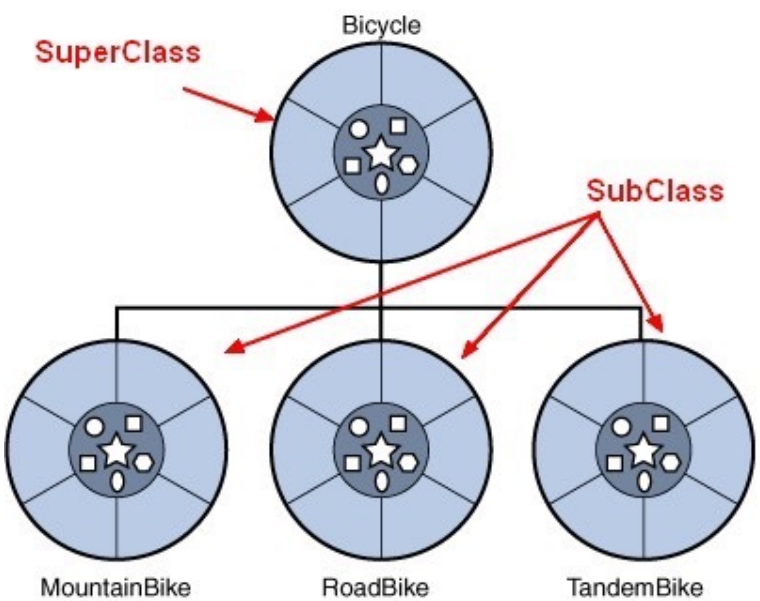
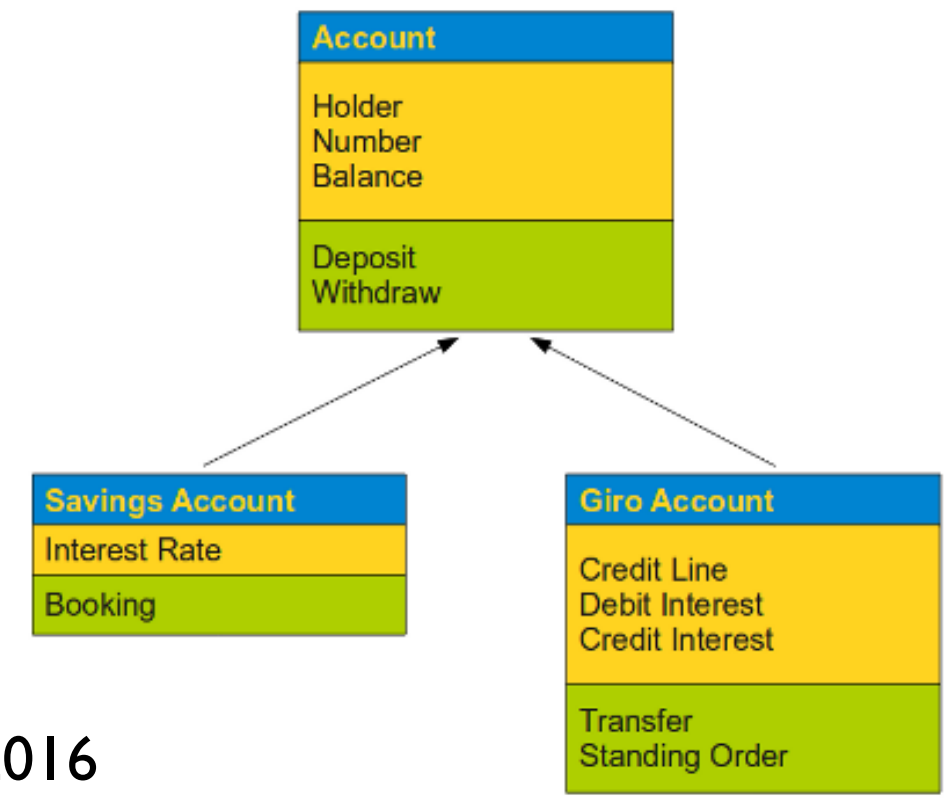
15-112
Fundamentals of Programming

Week 5 - Lecture 1:
OOP Part 2.





