Classes and Objects

You will learn how to define new types of variables.

Some Drawbacks Of Using A List

- Which field contains what type of information? This isn't immediately clear from looking at the program statements.

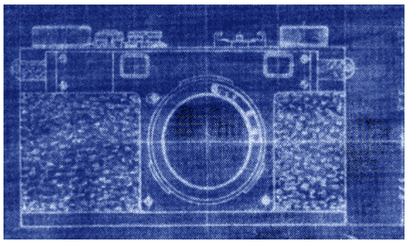
```
client = ["xxxxxxxxxxxxxxx",
          "0000000000",
          "xxxxxxxxx",
          0]
```

$\}$ **The parts of a composite list can be accessed via [index] but they cannot be labeled (what do these fields store?)**

- Is there any way to specify rules about the type of information to be stored in a field e.g., a data entry error could allow alphabetic information (e.g., 1-800-BUY-NOWW) to be entered in the phone number field.

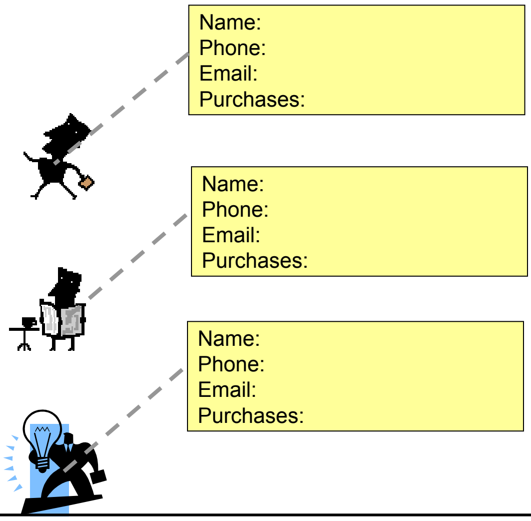
Classes

- Can be used to define a generic template for a new non-homogeneous composite type.
- It can label and define more complex entities than a list.
- This template defines what an instance (example) of this new composite type would consist of but it doesn't create an instance.



Classes Define A Composite Type

- The class definition specifies the type of information that each instance (example) tracks.



Defining A Class

Note the convention: The first letter is capitalized.

•Format:

```
class <Name of the class>:
    name of first field = <default value>
    name of second field = <default value>
```

•Example:

```
class Client:
    name = "default"
    phone = "(123)456-7890"
    email = "foo@bar.com"
    purchases = 0
```

Describes what information that would be tracked by a "Client" but doesn't actually create a client in memory

Contrast this with a list definition of a client

```
client = ["xxxxxxxxxxxxxxx",
          "0000000000",
          "xxxxxxxxx",
          0]
```

Creating An Instance Of A Class

•Creating an actual instance (instance = object) is referred to as *instantiation*

•Format:

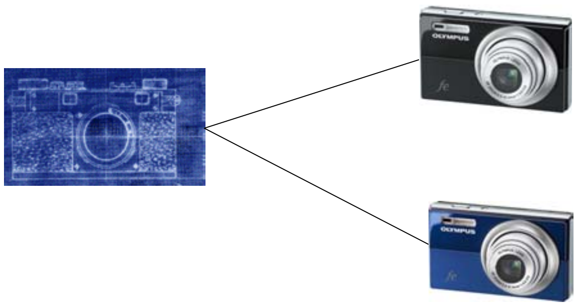
```
<reference name> = <name of class> ()
```

•Example:

```
firstClient = Client ()
```

Defining A Class Vs. Creating An Instance Of That Class

- Defining a class
  - A template that describes that class: how many fields, what type of information will be stored by each field, what default information will be stored in a field.
- Creating a class
  - Instances of that class (during instantiation) which can take on different forms.



Accessing And Changing The Fields

- **Format:**

```
<reference name>.<field name>                  # Accessing value
<reference name>.<field name> = <value>        # Changing value
```

- **Example:**

```
aClient.name = "James"
```

The Client List Example Implemented Using Classes

•Name of the online example: client.py

```
class Client:
    name = "default"
    phone = "(123)456-7890"
    email = "foo@bar.com"
    purchases = 0
```

The Client List Example Implemented Using Classes (2)

```
def main():
   firstClient = Client ()
   firstClient.name = "James Tam"
   firstClient.email = "tam@ucalgary.ca"
   print(firstClient.name)
   print(firstClient.phone)
   print(firstClient.email)
   print(firstClient.purchases)

main()
```

What Is The Benefit Of Defining A Class

- It allows new types of variables to be declared.
- The new type can model information about most any arbitrary entity:
  - Car
  - Movie
  - Your pet
  - A biological entity in a simulation
  - A 'critter' (e.g., monster, computer-controlled player) a video game
  - An 'object' (e.g., sword, ray gun, food, treasure) in a video game
  - Etc.

