipna=True*)

Return cumulative product over requested axis as DataFrame

Parameters axis : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns y : DataFrame

pandas.DataFrame.cumsum

DataFrame.**cumsum** (*axis=None, skipna=True*)

Return DataFrame of cumulative sums over requested axis.

Parameters axis : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

Returns **y** : DataFrame

pandas.DataFrame.describe

DataFrame.**describe** (*percentile_width=50*)

Generate various summary statistics of each column, excluding NaN values. These include: count, mean, std, min, max, and lower%/50%/upper% percentiles

Parameters **percentile_width** : float, optional

width of the desired uncertainty interval, default is 50, which corresponds to lower=25, upper=75

Returns **DataFrame of summary statistics** :

pandas.DataFrame.diff

DataFrame.**diff** (*periods=1*)

1st discrete difference of object

Parameters **periods** : int, default 1

Periods to shift for forming difference

Returns **differed** : DataFrame

pandas.DataFrame.kurt

DataFrame.**kurt** (*axis=0, skipna=True, level=None*)

Return unbiased kurtosis over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **kurt** : Series (or DataFrame if level specified)

pandas.DataFrame.mad

DataFrame.**mad** (*axis=0, skipna=True, level=None*)

Return mean absolute deviation over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **mad** : Series (or DataFrame if level specified)

pandas.DataFrame.max

DataFrame.**max** (*axis=0, skipna=True, level=None*)

Return maximum over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **max** : Series (or DataFrame if level specified)

pandas.DataFrame.mean

DataFrame.**mean** (*axis=0, skipna=True, level=None*)

Return mean over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **mean** : Series (or DataFrame if level specified)

pandas.DataFrame.median

DataFrame.**median** (*axis=0, skipna=True, level=None*)

Return median over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **median** : Series (or DataFrame if level specified)

pandas.DataFrame.min

`DataFrame.min` (*axis=0, skipna=True, level=None*)

Return minimum over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **min** : Series (or DataFrame if level specified)

pandas.DataFrame.pct_change

`DataFrame.pct_change` (*periods=1, fill_method='pad', limit=None, freq=None, **kws*)

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** : Series or DataFrame

pandas.DataFrame.prod

`DataFrame.prod` (*axis=0, skipna=True, level=None*)

Return product over requested axis. NA/null values are treated as 1

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **product** : Series (or DataFrame if level specified)

pandas.DataFrame.quantile

`DataFrame.quantile (q=0.5, axis=0, numeric_only=True)`

Return values at the given quantile over requested axis, a la `scoreatpercentile` in `scipy.stats`

Parameters **q** : quantile, default 0.5 (50% quantile)

0 <= q <= 1

axis : {0, 1}

0 for row-wise, 1 for column-wise

Returns **quantiles** : Series

pandas.DataFrame.rank

`DataFrame.rank (axis=0, numeric_only=None, method='average', na_option='keep', ascending=True)`

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, 1}, default 0

Ranks over columns (0) or rows (1)

numeric_only : boolean, default None

Include only float, int, boolean data

method : {'average', 'min', 'max', 'first'}

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

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)

Returns **ranks** : DataFrame

pandas.DataFrame.skew

`DataFrame.skew (axis=0, skipna=True, level=None)`

Return unbiased skewness over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **skew** : Series (or DataFrame if level specified)

pandas.DataFrame.sum

`DataFrame.sum(axis=0, numeric_only=None, skipna=True, level=None)`

Return sum over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, 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 data. If None, will attempt to use everything, then use only numeric data

Returns **sum** : Series (or DataFrame if level specified)

pandas.DataFrame.std

`DataFrame.std(axis=0, skipna=True, level=None, ddof=1)`

Return standard deviation over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **std** : Series (or DataFrame if level specified)

Normalized by N-1 (unbiased estimator).

pandas.DataFrame.var

`DataFrame.var(axis=0, skipna=True, level=None, ddof=1)`

Return variance over requested axis. NA/null values are excluded

Parameters **axis** : {0, 1}

0 for row-wise, 1 for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

Returns **var** : Series (or DataFrame if level specified)

Normalized by N-1 (unbiased estimator).