June 13, 2016

Today's Menu
(Wrapping up OOP)

>> Inheritance

- Employee and Student as subclasses of Person
- isintance( ) vs type( )
- super( )
- OOPy animation

>> Special methods of the form __foo__( )

>> Static methods, Class attributes

Inheritance: motivating example

You are the CMU president.

You have a program to keep track of people on campus.

Inheritance: motivating example

```
class Employee(object):
    def __init__(self, name, age, gender, salary):
        self.name = name
        self.age = age
        self.gender = gender
        self.salary = salary
        self.rating = 3  # initial value out of 5

    def changeName(self, newName):
        # Some code to check if newName is valid.
        # if it is, then self.name = newName

    def changeAge(self, newAge):
        …

    def changeRating(self, newRating):
        …

    def changeSalary(self, newSalary):
        …
```

Inheritance: motivating example

```
def printInfo(self):
    print("Name:", self.name)
    print("Age:", self.age)
    print("Gender:", self.gender)
    print("Salary:", self.salary)
    print("Rating:", self.rating)

def getNetSalary(self):
    …

def salaryInFuture(self, years):
    …

# Add other methods
```

Inheritance: motivating example

```
class Student(object):
    def __init__(self, name, age, gender, major):
        self.name = name
        self.age = age
        self.gender = gender
        self.major = major
        self.gpa = 0

    def changeName(self, newName):
        # Some code to check if newName is valid.
        # if it is, then self.name = newName

    def changeAge(self, newAge):
        …

    def changeMajor(self, newMajor):
        …

    def changeGpa(self, newGpa):
        …
```

Inheritance: motivating example

```
def printInfo(self):
    print("Name:", self.name)
    print("Age:", self.age)
    print("Gender:", self.gender)
    print("Major:", self.major)
    print("GPA:", self.gpa)

def isFailing(self):
    …


# Add other methods
```

Inheritance: motivating example

Problems:

- code duplication
- not best way of structuring code
  > missing the overlap between Employee and Student

Inheritance: motivating example

Employee and Student share:

Properties:

> name, age, gender

Methods:

> changeName, changeAge, printInfo

Why?

Employee and Student have a shared type.
Both are a Person.

Inheritance example

```
class Person(object):
    def __init__(self, name, age, gender):
        self.name = name
        self.age = age
        self.gender = gender

    def changeName(self, newName):
        # Some code to check if newName is valid.
        # if it is, then self.name = newName

    def changeAge(self, newAge):
        ...

    def printInfo(self):
        ...
```

Inheritance example

```
class Employee(Person):
    pass
```

Employee is now subclass of Person. Person is superclass of Employee.

Employee inherits every property and method of Person.

```
e = Employee("Bob Marley", 26, "male")
e.printInfo()
```

```
class Student(Person):
    pass
```

Student is now subclass of Person. Person is superclass of Student.

Student inherits every property and method of Person.

```
s = Student("Ada Lovelace", 21, "female")
s.changeAge(22)
```

Inheritance example

```
print(type(e))                          <class '__main__.Employee'>
print(type(s))                          <class '__main__.Student'>

print(type(e) == Employee)              True
print(type(s) == Student)               True

print(isinstance(e, Employee))          True
print(isinstance(s, Student))           True

print(isinstance(e, Person))            True
print(isinstance(s, Person))            True

print(type(e) == Person)                False
print(type(s) == Person)                False
```

Inheritance: overriding methods

```
class Employee(Person):
    def __init__(self, name, age, gender, salary):
        self.name = name
        self.age = age
        self.gender = gender
        self.salary = salary
        self.rating = 3

    def changeSalary(self, newSalary):
        …
    def changeRating(self, newRating):
        …
    def printInfo(self):
        …
    def getNetSalary(self):
        …
    def salaryInFuture(self, years):
        …
```

__init__ is overridden.

changeSalary is added.

changeRating is added.

printInfo is overridden.

getNetSalary is added.

salaryInFuture is added.

