

Lecture 15: Inheritance and Interfaces

7/17/2014

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Some (a lot of) material from these slides was borrowed from John DeNero.

Announcements

- Project 3, Ants, is out! Due Sunday 7/27
- Homework 7 released! Due Saturday 7/19
- Homework party tonight, 7/17, 6-10pm
- 61A Hackathon tomorrow, 7/18, 5pm-12am
- Mid-semester survey due tonight, 11:59pm

Inheritance

Inheritance

- Powerful idea in Object-Oriented Programming
- Way of *relating* similar classes together
- Common use: a *specialized* class inherits from a more *general* class

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

- The new class *shares* attributes with the base class, and *overrides* certain attributes
- Implementing the new class is now as simple as specifying how it's *different* from the base class

Inheritance Example

(demo)

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

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

- A `CheckingAccount` is a *specialized* type of `Account`.
- Checking accounts have:
 - an account holder
 - a balance
 - **an interest rate of 1%**
 - **a withdraw fee of \$1**
- You can:
 - deposit to a checking account
 - withdraw from a checking account **(but there's a fee!)**

Attribute Look Up

To look up a name in a class:

1. If the name is in the attributes of the class, return the corresponding value
2. If not found, look up the name in the base class, if there is one

Base class attributes *are not copied* into subclasses!

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

Designing for Inheritance

- ✓ • Don't repeat yourself! Use *existing implementations*
- ✓ • Reuse overridden attributes by accessing them through the *base class*
- ✓ • Use attribute look up through *instances* if possible

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

Inheritance vs Composition (demo)

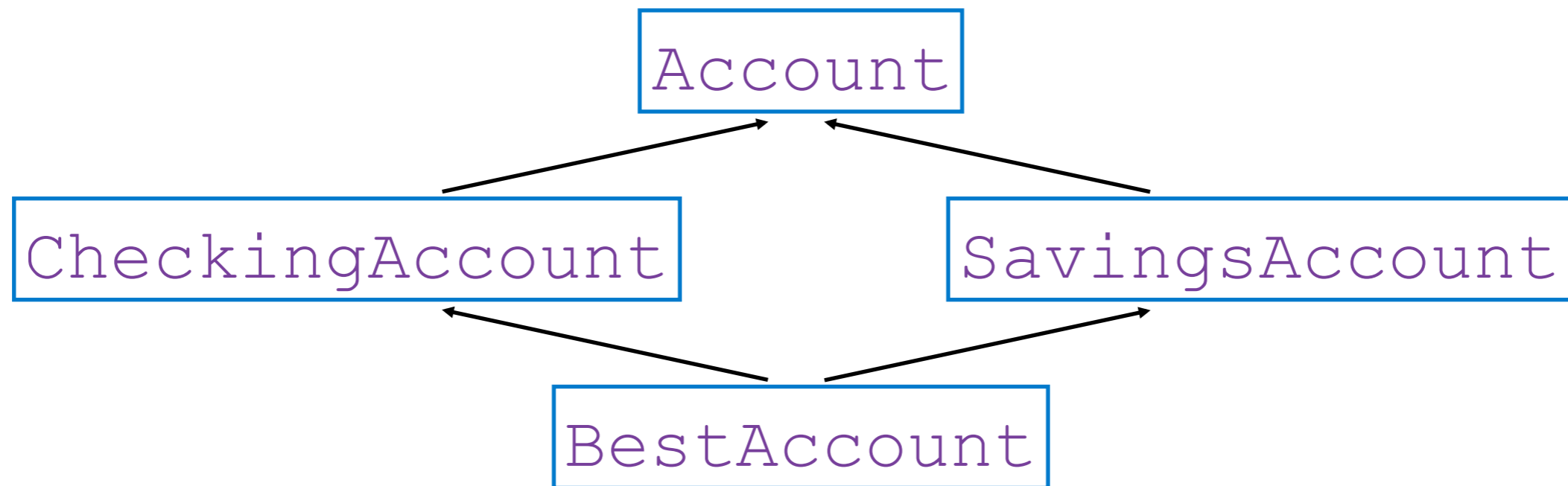
- Inheritance: relating two classes through specifying *similarities and differences*
 - Represents “is a” relationships, e.g. a checking account *is a* specific type of account
- Composition: relating two classes by how they *interact with one another*
 - Represents “has a” relationships, e.g. a bank *has a* collection of bank accounts

Multiple Inheritance Example

- Bank executive wants the following:
 - Low interest rate of 1%
 - \$1 withdrawal fee
 - \$2 deposit fee
 - A free dollar for opening the account!

```
class BestAccount(CheckingAccount, SavingsAccount):  
    def __init__(self, account_holder):  
        self.holder = account_holder  
        self.balance = 1 # best deal ever
```