21.3.7 Reindexing / Selection / Label manipulation

<code>DataFrame.add_prefix(prefix)</code>	Concatenate prefix string with panel items names.
<code>DataFrame.add_suffix(suffix)</code>	Concatenate suffix string with panel items names
<code>DataFrame.align(other[, join, axis, level, ...])</code>	Align two DataFrame object on their index and columns with the
<code>DataFrame.drop(labels[, axis, level])</code>	Return new object with labels in requested axis removed
<code>DataFrame.drop_duplicates([cols, take_last, ...])</code>	Return DataFrame with duplicate rows removed, optionally only
<code>DataFrame.duplicated([cols, take_last])</code>	Return boolean Series denoting duplicate rows, optionally only
<code>DataFrame.filter([items, like, regex])</code>	Restrict frame's columns to set of items or wildcard
<code>DataFrame.first(offset)</code>	Convenience method for subsetting initial periods of time series data
<code>DataFrame.head([n])</code>	Returns first n rows of DataFrame
<code>DataFrame.idxmax([axis, skipna])</code>	Return index of first occurrence of maximum over requested axis.
<code>DataFrame.idxmin([axis, skipna])</code>	Return index of first occurrence of minimum over requested axis.
<code>DataFrame.last(offset)</code>	Convenience method for subsetting final periods of time series data
<code>DataFrame.reindex([index, columns, method, ...])</code>	Conform DataFrame to new index with optional filling logic, placing
<code>DataFrame.reindex_axis(labels[, axis, ...])</code>	Conform DataFrame to new index with optional filling logic, placing
<code>DataFrame.reindex_like(other[, method, ...])</code>	Reindex DataFrame to match indices of another DataFrame, optionally
<code>DataFrame.rename([index, columns, copy, inplace])</code>	Alter index and / or columns using input function or functions.
<code>DataFrame.reset_index([level, drop, ...])</code>	For DataFrame with multi-level index, return new DataFrame with
<code>DataFrame.select(crit[, axis])</code>	Return data corresponding to axis labels matching criteria
<code>DataFrame.set_index(keys[, drop, append, ...])</code>	Set the DataFrame index (row labels) using one or more existing
<code>DataFrame.tail([n])</code>	Returns last n rows of DataFrame
<code>DataFrame.take(indices[, axis])</code>	Analogous to ndarray.take, return DataFrame corresponding to requested
<code>DataFrame.truncate([before, after, copy])</code>	Function truncate a sorted DataFrame / Series before and/or after

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.align

`DataFrame.align` (*other*, *join*='outer', *axis*=None, *level*=None, *copy*=True, *fill_value*=nan, *method*=None, *limit*=None, *fill_axis*=0)

Align two DataFrame object on their index and columns with the specified join method for each axis Index

Parameters **other** : DataFrame or Series

join : { 'outer', 'inner', 'left', 'right' }, default 'outer'

axis : {0, 1, None}, default None

Align on index (0), columns (1), or both (None)

level : int or name

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, 1}, default 0

Filling axis, method and limit

Returns (**left**, **right**) : (DataFrame, type of other)

Aligned objects

pandas.DataFrame.drop

`DataFrame.drop` (*labels*, *axis*=0, *level*=None)

Return new object with labels in requested axis removed

Parameters **labels** : array-like

axis : int

level : int or name, default None

For MultiIndex

Returns **dropped** : type of caller

pandas.DataFrame.drop_duplicates

`DataFrame.drop_duplicates` (*cols*=None, *take_last*=False, *inplace*=False)

Return DataFrame with duplicate rows removed, optionally only considering certain columns

Parameters **cols** : column label or sequence of labels, optional

Only consider certain columns for identifying duplicates, by default use all of the columns

take_last : boolean, default False

Take the last observed row in a row. Defaults to the first row

inplace : boolean, default False

Whether to drop duplicates in place or to return a copy

Returns **deduplicated** : DataFrame

pandas.DataFrame.duplicated

DataFrame.**duplicated** (*cols=None, take_last=False*)

Return boolean Series denoting duplicate rows, optionally only considering certain columns

Parameters **cols** : column label or sequence of labels, optional

Only consider certain columns for identifying duplicates, by default use all of the columns

take_last : boolean, default False

Take the last observed row in a row. Defaults to the first row

Returns **duplicated** : Series

pandas.DataFrame.filter

DataFrame.**filter** (*items=None, like=None, regex=None*)

