LONI Python tutorial

HPC@LSU

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Outline

- **Introduction**
  Why python?
- **Installation: Know your python setup**
  Setting up python and modules
- **Python language reference**
  Programming in python
- **Modules: Basic**
  A powerful aspect of python programming: Sys, Os
- **Modules: Advanced**
  A look at some advanced modules: Numpy, Scipy, Ipython, mpi4py

Goals

- **Understand its advantages and disadvantages**
  Especially if you are primarily a Fortran/C programmer
- **Understand how to set up modules you need**
  Don’t come asking for “Somepy” to be installed
- **Learn python programming basics**
  Stop using Fortran/C calls in python
- **Learn to take advantage of Modules**
  Learn to find useful tools which do more than just display colored text

Introduction

Python is a dynamic programming language : executes at runtime many common behaviors that other languages might perform during compilation.

Why would you use python?

- Open source code and libraries;
- Plenty of useful modules to satisfy varying tasks;
- Faster to code in, shorter development time;
- Portable across various platforms.

Why you would not use python?

- Slower at runtime;
- Modules can be taxing on memory;
- Module objects are harder to dig into.

Installation

Know what version of you have/want?
Current production versions are Python 2.7.3 and Python 3.3.0.

Python 3.3.0 (September 29, 2012)
Python 3.2.3 (April 10, 2012)
Python 3.1.5 (April 10, 2012)
Python 3.0.1 (February 13, 2009)
Python 2.7.3 (April 10, 2012)
Python 2.6.8 (April 10, 2012)
Python 2.5.6 (May 26, 2011)
Python 2.4.6 (December 19, 2008)
Python 2.3.7 (March 11, 2008)
Python 2.2.3 (May 30, 2003)
Python 2.1.3 (April 8, 2002)
Python 2.0.1 (June 2001)

Python on LONI and HPC

Python on Queenbee: 2.7.3 *Recommended*

$soft add +python-2.7.3-gcc-4.3.2

or add the key to your ~/.soft file

$ vi ~/.soft

+gcc-4.3.2

+python-2.7.3-gcc-4.3.2

@default

Installation

Get Python

$ wget http://www.python.org/ftp/python/2.7.3/Python-2.7.3.tar.bz2

$ tar -jxvf Python-2.7.3.tar.bz2

$ cd Python-2.7.3

Your usual make and install

$ ./configure --prefix=$HOME/python --exec-prefix=$HOME/python

$ make

$ make install

If you choose one compiler(gcc or Intel), stick to it for building all your modules

Installation: Modules

You can add modules locally/globally depending on sudo rights

```
$ wget http://sourceforge.net/projects/numpy/files/NumPy/1.6.2/numpy-1.6.2.tar.gz/download
$ wget http://sourceforge.net/projects/scipy/files/scipy/0.11.0/scipy-0.11.0.tar.gz/download

$ tar -zxvf numpy-1.6.2.tar.gz
$ tar -zxvf scipy-0.11.0.tar.gz

$ cd numpy-1.6.2
$ $HOME/python/bin/python setup.py config build --fcompiler=gnu95 install

$export BLAS=/usr/local/packages/lapack/3.4/lib/libblas.a
$export LAPACK=/usr/local/packages/lapack/3.4/lib/liblapack.a

$cd scipy-0.11.0
$ $HOME/python/bin/python setup.py config build --fcompiler=gnu95 install
```

Alternate Installation

Python modules: You can locally add modules

Most Python tools can be installed by just

```
$python setup.py config build install
```

Use home/user build for local install

```
$python setup.py config –prefix= --exec-prefix=
                                --user=
                                --home=
```

Alternate Installation

Python modules: Lets setup a couple !

Test your installation !

Running python

Interactive python shell

```
[bthakur@qb3 ]$ python
Python 2.7.3 (default, Jun 17 2012, 16:26:01)
[GCC 4.3.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

As a script

```
[bthakur@qb3 ]$ python -c 'import sys;  print sys.version'
[bthakur@qb3 ]$ python script.py
```

For the adventurous: Try ipython

Python: Data Structures

Standard python data types:

Numbers :	integers(normal, long), float(C- doubles), hexadecimal, binary, octal, complex
String :	collection of characters
Tuple :	ordered collection of arbitrary immutable objects
List :	ordered collection of arbitrary mutable objects
Dictionary :	unordered mutable collection of objects
Others:	fractions, sets

http://docs.python.org/2/library/stdtypes.html

- Note: python 2.6 vs python 3.0 important differences. 3.0 only has one integer type which supports unlimited precision
- type(x) can be used to check the type of a variable

Basic python: Numbers

Integers and floats:

```
>>> a=3.142
>>> int(a), float(int(a))
(3, 3.0)
```

Hex, bin oct:

```
>>> print hex(64), oct(64), bin(64)
0x400 02000 0b1000000
```

Operations:

Basic arithmetic :

x+y, x*y, x/y , x//y, x**y, x%y

Comparison(normal, chained) :

x<y , x<y<z

Bitwise operations :

x^2, x<<2 , x|1 , x&1

Math module:

```
>>> import math
>>> math.sqrt(144)
12
```

Random module:

```
>>> import random
>>> random.random()
>>> random.randint(1, 10)
>>> random.choice( [ 'a', 'b' ,'c' ] )
```

Sets:

```
>>> x= set('abc'); print x
set(['a', 'c', 'b'])
```

x - y, x | y, x & y

Basic python: Numbers

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Bitwise operations :

x<<2 , x|1 , x&1

Math module:

```
>>> import math
>>> math.sqrt(144), math.factorial(5)
(12.0, 120)
```

Random module:

```
>>> import random
>>> random.random()
>>> random.randint(1, 10)
>>> random.choice( [ 'a', 'b' ,'c' ] )
```

Sets:

```
>>> x= set('abc'); print x
set(['a', 'c', 'b'])
```

x - y, x | y, x & y

Basic python: Strings

Python strings:

```
>>> str = 'Hello World!';  print str
Hello World!
```

Indexing and slicing:

```
>>> print str[0:4], str[6:11]
Hell World
```

Repetition and concatenation:

```
>>> n=2;  print str*n
Hello World!Hello World!

>>> print str + ', ' + 'Good Morning'
Hello World!, Good Morning
```

Python strings:

```
>>> len(str)
26

>>> str=str.replace( 'Morn', 'Even' );
>>> print str
Hello World!, Good Evening

>>> str.find('o');
>>> str.count('l')
>>> str.upper()
```

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>>> print str
Hello World!, Good Evening

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>>> str.count('l')
>>> str.upper()
```

Python strings are immutable: New copies are generated when using replace

Basic python: Strings

Example:

```
>>> import os
>>> a=os.uname()
>>> b=str(os.uname())
>>> b.strip('(')
>>> b[0:2]='try'
TypeError

>>> c=list(os.uname)
>>> type(c)
<type 'list'>

>>>c[0]="*nix"
```

Python strings:

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>>> print str
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>>> b=str(os.uname())
>>> b.strip('(')
>>> b[0:2]='try'
TypeError

>>> c=list(os.uname)
>>> type(c)
<type 'list'>

>>>c[0]="*nix"
```

Example:

```
>>> a='abc'
>>> b='uvw'
>>> c=[ (m+n) for m in a for n in b ]
>>> d=''
>>> for n in c:
>>>     d=d+str(n)
>>> print d
'auavawbubvbwcucvcw'
```

Basic python: Lists

Python lists:

- Ordered collection of arbitrary objects
- Accessed by offset
- Variable length, heterogeneous and nestable
- Mutable sequences
- Array of object references

Examples:

Matrix:

```
>>> M= [[ 1, 2, 3 ],  [ 4, 5, 6 ], [ 7, 8, 9 ]]
>>> M[0]; M[0][1]
([1, 2, 3], 2)
```

Random objects:

```
>>> L = [ 307, 'Frey',  '80900' ]; L[1]
'Frey Computing'
```

Building lists:

```
>>> a = [ n for n in range(10) ];
>>> b = [ [m,n] for m in a for n in a ]
>>> b = ( [m,n] for m in a for n in a )
```

Basic python: Lists

Concatenate, repeat:

L1 + L2

L1 * 2

Iteration, membership:

for x in L: print(x)

Growing, shrinking:

L.append(4), L.insert(i,x), L.extend([3,4])

L.pop() L.remove(2) del L[i]; del L[i : j]

Search, count, sort, reverse:

L.index(), L.count(x), L.sort(), L.reverse()

Nesting:

```
>>> M= [[ 1, 2, 3 ],  [ 4, 5, 6 ], [ 7, 8, 9 ]]
>>> print M[1]; print M[1][2]
[ 4, 5, 6 ]
 6
```

List comprehension:

```
>>> col2= [ row[1] for row in M ];
>>> diag= [ M[ i ][ i ]  for i in [ 0, 1, 2 ] ]
[ 1, 5, 9 ]
```

Generators and maps:

```
>>> G= (sum(row) for row in M)
>>> next(G), next(G), next(G)
(6, 15, 24)
>>>list(map(sum, M))
[6, 15, 24]
```

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```

List comprehension:

```
>>> col2= [ row[1] for row in M ];
>>> diag= [ M[ i ][ i ]  for i in [ 0, 1, 2 ] ]
[ 1, 5, 9 ]

>>> squares= [ x**2 for x in range(10) ]
[0, 1, 4, 9, 19, 25, 36, 49, 64, 81]

>>> squares= ( x**2 for x in range(10) )
```

It's a generator !

Basic python: Lists

Concatenate, repeat:

L1 + L2

L1 * 2

Iteration, membership:

for x in L: print(x)

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>>> M= [[ 1, 2, 3 ],  [ 4, 5, 6 ], [ 7, 8, 9 ]]
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Generators and maps:

```
>>> G= (sum(row) for row in M)
>>> next(G), next(G), next(G)
(6, 15, 24)
>>>list(map(sum, M))
[6, 15, 24]
```

Basic python: Dictionary

Python dictionaries:

- Unordered collection of arbitrary objects
- Accessed by key, not offset: slicing and indexing operations unavailable
- Variable length, heterogeneous and nestable
- Mutable mapping (map keys to values)
- Tables(hash) of object references

Example:

```
>>>  table = { 'Python': 'Guido van Rossum',
                'Perl':    'Larry Wall',
                'C++':     'Bjarne Stroustrup' }
>>> language = 'Python'
>>> creator= table[ language ]
'Guido van Rossum'
```

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Key-value pair assignment:

