Practical Programming
in Python

Inspired by 'Practical Programming' by Paul Gries, Jennifer Campbell, Jason Montojo

Lecture 14
Object Oriented Programming

User Defined Types, Encapsulation, Polymorphism, Inheritance

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Abstract

> *"You wanted a banana but what you got was a gorilla holding the banana and the entire jungle."*
>
> *– Joe Armstrong*

We have worked with objects from the very beginning of this course. Using objects is not the same as Object Oriented programming. Object Oriented Programming is a programming *paradigm* that is quite fashionable. Practical programmers need to know at least a little bit about it. Good programmers do not blindly follow paradigms. For Python programmers, it is most important to understand *user defined types*.

Overview

- User defined types
- The `Book` type
- Encapsulation
- Polymorphism
- Inheritance
- A case study

We will focus on user defined types. OO design is beyond the scope of this course.

defining your Own Types

- Let’s say we need to keep track of books
- Every record of a book contains things like author, title, publisher price and ISBN

```
python_book = Book(
    'Practical Programming',
    ['Campbell', 'Gries', 'Montojo'],
    'Pragmatic Bookshelf',
    '978-1-93778-545-1',
    25.0)
```

```
survival_book = Book(
    "New Programmer's Survival Manual",
    ['Carter'],
    'Pragmatic Bookshelf',
    '978-1-93435-681-4',
    19.0)
```

```
print('{0}\nwas written by {1} authors.'.format(
    python_book.title,
    python_book.num_authors()))
```

```
print('{0}\nwas written by {1} authors.'.format(
    survival_book.title,
    survival_book.num_authors()))
```

- There is a problem: this code does not run

What does this code do?

Defining Our Own Types

- You might have guessed that we created two objects of type `Book`
- You probably also guess the output:

```
Practical Programming
was written by 3 authors.
```

```
New Programmer's Survival Manual
was written by 3 authors.
```

Python doesn’t know about the `Book` type yet.

Understanding the Problem Domain

- The code expresses what we *want* to do with books
- The idea of the `Book` type comes from the *problem domain*
- The problem domain determines the features we need
- We *decided* what information we need to keep track of
- Often we need multiple related types to reflect the problem domain

OO Design Steps

1. *Understand the problem domain*: you need to know what your users want
2. *Figure out what types you need*: start with the nouns in the problem domain
3. *Write the classes for the types*: you need to tell Python what your types are and what they can do
4. *Test your code*

It is important to think things through *before* you write code.

Another Way to Check for Types

- We have used the function `type` before
- Python also provides the function `isinstance`:

```
>>> isinstance('abc', str)
True
>>> isinstance(51.3, str)
False
```

- Python also has a class `object`
- Every other class is *based on* `object`:

```
>>> isinstance('abc', object)
True
>>> isinstance(51.3, object)
True
```

We say every class is *derived* from class `object`.

The Book Class

- This is the simplest class we can write:

```
>>> class Book:
...     """Information about a book."""
...
```

- Much like `str`, `Book` is a type:

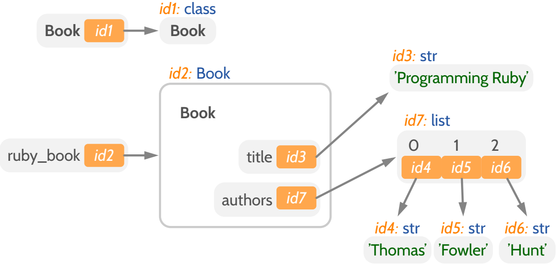
```
>>> type(str)
<class 'str'>
>>> type(Book)
<class 'Book'>
```

The keyword `class` tells Python we are defining a type.

The Book Class

- Let's use our new type:

```
>>> ruby_book = Book()
>>> ruby_book.title = 'Programming Ruby'
>>> ruby_book.authors = ['Thomas',
...     'Fowler',
...     'Hunt']
```



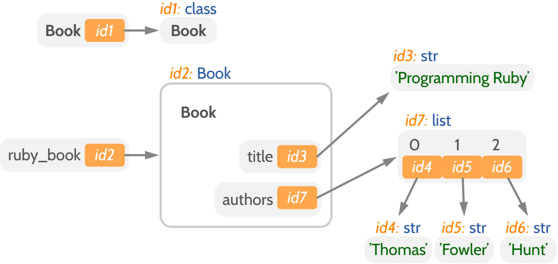
- The first assignment creates a `Book` object
- The second assignment creates `title` variable *inside* the `Book` object
- The third assignment creates another variable *inside* the `Book` object

The variables inside the Book object are called *instance variables*.

