Lecture 15: Object-Oriented Programming

Brian Hou
July 18, 2016

Announcements

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  - May cover mutability, object-oriented programming
- Midterm grades are released, regrade requests due tonight

Roadmap

Introduction

Functions

Data

Mutability

Objects

Interpretation

Paradigms

Applications

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  - To learn the paradigm of *object-oriented programming*

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Applications

- This week (Objects), the goals are:
  - To learn the paradigm of *object-oriented programming*
  - To study applications of, and problems that be solved using, OOP

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  - Program organization

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- A new programming paradigm: think in terms of *objects*
  - Objects have attributes and can take actions
  - Objects can interact with each other
- Computations are the result of interactions between objects

Classes

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Brian is a Human

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Brian has a name and an age

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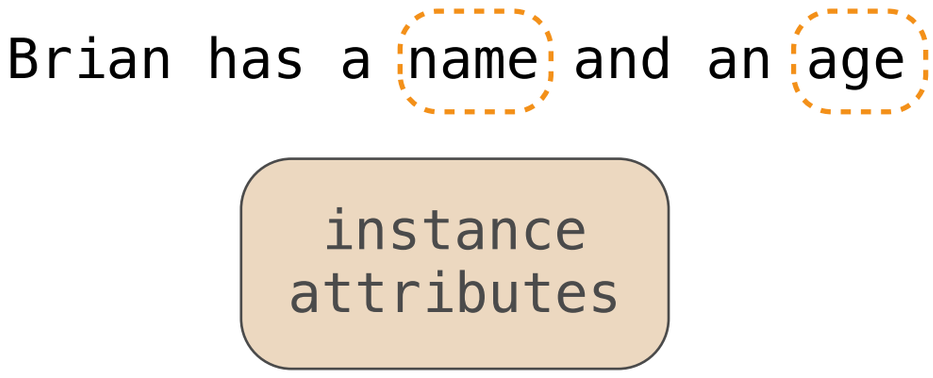

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- When executing a **class** statement, Python creates a new frame and executes the statements in <suite> (typically assignment and **def** statements)
- Once all the statements in <suite> have been executed, a new class with those bindings is created and bound to <name> in the first frame of the original environment

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`__init__` is called a constructor

An account instance

balance: 0 holder: 'Brian'

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>>> a.holder
'Brian'
>>> b.holder
'Marvin'
>>> a is b
False
```

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Every call to Account creates a new Account instance.

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Every call to Account creates a new Account instance.

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

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>>> c = a
>>> c is a
True
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    def deposit(self, amount):
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self should always be bound to an instance of the Account class

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Invoking Methods (demo)

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

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

Dot notation automatically passes the first argument to a method

Invoking Methods (demo)

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>>> a1 = Account('Brian')
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```
>>> a2 = Account('Brian')
>>> Account.deposit(a2, 100)
100
```

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Bound to self

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Invoked with one argument

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100
```

Bound to self

Invoked with one argument

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100
```

Invoked with two arguments

Attributes

Dot Notation

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Call expression

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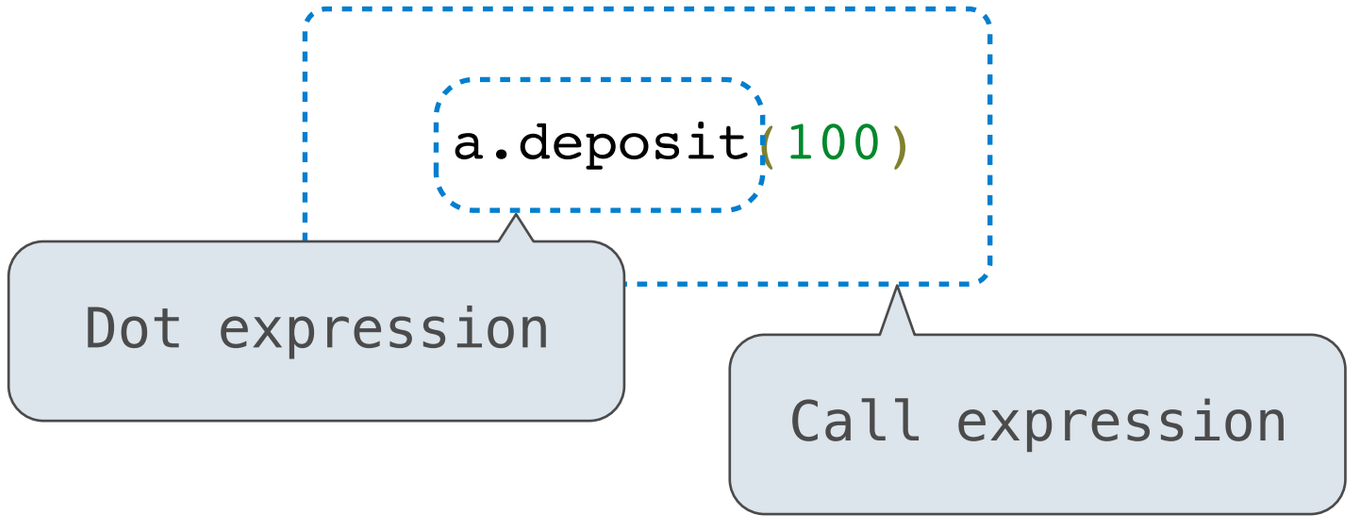