```
>>>D= {‘phys’:1, ‘chem’:2, math:3}; D
{'chem': 2, 'phys': 1, 'math': 3}
```

Membership: find value by key:

```
>>> D[‘math’]
3
>>> D.keys(); D.values(); D.items()
[1, 2, 3]
['chem', 'phys', 'math']
```

Attributes of object D:

```
>>> dir(D)
```

Basic python: Dictionary

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- Accessed by key, not offset: slicing and indexing operations unavailable
- Variable length, heterogeneous and nestable
- Mutable mapping (map keys to values)
- Tables(hash) of object references

List to dictionary:

```
>>> l= [ ‘a’, ‘b’, ‘c’, ‘d’ ]
>>> d={}
>>> for k in l:
>>>       d{k}=k*2
>>> print d
{’a': ‘aa’, ’b': ‘bb’, ’c': ‘cc’, ‘d’: ‘dd’}
```

Or :

```
>>> d= {l[n]:’’ for n in range(0,len(n)) }
```

Alternatively:

```
>>> from itertools import izip
>>> n=iter(l)
>>> b=dict( izip(n,n) )
```

Basic python: Files

Python files

- Use file iterators for reading files
- Content is strings, not objects
- Files are buffered and seekable. Flush forces buffered data to disk

```
>>> f = open( ‘test_file’, ‘w’ )
>>> print f
<open file 'test_file', mode 'w' at 0x1004bd250>
```

f.read(), f.readline(), f.readlines(),

f.seek(0)

```
>>> for line in f:
        print line
>>> with open(’test_file', 'r') as f:
...     read_data = f.read()
```

line.rstrip,

Basic python: Files

pickle:
Stores native python objects

struct: packed binary data
Store packed binary data

Example pickle:

```
>>> D= {‘a’:1, ‘b’:2}
>>> F= open(data.pkl, ‘wb’)
>>> import pickle
>>> pickle.dump(D, F)
>>> F.close()

>>> F= open(data.pkl, ‘rb’)
>>> E= pickle.load(F)
>>> E
{'a': 1, 'b': 2}
```

Conditionals: If-else

Python if else:

```
if test1:
        statements1
elif test2:
        statements2
…
else:
        statements
```

Example:

```
>>>x= int(raw_input(”Enter x: ”))
>>> if x < 0:
...     print 'x is –ve’
...   elif x == 0:
...     print 'x is 0'
...   else:
...     print 'x is +ve''
```

Basic python: While Loop

While executes a block of statements until a condition is satisfied

```
while <test>:
        <statements1>
else:
        <statements2>
```

```
while True:
        print 'This can go on forever'
```

```
a=0; b=9
while a<b:
        #print (a, end=' ') # python 3.0
        print a
        a+=1
```

Basic python: While Loop

continue:
lets you jump to top of the loop

pass:
placeholder statement

break:
immediate exit from the loop

```
while <tests1>:
        <statements1>
        if <tests2>: break
        if <tests3>: continue
else:
        <statements2>
```

```
a=10
while a:
        a=a-1
        if a%2 !=0: continue
        print a
```

```
while True: pass
```

```
while True:
        name=input('Enter name:')
        if name=='stop': break
        age=input('Enter age:')
        print('Hello', name, int(age)*2)
```

Basic python: For Loop

For loop steps through items in an ordered sequence

```
for <target> in <object>:
        <statements1>
else:
        <statements2>
```

```
for x in [1,2,3,4,5]:
        sum += x
        prod *= x
```

```
values= [“abc”, 123, (1,2), 3.14]
keys= [(1,2), 2.1]
for key in keys:
        if key in values:
            print (key, “found”)
        else:
            print (key, “not found”)
```

Basic python: For Loop

Range can be use to iterate over sequence

```
>>> range(10)
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

>>> range(1,11)
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

>>> range(0,10,3)
[0, 3, 6, 9]
```

```
for n in range(2,10):
    for x in range(2,n):
        if n%x ==0:
            print n,'is', x, '*', n/x
            break
    else:
        print n, "is prime"
```

Basic python: functions

Built-in Functions				
abs()	divmod()	input()	open()	staticmethod()
all()	enumerate()	int()	ord()	str()
any()	eval()	isinstance()	pow()	sum()
basestring()	execfile()	issubclass()	print()	super()
bin()	file()	iter()	property()	tuple()
bool()	filter()	len()	range()	type()
bytearray()	float()	list()	raw_input()	unichr()
callable()	format()	locals()	reduce()	unicode()
chr()	frozenset()	long()	reload()	vars()
classmethod()	getattr()	map()	repr()	xrange()
cmp()	globals()	max()	reversed()	zip()
compile()	hasattr()	memoryview()	round()	__import__()
complex()	hash()	min()	set()	apply()
delattr()	help()	next()	setattr()	buffer()
dict()	hex()	object()	slice()	coerce()
dir()	id()	oct()	sorted()	intern()

Source: http://docs.python.org/2/library/functions.html

Basic python: functions

Python functions:

A reusable set of statements which can compute a result based on input parameters.

- Maximize code reuse and eliminate redundancy
- Procedural decomposition