What Is The Benefit Of Defining A Class (2)

•Unlike creating a composite type by using a list a predetermined number of fields can be specified and those fields can be named.

```
class Client:
   name = "default"
   phone = "(123)456-7890"
   email = "foo@bar.com"
   purchases = 0

firstClient = Client ()
print(firstClient.middleName)
```

What Is The Benefit Of Defining A Class (2)

- Unlike creating a composite type by using a list a predetermined number of fields can be specified and those fields can be named.

```
class Client:
    name = "default"
    phone = "(123)456-7890"
    email = "foo@bar.com"
    purchases = 0

firstClient = Client ()
~~print(firstClient.middleName)~~
```

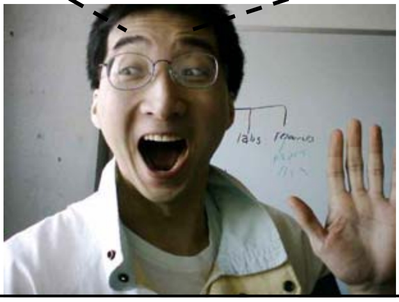
There is no field by this name

James Tam

Classes Can Have Attributes And Behaviors

ATTRIBUTES
Name:
Phone:
Email:
Purchases:

BEHAVIORS
Open account
Buy investments
Sell investments
Close account



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Class Methods ("Behaviors")

- Somewhat similar to the other composite types, classes can have functions associated with them.
  - E.g.,

```
filename = "foo.txt"
name, suffix = filename.split('.')
```

- Unlike these pre-created functions, the ones that you associate with classes can be customized to do anything that a regular function can.
- Functions that are associated with classes are referred to as *methods*.

Defining Class Methods

Format:

```
class <classname>:
    def <method name> (self, <other parameters>):
        <method body>
```

Example:

```
class Person:
  name = "I have no name :("
  def sayName (self):
    print ("My name is...", self.name)
```

Unlike functions, every method of a class must have the 'self' parameter (more on this later)

When the attributes are being accessed inside the methods of a class they MUST be preceded by the suffix ".self"

Defining Class Methods: Full Example

•Name of the online example: person1.py

```
class Person:
  name = "I have no name :("
  def sayName (self):
    print ("My name is...", self.name)

def main ():
  aPerson = Person ()
  aPerson.sayName ()
  aPerson.name = "Big Smiley :D"
  aPerson.sayName ()

main ()
```

What Is The 'Self' Parameter

•Reminder: When defining/call methods of a class there is always at least one parameter.

•This parameter is called the 'self' reference which allows an object to access it's attributes inside its methods.

•It's needed to distinguish the attributes of different objects of the same class.

•Example:

```
bart = Person ()
lisa = Person ()
lisa.sayName ()
```

```
def sayName ():
    print "My name is...", name
```

Whose name is this? (This won't work)

The Self Parameter: A Complete Example

•Name of the online example: person2.py

```
class Person:
  name = "I have no name :("
  def sayName (self):
    print ("My name is...", self.name)

def main ():
  lisa = Person ()
  lisa.name = "Lisa Simpson, pleased to meet you."
  bart = Person ()
  bart.name = "I'm Bart Simpson, who the h*ck are you???!!!"

  lisa.sayName ()
  bart.sayName ()

main ()
```

Initializing The Attributes Of A Class

•Classes have a special method that can be used to initialize the starting values of a class to some specific values.

•This method is automatically called whenever an object is created.

No spaces here

•**Format**:

```
class <Class name>:
def __init__ (self, <other parameters>):
    <body of the method>
```

•**Example**:

```
class Person:
  name = ""
  def __init__ (self):
     self.name = "No name"
```

Initializing The Attributes Of A Class

- Because the 'init' method is a method it can also be called with parameters which are then used to initialize the attributes.
- Example:

```
-# Attribute is set to a default in the class definition and then the attribute
-# can be set to a non-default value in the init method. (More common
-# approach)
class Person
    name = "Default name"
    def __init___(self, aName):
        self.name = aName
```

-OR

```
-# Create the attribute in the init method. (Approach often used in Python).
class Person
    def __init___(self, aName):
        self.name = aName
```

s2

Full Example: Using The "Init" Method

- The name of the online example: init_method1.py

```
class Person:
  name = “Nameless bard"

  def __init__ (self, aName):
     self.name = aName

def main ():
  aPerson = Person ("Finder Wyvernspur")
  print (aPerson.name)

main ()
```

Slide 22

s2 change online example to match
sysman, 11/7/2012

Constructor: A Special Method

- Constructor method: a special method that is used when defining a class and it is automatically called when an object of that class has been created.
  - E.g., aPerson = Person ()   # This calls the constructor
- In Python this method is named 'init'.
- Other languages may require a different name for the syntax but it serves the same purpose (initializing the fields of an objects as it's being created).
- This method should never have a return statement.

Default Parameters

- Similar to other methods, 'init' can be defined so that if parameters aren't passed into them then default values can be assigned.
- Example:

```
def __init__ (self, name = "I have no name"):
```

This method can be called either when a personalized name is given or if the name is left out.

