61A Lecture 14

Wednesday, February 25

Announcements

- Project 2 due Thursday 2/26 @ 11:59pm
  - Extra office hours on Wednesday 2/25 4pm–6pm in Bechtel (Garbarini Lounge)
  - Bonus point for early submission by Wednesday 2/25 @ 11:59pm!
- Relocated office hours on Thursday 2/26: 380 Soda (11am–3pm) & 606 Soda (3pm–6pm)

Object-Oriented Programming

Object-Oriented Programming

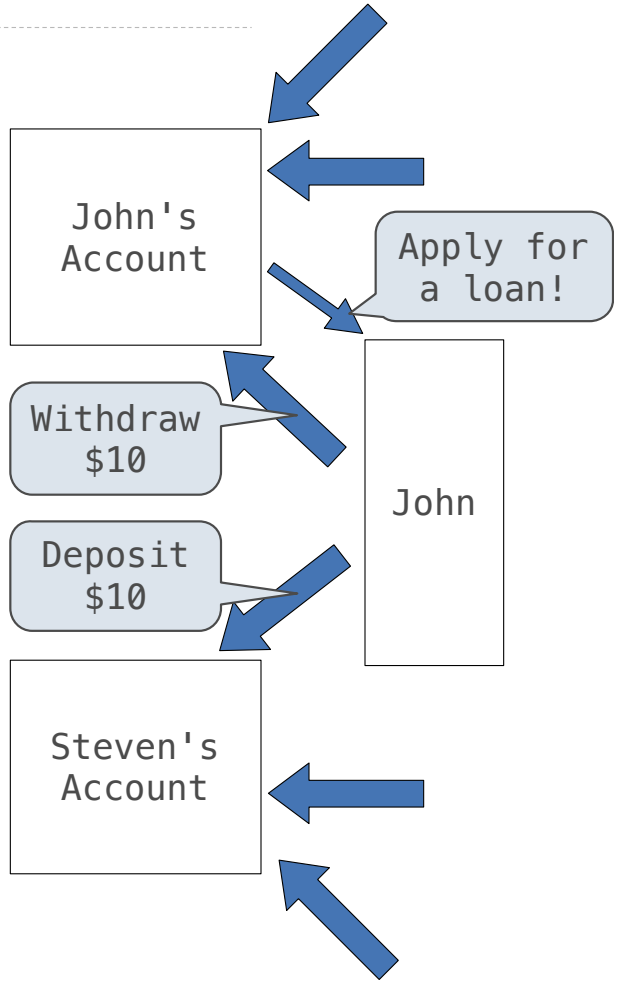
A method for organizing programs

- 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.

```
>>> 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 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'>
```

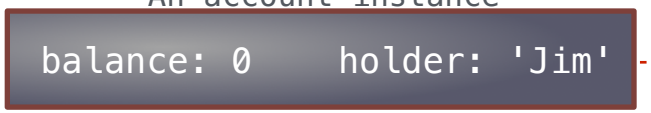
Object Construction

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:



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

    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
```

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

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
```

Defined with two parameters

Dot notation automatically supplies the first argument to a method.

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

Bound to self

Invoked with one argument

Dot Expressions

Objects receive messages via dot notation.

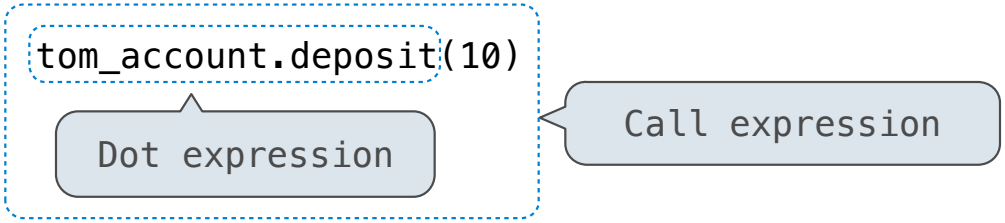
Dot notation accesses attributes of the instance or its class.

<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>.



(Demo)

Attributes

(Demo)

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

<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
```

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

Attribute Assignment

Assignment to 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

```
class Account:
    interest = 0.02
    def __init__(self, holder):
        self.holder = holder
        self.balance = 0
    ...

tom_account = Account('Tom')
```

Instance Attribute Assignment :

```
tom_account.interest = 0.08
```

This expression evaluates to an object

But the name ("interest") is not looked up

Attribute assignment statement adds or modifies the attribute named "interest" of tom_account

Class Attribute Assignment :

```
Account.interest = 0.04
```

Attribute Assignment Statements

Account class attributes

```
interest: 0.02  0.04  0.05
(withdraw, deposit, __init__)
```

Instance attributes of jim_account

```
balance:  0
holder:   'Jim'
interest: 0.08
```

Instance attributes of tom_account

```
balance:  0
holder:   'Tom'
```

```
>>> 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
0.04
```

```
>>> 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
```