Jython

Introduction to Jython programming

Agenda

- Module 1 - Introduction to Jython
- Module 2 - Jython language and semantics
- Module 3 - Data types
- Module 4 - Regular expressions
- **Module 5 - Functions, debugging, modules, and packages**
- Module 6 - Objects, classes and exceptions
- Module 7 - Java integration
- Module 8 - Testing
- Module 9 - System programming
- Module 10 - Conclusion

Topics

- Functions
- Scope and namespaces
- Debugging
- Modules
- Packages
- Quiz
- Q & A

Functions

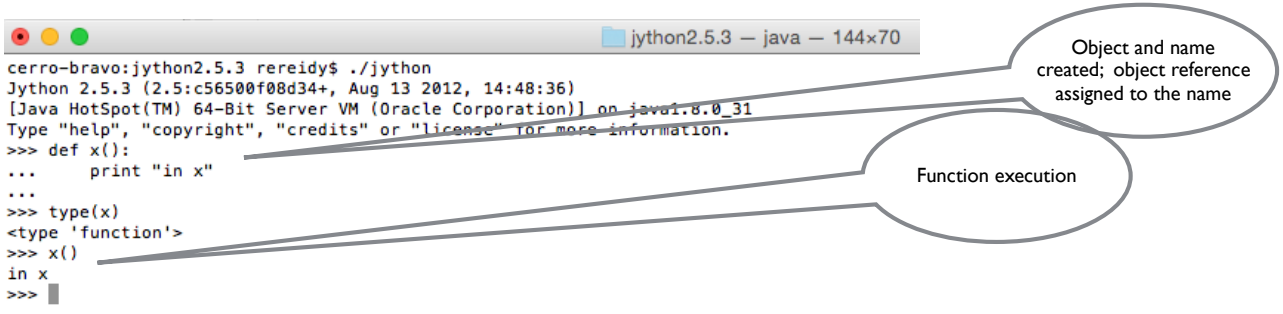
Jython

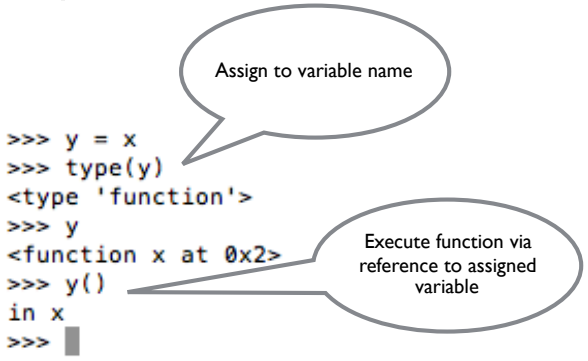
Overview

- Performs a specific task
  - Reducing duplication of code
  - Decomposing complex problems into simpler pieces
  - Improving clarity of the code
  - Reuse of code
  - Information hiding
- First class citizen
  - Equal status with other objects (classes, types, etc.)
  - Can be assigned to variables, passed as argument to classes, functions, etc.

Main concepts I

- The "def" keyword declares a function
  - Stand alone function
  - Classes
- "*def*" is an executable statement
  - Can be nested
    - if statements
    - while statements
    - Other def statements
- Creates an object and assigns a name (reference to the object)





Main concepts2

- "*lambda*" creates an anonymous, in-line function
- "*return*" sends result object back to caller
- "*yield*" sends result back to caller, but remembers where it left off in processing
- "*global*" declares module-level variables that are assigned later in processing

Built-in functions

Built-in functions

- Always available
- Part of the interpreter (module __builtins__)

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()	
delattr()	help()	next()	setattr()	
dict()	hex()	object()	slice()	
dir()	id()	oct()	sorted()	