Restrict frame's columns to set of items or wildcard

Parameters **items** : list-like

List of columns to restrict to (must not all be present)

like : string

Keep columns where "arg in col == True"

regex : string (regular expression)

Keep columns with re.search(regex, col) == True

Returns **DataFrame with filtered columns** :

Notes

Arguments are mutually exclusive, but this is not checked for

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.last('10D') -> First 10 days

pandas.DataFrame.head

`DataFrame.head(n=5)`
Returns first n rows of DataFrame

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, 1}

0 for row-wise, 1 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

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, 1}

0 for row-wise, 1 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

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.reindex

`DataFrame.reindex(index=None, columns=None, method=None, level=None, fill_value=nan, limit=None, copy=True)`

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 `index` : array-like, optional

New labels / index to conform to. Preferably an Index object to avoid duplicating data

columns : array-like, optional

Same usage as index argument

method : { 'backfill', 'bfill', 'pad', 'ffill', None }, default None

Method to use for filling holes in reindexed DataFrame pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation 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 size gap to forward or backward fill

Returns **reindexed** : same type as calling instance

Examples

```
>>> df.reindex(index=[date1, date2, date3], columns=['A', 'B', 'C'])
```

pandas.DataFrame.reindex_axis

`DataFrame.reindex_axis(labels, axis=0, method=None, level=None, copy=True, limit=None, fill_value=nan)`

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 **index** : array-like, optional

New labels / index to conform to. Preferably an Index object to avoid duplicating data

axis : {0, 1}

0 -> index (rows) 1 -> columns

method : { 'backfill', 'bfill', 'pad', 'ffill', None }, default None

Method to use for filling holes in reindexed DataFrame pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation 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 size gap to forward or backward fill

Returns **reindexed** : same type as calling instance

See Also:

`DataFrame.reindex`, `DataFrame.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*)

Reindex DataFrame to match indices of another DataFrame, optionally with filling logic

Parameters **other** : DataFrame

method : string or None

copy : boolean, default True

limit : int, default None

Maximum size gap to forward or backward fill

Returns **reindexed** : DataFrame

Notes

Like calling `s.reindex(index=other.index, columns=other.columns, method=...)`

pandas.DataFrame.rename

`DataFrame.rename` (*index=None*, *columns=None*, *copy=True*, *inplace=False*)

Alter index and / or columns using 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.

Parameters **index** : dict-like or function, optional

Transformation to apply to index values

columns : dict-like or function, optional

Transformation to apply to column values

copy : boolean, default True

Also copy underlying data

inplace : boolean, default False

Whether to return a new DataFrame. If True then value of copy is ignored.

Returns **renamed** : DataFrame (new object)

See Also:

`Series.rename`

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

pandas.DataFrame.select

`DataFrame.select` (*crit, axis=0*)

Return data corresponding to axis labels matching criteria

Parameters **crit** : function

To be called on each index (label). Should return True or False

axis : int

Returns **selection** : type of caller

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

```
indexed_df = df.set_index(['A', 'B']) indexed_df2 = df.set_index(['A', [0, 1, 2, 0, 1, 2]]) indexed_df3 =
df.set_index([[0, 1, 2, 0, 1, 2]])
```

pandas.DataFrame.tail

DataFrame.**tail** (*n=5*)

Returns last n rows of DataFrame

pandas.DataFrame.take

DataFrame.**take** (*indices, axis=0*)

Analogous to ndarray.take, return DataFrame corresponding to requested indices along an axis

Parameters **indices** : list / array of ints

axis : {0, 1}

Returns **taken** : DataFrame

pandas.DataFrame.truncate

DataFrame.**truncate** (*before=None, after=None, copy=True*)

Function truncate a sorted DataFrame / Series before and/or after some particular dates.