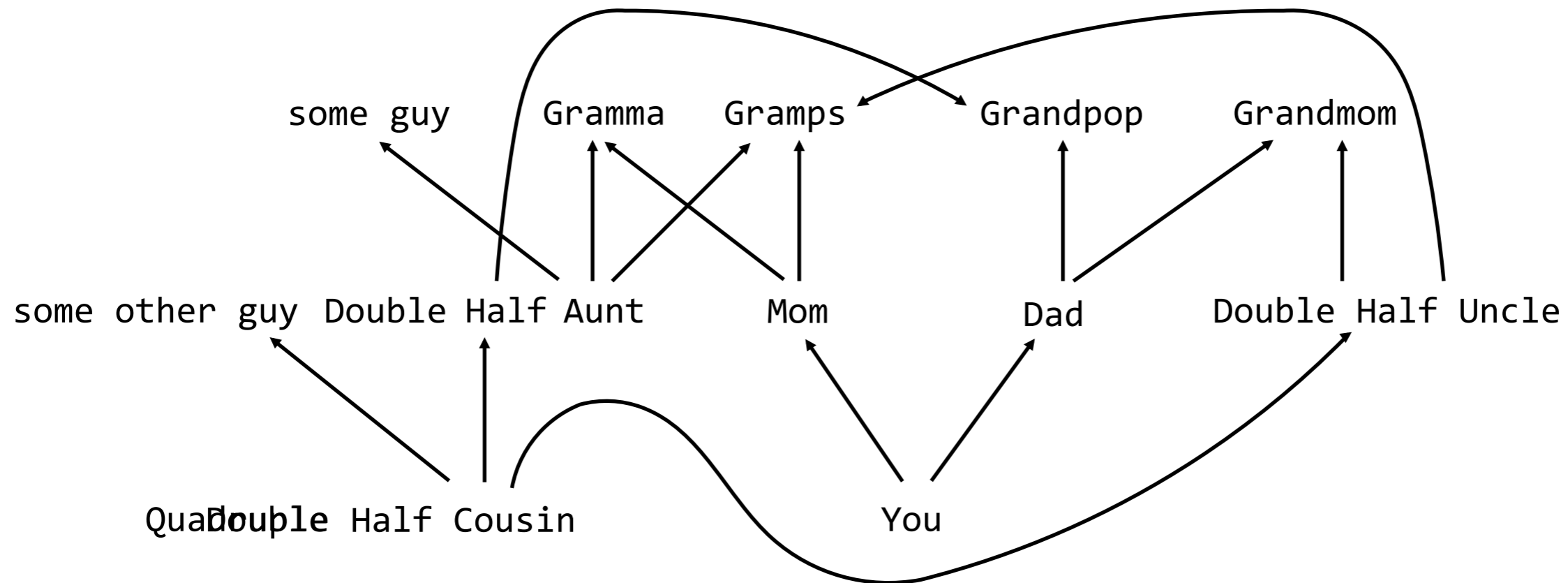
Multiple Inheritance Example



```
>>> such_a_deal = BestAccount('Marvin')
>>> such_a_deal.balance      # instance attribute
1
>>> such_a_deal.deposit(20)  # SavingsAccount
19
>>> such_a_deal.withdraw(5)  # CheckingAccount
13
```

Complicated Inheritance

To show how complicated inheritance can be, let's look at an analogy through biological inheritance.



Moral of the story: inheritance (especially multiple inheritance) is complicated and weird. Use it carefully!

Break

Interfaces

Interfaces

- Boundary that allows communication between different components by *specifying the rules for communication*
- E.g. hardware-software interfaces, user interfaces, API's, etc.
- In OOP, interfaces are defined by what the object has to *implement* (attributes, methods, etc.)

Two (Three) Examples

- Magic methods and Python protocols
 - the string representation protocol
 - the sequence protocol
- API's and the YouTube API

Python Magic Methods

- Special methods surrounded by double underscores (e.g., `__init__`) that add “magic” to your classes
- Used to implement several interfaces (called protocols) in Python
 - `__str__` and `__repr__`: the string representation protocol
 - `__len__` and `__getitem__`: the sequence protocol
 - `__iter__` and `__next__`: the iterator protocol
- We’ll look at the first two - the last will be talked about in depth next lecture!