https://docs.python.org/2/library/functions.html

User-defined functions

Creating functions

- Format

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

  <return>
```

- "*def*" executes at runtime
  - Function object and name created and assigned when file is read

Polymorphism

- Meaning of expression depends on object types

Function arguments

- Positional
- Named
- Default arguments
- Arbitrary arguments
- Dictionary arguments

Argument passing mechanism

- Some languages pass by value
  - Make a copy of object and pass copy
- Python uses pass by reference
  - Mutable objects changed in function are permanently changed

return keyword

- All functions return a value
- Explicit using the "`return`" keyword
  - Multiple values separated by comma ","

    `return a, b, c, d …`
- Implicit (falling off the end of the function)
  - `None` type

Anonymous functions

- Functional programming style
- Implemented by keyword "*`lambda`*"

lambda

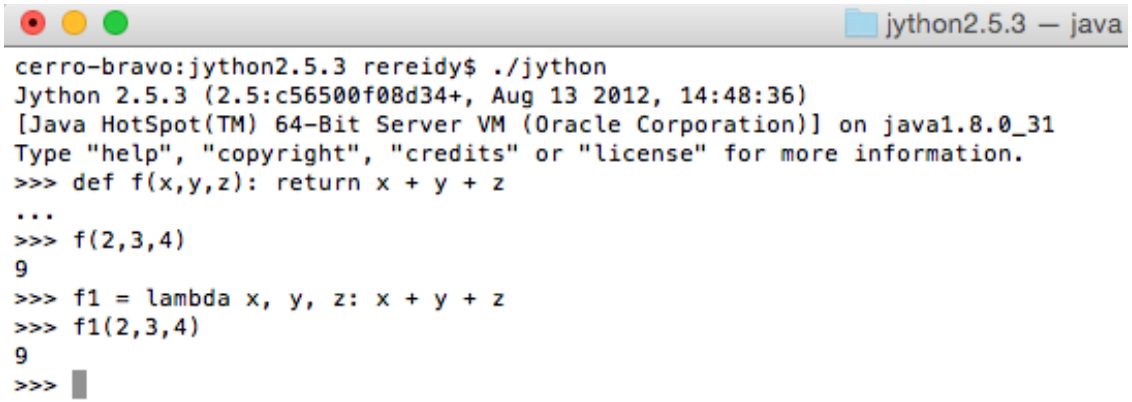
Why lambdas?

- Function shorthand
- Not mandatory - can use "`def`"ined functions

Anonyous function

- Functions with no name
- Syntax:

  lambda *argument list:* *expression*
- A *lambda* is an expression, not a statement
  - The body is a single expression, not a block



Functional programming

Tools

- Apply functions to sequences and other objects that can be iterated
- map()
- filter()
- reduce()

map

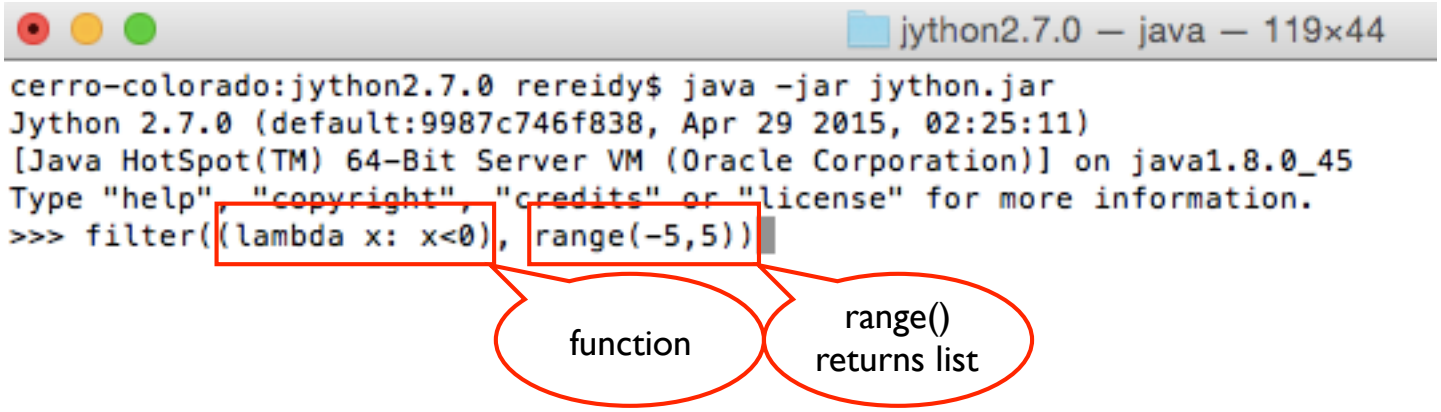
Apply a function to a sequence

- Apply to all items and collect results
- Easy to do in a `for` loop

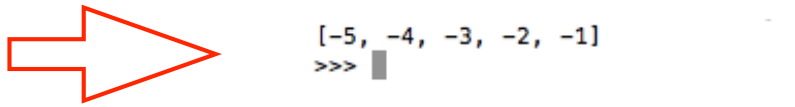
filter

Pull items

- Filter items from a list where the called function returns True



- Returns a list

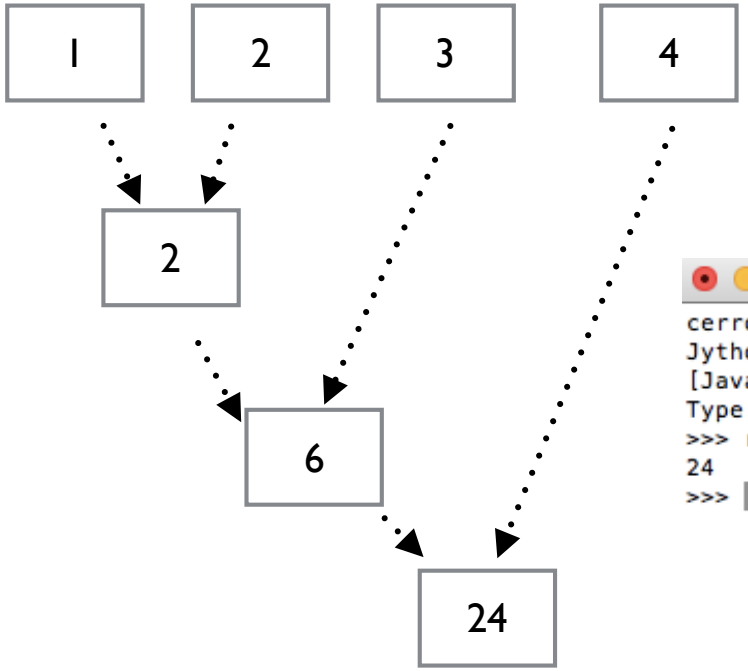


reduce

Reduce a sequence

- Continually apply a function to a sequence
  - Reduces the sequence to a single value

