Introduction to Python: Data types

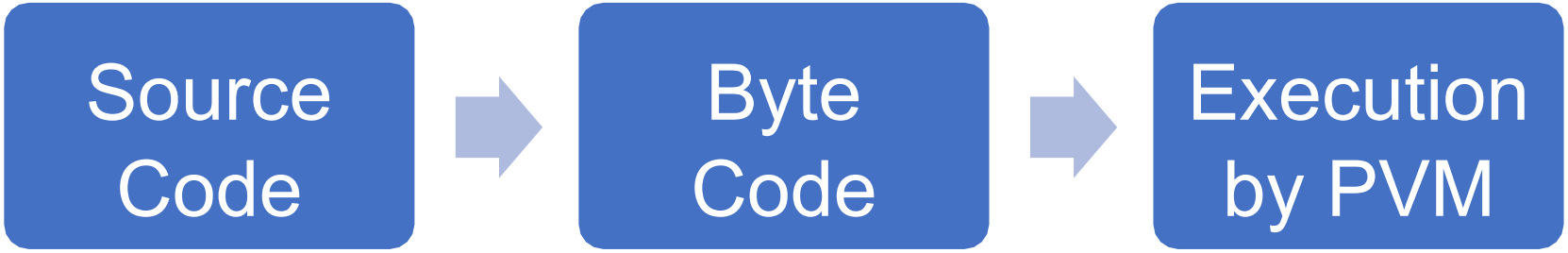
Why Python?

- Readability and ease-of-maintenance
  - Python focuses on well-structured easy to read code
  - Easier to understand source code…
  - ..hence easier to maintain code base
- Portability
  - Scripting language hence easily portabble
  - Python interpreter is supported on most modern OS's
- Extensibility with libraries
  - Large base of third-party libraries that greatly extend functionality. Eg., NumPy, SciPy etc.

Python Interpreter

- The system component of Python is the interpreter.
- The interpreter is independent of your code and is required to execute your code.
- Two major versions of interpreter are currently available:
  - Python 2.7.X (broader support, legacy libraries)
  - Python 3.6.X (newer features, better future support)

Python execution model



- Interpreter has two phases:
- Source code is compiled into byte code
- Byte code is executed on the Python Virtual Machine
- Byte code is regenerated every time source code OR the python version on the machine changes.
- Byte code generation saves repeated compilation time.

Script vs. command line

- Code can be written in a python script that is interpreted as a block.
- Code can also be entered into the Python command line interface.
  - You can exit the command line with Ctrl-z on windows and Ctrl-d on unix
- For complex projects use an IDE (For example, PyCharm, Jupyter notebook).
  - PyCharm is great for single-developer projects
  - Jupyter is great sharing code and output with markup

First script

```
kvarala@scholar-fe03:/scratch/scholar/k/kvarala/Week8 $ python
Python 2.6.6 (r266:84292, Aug  9 2016, 06:11:56)
[GCC 4.4.7 20120313 (Red Hat 4.4.7-17)] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> print('hello world!')
hello world!
>>>
```

- This is the command line interface
- Simply type in the command and the output, if any, is returned to the screen.
- May also be written as a script:

```
kvarala@scholar-fe03:/scratch/scholar/k/kvarala/Week8 $ cat hello.py
#!/usr/bin/python
print('hello world!')
kvarala@scholar-fe03:/scratch/scholar/k/kvarala/Week8 $ python hello.py
hello world!
kvarala@scholar-fe03:/scratch/scholar/k/kvarala/Week8 $
```

Variables and Objects

- Variables are the basic unit of storage for a program.
- Variables can be created and destroyed.
- At a hardware level, a variable is a reference to a location in memory.
- Programs perform operations on variables and alter or fill in their values.
- Objects are higher level constructs that include one or more variables and the set of operations that work on these variables.
- An object can therefore be considered a more complex variable.

Classes vs. Objects

- Every Object belongs to a certain class.
- Classes are abstract descriptions of the structure and functions of an object.
- Objects are created when an instance of the class is created by the program.
- For example, “Fruit” is a class while an “Apple” is an object.

