Inheritance

Announcements

Attributes

Terminology: Attributes, Functions, and Methods

All objects have attributes, which are name-value pairs

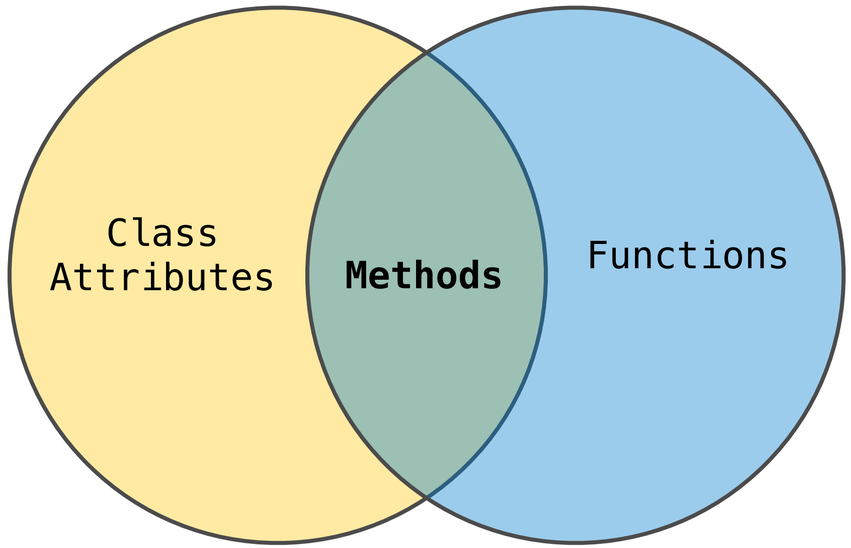
A class is a type (or category) of objects

Classes are objects too, so they have attributes

Instance attribute: attribute of an instance

Class attribute: attribute of the class of an instance

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

<instance>.<method_name>

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

A class attribute can be accessed from either an instance or its class. There is only one value for a class attribute, regardless of how many instances.

```
class Transaction:
    """A logged transaction.

    >>> s = [20, -3, -4]
    >>> ts = [Transaction(x) for x in s]
    >>> ts[1].balance()
    17
    >>> ts[2].balance()
    13
    """
    log = []

    def __init__(self, amount):
        self.amount = amount
        self.prior = _______________
        self.log.append(self)

    def balance(self):
        return self.amount + _________________
```

Always bound to some Transaction instance

(Demo)

Class Attributes

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```
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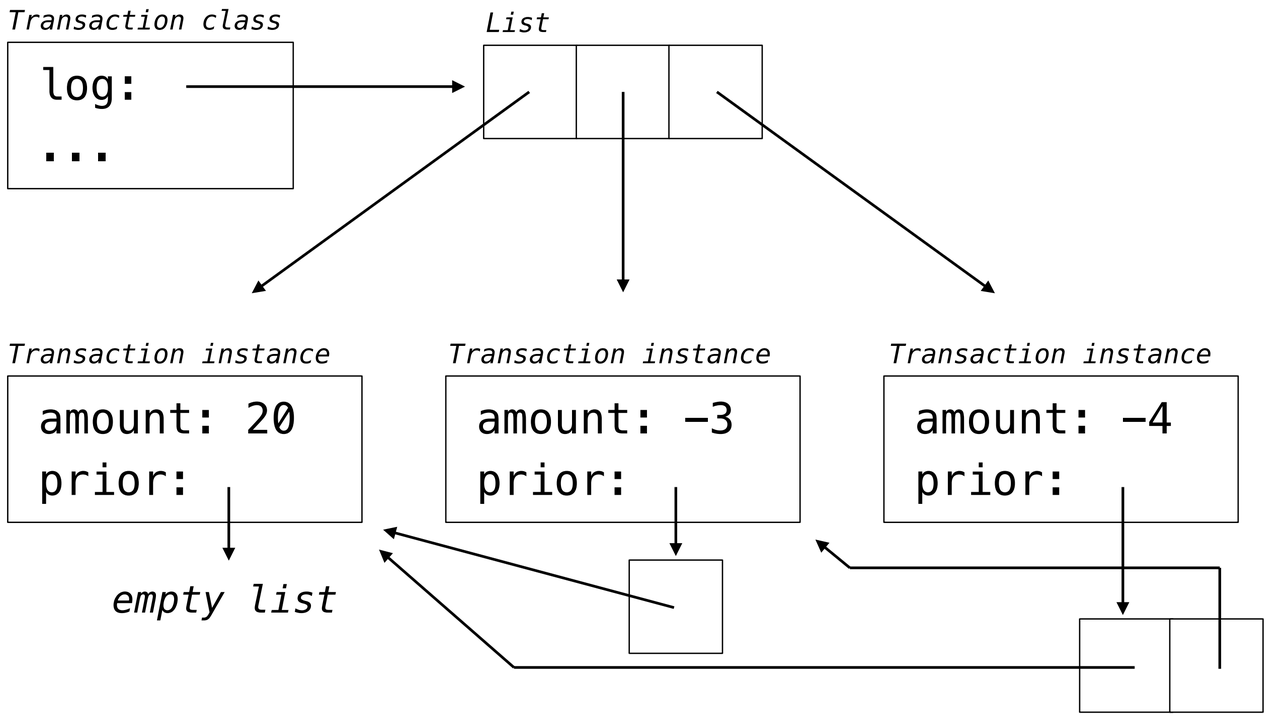
    """A logged transaction.