```
reduce(lambda a, b: a * b, [1,2,3,4])
```




```
jython2.5.3 — java — 105×43
cerro-colorado:jython2.5.3 rereidy$ java -jar jython.jar
Jython 2.5.3 (2.5:c56500f08d34+, Aug 13 2012, 14:48:36)
[Java HotSpot(TM) 64-Bit Server VM (Oracle Corporation)] on java1.8.0_45
Type "help", "copyright", "credits" or "license" for more information.
>>> reduce(lambda a, b: a * b, [1,2,3,4])
24
>>>
```

Scopes

Preliminaries

- When a name is used, Python will
  - Create
  - Change
  - Look up
- This is a namespace - where the names exist
  - Implemented as a dictionary (but that could change)

Scoping rules

Enclosing module

- Exists global scope
  - Variables assigned at the top of a module
  - Attributes of the module
    - Can be used as simple variables within the module file

Scoping rules

Span

- Global scope spans single file only
  - Names at the top of a file are only global to code within that file
- No single, all-encompassing global scope
  - Names are partitioned into modules
  - Modules must be imported explicitly to use the names defined
- In Python: global == module

Scoping rules

Default assignment

- Global scope spans single file only
  - Names at the top of a file are only global to code within that file
- No single, all-encompassing global scope
  - Names are partitioned into modules
  - Modules must be imported explicitly to use the names defined
- In Python: global == module
- All assigned names are local unless declared global
- All other names
  - When not assigned value in function definition
    - Assumed to enclosing scope
      - Local (enclosing def)
      - Global (enclosing module namespace)
      - Built-in (predefined `__builtin__` module

Name resolution

- Name references search within four scopes
  - Local
  - Enclosing functions
  - Global
  - Built-in
- Name assignments create or change local names by default
- global declarations map assigned names to the enclosing module and function scopes

Built-in
Names preassigned in __builtin__ module:
Functions (open, range, abs, etc.), exceptions

Global (module/file)
Names assigned at top-level of file or declared "global" in a def

Enclosing function locals
Names in local scope of any and all enclosing functions (def/lambda) from inner most out

Local (function)
Names assigned in any way within a function and not declared global in the function

Minimize global variables

- Because names assigned in functions are local
  - Write extra code to change in functions (global)
    - This is a language feature - write more code to do potential harm
  - Default of local is a best software engineering practice
- Value of globals dependent on order of calls to functions

What is the value?

```
Y = 100

def f1():
    global Y
    Y = -1

def f2():
    global Y
    Y = 101
```

- What is Y
- Timing dependent
  - Which function is called last

Debugging

Debugging strategies

- Using "*`print`*" statements
- Using a debugger

The Python debugger

- Module that allows interactive source code debugging
  - Conditional breakpoints
  - Single stepping
  - Inspect stack frame
  - Evaluation of arbitrary Python code
  - Source code listing
- Invoke from the command line