Parameters **before** : date

Truncate before date

after : date

Truncate after date

Returns **truncated** : type of caller

21.3.8 Missing data handling

DataFrame. dropna (<i>[axis, how, thresh, subset]</i>)	Return object with labels on given axis omitted where alternately any
DataFrame. fillna (<i>[value, method, axis, ...]</i>)	Fill NA/NaN values using the specified method

pandas.DataFrame.dropna

DataFrame.**dropna** (*axis=0, how='any', thresh=None, subset=None*)

Return object with labels on given axis omitted where alternately any or all of the data are missing

Parameters **axis** : {0, 1}, 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

Returns **dropped** : DataFrame

pandas.DataFrame.fillna

DataFrame.**fillna** (*value=None, method=None, axis=0, inplace=False, limit=None*)

Fill NA/NaN values using the specified method

Parameters **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

value : scalar or dict

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)

axis : { 0, 1 }, default 0

0: fill column-by-column
1: fill row-by-row

inplace : boolean, default False

If True, fill the DataFrame in place. Note: this will modify any other views on this DataFrame, like if you took a no-copy slice of an existing DataFrame, for example a column in a DataFrame. Returns a reference to the filled object, which is self if inplace=True

limit : int, default None

Maximum size gap to forward or backward fill

Returns **filled** : DataFrame

See Also:

`reindex`, `asfreq`

21.3.9 Reshaping, sorting, transposing

DataFrame.delevel(*args, **kwargs)	
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([columns, column, axis, ...])	Sort DataFrame either by labels (along either axis) or by the values in
Continued on next page	

Table 21.30 – continued from previous page

<code>DataFrame.sort_index([axis, by, ascending, ...])</code>	Sort DataFrame either by labels (along either axis) or by the values in
<code>DataFrame.sortlevel([level, axis, ...])</code>	Sort multilevel index by chosen axis and primary level.
<code>DataFrame.swaplevel(i, j[, axis])</code>	Swap levels i and j in a MultiIndex on a particular axis
<code>DataFrame.stack([level, dropna])</code>	Pivot a level of the (possibly hierarchical) column labels, returning a
<code>DataFrame.unstack([level])</code>	Pivot a level of the (necessarily hierarchical) index labels, returning
<code>DataFrame.T</code>	Returns a DataFrame with the rows/columns switched. If the DataFrame is
<code>DataFrame.to_panel()</code>	Transform long (stacked) format (DataFrame) into wide (3D, Panel)
<code>DataFrame.transpose()</code>	Returns a DataFrame with the rows/columns switched. If the DataFrame is

pandas.DataFrame.delevel

`DataFrame.delevel (*args, **kwargs)`

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 and return either DataFrame or Panel, depending on whether you request a single value column (DataFrame) or all columns (Panel)

Parameters **index** : string or object

Column name to use to make new frame’s 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

Returns **pivoted** : DataFrame

If no values column specified, will have hierarchically indexed columns

Notes

For finer-tuned control, see hierarchical indexing documentation along with the related stack/unstack methods

Examples

```
>>> 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('foo', 'bar', 'baz')
   A  B  C
one 1  2  3
two 4  5  6
```

```
>>> df.pivot('foo', 'bar')['baz']
      A  B  C
one   1  2  3
two   4  5  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 representing new level order. :

(reference level by number not by key)

axis: where to reorder levels :

Returns type of caller (new object) :

pandas.DataFrame.sort

DataFrame.**sort** (*columns=None, column=None, axis=0, ascending=True, inplace=False*)

Sort DataFrame either by labels (along either axis) or by the values in column(s)

Parameters **columns** : object

Column name(s) in frame. Accepts a column name or a list or tuple for a nested sort.

ascending : boolean or list, default True

Sort ascending vs. descending. Specify list for multiple sort orders

axis : {0, 1}

Sort index/rows versus columns

inplace : boolean, default False

Sort the DataFrame without creating a new instance

Returns **sorted** : DataFrame

Examples

```
>>> result = df.sort(['A', 'B'], ascending=[1, 0])
```

pandas.DataFrame.sort_index

DataFrame.**sort_index** (*axis=0, by=None, ascending=True, inplace=False*)

Sort DataFrame either by labels (along either axis) or by the values in a column

Parameters **axis** : {0, 1}

Sort index/rows versus columns

by : object

Column name(s) in frame. Accepts a column name or a list or tuple for a nested sort.

ascending : boolean or list, default True

Sort ascending vs. descending. Specify list for multiple sort orders

inplace : boolean, default False

Sort the DataFrame without creating a new instance

Returns **sorted** : DataFrame

Examples