    >>> s = [20, -3, -4]
    >>> ts = [Transaction(x) for x in s]
    >>> ts[1].balance()
    17
    >>> ts[2].balance()
    13
    """
    log = []

    def __init__(self, amount):
        self.amount = amount
        self.prior = list(self.log)
        self.log.append(self)

    def balance(self):
        return self.amount + sum([t.amount for t in self.prior])
```

Always bound to some Transaction instance



Equivalently: list(type(self).log)

(Demo)

Class Attributes (an alternative implementation)

A class attribute can be accessed from either an instance or its class. There is only one value for a class attribute, regardless of how many instances.

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class Transaction:
    """A logged transaction.

    >>> s = [20, -3, -4]
    >>> ts = [Transaction(x) for x in s]
    >>> ts[1].balance()
    17
    >>> ts[2].balance()
    13
    """
    log = []

    def __init__(self, amount):
        self.amount = amount
        self.log.append(self)
        self.lst = list(self.log)

    def balance(self):
        return sum([t.amount for t in self.lst])
```

(Demo)

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
```

Practice: Attributes

https://pythontutor.com/cp/composingprograms.html#code=Foo%20%3D%201%0A%0Aclass%20Foo%3A%0A%20%20%20%20bar%20%3D%202%0A%20%20%20%20%0A%20%20%20%20def%20__init__%28self,%20baz,
%20qux%29%3A%0A%20%20%20%20%20%20%20%20self.baz%20%3D%20baz%0A%20%20%20%20%20%20%20%20Foo.bar%20%3D%20qux%0A%0A%20%20%20%20def%20a%28self,
%20x%29%3A%0A%20%20%20%20%20%20%20%20self.bar%20%3D%20x%0A%0Aa%20%3D%20Foo%283,%204%29%0Ab%20%3D%20a.a%0Aprint%28a.bar%29%0Ab%285%29%0Aprint%28a.bar%29%0AFoo.bar%20%3D%206%0Aprint%28a.bar%29%0A%0A%20%20%20%20%20%20%20%20%0A%20%20%20%20%20%20%20%20%20%20&cumulative=tru
mode=edit&origin=composingprograms.js&py=3&rawInputLstJSON=%5B%5D

Inheritance

Inheritance

Inheritance is a technique for relating classes together

A common use: Two similar classes differ in their degree of specialization

The specialized class may have the same attributes as the general class, along with some special-case behavior

```
class <Name>(<Base Class>):
    <suite>
```

Conceptually, the new subclass inherits attributes of its base class

The subclass may override certain inherited attributes

Using inheritance, we implement a subclass by specifying its differences 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)
```

or

```
        return super().withdraw(      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
```

(Demo)

Object-Oriented Design

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

Preferred to CheckingAccount.withdraw_fee to allow for specialized accounts

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 accounts as an attribute

(Demo)

Example: Three Attributes

```
class A:
    x, y, z = 0, 1, 2

    def f(self):
        return [self.x, self.y, self.z]

class B(A):
    """What would Python Do?

    >>> A().f()

    [0, 1, 2]

    >>> B().f()
     [6, 1, 'A']
    ______________

    """
    x = 6
    def __init__(self):
        self.z = 'A'
```

A class

x: 0
y: 1
z: 2

B class

x: 6

A instance

B instance

z: 'A'

Multiple Inheritance

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 has an idea:

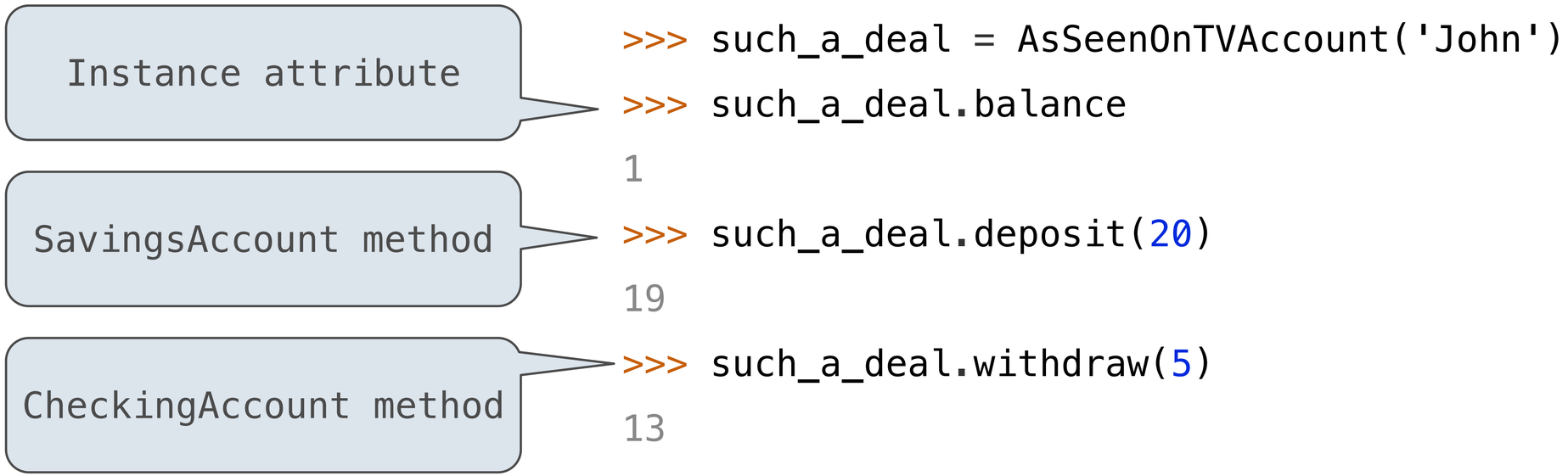
- Low interest rate of 1%
- A $1 fee for withdrawals
- A $2 fee for deposits
- A free dollar when you open your account

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

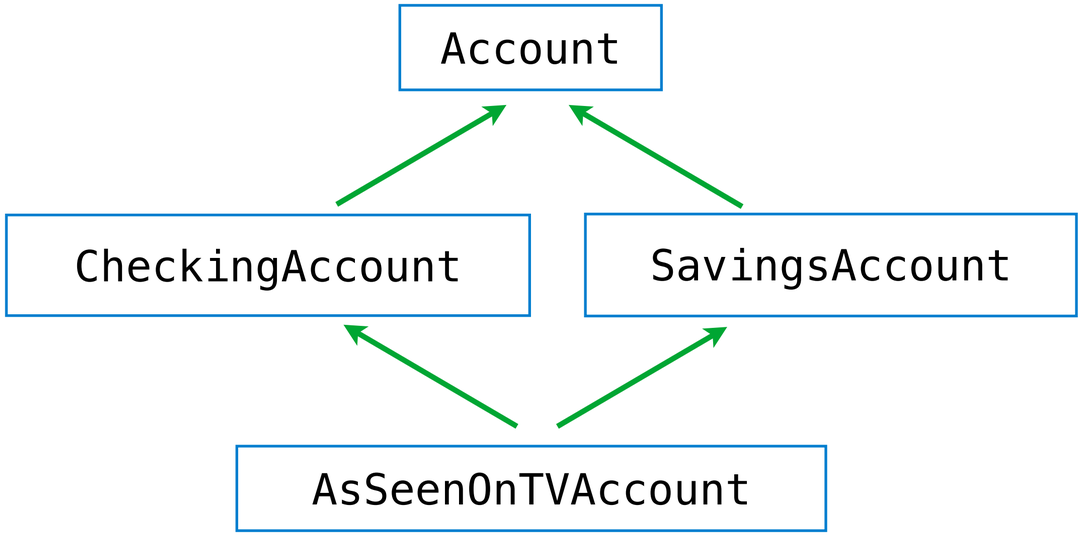
Multiple Inheritance

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!
```



Resolving Ambiguous Class Attribute Names



Instance attribute

SavingsAccount method

CheckingAccount method

```
>>> such_a_deal = AsSeenOnTVAccount('John')
>>> such_a_deal.balance
1
>>> such_a_deal.deposit(20)
19
>>> such_a_deal.withdraw(5)
13
```