```
./jython -m pdb file.py
```

https://docs.python.org/2/library/pdb.html

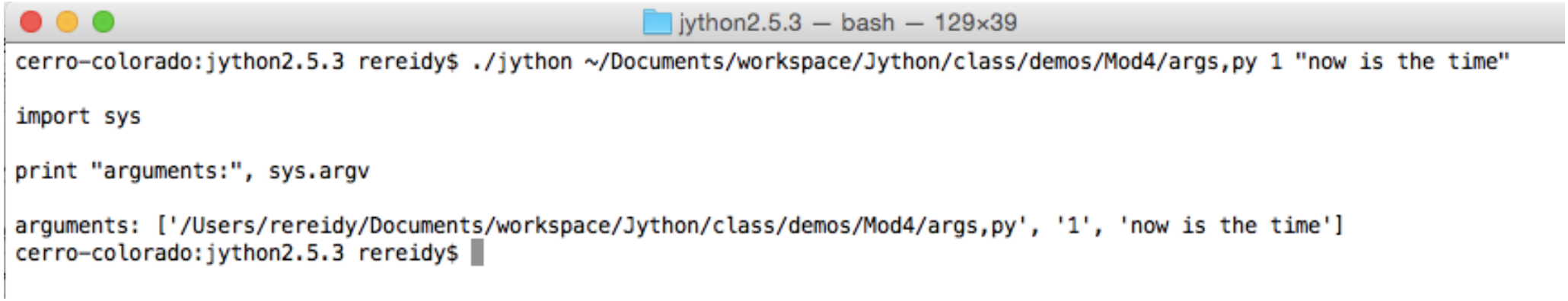
Modules

Modules

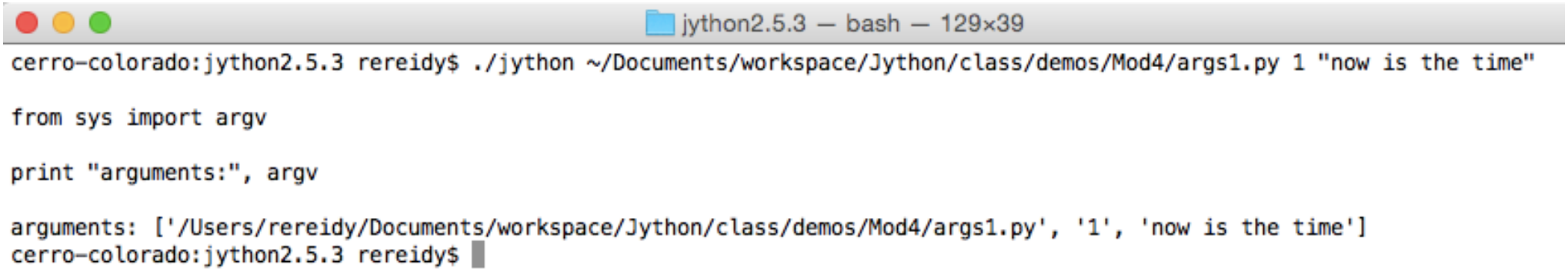
- All Python files are modules
- Implement a set of functions, variables, classes
- Modules process with
  - `import` - fetch a whole module
  - `from` - fetch particular names from a module

Using modules

- Use the "*import*" statement



- Can also use "*from mod import …*"



Aliasing imports

- The imported module can be aliased

jython2.5.3 — java — 107×39

```
cerro-colorado:jython2.5.3 rereidy$ ./jython
Jython 2.5.3 (2.5:c56500f08d34+, Aug 13 2012, 14:48:36)
[Java HotSpot(TM) 64-Bit Server VM (Oracle Corporation)] on java1.8.0_45
Type "help", "copyright", "credits" or "license" for more information.
>>> import sys as s
>>> len(s.argv)
1
>>> len(sys.argv)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'sys' is not defined
>>>
```

jython2.5.3 — java — 107×39

