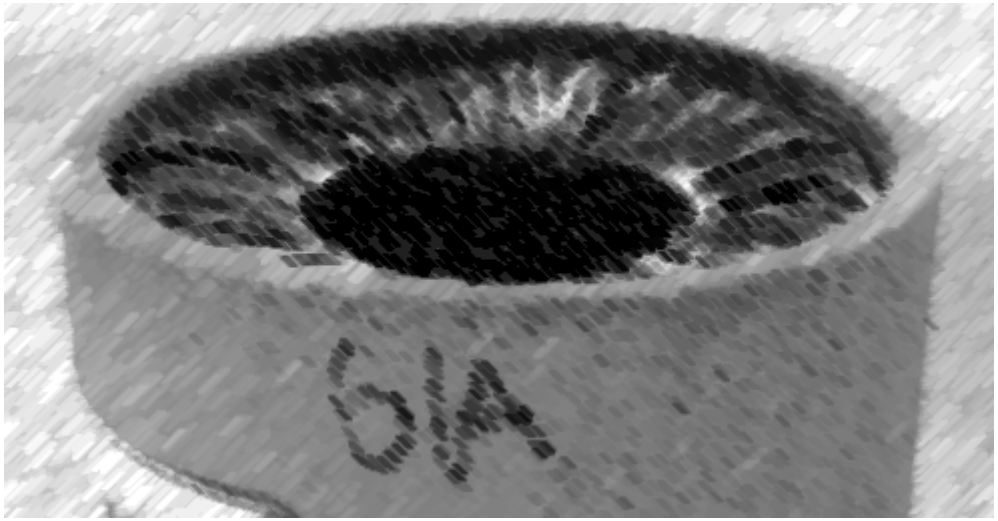

CS61A Lecture 20

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Announcements

- HW7 due on Wednesday
- Ants project out

Dot Expressions

Objects receive messages via dot notation

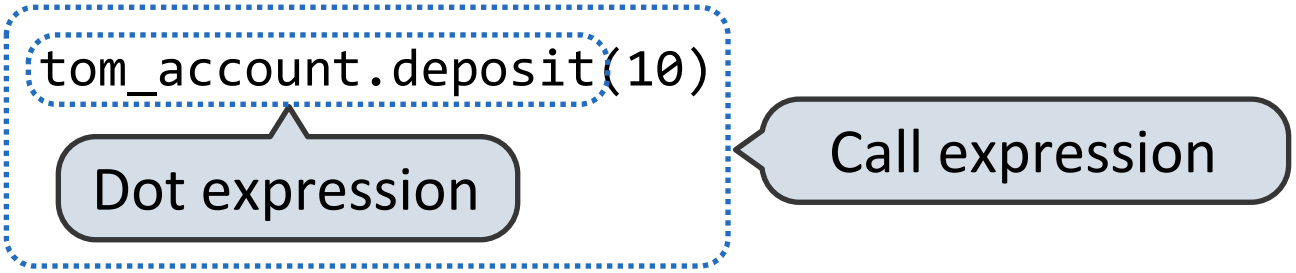
Dot notation accesses attributes of the instance or its class

`<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>`**



Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> 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(1000)
2011
```

Methods and Currying

Earlier, we saw *currying*, which converts a function that takes in multiple arguments into multiple chained functions.

The same procedure can be used to create a bound method from a function

```
def curry(f):
    def outer(x):
        def inner(*args):
            return f(x, *args)
        return inner
    return outer
```