Inheritance: overriding methods

```
class Employee(Person):
    def __init__(self, name, age, gender, salary):
        self.name = name
        self.age = age
        self.gender = gender
        self.salary = salary
        self.rating = 3

    def changeSalary(self, newSalary):
        …
    def changeRating(self, newRating):
        …
    def printInfo(self):
        …
    def getNetSalary(self):
        …
    def salaryInFuture(self, years):
        …
```

changeName is inherited.
(from Person class)

changeAge is inherited.
(from Person class)

Inheritance: overriding methods

```
class Student(Person):
    def __init__(self, name, age, gender, major):
        self.name = name
        self.age = age
        self.gender = gender
        self.major = major
        self.gpa = 0

    def changeMajor(self, newMajor):
        …
    def changeGpa(self, newGpa):
        …
    def printInfo(self):
        …
    def isFailing(self):
        …
```

__init__ is overridden.

changeMajor is added.

changeGpa is added.

printInfo is overridden.

isFailing is added.

Inheritance: overriding methods

```
class Student(Person):
    def __init__(self, name, age, gender, major):
        self.name = name
        self.age = age
        self.gender = gender
        self.major = major
        self.gpa = 0

    def changeMajor(self, newMajor):
        …
    def changeGpa(self, newGpa):
        …
    def printInfo(self):
        …
    def isFailing(self):
        …
```

changeName is inherited.
(from Person class)

changeAge is inherited.
(from Person class)

Inheritance: avoiding code duplication

```
class Person(object):
    def __init__(self, name, age, gender):
        self.name = name
        self.age = age
        self.gender = gender
    ...
```

Code duplicated!

```
class Employee(Person):
    def __init__(self, name, age, gender, salary):
        self.name = name
        self.age = age
        self.gender = gender
        self.salary = salary
        self.rating = 3
    ...
```

Inheritance: avoiding code duplication

```
class Person(object):
    …
    def printInfo(self):
        print("Name:", self.name)
        print("Age:", self.age)
        print("Gender:", self.gender)
    …
```

Code duplicated!

```
class Employee(Person):
    …
    def printInfo(self):
        print("Name:", self.name)
        print("Age:", self.age)
        print("Gender:", self.gender)
        print("Salary:", self.salary)
        print("Rating:", self.rating)
    …
```

NOTE:
This is a simple example.
In general, the duplicated code can be much longer and complex.

Inheritance: avoiding code duplication

```
class Person(object):
    …
    def printInfo(self):
        print("Name:", self.name)
        print("Age:", self.age)
        print("Gender:", self.gender)
    …


class Employee(Person):
    …
    def printInfo(self):
        super().printInfo()
        print("Salary:", self.salary)
        print("Rating:", self.rating)
    …
```

Inheritance: avoiding code duplication

```
class Person(object):
    def __init__(self, name, age, gender):
        self.name = name
        self.age = age
        self.gender = gender
    ...


class Employee(Person):
    def __init__(self, name, age, gender, salary):
        super().__init__(name, age, gender)
        self.salary = salary
        self.rating = 3
    ...
```

Inheritance: another example

OOPy Animation

Today's Menu (Wrapping up OOP)

>> Inheritance

- Employee and Student as subclasses of Person
- isintance( ) vs type( )
- super( )
- OOPy animation

>> Special methods of the form __foo__( )

>> Static methods, Class attributes

object: mother of all classes

```
class Person(object):
    ...
```

object is actually a built-in data type (i.e. class).

When we define a class, we always make it a subclass of object.

