61A Lecture 16

Wednesday, October 8

Announcements

- Project 2 due Thursday 10/9 @ 11:59pm
- Homework 5 due Wednesday 10/15 @ 11:59pm
- Special event on Tuesday 10/14 @ 7pm, John interviews Dropbox CEO/founder Drew Houston
  - No video, so come to Wheeler
  - Suggest questions and vote for your favorites at http://goo.gl/HtkXFf or on Piazza

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Object-Oriented Programming
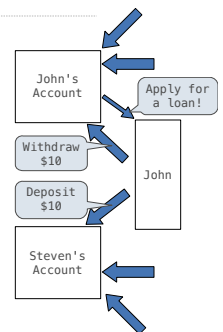

Object-Oriented Programming

A method for organizing modular programs

- Data abstraction
- Bundling together information and related behavior

A metaphor for computation using distributed state

- Each object has its own local state
- Each object also knows how to manage its own local state, based on method calls
- Method calls are messages passed between objects
- Several objects may all be instances of a common type
- Different types may relate to each other

Specialized syntax & vocabulary to support this metaphor

Classes

A class serves as a template for its instances.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

Better idea: All bank accounts share a "withdraw" method and a "deposit" method.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
>>> a.balance
5
>>> a.withdraw(10)
'Insufficient funds'
```

Class Statements

The Class Statement

```
class <name>:
    <suite>
```

The suite is executed when the class statement is executed.

A class statement creates a new class and binds that class to <name> in the first frame of the current environment.

Assignment & def statements in <suite> create attributes of the class (not names in frames)

```
>>> class Clown:
...     nose = 'big and red'
...     def dance():
...         return 'No thanks'
...
>>> Clown.nose
'big and red'
>>> Clown.dance()
'No thanks'
>>> Clown
<class '__main__.Clown'>
```

Object Construction

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each of its instances

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

When a class is called:

1. A new instance of that class is created: `balance: 0    holder: 'Jim'`

2. The __init__ method of the class is called with the new object as its first argument (named self), along with any additional arguments provided in the call expression.

```
class Account:
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```

__init__ is called a constructor

Object Identity

Every object that is an instance of a user-defined class has a unique identity:

```
>>> a = Account('Jim')
>>> b = Account('Jack')
>>> a.balance
0
>>> b.holder
'Jack'
```

> Every call to Account creates a new Account instance. There is only one Account class.

Identity operators "is" and "is not" test if two expressions evaluate to the same object:

```
>>> a is a
True
>>> a is not b
True
```

Binding an object to a new name using assignment does not create a new object:

```
>>> c = a
>>> c is a
True
```

Methods

Methods

Methods are functions defined in the suite of a class statement

```
class Account:
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```

> self should always be bound to an instance of the Account class

```
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
    def withdraw(self, amount):
        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
        return self.balance
```

These def statements create function objects as always, but their names are bound as attributes of the class

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Invoking Methods

All invoked methods have access to the object via the self parameter, and so they can all access and manipulate the object's state.

```
    class Account:
        ...
        def deposit(self, amount):
            self.balance = self.balance + amount
            return self.balance
```

> Defined with two arguments

Dot notation automatically supplies the first argument to a method.

```
>>> tom_account = Account('Tom')
>>> tom_account.deposit(100)
100
```

> Invoked with one argument

Dot Expressions

Objects receive messages via dot notation.

Dot notation accesses attributes of the instance or its class.

<expression> . <name>

The <expression> can be any valid Python expression.

The <name> must be a simple name.

Evaluates to the value of the attribute looked up by <name> in the object that is the value of the <expression>.

```
tom_account.deposit(10)
```

> Dot expression   Call expression

(Demo)

Attributes

Accessing Attributes

Using getattr, we can look up an attribute using a string

```
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```

getattr and dot expressions look up a name in the same way

Looking up an attribute name in an object may return:

- One of its instance attributes, or

- One of the attributes of its class

Methods and Functions

Python distinguishes between:

- Functions, which we have been creating since the beginning of the course, and
- Bound methods, which couple together a function and the object on which that method will be invoked.

Object + Function = Bound Method

```
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
<class 'method'>

>>> Account.deposit(tom_account, 1001)
1011
>>> tom_account.deposit(1003)
2014
```

> **Function:** all arguments within parentheses

> **Method:** One object before the dot and other arguments within parentheses

Looking Up Attributes by Name

<center><expression> . <name></center>

To evaluate a dot expression:

1. Evaluate the <expression> to the left of the dot, which yields the object of the dot expression.

2. <name> is matched against the instance attributes of that object; if an attribute with that name exists, its value is returned.

3. If not, <name> is looked up in the class, which yields a class attribute value.

4. That value is returned unless it is a function, in which case a bound method is returned instead.

Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance.

```
class Account:
    interest = 0.02   # A class attribute
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    # Additional methods would be defined here
```

```
>>> tom_account = Account('Tom')
>>> jim_account = Account('Jim')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
```

The **interest** attribute is *not* part of the instance; it's part of the class!

Attribute Assignment

Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

- If the object is an instance, then assignment sets an instance attribute

- If the object is a class, then assignment sets a class attribute

```
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
>>> Account.interest = 0.04
>>> tom_account.interest
0.04
```

```
>>> jim_account.interest = 0.08
>>> jim_account.interest
0.08
>>> tom_account.interest
0.04
>>> Account.interest = 0.05
>>> tom_account.interest
0.05
>>> jim_account.interest
0.08
```