```
def <name> (arg1, arg2, …):
        <statements>
        return <value>
```

Example:

Typeless behavior

```
>>>def  mult(x, y):
        …   return x * y
>>> mult( 2,4 ); mult( 'Hi',2 )
8
'HiHiHi'
```

def is executable

```
>>> if test:
        def func():
>>> else:
        def func():
```

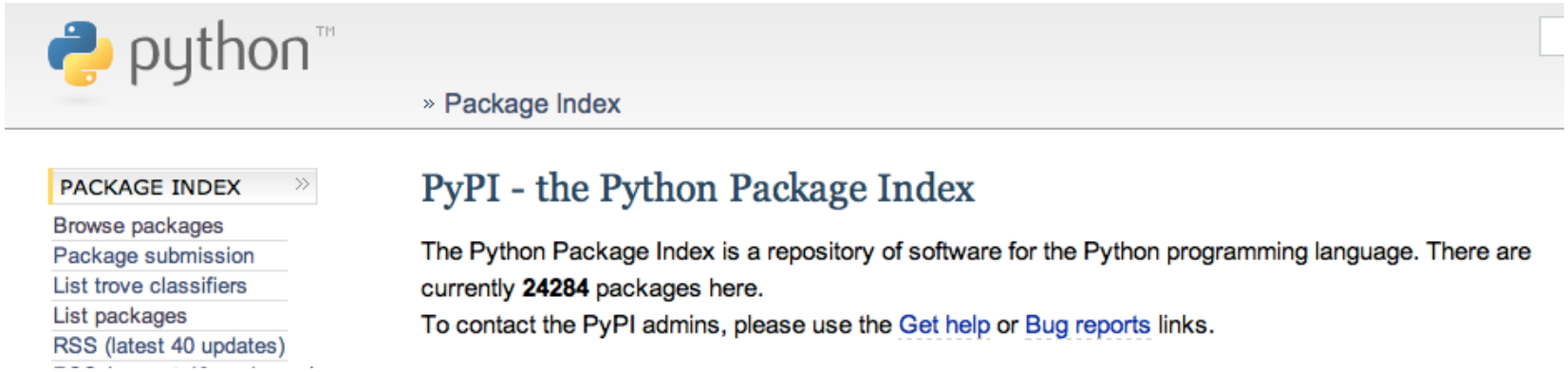
Basic python: Exception

```
try:
    mult( 'Hi', 2.5 )
except TypeError:
    print 'There is an error here'
```

```
+-- Exception
    +-- StopIteration
    +-- StandardError
    |    +-- BufferError
    |    +-- ArithmeticError
    |    |    +-- FloatingPointError
    |    |    +-- OverflowError
    |    |    +-- ZeroDivisionError
    |    +-- AssertionError
    |    +-- AttributeError
    |    +-- EnvironmentError
    |    |    +-- IOError
    |    |    +-- OSError
    |    |         +-- WindowsError (Windows)
    |    |         +-- VMSError (VMS)
    |    +-- EOFError
    |    +-- ImportError
    |    +-- LookupError
    |    |    +-- IndexError
    |    |    +-- KeyError
    |    +-- MemoryError
    |    +-- NameError
    |    |    +-- UnboundLocalError
    |    +-- ReferenceError
    |    +-- RuntimeError
    |    |    +-- NotImplementedError
    |    +-- SyntaxError
    |    |    +-- IndentationError
    |    |         +-- TabError
    |    +-- SystemError
    |    +-- TypeError
    |    +-- ValueError
    |         +-- UnicodeError
    |              +-- UnicodeDecodeError
    |              +-- UnicodeEncodeError
    |              +-- UnicodeTranslateError
    +-- Warning
         +-- DeprecationWarning
```

Python: Using modules

http://pypi.python.org/pypi



Python: Using modules

Modules

- sys, os
- math, numpy, scipy
- subprocess, ipython, re
- paramiko, sqlite
- mpi4py, pycuda, pyxml, matplotlib

Python: Using modules

Index of Packages

Updated	Package	Description
2012-09-27	cop 0.2	Coroutines for dataflow pipelines
2012-09-27	praw 1.0.10	PRAW, an acronym for `Python Reddit API Wrapper`, is a python package that allows for simple access to reddit's API.
2012-09-27	telemundo 0.1.1	Telemundo Libraries
2012-09-27	Hoboken 0.5.0	A Sinatra-inspired web framework for Python
2012-09-27	bbfreeze 1.0.1	create standalone executables from python scripts
2012-09-27	django-postgrespool 0	
2012-09-27	libthumbor 1.0.1	libthumbor is the python extension to thumbor
2012-09-27	desktop 0.4.1	Simple desktop integration for Python
2012-09-27	pyramid_saauditrail 0.2	Automatically audit db changes for pyramid and sqlalchemy
2012-09-27	fbfbot 0.1.1	The FeedBackFlow bot
2012-09-27	simpleblog 0.3	A simple Python blogging system.
2012-09-27	mercurial_keyring 0.5.3	Mercurial Keyring Extension
2012-09-27	collective.z3cform.widgets 1.0b2	A widget package for Dexterity projects.
2012-09-27	plib 0.8.2	A namespace package for a number of useful sub-packages and modules.
2012-09-27	setuputils 0.9.1	A utility to automate away boilerplate in Python setup scripts.
2012-09-27	err 1.6.6	err is a plugin based team chatbot designed to be easily deployable, extensible and maintainable.
2012-09-27	mimeprovider 0.1.1	RESTful mime handling plugin for Pyramid
2012-09-27	hgreview 0.3	Mercurial extension to work with rietveld codereview
2012-09-27	tlslite 0.4.3	tlslite implements SSL and TLS.
2012-09-27	pyramid_mustache 0.3.1	pyramid_mustache
2012-09-27	tackpy 0.9.9a	Tackpy implements TACK in python

Python: Using modules

Get help:

dir():

Without arguments, return the list of names in the current local scope. With an argument, attempt to return a list of valid attributes for that object.

help(‘scipy')

Get help on any python object

PYTHONPATH:

Modify PYTHONPATH to find locally installed modules

Python: Using modules

Module search

Python module sys:

This module provides access to some variables used or maintained by the interpreter and to functions that interact strongly with the interpreter. It is always available.

Python module pp:

The pprint module provides a capability to “pretty-print” arbitrary Python data structures in a form which can be used as input to the interpreter.

