Modularizing Python
Modules & Packages

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Modules
Basics on Modules

A module is a simple text file of Python's statements.

import
Lets a client (importer) fetch a module as a whole

from
Allows clients to fetch particular names from a module

`imp.reload`
Provides a way to reload a module's code without stopping Python

Modules
How Imports Work

Imports are run-time operations that:

1. find the module's file

```
import rectangle
```

   This looks for `rectangle.py` through a standard module search path
2. compile it to byte code (if needed)
   - if a `.pyc` file newer than the found source file python does not recompile the source
   - if only a `.pyc` file is available this is simply loaded
   - compilation occurs at import so only imported modules will leave a `.pyc` file
3. run the module's code to build the objects it defines.

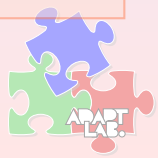
Modules
Python's Module Search Path

Python looks for module in:

1. The home directory of the program
2. `PYTHONPATH` directories (if set)
3. Standard library directories
4. The contents of any `.pth` files (if present)

The concatenation of these four components becomes `sys.path`.

```
[DING!]cazzola@ulik:~/esercizi-pa>python3
>>> import sys
>>> sys.path
['', '/usr/lib/python31.zip', '/usr/lib/python3.1', '/usr/lib/python3.1/plat-linux2',
     '/usr/lib/python3.1/lib-dynload', '/usr/lib/python3.1/site-packages']
```



Modules
Imports Happen Only Once

Modules are imported only once, so, code is executed just at import time.

Let us consider

```
print('hello')
spam = 1        # Initialize variable
```

```
[16:45]cazzola@ulik:~/esercizi-pa>python3
>>> import simple   # First import: loads and runs file's code
hello
>>> simple.spam     # Assignment makes an attribute
1
>>> simple.spam = 2 # Change attribute in module
>>> import simple   # Just fetches already loaded module
>>> simple.spam     # Code wasn't rerun: attribute unchanged
2
```

- the module `simple` is imported just the first time
- the assignment for `spam` in the module is executed only the first time.

Modules
import and from Are Assignments

`import` and `from` are statements not compile-time declarations.

- they may be used in statements, in function definition, ...;
- they are not resolved or run until the execution flow reaches them.

`import` and `from` are assignments:

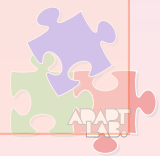
```
x = 1
y = [1, 2]
```

- `import` assigns an entire module object to a single name

```
[23:10]cazzola@ulik:~/esercizi-pa>python3
>>> import small
>>> small
<module 'small' from 'small.py'>
```

- `from` assigns new names to homonyms objects of another module.

```
>>> from small import x, y
>>> x = 42
>>> y[0] = 42
>>> import small
>>> small.x
1
>>> small.y
[42, 2]
```



Modules
"Import" and "From" Equivalence

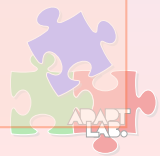
The following

```
from small import x,y   # Copy these two names out (only)
```

is equivalent to

```
import small            # Fetch the module object
x = small.x             # Copy names out by assignment
y = small.y
del small               # Get rid of the module name
```

```
[9:03]cazzola@ulik:~/aux_work/projects/python/esercizi-pa>python3
>>> from small import x,y
>>> small
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'small' is not defined
>>> import small
>>> small
<module 'small' from 'small.py'>
>>> x = small.x
>>> y = small.y
>>> del small
>>> small
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'small' is not defined
>>> x
1
```



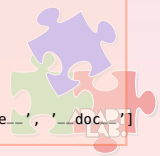
Modules
Module Namespaces

Files generate namespaces

- module statements run once at the first import
- every name that is assigned a value at the top level of a module file becomes an attribute of that module.
- module namespaces can be accessed via `__dict__` or `dir(module)`
- module are single scope (local is global)

```
print('starting to load...')
import sys
name = 42
def func(): pass
print('done loading')
```

```
[23:37]cazzola@ulik:~/esercizi-pa>python3
>>> import module2
starting to load...
done loading
>>> module2.sys
<module 'sys' (built-in)>
>>> module2.name
42
>>> module2.func
<function func at 0xb7a0cbac>
>>> list(module2.__dict__.keys())
['name', '__builtins__', '__file__', '__package__', 'sys', 'func', '__name__', '__doc__']
```



Modules
Module Reload

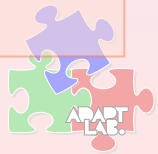
The `imp.reload` function forces an already loaded module's code to be reloaded and rerun.