```
>>> result = df.sort_index(by=['A', 'B'], ascending=[1, 0])
```

pandas.DataFrame.sortlevel

DataFrame.**sortlevel** (*level=0, axis=0, ascending=True, inplace=False*)

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, 1}

ascending : bool, default True

inplace : boolean, default False

Sort the DataFrame without creating a new instance

Returns **sorted** : DataFrame

pandas.DataFrame.swaplevel

DataFrame.**swaplevel** (*i, j, axis=0*)

Swap levels *i* and *j* in a MultiIndex on a particular axis

Returns **swapped** : type of caller (new 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.

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.unstack

DataFrame.**unstack** (*level=-1*)

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)

Parameters **level** : int, string, or list of these, default last level

Level(s) of index to unstack, can pass level name

Returns **unstacked** : DataFrame or Series

Examples

```
>>> s
one a    1.
   b    2.
two a    3.
   b    4.

>>> s.unstack(level=-1)
      a  b
one  1.  2.
two  3.  4.

>>> df = s.unstack(level=0)
>>> df
      one two
a    1.  2.
b    3.  4.

>>> df.unstack()
one a    1.
   b    3.
two a    2.
   b    4.
```

pandas.DataFrame.T

DataFrame.**T**

Returns a DataFrame with the rows/columns switched. If the DataFrame is homogeneously-typed, the data is not copied

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.transpose**`DataFrame.transpose()`

Returns a DataFrame with the rows/columns switched. If the DataFrame is homogeneously-typed, the data is not copied

21.3.10 Combining / joining / merging

<code>DataFrame.append(other[, ignore_index, ...])</code>	Append columns of other to end of this frame's columns and index, returning a
<code>DataFrame.join(other[, on, how, lsuffix, ...])</code>	Join columns with other DataFrame either on index or on a key
<code>DataFrame.merge(right[, how, on, left_on, ...])</code>	Merge DataFrame objects by performing a database-style join operation by
<code>DataFrame.replace(to_replace[, value, ...])</code>	Replace values given in 'to_replace' with 'value' or using 'method'
<code>DataFrame.update(other[, join, overwrite, ...])</code>	Modify DataFrame in place using non-NA values from passed

pandas.DataFrame.append`DataFrame.append(other, ignore_index=False, verify_integrity=False)`

Append columns of other to end of this frame's columns and index, returning a new object. Columns not in this frame are added as new columns.

Parameters `other` : DataFrame or list of Series/dict-like objects`ignore_index` : boolean, default False

If True do not use the index labels. Useful for gluing together record arrays

`verify_integrity` : boolean, default False

If True, raise Exception on creating index with duplicates

Returns `appended` : DataFrame**Notes**

If a list of dict 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

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) to use for joining, otherwise join 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' }

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

sort : boolean, default False

Order result DataFrame lexicographically by the join key. If False, preserves the index order of the calling (left) DataFrame

Returns **joined** : DataFrame

Notes

on, lsuffix, and rsuffix options are not supported when passing a list of DataFrame objects

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)`

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 (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)

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

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

Returns **merged** : DataFrame

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

>>> merge(A, B, left_on='lkey', right_on='rkey', how='outer')
   lkey  value_x  rkey  value_y
0  bar     2     bar     6
1  bar     2     bar     8
2  baz     3    NaN    NaN
3  foo     1     foo     5
4  foo     4     foo     5
5  NaN    NaN    qux     7
```

pandas.DataFrame.replace

`DataFrame.replace(to_replace, value=None, method='pad', axis=0, inplace=False, limit=None)`

Replace values given in 'to_replace' with 'value' or using 'method'

Parameters **value** : scalar or dict, 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)

method : {'backfill', 'bfill', 'pad', 'ffill', None}, default 'pad'

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}, default 0

0: fill column-by-column 1: fill row-by-row

inplace : boolean, default False

If True, fill the DataFrame in place. Note: this will modify any other views on this DataFrame, like if you took a no-copy slice of an existing DataFrame, for example a column in a DataFrame. Returns a reference to the filled object, which is self if inplace=True

limit : int, default None

Maximum size gap to forward or backward fill

Returns **filled** : DataFrame

See Also:

`reindex`, `asfreq`

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', 'right', 'outer', 'inner' }, 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 : bool

If True, will raise an error if the DataFrame and other both contain data in the same place.