Protocols

- Protocols are what Python (and many other languages) call *interfaces for object-oriented programming*
- Sometimes, they're just called interfaces (e.g., Java)
- To implement a protocol, objects typically need to have a certain set of attributes. In Python, these attributes are usually a collection of *magic methods*

String Representation

(demo)

- Python has two functions to produce string representations of objects: `str` and `repr`
- The “repr” string is legible to the *Python interpreter*, while the “str” string is legible to *humans*
- The “repr” string is what Python displays *in an interactive session*, and the “str” string is what Python prints *using the `print` function*

Implementing `str` and `repr` (demo)

- Implementing the “repr” string for an object requires defining the `__repr__` magic method for the corresponding class
- Implementing the “str” string for an object requires defining the `__str__` magic method for the corresponding class
- It’s a bit more subtle than this, but we won’t go into details

Sequences

(demo)

- Python has many built-in sequence types: lists, tuples, ranges, strings, etc.
- Python also has a protocol for defining custom sequence classes
- Defining custom sequences is as easy as implementing the `__len__` and `__getitem__` magic methods
- `__len__` is called by the `len` function, and `__getitem__` is used in sequence indexing

Note about Magic Methods

- Magic methods, when used properly, allow for very versatile, powerful, and integrated classes and objects
- We only scratched the surface of the magic methods that exist in Python. For a more in depth discussion, check out the following link:

<http://www.rafekettler.com/magicmethods.html>

API's

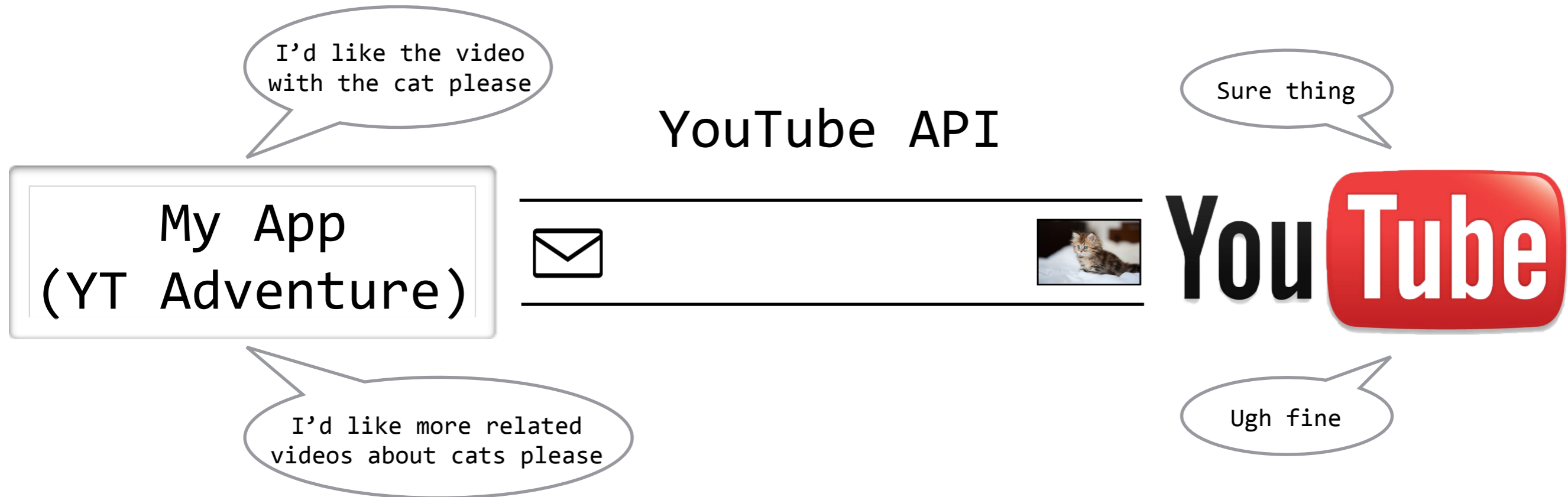
- Application Programming Interfaces (API's) are interfaces that define how different software components (i.e., *applications*) should interact
- API's take the form of *libraries* containing functions and classes, or *remote function calls*, i.e. queries for some specific data
- API's are incredibly important in the real world - almost every application depends on some other application

YouTube API

- The API for YouTube allows programs to retrieve and play videos, fetch search results, collect related videos, etc.
- The YouTube API is an *interface* for working with the YouTube application
- We'll look at an example of a program built using this API: ytadventure.com

How the YouTube API Works (demo)

The YouTube API is accessed through a set of *remote function calls* (URL's that return some specific data)



This is, of course, drastically simplified - check out the actual API for more details and actual code!

<https://developers.google.com/youtube/v3/getting-started>

Interface Wrap-up

- Interfaces are a broad concept, and it can be hard to wrap your head around what it really means
- The thing to remember is that interfaces are always about *defining the rules for communication*
- Python protocols are interfaces for Python objects, as they allow communication with custom classes and objects through *specific magic methods*
- API's are interfaces for applications, as they allow communication with the application through a *library and/or remote function calls*

Summary

- Inheritance allows for *abstraction* and *implementing relationships* in object-oriented programming
- Interfaces allow for *systematic and meaningful communication* by defining how to communicate, not only in OOP but many other areas of computer science
- Learning these ideas well is one of the keys to becoming a great programmer