```
>>> import pprint as pp
>>> import sys

>>> a=sys.modules

>>> type(a)
>>> pp.pprint (a.keys())
>>> pp.pprint (a.values())

>>> a[‘os’]
```

Python: module ‘sys’

Python module sys:

This module provides access to some variables used or maintained by the interpreter and to functions that interact strongly with the interpreter. It is always available.

sys.modules:	List modules
sys.path:	Show path
sys.argv:	List arguments
sys.platform:	Platform type
sys.executable:	Python executable
sys.maxint:	

```
>>> import sys
>>> sys.modules

>>> sys.path
>>> sys.path.append(newpath)

>>> sys.platform
```

Python: module ‘os’

Python module os:

os.getcwd()
os.environ[‘HOME’],
os.environ[‘PWD’],
os.chdir(), os.fchdir()
os.fdopen()
os.popen()
os.getloadavg()
os.fchmod(), os.fchown(fd, uid, gid)

```
#!/usr/bin/python

import os, sys

# First go to the "/var/www/html" directory
os.chdir("/var/www/html" )

# Print current working directory
print "Current working dir : %s" % os.getcwd()

# Now open a directory ”dir"
fd = os.open( “dir", os.O_RDONLY )

# Use os.fchdir() method to change the dir
os.fchdir(fd)

# Print current working directory
print "Current working dir : %s" % os.getcwd()

# Close opened directory.
os.close( fd )
```

Python: module ‘os’

Python module os:

os.path.isfile()

os.path.isdir()

os.path.islink()

os.walk()

Example:

```
>>> path = os.getcwd()
>>> files = os.listdir(path)
>>> os.path.isfile( files[10] )
```

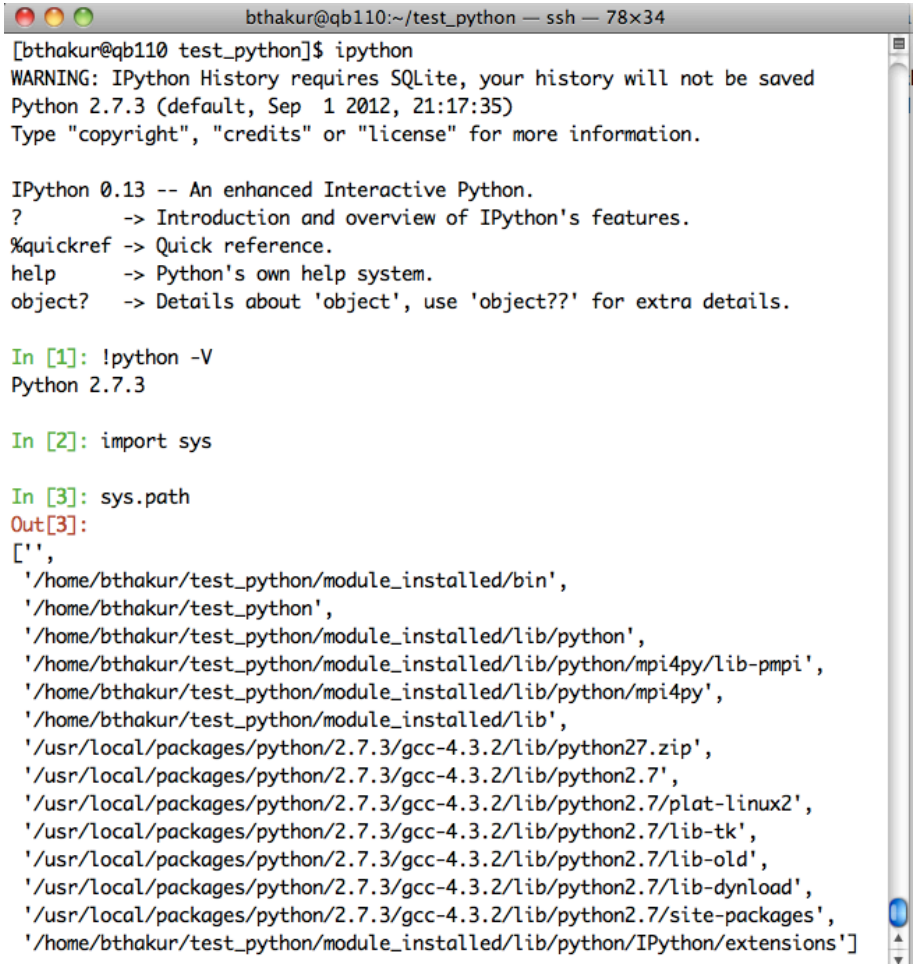
Example:

```
>>> for top, dirs, files in os.walk(path)
>>>     print top
>>>     print dirs
>>>     print files
```

Using modules: Ipython

Ipython: A powerful Interactive interface to python

- System calls and tab completion
- GUI support
- Easy to use, high performance tools for parallel computing.



Using modules: Ipython

Ipython: A powerful Interactive interface to python

- Easy shell system calls and tab completion
- GUI support
- Easy to use hpc-tools for parallel computing.

```
>>> a = ! ls –al
>>> for I in a:
>>>     try:
>>>         j=i.split(); j[0], j[3], j[-1]
>>>     except:
>>>         print (“Error reading %s”, j[0])
```

Scipy Numpy

Testing Scipy

```
>>> import scipy
>>> scipy.test()
Running unit tests for scipy
NumPy version 1.6.2
...
Ran 5482 tests in 79.026s

OK (KNOWNFAIL=15, SKIP=41)
<nose.result.TextTestResult run=5482 errors=0 failures=0>
```

Numpy: Organization

[bthakur@qb3 ~]$ ls /usr/local/packages/python/2.7.3/gcc-4.3.2/lib/python2.7/site-packages/numpy/

add_newdocs.py	fft	polynomial	__config__.pyc	__init__.pyc
ctypeslib.py	linalg	testing	dual.py	matrixlib
f2py	oldnumeric	__config__.py	__init__.py	setup.pyc
lib	setupscons.pyc	doc	matlib.pyc	version.pyc
numarray	compat	_import_tools.pyc	setup.py	
setupscons.py	distutils	matlib.py	version.py	
add_newdocs.pyc	_import_tools.py	random	core	
ctypeslib.pyc	ma	tests	dual.pyc	

scipy: Organization

[bthakur@qb3 ~]$ ls /usr/local/packages/python/2.7.3/gcc-4.3.2/lib/python2.7/site-packages/scipy/

BENTO_BUILD.txt	__init__.py	optimize	sparse	version.pyc
HACKING.rst.txt	LATEST.txt odr	signal	version.py	fftpack
io	setupscons.pyc	TOCHANGE.txt	constants	interpolate
ndimage	THANKS.txt	__config__.pyc	integrate	misc
setupscons.py	__config__.py	INSTALL.txt	linalg	setup.pyc
stats	__init__.pyc	LICENSE.txt	setup.py	special
cluster	lib	README.txt	spatial	weave

scipy: Organization

Subpackage	Description
`cluster`	Clustering algorithms
`constants`	Physical and mathematical constants
`fftpack`	Fast Fourier Transform routines
`integrate`	Integration and ordinary differential equation solvers
`interpolate`	Interpolation and smoothing splines
`io`	Input and Output
`linalg`	Linear algebra
`ndimage`	N-dimensional image processing
`odr`	Orthogonal distance regression
`optimize`	Optimization and root-finding routines
`signal`	Signal processing
`sparse`	Sparse matrices and associated routines
`spatial`	Spatial data structures and algorithms
`special`	Special functions
`stats`	Statistical distributions and functions
`weave`	C/C++ integration

Numpy: array class

Creating numpy array class

```
>>> import numpy as np

>>> x = np.array([2,3,1,0]); print x
array([2, 3, 1, 0])

>>>  np.zeros( (12), dtype=int )
>>>  np.arange(10)
>>>  np.linspace(1., 4., 6)
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0], dtype=int8)
array([ 1. ,  1.6,  2.2,  2.8,  3.4,  4. ])
```

Type, size, trace, shape, dimensions

```
>>> x.dtype, x.ndim, x.shape, x.size
```

Indexing and slicing, Max, min, sum

x.max(), x.min(), x.sum()

Reshape, resize, inverse

reshape(), resize(), a.getI()

Relational operators

b= x>3; c= x[(x>2) & (x<7)]

sum((a%2) == 0)

any(a == 10)

Numpy: matrix class

Numpy matrix class

- Returns a matrix from an array-like object, or from a string of data.
- Specialized 2-D array that retains its 2-D nature through operations.
- Special operators, such as (*) multiplication and (**) power.

Create and view matrix

```
>>> import numpy as np
>>> a=np.matrix('[1 2 3; 4 5 6; 7 8 9]')
>>> a
matrix( [[1, 2, 3],
         [4, 5, 6],
         [7, 8, 9]])
```

Sum, trace, shape, dimensions

```
>>> np.sum(a), np.trace(a), np.ndim(a)
(45, 15, 2)
>>> np.shape(a)
(3, 3)
```

Diagonal, transpose

