UC Berkeley's CS61A – Lecture 16 – Objects

https://techcrunch.com/2019/02/27/the-shadow-ghost-turns-cloud-gaming-into-a-seamless-experience/

"French startup Blade, the company behind Shadow, is launching a new set-top box to access its cloud gaming service — the Shadow Ghost… Shadow is a cloud computing service for gamers. For $35 per month, you can access a gaming PC in a data center and interact with this computer. Right now, Shadow gives you eight threads on an Intel Xeon 2620 processor, an Nvidia Quadro P5000 GPU that performs more or less as well as an Nvidia GeForce GTX 1080, 12GB of RAM and 256GB of storage. You can optionally get more storage with an extra subscription. It's a full Windows 10 instance and you can do whatever you want with it."

tldr; It's now becoming increasingly possible for users with cheap computers and suboptimal hardware to experience crisp, gorgeous graphics using **cloud computing** (doing heavy computation on the server). Also, shameless plug for CS 184, where you can learn about the computing subfield of graphics.

Announcements

- Homework 4 is due today (3/1)

- Guerrilla Section this Saturday 3/2 12-2PM, Soda 271

- CS Mentors Sections
  - Small sections designed to help you get more individual attention
  - See @684 on Piazza
  - You can still sign up at https://scheduler.csmentors.org/

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

Dan's Account

Dan

Withdraw $10

Deposit $10

Gibbes's Account

Message "thx Dan!"
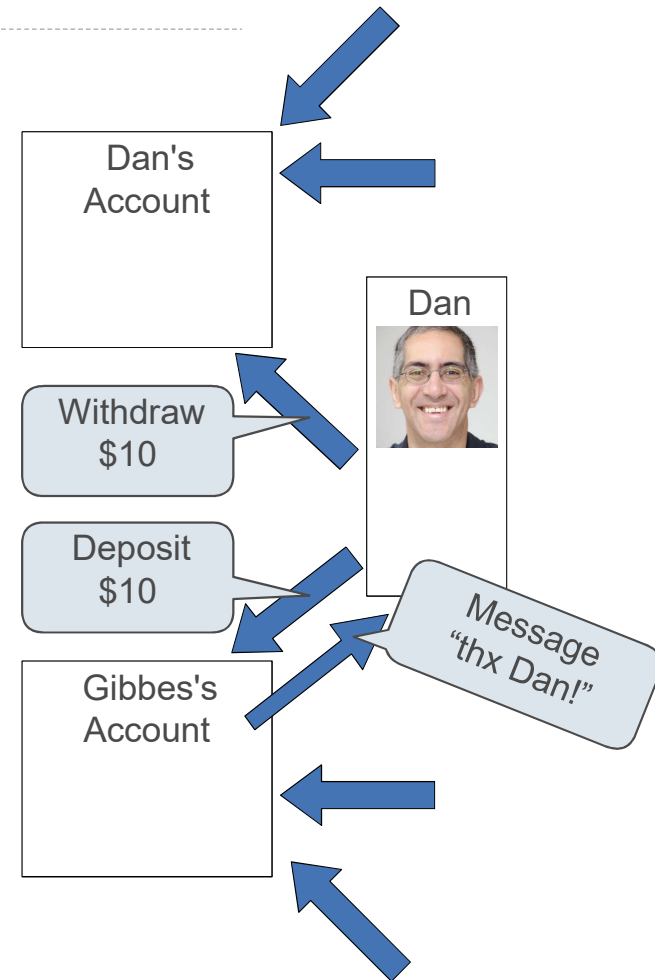
Classes

A class describes the general behavior of 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('Dan')
>>> a.holder
'Dan'
>>> a.balance
0
```

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.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('Oski')
>>> a.holder
'Oski'
>>> a.balance
0
```

When a class is called:

An account instance

1. A new instance of that class is created: | balance: 0   holder: 'Oski' |

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('Dan')
>>> b = Account('Gibbes')
>>> a.balance
0
>>> b.holder
'Gibbes'

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

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

Bound methods automatically supply the first argument during a function call

```
>>> oski_account = Account('Oski')
>>> oski_account.deposit(100)
100
```

Bound to self

Invoked with one argument

Dot Expressions
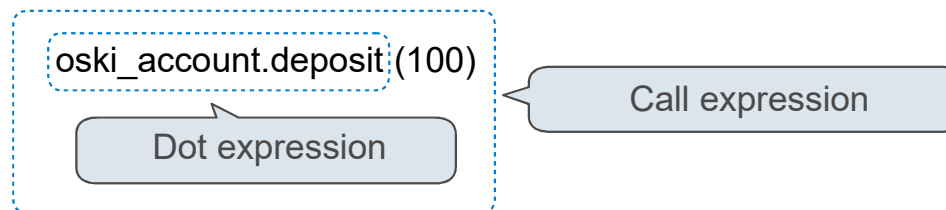
Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

<div align="center"><expression> . <name></div>

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>

oski_account.deposit (100)

Dot expression

Call expression

Attributes

(Demo)

Accessing Attributes

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

```
>>> getattr(oski_account, 'balance')
100
>>> hasattr(oski_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 Instance + Function = Bound Method

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

```
>>> Account.deposit(oski_account, 912)
1012
>>> oski_account.deposit(1007)
2019
```

Function: all arguments within parentheses

Method: instance 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

```python
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

>>> dan_account = Account('Dan')
>>> gibbes_account = Account('Gibbes')
>>> gibbes_account.interest
0.02
>>> dan_account.interest
0.02
```

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

Summary

- Object-oriented programming (OOP) is a programming paradigm that emphasizes re-usability and distributed state: an object stores and modifies its own local state.

- Objects have attributes. Specifically, classes store "class attributes" that get passed down to instances as "instance attributes" that can be further customized per instance.

- When you construct an instance (a.k.a. call __init__ using <class>(<args>)), the **functions** stored in the class become **bound methods**.