What does object contain?

```
>>> dir(object)
['__class__', '__delattr__', '__dir__', '__doc__', '__eq__', '__format__',
'__ge__', '__getattribute__', '__gt__', '__hash__', '__init__', '__le__',
'__lt__', '__ne__', '__new__', '__reduce__', '__reduce_ex__', '__repr__',
'__setattr__', '__sizeof__', '__str__', '__subclasshook__']
```

Understanding methods __foo__( )

```
class Fraction(object):
    def __init__(self, num, den):
        self.num = num
        self.den = den
        self.simplify()

    def toString(self):
        return str(self.num) + "/" + str(self.den)

    def add(self, other):
        …
    def mul(self, other):
        …
    def toFloat(self):
        …
    def simplify(self):
        …
```

```
f1 = Fraction(4, 6)
f2 = Fraction(5, 9)
print(f1) <__main__.Fraction object at 0x1010349b0>
print(f1.toString())    2/3
print(f1.add(f2).toString())  11/9

print(f1.__str__())
                <__main__.Fraction object at 0x1010349b0>
```

print implicitly calls object's __str__ method

Understanding methods __foo__( )

```
class Fraction(object):
    def __init__(self, num, den):
        self.num = num
        self.den = den
        self.simplify()

    def __str__(self):
        return str(self.num) + "/" + str(self.den)

    def add(self, other):
        …
    def mul(self, other):
        …
    def toFloat(self):
        …
    def simplify(self):
        …
```

```
f1 = Fraction(4, 6)
f2 = Fraction(5, 9)
print(f1)    2/3

print(f1.add(f2))    11/9

print(f1.__str__())    2/3
```

print implicitly calls object's __str__ method

Understanding methods __foo__( )

```
class Fraction(object):
    def __init__(self, num, den):
        self.num = num
        self.den = den
        self.simplify()

    def __str__(self):
        return str(self.num) + "/" + str(self.den)

    def __add__(self, other):
        …
    def mul(self, other):
        …
    def toFloat(self):
        …
    def simplify(self):
        …
```

```
f1 = Fraction(4, 6)
f2 = Fraction(5, 9)
print(f1)    2/3

print(f1 + f2)        11/9
```

+ implicitly calls object's __add__ method

Understanding methods __foo__( )

```
class Fraction(object):
    def __init__(self, num, den):
        self.num = num
        self.den = den
        self.simplify()

    def __str__(self):
        return str(self.num) + "/" + str(self.den)

    def __add__(self, other):
        …
    def __mul__(self, other):
        …
    def toFloat(self):
        …
    def simplify(self):
        …
```

```
f1 = Fraction(4, 6)
f2 = Fraction(5, 9)
print(f1)    2/3

print(f1 * f2)        10/27
```

* implicitly calls object's __mul__ method

Understanding methods __foo__( )

```
class Fraction(object):
    def __init__(self, num, den):
        self.num = num
        self.den = den
        self.simplify()

    def __str__(self):
        return str(self.num) + "/" + str(self.den)

    def __add__(self, other):
        …
    def __mul__(self, other):
        …
    def __float__(self):
        …
    def simplify(self):
        …
```

```
f1 = Fraction(4, 6)
f2 = Fraction(5, 9)
print(f1)    2/3

print(float(f1))    0.6666666666666666
```

float implicitly calls object's __float__ method

Understanding methods __foo__( )

<	__lt__
<=	__le__
>	__gt__
>=	__ge__
==	__eq__
!=	__ne__

Understanding methods __foo__( )

Be careful implementing these methods!

```
def __eq__(self, other):
    return ((self.num == other.num) and (self.den == other.den))

f1 = Fraction(4, 6)
f2 = Fraction(2, 3)
f3 = Fraction(2, 4)
print(f1 == f2)          True
print(f1 == f3)          False

print(f1 == 5)           Crash
```

```
def __eq__(self, other):
    return (isinstance(other, Fraction) and
            (self.num == other.num) and (self.den == other.den))
```

Understanding methods __foo__( )

What if we try to put our objects in a set?

```
f1 = Fraction(4, 6)
s = set()
s.add(f1)
```

Either crashes, or doesn't work the way you want.

