61A Lecture 16

Wednesday, October 3

Terminology: Attributes, Functions, and Methods

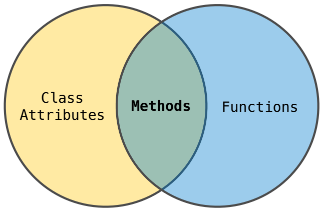
All objects have attributes, which are name-value pairs

Classes are objects too, so they have attributes

Instance attributes: attributes of instance objects

Class attributes: attributes of class objects

Terminology:



Python object system:

Functions are objects.

Bound methods are also objects: a function that has its first parameter "self" already bound to an instance.

Dot expressions evaluate to bound methods for class attributes that are functions.

Looking Up Attributes by Name (Abbreviated)

<expression> . <name>

To evaluate a dot expression:

1. Evaluate the <expression>.
2. <name> is matched against the instance attributes.
3. If not found, <name> is looked up in the class.
4. That class attribute value is returned **unless it is a function**, in which case a *bound method* is returned.

Class Attributes

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

```
class Account(object):

    interest = 0.02        # Class attribute

    def __init__(self, account_holder):
        self.balance = 0   # Instance attribute
        self.holder = account_holder

    # Additional methods would be defined here
```

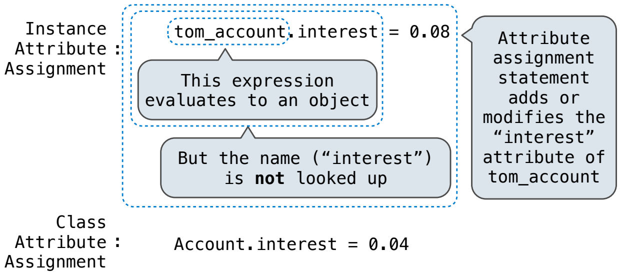
```
>>> tom_account = Account('Tom')
>>> jim_account = Account('Jim')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
```

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

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



Instance Attribute : Assignment

tom_account.interest = 0.08

This expression evaluates to an object

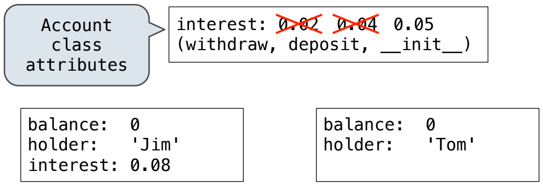
But the name (“interest”) is **not** looked up

Attribute assignment statement adds or modifies the “interest” attribute 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__)

balance: 0
holder: 'Jim'
interest: 0.08

balance: 0
holder: 'Tom'

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

Inheritance

A technique for relating classes together

Common use: Similar classes differ in amount of specialization

Two classes have overlapping attribute sets, but one represents a special case of the other.

```
class <name>(<base class>):
    <suite>
```

Conceptually, the new *subclass* "shares" attributes with its base class.

The subclass may *override* certain inherited attributes.

Using inheritance, we implement a subclass by specifying its difference from the the base class.

Inheritance Example

A CheckingAccount is a specialized type of Account.

```
>>> ch = CheckingAccount('Tom')
>>> ch.interest     # Lower interest rate for checking accounts
0.01
>>> ch.deposit(20)  # Deposits are the same
20
>>> ch.withdraw(5)  # Withdrawals incur a $1 fee
14
```

Most behavior is shared with the base class Account

```
class CheckingAccount(Account):
    """A bank account that charges for withdrawals."""
    withdraw_fee = 1
    interest = 0.01
    def withdraw(self, amount):
        return Account.withdraw(self, amount + self.withdraw_fee)
```

Looking Up Attribute Names on Classes

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

To look up a name in a class.