21.3.11 Time series-related

<code>DataFrame.asfreq(freq[, method, how, normalize])</code>	Convert all TimeSeries inside to specified frequency using DateOffset
<code>DataFrame.shift([periods, freq])</code>	Shift the index of the DataFrame by desired number of periods with an
<code>DataFrame.first_valid_index()</code>	Return label for first non-NA/null value
<code>DataFrame.last_valid_index()</code>	Return label for last non-NA/null value
<code>DataFrame.resample(rule[, how, axis, ...])</code>	Convenience method for frequency conversion and resampling of regular t
<code>DataFrame.to_period([freq, axis, copy])</code>	Convert DataFrame from DatetimeIndex to PeriodIndex with desired
<code>DataFrame.to_timestamp([freq, how, axis, copy])</code>	Cast to DatetimeIndex of timestamps, at <i>beginning</i> of period
<code>DataFrame.tz_convert(tz[, axis, copy])</code>	Convert TimeSeries to target time zone. If it is time zone naive, it
<code>DataFrame.tz_localize(tz[, axis, copy])</code>	Localize tz-naive TimeSeries to target time zone

pandas.DataFrame.asfreq

DataFrame.**asfreq** (*freq, method=None, how=None, normalize=False*)

Convert all TimeSeries inside to specified frequency using DateOffset objects. Optionally provide fill method to pad/backfill missing values.

Parameters **freq** : DateOffset object, or string

method : { 'backfill', 'bfill', 'pad', 'ffill', 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 methdo

how : { 'start', 'end' }, default end

For PeriodIndex only, see PeriodIndex.asfreq

normalize : bool, default False

Whether to reset output index to midnight

Returns **converted** : type of caller

pandas.DataFrame.shift

DataFrame.**shift** (*periods=1, freq=None, **kws*)

Shift the index of the DataFrame 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 datetools module or time rule (e.g. 'EOM')

Returns **shifted** : DataFrame

Notes

If freq is specified then the index values are shifted but the data if not realigned

pandas.DataFrame.first_valid_index

DataFrame.**first_valid_index**()

Return label for first non-NA/null value

pandas.DataFrame.last_valid_index

DataFrame.**last_valid_index**()

Return label for last non-NA/null value

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*)

Convenience method for frequency conversion and resampling of regular time-series data.

Parameters **rule** : the offset string or object representing target conversion

how : string, method for down- or re-sampling, default to 'mean' for downsampling

fill_method : string, fill_method for upsampling, default None

axis : int, optional, default 0

closed : { 'right', 'left' }, default None

Which side of bin interval is closed

label : { 'right', 'left' }, default None

Which bin edge label to label bucket with

convention : { 'start', 'end', 's', 'e' }

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

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, 1}, 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_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, 1} 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.tz_convert

DataFrame.**tz_convert** (*tz, axis=0, copy=True*)

Convert TimeSeries to target time zone. If it is time zone naive, it will be localized to the passed time zone.

Parameters **tz** : string or pytz.timezone object

copy : boolean, default True

Also make a copy of the underlying data

pandas.DataFrame.tz_localize

DataFrame.**tz_localize** (*tz, axis=0, copy=True*)

Localize tz-naive TimeSeries to target time zone

Parameters **tz** : string or pytz.timezone object

copy : boolean, default True

Also make a copy of the underlying data

21.3.12 Plotting

DataFrame. boxplot ([column, by, ax, ...])	Make a box plot from DataFrame column/columns optionally grouped
DataFrame. hist (data[, column, by, grid, ...])	Draw Histogram the DataFrame's series using matplotlib / pylab.
DataFrame. plot ([frame, x, y, subplots, ...])	Make line or bar plot of DataFrame's series with the index on the x-axis

pandas.DataFrame.boxplot

DataFrame.**boxplot** (*column=None, by=None, ax=None, fontsize=None, rot=0, grid=True, **kwargs*)

Make a box plot from DataFrame column/columns optionally grouped (stratified) by one or more columns

Parameters **data** : DataFrame

column : column names or list of names, or vector

Can be any valid input to groupby

by : string or sequence

Column in the DataFrame to group by

fontsize : int or string

Returns **ax** : matplotlib.axes.AxesSubplot

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*, ***kws*)

Draw Histogram the DataFrame's series using matplotlib / pylab.