The Book Class

- We can access the instance variables like this:

```
>>> ruby_book.title
'Programming Ruby'
>>> ruby_book.authors
['Thomas', 'Fowler', 'Hunt']
```



This is similar to what we learned about modules.

Adding a Method to the Book Class

- We have used methods before:

```
>>> str.capitalize('browning')
'Browning'
>>> 'browning'.capitalize()
'Browning'
```

- We would like to be able to do something like this:

```
>>> Book.num_authors(ruby_book)
3
>>> ruby_book.num_authors()
3
```

Methods define the *behaviour* of classes.

Adding a Method to the Book Class

- We can add a method to the `Book` class as follows:

```
class Book:
    """Information about a book."""

    def num_authors(self):
        """Return the number of authors"""
        return len(self.authors)
```

- Assuming we have a module `book.py`, we can call the method like this:

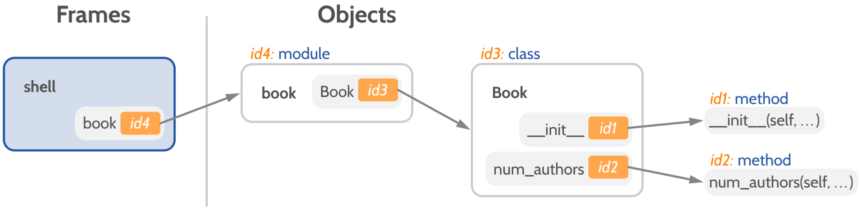
```
import book
>>> ruby_book = book.Book()
>>> ruby_book.title = 'Programming Ruby'
>>> ruby_book.authors = ['Thomas', 'Fowler', 'Hunt']
>>> book.Book.num_authors(ruby_book)
3
>>> ruby_book.num_authors()
3
```

All methods expect a class instance as first argument. The name `self` is a convention.

The book Module

- Let's assume the class is defined in `book.y`
- When we import `book` the definition gets executed

```
>>> import book
```



The class definition is just a complicated statement.

Object Initialization: Constructors

- Previously we have added variables to an object instance
- This is *not* what we normally do
- Instead we add the variables in the *constructor* method
- Constructor methods have a special name: `__init__`

```python
"""Information about a book."""

def __init__(self, title, authors, publisher, isbn, price):
    self.title = title
    self.authors = authors
    self.publisher = publisher
    self.isbn = isbn
    self.price = price
```

You can do anything in a constructor that you can do in other methods.

Object Creation

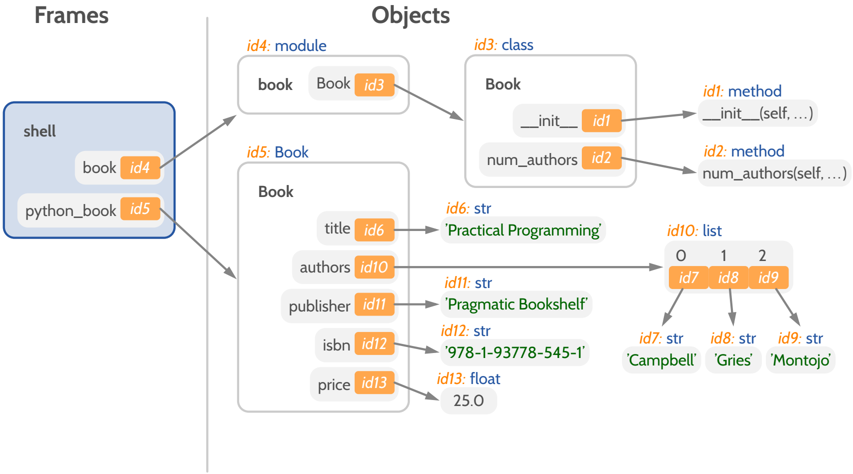
- Python executes the constructor when an object is created:

```
>>> python_book = Book(
        'Practical Programming',
        ['Campbell', 'Gries', 'Montojo'],
        'Pragmatic Bookshelf',
        '978-1-93778-545-1',
        25.0)
```

```
>>> python_book.title
'Practical Programming'
>>> python_book.authors
['Campbell', 'Gries', 'Montojo']
>>> python_book.publisher
'Pragmatic Bookshelf'
>>> python_book.ISBN
'978-1-93778-545-1'
>>> python_book.price
25.0
```