Accessing Attributes

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Methods and Functions

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>>> a = Account('Brian')
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<class 'function'>
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<class 'function'>
>>> type(a.deposit)
<class 'method'>
>>> Account.deposit(a, 100)
100
```

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Function: all arguments are within parentheses

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>>> type(Account.deposit)
<class 'function'>
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<class 'method'>
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100
>>> a.deposit(100)
200
```

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Methods and Functions (demo)

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  - *Bound methods*, which combines a function and the instance on which that function will be invoked

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>>> a = Account('Brian')
>>> type(Account.deposit)
<class 'function'>
>>> type(a.deposit)
<class 'method'>
>>> Account.deposit(a, 100)
100
>>> a.deposit(100)
200
```

Function: all arguments are within parentheses

Method: one argument (self) before the dot and other arguments within parentheses

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class Account:
    interest = 0.02
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class Account:
    interest = 0.02
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        self.balance = 0
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class Account:
    interest = 0.02
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class Account:
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Class Attributes (demo)

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

```
>>> a = Account('Brian')
>>> b = Account('Marvin')
>>> a.interest
0.02
>>> b.interest
0.02
```

Class Attributes (demo)

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

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

```
>>> a = Account('Brian')
>>> b = Account('Marvin')
>>> a.interest
0.02
>>> b.interest
0.02
```

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

Evaluating Dot Expressions

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- <name> is matched against the instance attributes of that object; if an attribute with that name exists, its value is returned
- If not, <name> is looked up in the class, which yields a class attribute value
- That value is returned unless it is a function, in which case a bound method is returned instead

Break!

Inheritance

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class <new class>(<base class>):
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```

- The new class *shares* attributes with the base class (inherits attributes of its base class)
- The new class *overrides* certain inherited attributes
- Implementing the new class is now as simple as specifying how it’s *different* from the base class

Inheritance Example

```
class Account:
    """A bank account."""
    ...
```

```
class CheckingAccount(Account):
    """A checking account."""
    ...
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Inheritance Example

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class Account:
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class Account:
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- Bank accounts have:
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  - an interest rate of 2%

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class Account:
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Inheritance Example

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- Bank accounts have:
  - an account holder
  - a balance
  - an interest rate of 2%
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  - deposit to an account

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  - an interest rate of **1%**
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- You can:
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Inheritance Example (demo)

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class Account:
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  - an interest rate of **1%**
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  - deposit to an account
  - withdraw from an account **(but there's a fee!)**

Attribute Lookup on Classes

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Base class attributes *aren't* copied into subclasses!

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>>> ch = CheckingAccount('Marvin')
```

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>>> ch = CheckingAccount('Marvin')    # Account.__init__
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>>> ch = CheckingAccount('Marvin')    # Account.__init__
>>> ch.interest
```

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>>> ch = CheckingAccount('Marvin')    # Account.__init__
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>>> ch = CheckingAccount('Marvin')    # Account.__init__
>>> ch.interest                       # Found in CheckingAccount
0.01
```

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>>> ch.interest                       # Found in CheckingAccount
0.01
>>> ch.deposit(20)
```

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>>> ch = CheckingAccount('Marvin')    # Account.__init__
>>> ch.interest                       # Found in CheckingAccount
0.01
>>> ch.deposit(20)                    # Found in Account
20
>>> ch.withdraw(5)
```

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14
```

Attribute Lookup on Classes (demo)

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0.01
>>> ch.deposit(20)                    # Found in Account
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>>> ch.withdraw(5)                    # Found in CheckingAccount
14
```

Designing for Inheritance

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- Don't repeat yourself; use existing implementations

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```
class CheckingAccount(Account):
    withdraw_fee = 1
    interest = 0.01
    def withdraw(self, amount):
        return Account.withdraw(self,
                                amount + self.withdraw_fee)
```

Designing for Inheritance

- Don't repeat yourself; use existing implementations
- Attributes that have been overridden are still accessible via class objects

```
class CheckingAccount(Account):
    withdraw_fee = 1
    interest = 0.01
    def withdraw(self, amount):
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Designing for Inheritance

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Attribute look-up on base class

Designing for Inheritance

- Don't repeat yourself; use existing implementations
- Attributes that have been overridden are still accessible via class objects
- Look up attributes on instances whenever possible

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class CheckingAccount(Account):
    withdraw_fee = 1
    interest = 0.01
    def withdraw(self, amount):
        return Account.withdraw(self,
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Attribute look-up on base class

Designing for Inheritance

- Don't repeat yourself; use existing implementations
- Attributes that have been overridden are still accessible via class objects
- Look up attributes on instances whenever possible

```
class CheckingAccount(Account):
    withdraw_fee = 1
    interest = 0.01
    def withdraw(self, amount):
        return Account.withdraw(self,
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```

Attribute look-up on base class

Preferred to CheckingAccount.withdraw_fee to allow for further specialization

Summary

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- Inheritance is a powerful tool for further extending these user-defined data types