- Assignments in the file's new code change the existing module object in-place.

```
# changer.py
message = "First version"
def printer():
  print(message)
```

```
# changer.py after the editing
message = "After editing"
def printer():
    print('reloaded:', message)
```

```
[9:57]cazzola@ulik:~/esercizi-pa>python3
>>> import changer
>>> changer.printer()
First version
>>> ^Z
Suspended
[9:57]cazzola@ulik:~/esercizi-pa>gvim changer.py
[9:58]cazzola@ulik:~/esercizi-pa>fg
python3
>>> import changer
>>> changer.printer()
First version
>>> from imp import reload
>>> reload(changer)
<module 'changer' from 'changer.py'>
>>> changer.printer()
reloaded: After editing
```



Packages
Basics on Python's Packages

An **import** can name a directory path.

- A directory of Python code is said to be a **package**, so such imports are known as package imports.
- A package import turns a directory into another Python namespace, with attributes corresponding to the subdirectories and module files that the directory contains.

Packages are organized in directories, e.g., $\texttt{dir}_0/\texttt{dir}_1/\texttt{mod}_0$

- **import**s are independent of the file system conventions, i.e., **import** $\texttt{dir}_0.\texttt{dir}_1.\texttt{mod}_0$ loads $\texttt{dir}_0/\texttt{dir}_1/\texttt{mod}_0$;
- the package must be reachable via the Python's search path mechanism.

Packages
Package __init__.py files

Each directory named within the path of a package import statement must contain a file named `__init__.py`

- They contain standard python code
- They provide a hook for package-initialization-time actions, generate a module namespace for a directory, and support the **from** * when used in combination with package imports.

Package Initialization

The first time Python imports through a directory, it automatically runs all the code in the directory's `__init__.py` file.

Package Namespace Initialization

In the package import model, the directory paths in your script become real nested object paths after an import.

From * Statement Behavior

`__all__` lists in `__init__.py` files can be used to define what is exported when a directory is imported with the **from** * statement form.

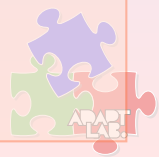
Packages
Package Example

```
# dir0/__init__.py
print('dir0 init')
x = 1
```

```
# dir0/dir1/__init__.py
print('dir1 init')
y = 2
```

```
# dir0/dir1/mod.py
print('in mod.py')
z = 3
```

```
[11:08]cazzola@ulik:~/esercizi-pa>python3
>>> import dir0.dir1.mod
dir0 init
dir1 init
in mod.py
>>> from imp import reload
>>> reload(dir0)
dir0 init
<module 'dir0' from 'dir0/__init__.py'>
>>> reload(dir0.dir1)
dir1 init
<module 'dir0.dir1' from 'dir0/dir1/__init__.py'>
>>> dir0.dir1
<module 'dir0.dir1' from 'dir0/dir1/__init__.py'>
>>> dir0.dir1.mod
<module 'dir0.dir1.mod' from 'dir0/dir1/mod.py'>
>>> dir0.x,dir0.dir1.y,dir0.dir1.mod.z
(1, 2, 3)
>>> from dir0.dir1.mod import z
>>> z
3
>>> import dir0.dir1.mod as mod
>>> mod.z
3
```



Packages
Absolute vs Relative Imports

imports in packages have a slightly different beahvior

- they are absolute with respect to the Python's search path
- to look for modules in the package you have to use the relative path search statement **from** .

```
# mypkg/spam.py
from . import eggs
print(eggs.X)
```

```
# mypkg/eggs.py
X = 99999
import string
print(string)
```

```
[11:33]cazzola@ulik:~/aux_work/projects/python/esercizi-pa>python3
>>> import mypkg.spam
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "mypkg/spam.py", line 2, in <module>
    import eggs
ImportError: No module named eggs
>>> import mypkg.spam
<module 'string' from '/usr/lib/python3.1/string.py'>
99999
>>>
```

Advances on Packages & Modules
Data Hiding & Future Extensions

Data hiding in Python is only a convention

- to prefix a name with a '_' will prevent the **from** * statement to import such a name.
- to assign a list of strings to the __all__ will force the **from** * statement to import only the listed names,

Enabling Future Language Features

Python permits a gradual introduction of new concepts in the language

```
from __future__ import featurename
```

This permits to turn on a novel featured disabled by default

- this is particularly useful for backwards compatibility.

References

- Jennifer Campbell, Paul Gries, Jason Montojo, and Greg Wilson.
  Practical Programming: An Introduction to Computer Science Using Python.
  The Pragmatic Bookshelf, second edition, 2009.
- Mark Pilgrim.
  Dive into Python 3.
  Apress*, 2009.
- Mark Summerfield.
  Programming in Python 3: A Complete Introduction to the Python Language.
  Addison-Wesley, October 2009.