```
cerro-colorado:jython2.5.3 rereidy$ ./jython
Jython 2.5.3 (2.5:c56500f08d34+, Aug 13 2012, 14:48:36)
[Java HotSpot(TM) 64-Bit Server VM (Oracle Corporation)] on java1.8.0_45
Type "help", "copyright", "credits" or "license" for more information.
>>> from sys import argv as args
>>> len(args)
1
>>> len(sys.args)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'sys' is not defined
>>>
```

Using modules

- When using the "*`from mod import …`*" form
  - Do not use "*" (e.g. *`from sys import *`*)

Import mechanics

- Import is not a textual insertion or substitution (like C)
- Runtime operations
  - Find the module file
  - Compile to bytecode (if needed)
  - Run the module code to build objects

Find the module

- The import statement looks for the file with a .py extension implied (do not include it in the import statement)
- Does not include the path to the file (more later)
  - Uses the standard module search path mechanisms

Compile to bytecode

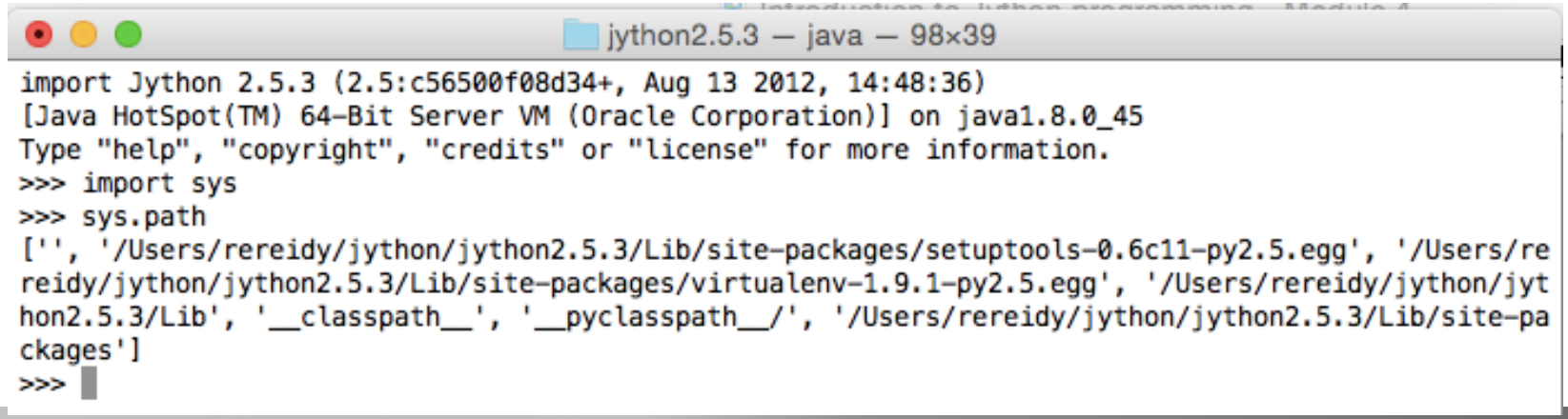
- When modules are fist imported