Built-in hash function calls the object's __hash__ method

You need to override __hash__ inherited from object

```
def __hash__(self):
    hashables = (self.num, self.den)
    return hash(hashables)
```

```
def getHashables(self):
    return (self.num, self.den)

def __hash__(self):
    return hash(self.getHashables())
```

Understanding methods __foo__( )

One annoying problem:

```
f1 = Fraction(4, 6)
L = [f1]
print(L)          [<__main__.Fraction object at 0x101e34a20>]
```

print actually calls __repr__ for each element of the list.

So you should rewrite __repr__.

Understanding methods __foo__( )

Summary

__str__	Used by built-in str function
__repr__	To create computer readable form
__hash__	Used by built-in hash function
__float__	Used by built-in float function
__lt__	<
__le__	<=
__gt__	>
__ge__	>=
__eq__	==

Today's Menu (Wrapping up OOP)

- Inheritance
  - Employee and Student as subclasses of Person
  - isintance( ) vs type( )
  - super( )
  - OOPy animation
- Special methods of the form __foo__( )

>> Static methods, Class attributes

Static methods

```
class Fraction(object):
    def __init__(self, num, den):
        self.num = num
        self.den = den
        self.simplify()

    def simplify(self):
        g = gcd(self.num, self.den)
        self.num = self.num//g
        self.den = self.den//g

    ...

def gcd(a, b):
    while (b != 0):
        (a, b) = (b, a%b)
    return a
```

You might decide that you'll only use gcd inside the Fraction class.

You might decide it *belongs* inside the Fraction class.

Yet, it can't really be a method.

Static methods

```
class Person(object):
    def __init__(self, name, age, gender):
        self.name = name
        self.age = age
        self.gender = gender

    def changeName(self, newName):
        if (isValidName(newName)):
            self.name = newName

    def changeAge(self, newAge):
        ...


def isValidName(name):
    ...
```

isValidName is a helper function (and not a method).

We won't really use it outside of Person class.

And we shouldn't pollute the global space with it.

Static methods

```
class Fraction(object):
    def __init__(self, num, den):
        self.num = num
        self.den = den
        self.simplify()

    def simplify(self):
        g = Fraction.gcd(self.num, self.den)
        self.num = self.num//g
        self.den = self.den//g

    @staticmethod
    def gcd(a, b):
        while (b != 0):
            (a, b) = (b, a%b)
        return a
```

Static methods

```
class Person(object):
    def __init__(self, name, age, gender):
        self.name = name
        self.age = age
        self.gender = gender

    def changeName(self, newName):
        if (Person.isValidName(newName)):
            self.name = newName

    def changeAge(self, newAge):
        ...

    @staticmethod
    def isValidName(name):
        ...
```

Class attributes

Suppose we have a class called Maze.

```
class Maze(object):

    def __init__(self):
        ...

    ...
```

Want to store directions:

```
NORTH = (-1,0)
SOUTH = (1,0)
EAST  = (0,1)
WEST  = (0,-1)
```

- These are not really properties/fields of a maze.
- We are only going to use them in the Maze class.
- Every Maze object should share these variables.

Class attributes

```
class Maze(object):

    NORTH = (-1,0)
    SOUTH = (1,0)
    EAST  = (0,1)
    WEST  = (0,-1)

    def __init__(self):
        ...

    def solve(self, row,col):
        ...
        for drow,dcol in [Maze.NORTH, Maze.SOUTH, Maze.EAST, Maze.WEST]:
            ...
```

Make them class attributes.

Note: NORTH, SOUTH, EAST, WEST are constants that don't change.

Class attributes

Another example: back to dots demo.

```
class Dot(object):

    def __init__(self):
        ...

    ...
```

Want to store the total number of Dot instances created:

dotCount = 0

- This is not a property/field of a dot.
- Every Dot object should share this variable.
- Don't want to pollute the global space.

Class attributes

```
class Dot(object):

    dotCount = 0

    def __init__(self):
        Dot.dotCount += 1
        ...

    ...
```

Make it a class attribute.

Properties/fields:

Every object/instance gets its own copy.

Class attributes:

There is only one copy (regardless of the number of instances).

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