```
>>> add2 = curry(add)(2)
>>> add2(3)
5
```

```
>>> tom_deposit = curry(Account.deposit)(tom_account)
>>> tom_deposit(1000)
3011
```

Attributes, Functions, and Methods

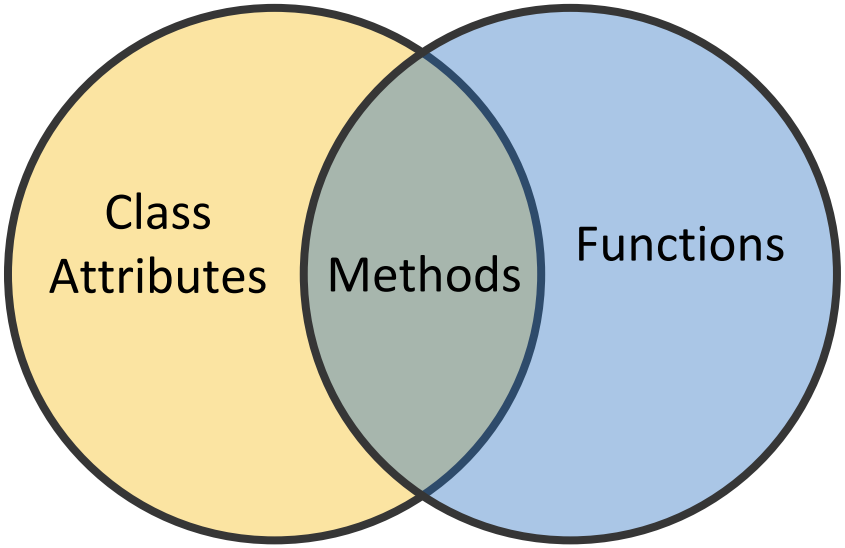
All objects have attributes, which are name-value pairs

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 on instances evaluate to bound methods for class attributes that are functions.

Looking Up Attributes by Name

`<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

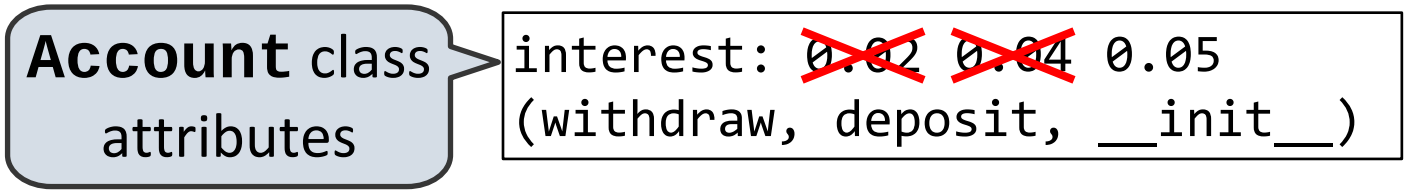
But the name ("interest") is not looked up

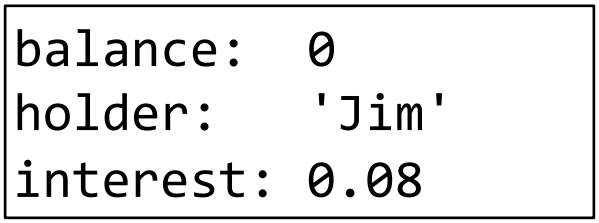
Attribute assignment statement adds or modifies the "interest" attribute of tom_account

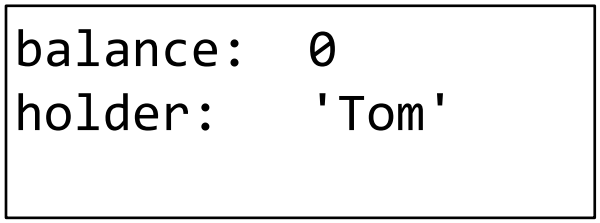
Class Attribute Assignment :

```
Account.interest = 0.04
```

Attribute Assignment Statements








```
>>> 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 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`

General Base Classes

Base classes may contain logic that is meant for subclasses.

Example: Same **`CheckingAccount`** behavior; different approach

```
class Account(object):
    interest = 0.02
    withdraw_fee = 0
    def withdraw(self, amount):
        amount += self.withdraw_fee
        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
        return self.balance

class CheckingAccount(Account):
    interest = 0.01
    withdraw_fee = 1
```

May be overridden by subclasses

Nothing else needed in this class

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!
```

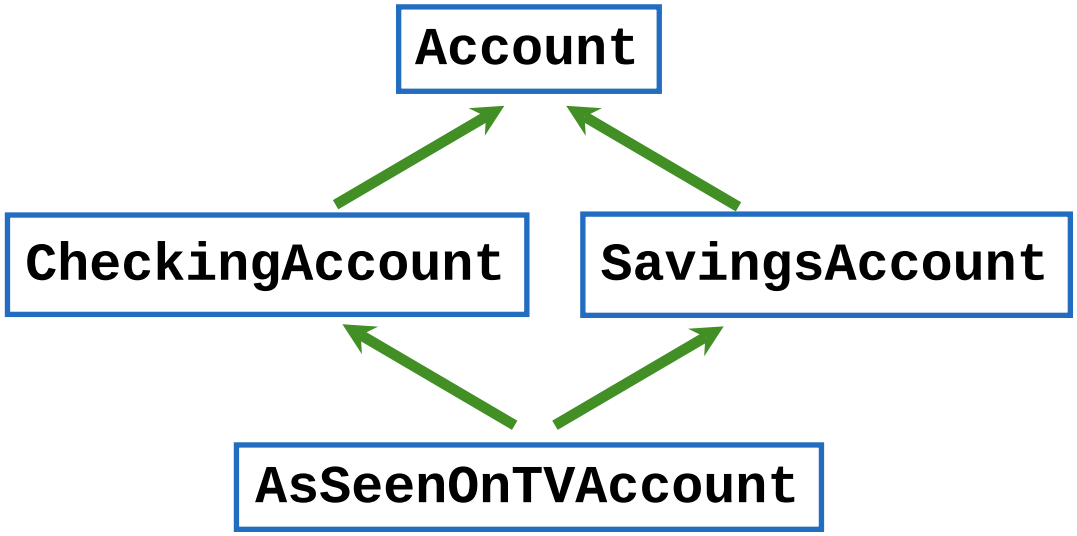
Instance attribute

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
```

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
```

Human Relationships