

61A Lecture 15

Monday, October 7

Announcements

- Homework 4 due Tuesday 10/8 @ 11:59pm.
- Project 2 due Thursday 10/10 @ 11:59pm.
- Homework 5 due Tuesday 10/15 @ 11:59pm.
- Extra reader office hours this week in **405 Soda**:
 - Tuesday 6–8pm, Wednesday 5:30–7pm, Thursday 5–7pm
 - (You can also go to regular office hours with questions about your project.)
- Guest lecture on Wednesday 10/9, Peter Norvig on Natural Language Processing in Python.
 - No video (except a screencast). Come to Wheeler!

Object-Oriented Programming

Object-Oriented Programming

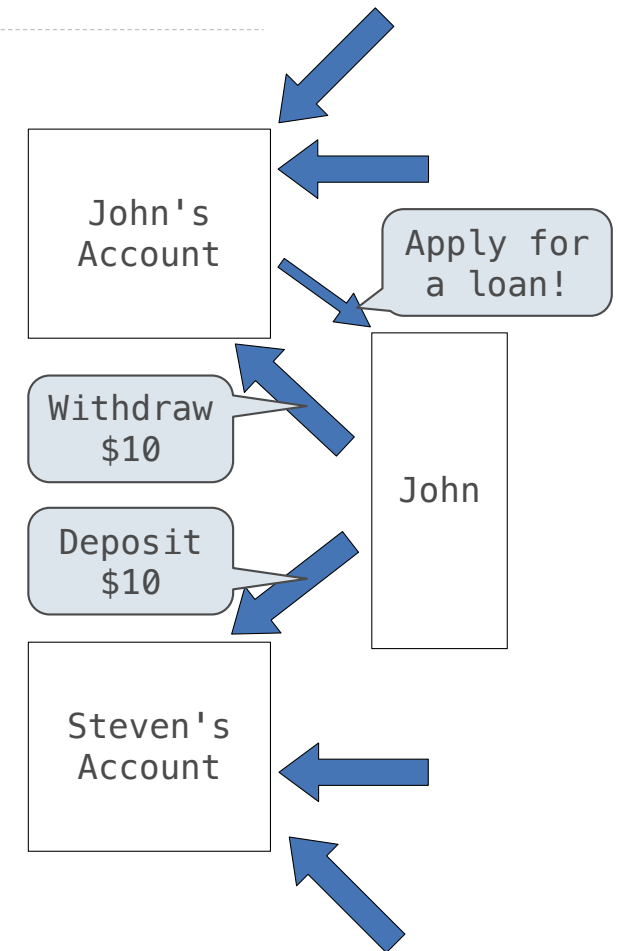
A method for organizing modular programs

- Abstraction barriers
- 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.

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

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

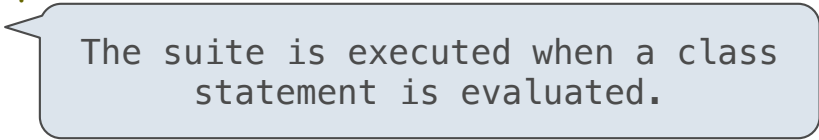
```
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
>>> a.balance
5
>>> a.withdraw(10)
'Insufficient funds'
```

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

Class Statements

The Class Statement

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



The suite is executed when a class statement is evaluated.

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

Statements in the `<suite>` create attributes of the class.

As soon as an instance is created, it is passed to `__init__`, which is an attribute of the class called the *constructor method*.

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

Initialization

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 constructor `__init__` 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
```


Object Identity

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

```
>>> a = Account('Jim')
>>> b = Account('Jack')
```

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

Identity testing is performed by "is" and "is not" operators:

```
>>> 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 defined in the suite of a class statement

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

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

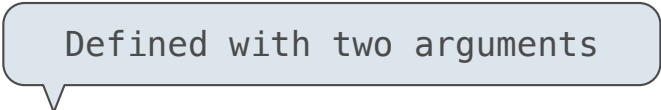
    def withdraw(self, amount):
        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
        return self.balance
```

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

Invoking Methods

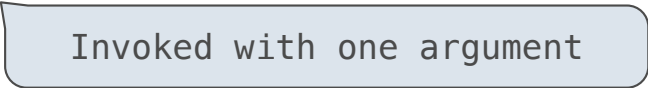
All invoked methods have access to the object via the `self` parameter, and so they can all access and manipulate the object's state.

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



Dot notation automatically supplies the first argument to a method.

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



Dot Expressions

Objects receive messages via dot notation.

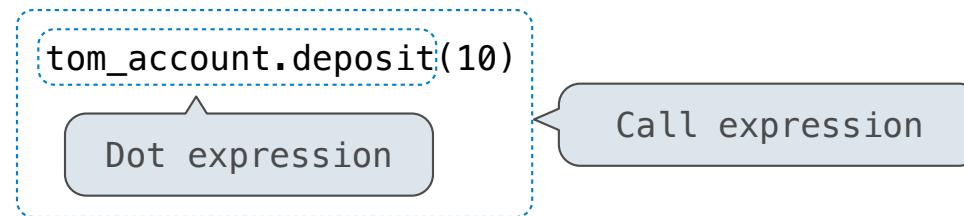
Dot notation accesses attributes of the instance **or** its class.

`<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>`.



(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(1000)
2011
```


Looking Up Attributes by Name

`<expression> . <name>`

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
```

interest is not part of the instance that was somehow copied from 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
```