  - Creates a *.pyc* file
    - Jython - *module$py.class* file
- Not when a module file is executed as a program
- Can be done manually

Run the module

- All statements are executed from the top of the file to the bottom
- Assignments made to names generate attributes of objects

Finding modules

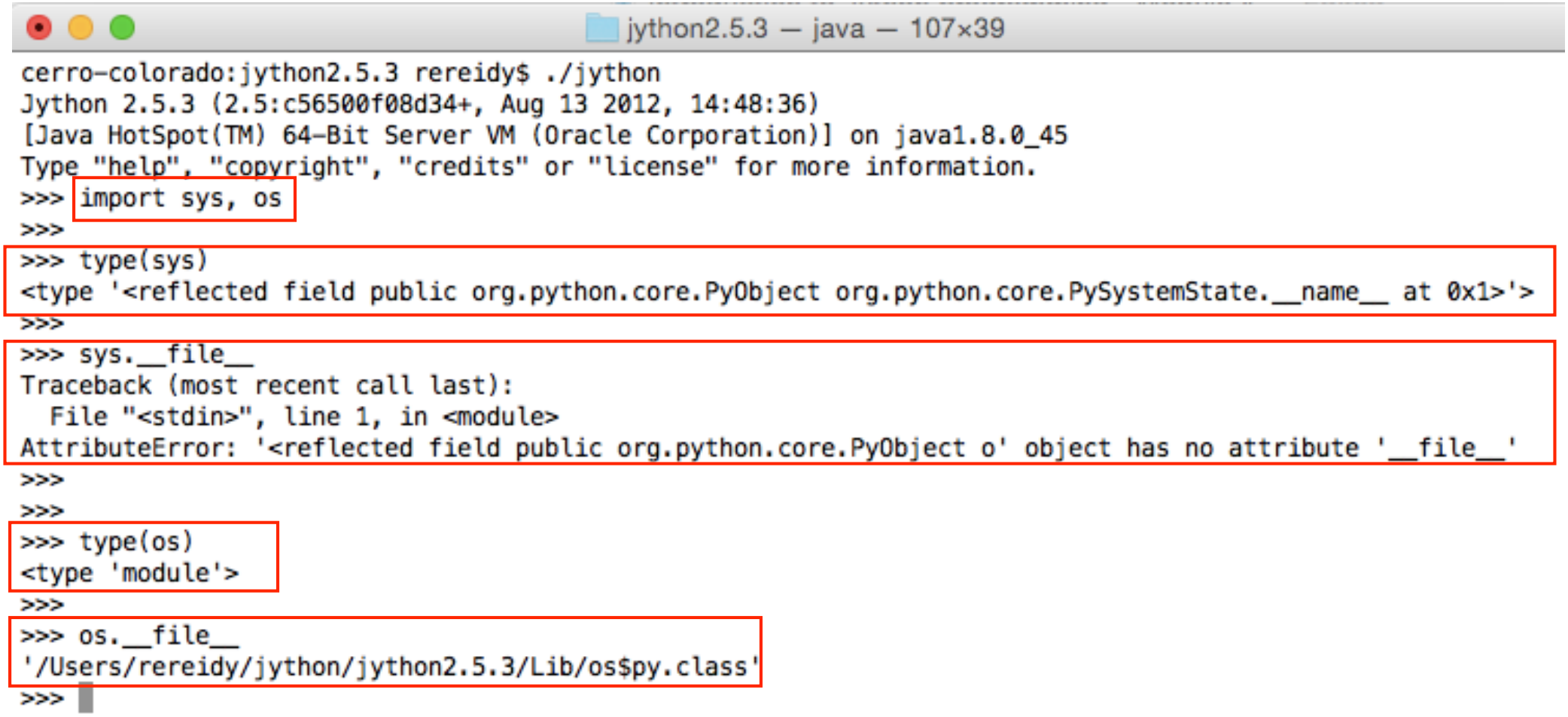
- In the current directory
- In the directory where your script exists
- In $PYTHONHOME (where Python is installed)
- In $PYTHONPATH (list of directories separated by ":")
  - Present in *sys.path*



Module file types

- Python
  - Python files (suffix of .py or compiled Python .pyc)
  - Defined C extension files
  - Modules built in to the interpreter
- Jython
  - Python files (suffix of .py or compiled Python .pyc)
    - Jython Java class files are `file$py.class`
  - Java .class files
  - Modules built in to the interpreter

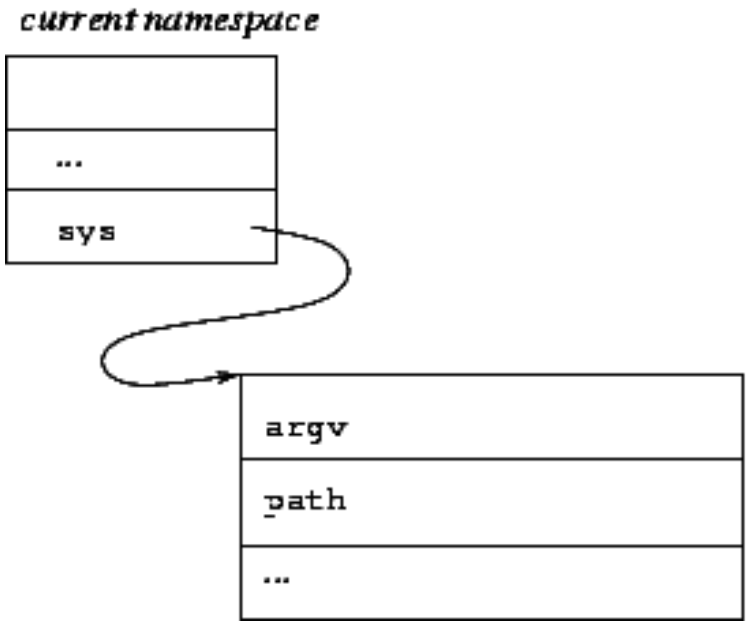
Built in and class files



How it works

- When importing
  - Interpreter creates a new namespace
    - Code is executed in this namespace