Parameters *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 : bool, if True, the X axis will be shared amongst all subplots.

sharey : bool, if True, the Y axis will be shared amongst all subplots.

kws : other plotting keyword arguments

To be passed to hist function

pandas.DataFrame.plot

`DataFrame.plot` (*frame=None*, *x=None*, *y=None*, *subplots=False*, *sharex=True*, *sharey=False*, *use_index=True*, *figsize=None*, *grid=False*, *legend=True*, *rot=None*, *ax=None*, *style=None*, *title=None*, *xlim=None*, *ylim=None*, *logx=False*, *logy=False*, *xticks=None*, *yticks=None*, *kind='line'*, *sort_columns=False*, *fontsize=None*, *secondary_y=False*, ***kws*)

Make line or bar plot of DataFrame's series with the index on the x-axis using matplotlib / pylab.

Parameters *x* : label or position, default None

y : label or position, default None

Allows plotting of one column versus another

subplots : boolean, default False

Make separate subplots for each time series

sharex : boolean, default True

In case subplots=True, share x axis

sharey : boolean, default False

In case subplots=True, share y axis

use_index : boolean, default True

Use index as ticks for x axis

stacked : boolean, default False

If True, create stacked bar plot. Only valid for DataFrame input

sort_columns: boolean, default False :

Sort column names to determine plot ordering

title : string

Title to use for the plot

grid : boolean, default True

Axis grid lines

legend : boolean, default True

Place legend on axis subplots

ax : matplotlib axis object, default None

style : list or dict

matplotlib line style per column

kind : { 'line', 'bar', 'barh' }

bar : vertical bar plot barh : horizontal bar plot

logx : boolean, default False

For line plots, use log scaling on x axis

logy : boolean, default False

For line plots, use log scaling on y axis

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

secondary_y : boolean or sequence, default False

Whether to plot on the secondary y-axis If dict then can select which columns to plot on secondary y-axis

kws : keywords

Options to pass to matplotlib plotting method

Returns **ax_or_axes** : matplotlib.AxesSubplot or list of them

21.3.13 Serialization / IO / Conversion

<code>DataFrame.from_csv(path[, header, sep, ...])</code>	Read delimited file into DataFrame
<code>DataFrame.from_dict(data[, orient, dtype])</code>	Construct DataFrame from dict of array-like or dicts
<code>DataFrame.from_items(items[, columns, orient])</code>	Convert (key, value) pairs to DataFrame. The keys will be the axis
<code>DataFrame.from_records(data[, index, ...])</code>	Convert structured or record ndarray to DataFrame
<code>DataFrame.info([verbose, buf, max_cols])</code>	Concise summary of a DataFrame, used in <code>__repr__</code> when very large.
<code>DataFrame.load(path)</code>	
<code>DataFrame.save(path)</code>	
<code>DataFrame.to_csv(path_or_buf[, sep, na_rep, ...])</code>	Write DataFrame to a comma-separated values (csv) file
<code>DataFrame.to_dict([outtype])</code>	Convert DataFrame to dictionary.
<code>DataFrame.to_excel(excel_writer[, ...])</code>	Write DataFrame to a excel sheet
<code>DataFrame.to_html([buf, columns, col_space, ...])</code>	to_html-specific options
<code>DataFrame.to_records([index, convert_datetime64])</code>	Convert DataFrame to record array. Index will be put in the
<code>DataFrame.to_sparse([fill_value, kind])</code>	Convert to SparseDataFrame
<code>DataFrame.to_string([buf, columns, ...])</code>	Render a DataFrame to a console-friendly tabular output.

pandas.DataFrame.from_csv

classmethod `DataFrame.from_csv` (*path, header=0, sep=', ', index_col=0, parse_dates=True, encoding=None*)

Read delimited file into DataFrame

Parameters **path** : string file path or file handle / StringIO

header : int, default 0

Row to use at 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`

Returns **y** : DataFrame

Notes

Preferable to use `read_table` for most general purposes but `from_csv` makes for an easy roundtrip to and from file, especially with a DataFrame of time series data

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’.

