

Shh

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- ▶ slow.

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- ▶ A tight loop like below runs 10 to 100 (or more) times slower than C or java.

```
1 total = 0
2 for i in range(1000):
3     for j in range(1000):
4         total += i           # how many times this statement runs?
5
6 print total
7 # 499950000000
```

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```

- ▶ Although you can re-write the above and make it run almost, but not quite, as fast.

```
1 print sum([1000 * i for i in xrange(1000)])
2 # 499950000000
```

Why is Python slow

- ▶ Interpreted, not compiled.
- ▶ Almost no automatic optimization.
- ▶ High-level, versatile programming constructs tend to be larger, more complicated, and slower.
- ▶ A simple piece of code may have a huge performance implication. e.g. `range(1000)` creates and returns a 1000-element list every time it is called.

Why Python is *not* slow

- ▶ Faster programming constructs (e.g., `xrange()` vs. `range()`, comprehension vs. `for` loop)
- ▶ Modules written in C (e.g., `cPickle` vs. `pickle`)
- ▶ NumPy and SciPy for scientific computation.
- ▶ Python/C API (<http://docs.python.org/2/c-api>)
- ▶ Cython (<http://cython.org>) takes Python code and generates efficient C code.
- ▶ PyPy Just-In-Time (JIT) compiler. (<http://pypy.org>)

Implementations

- ▶ The reference implementation (in C) is called CPython, which Guido van Rossum authored, starting in 1989



- ▶ Guido is also known as Benevolent Dictator For Life (BDFL. See <http://tinyurl.com/5pg99q>)

Implementations (cont.)

- ▶ There are other implementations as well.
- ▶ IronPython (.NET CLR <http://ironpython.net>)
- ▶ Jython (Java VM <http://www.jython.org/>)
- ▶ pyjs (JavaScript <http://pyjs.org/>)
- ▶ Skulpt (web browser <http://www.skulpt.org>)
- ▶ CodeSkulptor (web browser <http://www.codeskulptor.org>)

Python 2 or 3?

- ▶ Python 3.0 (2008) broke backward compatibility.
 - ▷ Can't use 2 modules in 3 and vice versa.
- ▶ "2 is legacy, 3 is the present and future."
(<http://tinyurl.com/omgx9tk>)
 - ▷ 3.4 is expected in early 2014.
 - ▷ 2.0 was released in 2000.
 - ▷ 2.7 (2010) will be the last 2.x branch.
- ▶ Many of 3's major futures have been backported to 2.6 and 2.7, but not all.
- ▶ Other implementations in general still lack support for Python 3.

Editors and IDE's

- ▶ EMACS comes with `python.el` (24.2 and up) and `python-mode.el` (newer). See (<http://tinyurl.com/y67za8d>)
- ▶ VIM configuration links at <http://tinyurl.com/apx3avc>
- ▶ IDLE (<http://tinyurl.com/c7j2k3x>)
- ▶ (Semi-) commercial editors, e.g., Komodo, PyCharm, Sublime, ...
- ▶ IPython (<http://ipython.org>) and IPython notebook.
- ▶ And many others. See <http://tinyurl.com/leqyjw7>.

IPython and IPython Notebook

- ▶ A comprehensive environment for interactive and exploratory computing.
- ▶ A “new killer app” back in 2011. 1.0 released in 2013. Stable version 2.0 in April 2014.
- ▶ One of the six core packages of SciPy stack.



NumPy

Base N-dimensional
array package



SciPy library

Fundamental library
for scientific
computing



Matplotlib

Comprehensive 2D
Plotting

IP[y]:
IPython

IPython

Enhanced
Interactive Console



Sympy

Symbolic
mathematics



pandas

Data structures &
analysis

PyPI and pip

- ▶ Python Package Index (PyPI) is the repository of software for Python at <http://pypi.python.org/pypi>.
- ▶ As of a day in Jan 2014, it has about 38,800 packages.
- ▶ Python Indexing Project (pip) (<http://www.pip-installer.org>) is the standard tool for *installing* packages (or modules) from PyPI.
- ▶ Some examples of using pip. At the shell prompt:
 - 1 \$ pip
 - 2 \$ pip list
 - 3 \$ pip install SomePackage
 - 4 \$ pip install --user SomePackage
 - 5 \$ pip install --upgrade SomePackage
 - 6 \$ pip uninstall
- ▶ Once a package is successfully installed, then you can `import` the module within your script.

Installing SciPy Stack

- ▶ It *is* possible to install all the packages one by one (and all the dependencies). It *could* turn out to be tricky.
- ▶ An alternative is to download and install free or commercial distributions. Some names are: Anaconda, Enthought Canopy, Python(x,y), WinPython, ...
- ▶ See <http://www.scipy.org/install.html>.
- ▶ Check out Wakari.IO (<https://www.wakari.io>) for playing with SciPy stack on the cloud, without local installation.