```
>>> np.diagonal(a); np.transpose(a)
array([1, 5, 9])
matrix([[1, 4, 7],
        [2, 5, 8],
        [3, 6, 9]])
```

Reshape, resize, inverse

reshape(), resize(), a.getI()

Scipy: Linear Algebra support

Scipy tutorial:
Solving a system of linear equations

$$x + 3y + 5z = 10$$
$$2x + 5y + z = 8$$
$$2x + 3y + 8z = 3$$

$$\begin{pmatrix} 1 & 3 & 5 \\ 2 & 5 & 1 \\ 2 & 3 & 8 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 10 \\ 8 \\ 3 \end{pmatrix}$$

http://docs.scipy.org/doc/scipy/reference/tutorial/linalg.html

```
>>> from numpy import *
>>> from scipy import linalg

>>> A = mat('[1 3 5; 2 5 1; 2 3 8]')
>>> b = mat('[10;8;3]')
>>> linalg.det(A)
-25.000000000000007

>>> linalg.solve(A,b)
matrix([[-9.28],
        [ 5.16],
        [ 0.76]])
```

Scipy: Using ARPACK

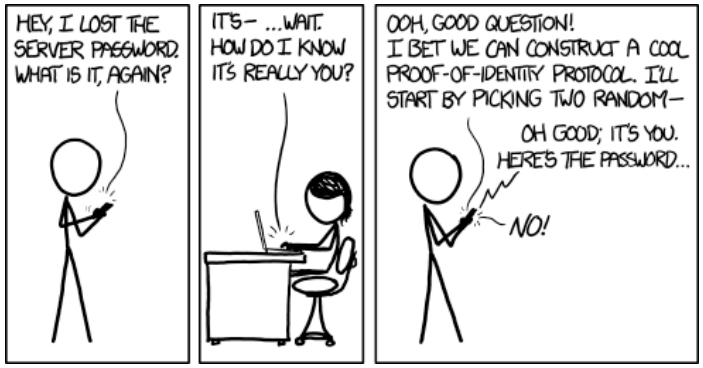
Scipy tutorial: http://docs.scipy.org/doc/scipy/reference/tutorial/arpack.html

```
>>> import numpy as np
>>> from scipy.linalg import eigh
>>> from scipy.sparse.linalg import eigsh
>>> np.set_printoptions(suppress=True)
>>> np.random.seed(0)
>>> X = np.random.random((100,100)) - 0.5
>>> X = np.dot(X, X.T)
>>> evals_all, evecs_all = eigh(X)
>>> evals_large, evecs_large = eigsh(X, 3, which='LM')
>>> print evals_large
```

Using modules: SSH

SSH using Paramiko:

Setup ssh connection to remote machine and execute commands




```
>>> import paramiko

>>> pol=     paramiko.AutoAddPolicy()
>>> user=    'myid'
>>> pass=    'mypass'
>>> server= 'mymachine.lsu.edu'

>>> ssh= paramiko.SSHClient()
>>> ssh.set_missing_host_key_policy( pol)

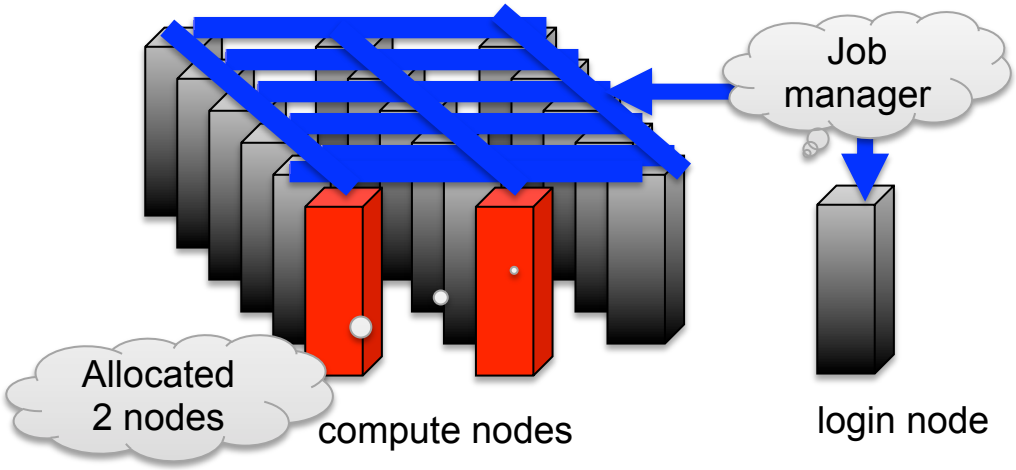
>>> ssh.connect(server, username=user, password=pass)
>>>sin,sou,serr= ssh.exec_command('hostname')
>>> ssh.close()
```

Using mpi: mpi4py

Mpi using mpi4py:

MPI library for running parallel jobs

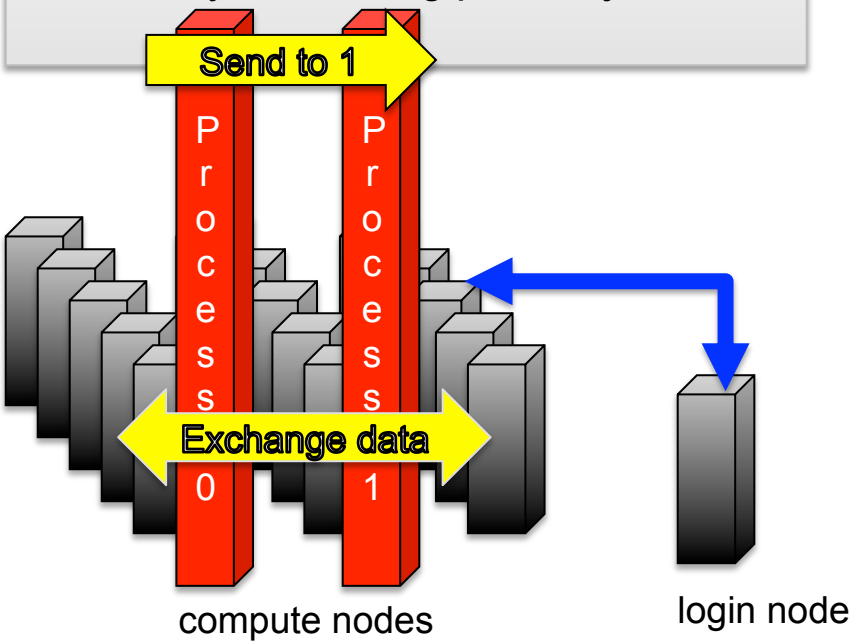
- Job manager allocates resources on compute nodes.
- Users usually submit jobs in batch or interactive mode from the login node.



Using mpi: mpi4py

Mpi using mpi4py:

MPI library for running parallel jobs