What is an Object?

- Almost everything is an object in Python, and it belongs to a certain class.
- Python is dynamically and strongly typed:
  - Dynamic: Objects are created dynamically when they are initiated and assigned to a class.
  - Strong: Operations on objects are limited by the type of the object.
- Every variable you create is either a built-in data type object OR a new class you created.

Core data types

- Numbers
- Strings
- Lists
- Dictionaries
- Tuples
- Files
- Sets

Numbers

- Can be integers, decimals (fixed precision), floating points (variable precision), complex numbers etc.
- Simple assignment creates an object of number type such as:
  - a = 3
  - b = 4.56
- Supports simple to complex arithmetic operators.
- Assignment via numeric operator also creates a number object:
  - c = a / b
- a, b and c are numeric objects.
- Try dir(a) and dir(b) . This command lists the functions available for these objects.

Strings

- A string object is a ‘sequence’, i.e., it’s a list of items where each item has a defined position.
- Each character in the string can be referred, retrieved and modified by using its position.
- This order id called the ‘index’ and always starts with

```
>>> S = 'Hello'
>>> len(S)
5
>>> S[0]
'H'
>>> S[4]
'o'
>>> S[5]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IndexError: string index out of range
```

```
>>> S[-1]
'o'
>>> S[3:]
'lo'
>>> S[2:5]
'llo'
```

Strings … continued

- String objects support concatenation and repetition operations.

```
>>> S + 'World!'
'HelloWorld!'
>>> S + ' World!'
'Hello World!'
>>> S * 4
'HelloHelloHelloHello'
>>> S + ' World! ' * 4
'Hello World!  World!  World!  World! '
>>> (S + ' World! ') * 4
'Hello World! Hello World! Hello World! Hello World! '
```

Lists

- List is a more general sequence object that allows the individual items to be of different types.
- Equivalent to arrays in other languages.
- Lists have no fixed size and can be expanded or contracted as needed.
- Items in list can be retrieved using the index.
- Lists can be nested just like arrays, i.e., you can have a list of lists.

Lists

- Simple list:

```
>>> L = [123, 3.14, 'Hello']
>>> L
[123, 3.1400000000000001, 'Hello']
```

```
>>> L[0]
123
```

- Nested list:

```
>>> DDL = [[1,2,3],
... [4,5,6],
... [7,8,9]]
>>> DDL
[[1, 2, 3], [4, 5, 6], [7, 8, 9]]
```

```
>>> DDL[2][1]
8
```

Dictionaries

- Dictionaries are unordered mappings of 'Name : Value' associations.
- Comparable to hashes and associative arrays in other languages.
- Intended to approximate how humans remember associations

```
>>> D = {'name':'apple','color':'red','taste':'sweet','number':'5'}
>>> D['name']
'apple'
>>> D
{'color': 'red', 'taste': 'sweet', 'name': 'apple', 'number': '5'}
```

Files

- File objects are built for interacting with files on the system.
- Same object used for any file type.
- User has to interpret file content and maintain integrity.

```
>>> f = open('test.txt','w')
>>> f.write('Hello\t')
>>> f.write('world!\n')
>>> f.close()
>>> f = open('test.txt')
>>> text = f.read()
>>> text
'Hello\tworld!\n'
>>> print(text)
Hello   world!
```

Mutable vs. Immutable

- Numbers, strings and tuples are immutable i.,e cannot be directly changed.
- Lists, dictionaries and sets can be changed in place.

```
>>> S[0]
'H'
>>> S[0] = 'h'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'str' object does not support item assignment
>>> L[1]
3.1400000000000001
>>> L[1] = 3.145
```

Tuples

- Tuples are immutable lists.
- Maintain integrity of data during program execution.

Sets

- Special data type introduced since Python 2.4 onwards to support mathematical set theory operations.
- Unordered collection of *unique* items.
- Set itself is mutable, BUT every item in the set has to be an immutable type.
- So, sets can have numbers, strings and tuples as items but cannot have lists or dictionaries as items.