Quiz

- ▶ Choose the best one that fits each description:
 1. Standard module supporting object (de-)serialization, which is written in C.
 2. Compiler that turns Python source into efficient C code.
 3. Software tool for installing / managing packages.
 4. Benevolent Dictator For Life.
 5. Provides a rich architecture for interactive (scientific) computing. Version 1.0 was released in 2013.

comprehension cPickle CPython Cython Guido van Rossum IPython Niklaus Wirth Pickle pip Sublime xrange() Yukihiro Matsumoto

NumPy

- ▶ Provides the `ndarray` object.
- ▶ `ndarray` implements an efficient homogeneous multidimensional array.
- ▶ Element-wise and vectorized matrix operations are provided.
- ▶ Lots of modules use / built on NumPy.
- ▶ Documentation at <http://docs.scipy.org/doc>.

SciPy

- ▶ Collection of mathematical algorithms and utility functions built on NumPy.
- ▶ Organized into subpackages: cluster, constants, fftpack, integrate, interpolate, io, linalg (linear algebra), ndimage (N-dimensional image processing), odr (orthogonal distance regression), optimize, signal (signal processing), sparse (sparse matrices), spatial, special (functions), stats, weave (C/C++ integration)
- ▶ Documentation at <http://docs.scipy.org/doc>.

Matplotlib

- ▶ Provides comprehensive 2D and simple 3D plotting.
- ▶ Simple plot, Subplots (multiple axes), Histograms, Path, Simple 3D plot (surface, wireframe, scatter, bar), Streamlines (of a vector field), Ellipses, Bar charts, Pie charts, Filled (curves and polygons), Financial charts, Polar plots, . . . , including TeX expressions support (internal or external) and Sketch plots (XKCD style)
- ▶ Screenshots are (with source code) at <http://matplotlib.org/users/screenshots.html>.
- ▶ Documentation at <http://matplotlib.org/contents.html>.

pandas

- ▶ “Python Data Analysis Library” (Release 0.12 as of 2013).
- ▶ Series, DataFrame , and Panel objects
- ▶ reading/writing data to and from: CSV, text file, Excel, SQL db, and fast HDF5 (scientific data file formats and libraries developed at NCSA), JSON, HTML Table, STATA.
- ▶ Labeling columns, iteration, Hierarchical Indexing, Transformation, Selection, Missing Data, Merge, Grouping (or split-apply-combine), Reshaping (or pivoting), Time Series, I/O tools, R interface (via rpy2).
- ▶ Documentation at <http://pandas.pydata.org>.
- ▶ Wes McKinney, “10-minute tour of pandas” (<http://vimeo.com/59324550>) or workshop (<http://www.youtube.com/watch?v=MxRMXhjXZos>)

Learning Resources

► Websites:

- ▷ Main website <http://www.python.org> and SciPy site <http://scipy.org>.
- ▷ Official Python Tutorial <http://docs.python.org/2/tutorial/index.html>.
- ▷ Google's Python Class (2 day class materials including video and exercises) <https://developers.google.com/edu/python>.

Learning Resources

- ▶ Three advanced level tutorial videos:

- ▷ technical (old)

- http://www.youtube.com/watch?v=E_kZDvwofHY.

- ▷ idioms (new)

- <http://www.youtube.com/watch?v=0SGv2VnC0go>.

- ▷ functional style

- <http://www.youtube.com/watch?v=Ta1bAMOMFOI>.

- ▷ 2000+ videos at <http://pyvideo.org>.

Learning Resources

► Books:

- ▷ Mark Lutz (2013) *Learning Python* 5th ed (1,400 plus pages).
- ▷ “6 Free E-Books” mentioned on <http://tinyurl.com/m2y9rad>.
- ▷ Matthew Russell (2013) “Mining the Social Web” 2nd edition is out. Example code files (in IPython Notebook file .ipynb format) are at <http://tinyurl.com/n3txeu5>.

Learning Resources

- ▶ Any cool computer language has:
 - ▷ Zen (read and memorize!)
<http://www.python.org/dev/peps/pep-0020/>
 - ▷ Koans (unit testing) <http://tinyurl.com/7n6yfvn>
 - ▷ Challenges (old) <http://www.pythonchallenge.com/>
- ▶ Need more challenges?
 - ▷ Try the Project Euler <http://projecteuler.net>

Learning Resources

- ▶ MOOC's using Python extensively:
 - ▷ "Introduction to Computer Science and Programming Using Python" (edX, <http://tinyurl.com/o3pbmc3>)
 - ▷ "Introduction to Interactive Programming in Python" (Coursera, <http://tinyurl.com/c95qh2q>)
 - ▷ "Coding the Matrix: Linear Algebra through Computer Science Applications" (Coursera, <http://tinyurl.com/awkbdho>)

Learning Resources

- ▶ Twitter:

- ▷ "teaching python 140 character at a time":
<http://twitter.com/raymondh>

- ▶ Gallery

- ▷ IPython Notebook gallery (including social data)
<http://tinyurl.com/c5tj9xh>