```
>>> from mpi4py import MPI

>>> comm = MPI.COMM_WORLD
>>> size = comm.Get_size()
>>> rank = comm.Get_rank()

print ”My process id is ", rank, "of", size
```

```
My process id is  2 of 4
My process id is  0 of 4
My process id is  3 of 4
My process id is  1 of 4
```

Using mpi: mpi4py

Mpi using mpi4py:

MPI Broadcast example using dictionary

```
comm = MPI.COMM_WORLD
rank = comm.Get_rank()

# Initialize data
data = {'key1' : [0, 0.0, 0+0j],
        'key2' : ( '000', '000')}

# Change values on root node
if rank == 0:
   data = {'key1' : [7, 2.72, 2+3j],
           'key2' : ( 'abc', 'xyz')}

# data on two processes before broadcast
if rank == 0 or rank == 1:
   print "Before we receive", rank, data
```

```
# Broadcast from root
data = comm.bcast(data, root=0)

# Print data on two processes after broadcast
if rank == 0 or rank == 1:
   print "After we receive", rank, data
```

```
Before we receive 0
{'key2': ('abc', 'xyz'), 'key1': [7, 2.72, (2+3j)]}
Before we receive 1
{'key2': ('000', '000'), 'key1': [0, 0.0, 0j]}

After we receive 0
{'key2': ('abc', 'xyz'), 'key1': [7, 2.72, (2+3j)]}
After we receive 1
{'key2': ('abc', 'xyz'), 'key1': [7, 2.72, (2+3j)]}
```

Using sqlite: pysqlite

http://www.sqlite.org/

SQLite is a software library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine. SQLite is the most widely deployed SQL database engine in the world. The source code for SQLite is in the public domain.

Using sqlite: pysqlite

sqlite using pysqlite:

```
>>> import sqlite3 as sq
>>> con=sq.connect('testpy.db')

>>> cur=con.cursor()
>>> cur.execute("""CREATE TABLE contacts(name text, phone integer)""")

>>> cur.execute("INSERT INTO contacts VALUES('HPC help', '2255780900')")
>>> cur.execute("INSERT INTO contacts VALUES('ITS help',  '2255783375')")
>>> con.commit()
>>> con.close()
```

```
$ sqlite3 testpy.db
  sqlite> select * from contacts;
  HPC help|2255780900
  ITS help|2255783375
```

```
$ python sqlite_read.py
  (u'HPC help', 2255780900L)
  (u'ITS help', 2255783375L)
```

Using xml: xml.dom

Using xml.dom:

```
<result>

  <value>
      <name> John Doe </name>
      <age>  42 </age>
      <sex> M </sex>
  </value>

  <value>
     <name> Tom Doe </name>
     <age>  21 </age>
     <sex> M </sex>
 </value>

</result>
```

```
>>> from xml.dom.minidom import parse
>>> doc=parse("parse.xml”)

>>> values = doc.getElementsByTagName("value")

>>> for entry in values:
>>>      name=entry.childNodes[1]
>>>      for f in name.childNodes:
>>>            print f.data
```

```
$ python parse.py
John Doe
Tom Doe
```

Broader than you think!

- Database: mysql-python, PyMySQL, PyGreSQL, pysqlite
- More parallel programming: Multiprocessing, Mpi4py, ipython
- Graphics/GPU programming: PyOpenGL, PyOpenCL, PyCUDA, Pygame
- Networking
- Regular expressions
- The list is endless ……..

Broader than you think!

- Database: mysql-python, PyMySQL, PyGreSQL, pysqlite
- More parallel programming: Multiprocessing, Mpi4py, Parallel Python
- Graphics/GPU programming: PyOpenGL, PyOpenCL, PyCUDA, Pygame
- Networking

Conclusion

- **Python is powerful and easy**: Understand its advantages(user friendly/object oriented) and disadvantages (impact on performance) for your project.
- **Module let you have useful tools and libraries at your disposal with minimal effort**
- **Interface to various languages, libraries and tools.**