1. If it names an attribute in the class, return the attribute value.

2. Otherwise, look up the name in the base class, if there is one.

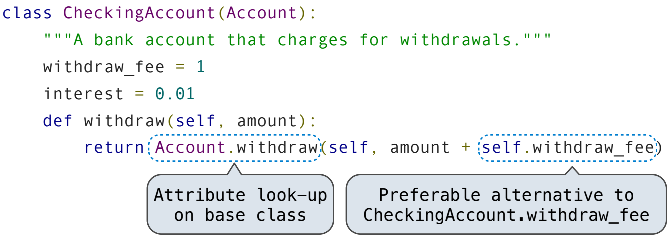
```
>>> ch = CheckingAccount('Tom')  # Calls Account.__init__
>>> ch.interest     # Found in CheckingAccount
0.01
>>> ch.deposit(20)  # Found in Account
20
>>> ch.withdraw(5)  # Found in CheckingAccount
14
```

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):
    """A bank account that charges for withdrawals."""
    withdraw_fee = 1
    interest = 0.01
    def withdraw(self, amount):
        return Account.withdraw(self, amount + self.withdraw_fee)
```

Attribute look-up on base class
Preferable alternative to CheckingAccount.withdraw_fee

Designing for Inheritance: General Base Classes

Base classes may contain logic that is meant for subclasses.

Example: Same CheckingAccount behavior; different approach

Demo

Inheritance and Composition

Object-oriented programming shines when we adopt the metaphor.

Inheritance is best for representing *is-a* relationships.

E.g., a checking account **is a** specific type of account.

So, CheckingAccount inherits from Account.

Composition is best for representing *has-a* relationships.

E.g., a bank **has a** collection of bank accounts it manages.

So, A bank has a list of Account instances as an attribute.

No local state at all? Just write a pure function!

Multiple Inheritance

```
class SavingsAccount(Account):
    deposit_fee = 2
    def deposit(self, amount):
        return Account.deposit(self, amount - self.deposit_fee)
```

A class may inherit from multiple base classes in Python.

CleverBank marketing executive wants:

- Low interest rate of 1%
- A $1 fee for withdrawals
- A $2 fee for deposits
- A free dollar when you open your account

```
class AsSeenOnTVAccount(CheckingAccount, SavingsAccount):
    def __init__(self, account_holder):
        self.holder = account_holder
        self.balance = 1             # A free dollar!
```

Multiple Inheritance

A class may inherit from multiple base classes in Python.

```
class AsSeenOnTVAccount(CheckingAccount, SavingsAccount):
    def __init__(self, account_holder):
        self.holder = account_holder
        self.balance = 1             # A free dollar!
```

Instance attribute

```
>>> such_a_deal = AsSeenOnTVAccount("John")
>>> such_a_deal.balance
1
```

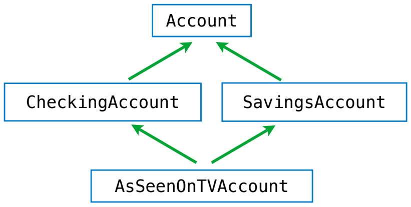
SavingsAccount method

```
>>> such_a_deal.deposit(20)
19
```

CheckingAccount method

```
>>> such_a_deal.withdraw(5)
13
```

Resolving Ambiguous Class Attribute Names



Instance attribute

```
>>> such_a_deal = AsSeenOnTVAccount("John")
>>> such_a_deal.balance
1
```

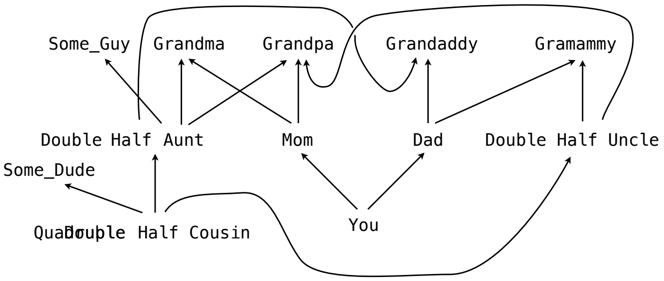
SavingsAccount method

```
>>> such_a_deal.deposit(20)
19
```

CheckingAccount method

```
>>> such_a_deal.withdraw(5)
13
```

Human Relationships


Some_Guy
Grandma
Grandpa
Grandaddy
Gramammy
Double Half Aunt
Mom
Dad
Double Half Uncle
Some_Dude
Quadruple Half Cousin
Double Half Cousin
You