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, optional

Must be passed in the

orient : { ‘columns’, ‘index’ }, 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’

Returns **frame** : DataFrame

pandas.DataFrame.from_records

classmethod **DataFrame.from_records** (*data, index=None, exclude=None, columns=None, coerce_float=False, nrow=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 named 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 to non-string, non-numeric objects (like decimal.Decimal) to floating point, useful for SQL result sets

Returns **df** : DataFrame

pandas.DataFrame.info

`DataFrame.info(verbose=True, buf=None, max_cols=None)`

Concise summary of a DataFrame, used in `__repr__` when very large.

Parameters **verbose** : boolean, default True

If False, don't print column count summary

buf : writable buffer, defaults to `sys.stdout`

max_cols : int, default None

Determines whether full summary or short summary is printed

pandas.DataFrame.load

classmethod `DataFrame.load(path)`

pandas.DataFrame.save

`DataFrame.save(path)`

pandas.DataFrame.to_csv

`DataFrame.to_csv(path_or_buf, sep=',', na_rep='', float_format=None, cols=None, header=True, index=True, index_label=None, mode='w', nanRep=None, encoding=None, quoting=None, line_terminator='n')`

Write DataFrame to a comma-separated values (csv) file

Parameters **path_or_buf** : string or file handle / StringIO

File path

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

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, 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

nanRep : deprecated, use *na_rep* *mode* : Python write mode, default 'w' *encoding* : string, optional

a string representing the encoding to use if the contents are non-ascii, for python versions prior to 3

line_terminator: string, default ‘

,

The newline character or character sequence to use in the output file

quoting [optional constant from csv module] defaults to csv.QUOTE_MINIMAL

pandas.DataFrame.to_dict

DataFrame.**to_dict** (outtype='dict')

Convert DataFrame to dictionary.

Parameters **outtype** : str {'dict', 'list', 'series'}

Determines the type of the values of the dictionary. The default *dict* is a nested dictionary {column -> {index -> value}}. *list* returns {column -> list(values)}. *series* returns {column -> Series(values)}. Abbreviations are allowed.

Returns **result** : dict like {column -> {index -> value}}

pandas.DataFrame.to_excel

DataFrame.**to_excel** (excel_writer, sheet_name='sheet1', na_rep='', float_format=None, cols=None, header=True, index=True, index_label=None, startrow=0, startcol=0)

Write DataFrame to a 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

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

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 = ExcelWriter('output.xlsx') >>> df1.to_excel(writer,'sheet1') >>> df2.to_excel(writer,'sheet2') >>> writer.save()

pandas.DataFrame.to_html

`DataFrame.to_html` (*buf=None, columns=None, col_space=None, colSpace=None, header=True, index=True, na_rep='NaN', formatters=None, float_format=None, sparsify=None, index_names=True, justify=None, force_unicode=None, bold_rows=True, classes=None*)

to_html-specific options **bold_rows** : boolean, default True

Make the row labels bold in the output

Render a DataFrame to an html table.

Parameters **frame** : DataFrame

object to render

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, if the result is a string , it 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

sparsify : bool, optional

Set to False for a DataFrame with a hierarchical index to print every multiindex key at each row, default True

justify : { 'left', 'right' }, default None

Left or right-justify the column labels. If None uses the option from the print configuration (controlled by `set_printoptions`), 'right' out of the box.

index_names : bool, optional

Prints the names of the indexes, default True

force_unicode : bool, default False

Always return a unicode result. Deprecated in v0.10.0 as string formatting is now rendered to unicode by default.

Returns **formatted** : string (or unicode, depending on data and options)

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_string

`DataFrame.to_string(buf=None, columns=None, col_space=None, colSpace=None, header=True, index=True, na_rep='NaN', formatters=None, float_format=None, sparsify=None, nanRep=None, index_names=True, justify=None, force_unicode=None, line_width=None)`

Render a DataFrame to a console-friendly tabular output.

Parameters **frame** : DataFrame

object to render

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, if the result is a string, it 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

sparsify : bool, optional

Set to False for a DataFrame with a hierarchical index to print every multiindex key at each row, default True

justify : { 'left', 'right' }, default None

Left or right-justify the column labels. If None uses the option from the print configuration (controlled by set_printoptions), 'right' out of the box.

index_names : bool, optional

Prints the names of the indexes, default True

force_unicode : bool, default False

Always return a unicode result. Deprecated in v0.10.0 as string formatting is now rendered to unicode by default.

Returns **formatted** : string (or unicode, depending on data and options)

21.4 Panel

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