```
import sys
```



Adding modules

- In Jython, modules can only be
  - Pure Python (no C extensions)
  - Install from PyPi (Python Package Index)
    - Use setuptools (pip)
  - Java class or JAR files
    - Add location to CLASSPATH

Standard library

- Built-in modules (written in C) or Python
  - Standard solutions for everyday programming problems
- Jython implements the standard library in .class and .py files

https://docs.python.org/2/library/index.html

Modules of interest

sys module

- Parameters and variables that have strong ties to the interpreter
- Python command line arguments (sys.argv)
  - Not interpreter command line arguments

OS

- Miscellaneous operating system functions
  - For path interfaces, import os.path
- In Jython, the os module is different than in CPython

__future__ module

- Future statement definitions

```
all_feature_names = [
    "nested_scopes",
    "generators",
    "division",
    "absolute_import",
    "with_statement",
]

__all__ = ["all_feature_names"] + all_feature_names
```

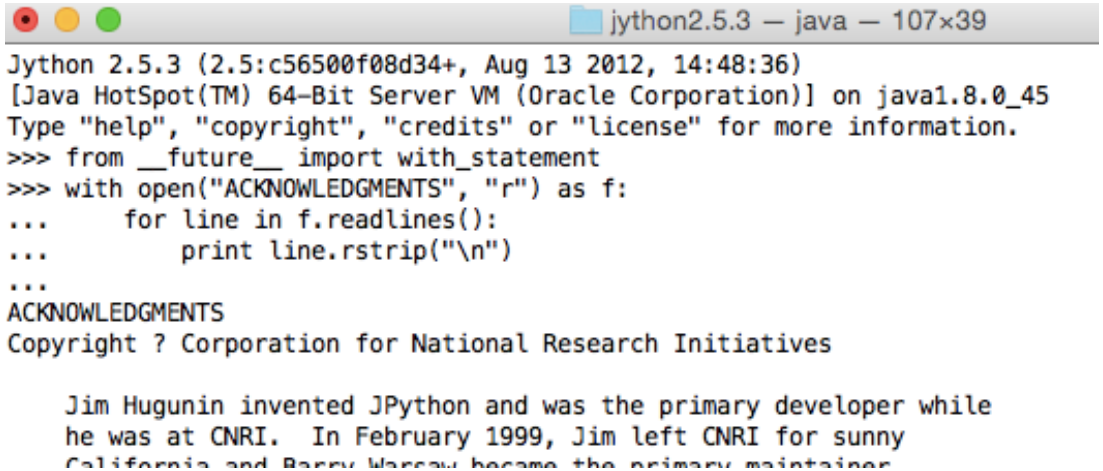
from __future__ import with_statement

- Imports *from __future__* must always be first lines in Python file

https://docs.python.org/2/library/__future__.html

Reading a file

- When you use the "*with*" statement
  - No need to close file at end of I/O operations

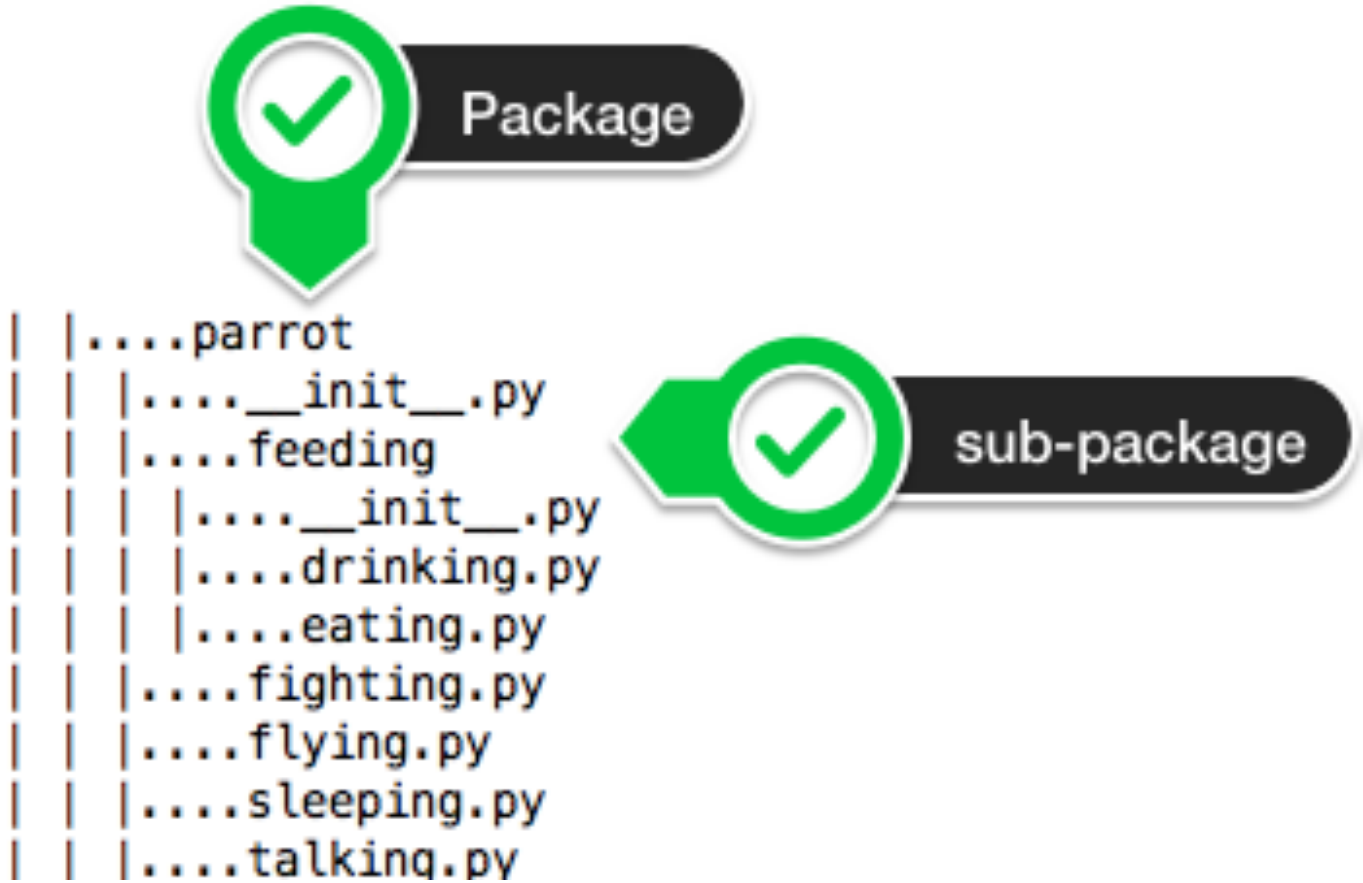


Packages

Packages

- A package is a directory with potentially several Python files
  - Also contains a `__init__.py` file
    - Used to define classes, functions, variables that are directly visible
      - **Not** sub-packages or sub-modules

Package example



Package use

- Many ways to use the package