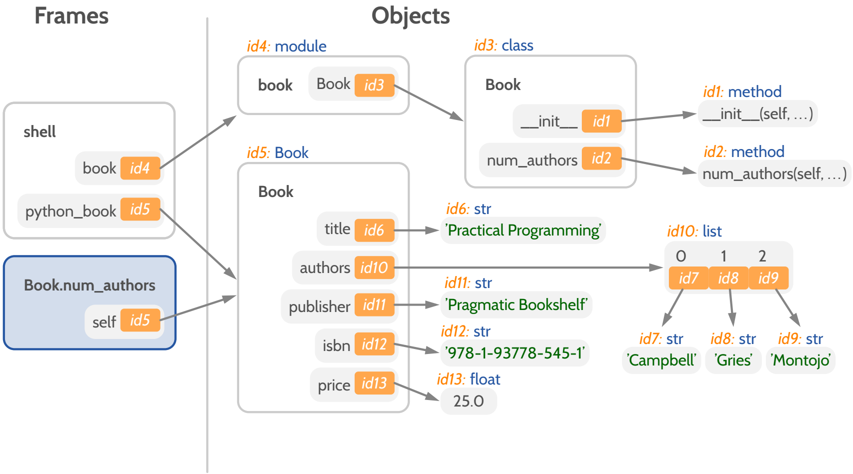
You almost always want to define `__init__` for your classes.

Memory Model After Creating Book Object



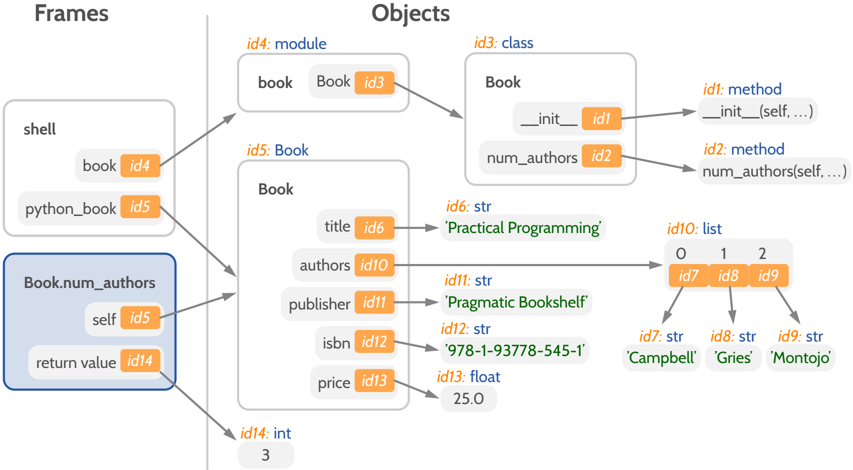
Tracing a Method Call

```
>>> python-book.num_authors()
```



Tracing a Method Call

```
3
```



More Methods Special to Python

- When we print an object the `__str__` is called
- We can write this method for book:

```
def __str__(self):
    return '"{}" ISBN: {}'.format(self.title, self.isbn)
```

- Is common to ask whether to object have equal values
- The operator **==** calls the `__eq__` method.

```
def __eq__(self, other):
    return self.isbn == other.isbn
```

This is an example of *polymorphism*.

Inheritance

- Sometimes classes share a lot of functionality
- Then it is useful to factor out the common things and use *inheritance*

```python
class InstituteMember:

    def __init__(self, name, id):
        self.name = name
        self.id = id
```

```python
class Student(InstituteMember):
    """Student information."""
```

```python
class Professor(InstituteMember):
    """Professor information."""
```

Use with great care.

Exercises Lecture 14