```
import parrot                                  # loads parrot/__init__.py
import parrot.talking                          # loads parrot/talking.py
from parrot import sleeping                    # load parrot/sleeping.py
import parrot.feeding                          # load parrot/feeding.py
from parrot.feeding.eating import eat_cracker  # object within eating.py
```

- Common (but not mandatory) is for parrot/__init__.py to import all modules

```
import parrot                          # loads parrot/__init__.py
parrot.feeding.eating.eat_cracker()
```

- No need to import sub package(s)

__init__.py

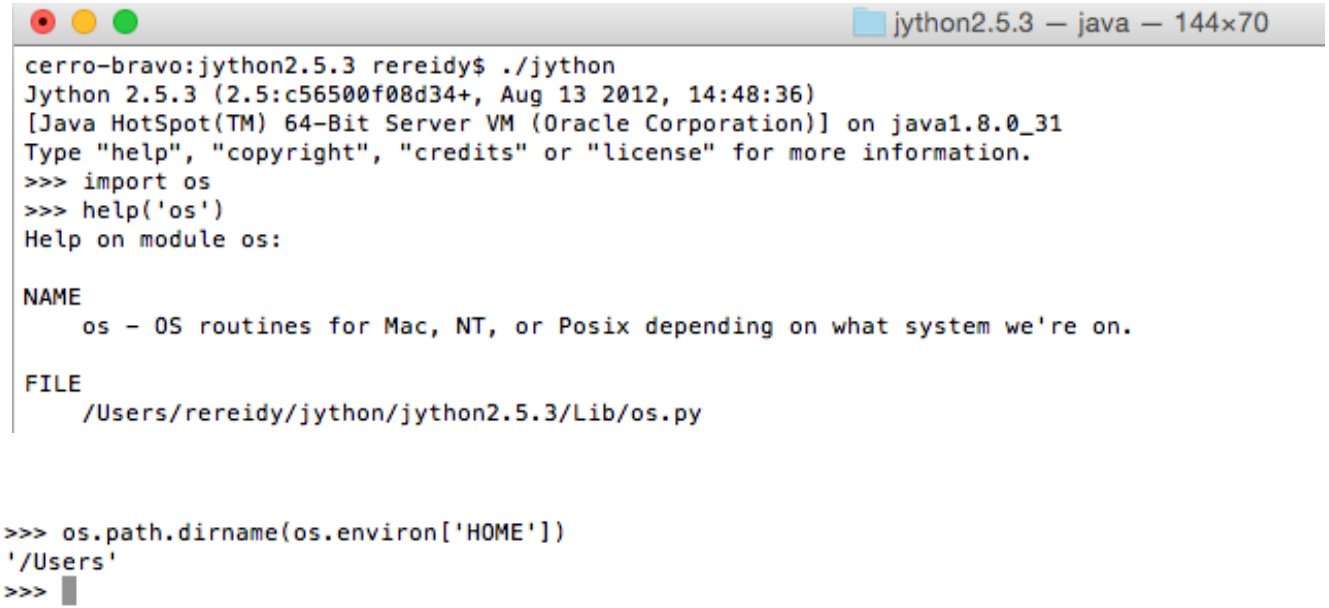
- To import objects in the package
  - Set list object (__all__) to the values

```
__all__ = ['feeding', 'fighting', 'flying', 'sleeping', 'talking']
```

- List of public objects in the package

os module

- Behaves similarly
  - import os
    - Can access objects in os.path package



Quiz

Jython

1. What is returned from a function when no "return" statement is issued?

A. None type

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2. What does the lambda statement do?

A. Creates an anonymous function

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3. What does the following code print?

```
>>> s = "Test"
>>> def f():
...     global s
...     s = "no test"
...
>>> f()
>>> print s
```

A. The text "no test" is printed.

4. Why?

A. Because the name "s" was identified as global in the function "f" and then modified.

Jython

5. What is the result of the following code?

```
>>> from os import getenv as ge
>>> print getenv('HOME')
```

A. Throws the NameError exception because "getenv" is not defined

```
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'getenv' is not defined
>>>
```

Q & A

Exercises

1. Write a program to read a file using the "with" statement - e.g.

```
from __future__ import with_statement
```

2. Modify the program in #1 to write the contents of the file read into a new file.

3. Create a function that solves the fibonacci sequence.