- Method calls (to 'init'), both will work

```
smiley = Person ()
jt = Person ("James")
```

Default Parameters: Full Example

- Name of the online example: init_method2.py

```
class Person:
   name = ""
   def __init__ (self, name = "I have no name"):
       self.name = name

def main ():
   smiley = Person ()
   print ("My name is...", smiley.name)
   jt = Person ("James")
   print ("My name is...", jt.name)

main ()
```

Lists Of References To Objects

- You have already seen examples of composite types which are composed of other composite types.
  - E.g., list of strings, each element of the list consists of a string, each string consists of a series of characters. aList = [“james”, “stacey”]
- One important combination of composite types occurs with lists and objects.
  - Each element in the list is a reference to an object.

Past approach

```
client1 = Client()
client2 = Client()
```

Better approach

```
clients = []
for i in range (0, MAX_CLIENTS,1):
   clients[i].append (Client())
```

Example: List Of References To Objects

•Name of the online example: people.py

```
SIZE = 4

class Person:
      name = ""
      age = -1

      def __init__(self,aName,anAge):
         self.name = aName
         self.age = anAge

      def display (self):
            print("My name is...%s" %self.name)
            print("My age is...%d" %self.age)
```

James Tam

Example: List Of References To Objects (2)

```
def main ():
    people  = []
    for i in range (0,SIZE,1):
        tempName = "Person #" + str(i+1)
        people.append(Person(tempName,i))

    for i in range (0,SIZE,1):
        people[i].display()
        print()

main()
```

James Tam

Modules: Dividing Up A Large Program

- Module: In Python a module contains a part of a program in a separate file (module name matches the file name).
- In order to access a part of a program that resides in another file you must ‘import’ it.
- Example:

File: fun.py

```
def fun ():
    print("I'm fun!“)
```

File: main.py

```
from fun import *1

def main ():
  fun ()

main ()
```

1 Import syntax:

From <file name> import <function names>

OR

import <file name>

Modules: Complete Example

- Name of the online example: modules1.zip
- Extract both files into the same folder/directory and run the ‘main’ method (type: “python main.py”)

```
<< In file main.py >>
from file1 import fun1, fun2
import file2

def main ():
  fun1 ()
  fun2 ()
  file2.fun3()

main ()
```

Note the difference in how fun1 & fun2 vs. fun3 are called

Modules: Complete Example (2)

<< In module file1.py >>

```
def fun1 ():
  print ("I'm fun1!")

def fun2 ():
  print ("I'm fun2!")
```

<< In module file2.py >>

```
def fun3 ():
    print("I'm fun3!")
```

Modules And Classes

- Class definitions are frequently contained in their own module.
- A common convention is to have the module (file) name match the name of the class.

Filename: Person.py

```
class Person:
    def fun1 (self):
      print "fun1"

    def fun2 (self):
      print "fun2"
```

Modules And Classes: Complete Example

- The name of the online example: modules2.zip
- Extract both files into the same folder/directory and run the 'main' method which is in the file called "Driver.py" (type: "python Driver.py")

```
<< File Driver.py >>
from Greetings import *

def main ():
  aGreeting = Greeting ()
  aGreeting.sayGreeting ()

main ()
```

When importing modules containing class definitions the syntax is:

From <*filename*> import <*classes to be used in this module*>

Modules And Classes: Complete Example (2)

```
<< File Greetings.py >>
class Greetings:
   def sayGreeting (self):
      print ("Hello! Hallo! Sup?! Guten tag/morgen/aben! Buenos! Wei!  \
              Konichiwa! Shalom! Bonjour! Salaam alikum! Kamostaka?")
```

Calling A Classes' Method Inside Another Method Of The Same Class

- Similar to how attributes must be preceded by the keyword 'self' before they can be accessed so must the classes' methods:
- **Example**:

```
class Bar:
    x = 1
    def fun1(self):
        print (self.x)

    def fun2 (self):
        self.fun1()
```

Complete Example: Accessing Attributes And Methods

- Name of the online example: modules3.zip
- To run the program extract both files into the same directory and run the "Driver.py" file, at the command line type "python Driver.py"

```
<< Driver.py >>
from Foo import *
def main ():
    aFoo = Foo()
    aFoo.fun2()
    aFoo.fun3()
    print(aFoo.x)

main()
```

- **Access to the methods and attributes of a class outside that classes' methods requires a reference and an object to be created.**
- **This allows access to the attributes and methods using the dot-operator via that reference**

Complete Example: Accessing Attributes And Methods (2)

```
class Foo:
  x = 1

  def fun1 (self):
    print ("fun1")

  def fun2 (self):
   print ("fun2")
   self.fun1()

  def fun3 (self):
   x = 2
   print("Local x:", x)
   print("Attribute x:", self.x)
```

Access to the methods and attributes of a class inside that classes' methods requires the use of the 'self' keyword and the dot-operator

Important Recap: Accessing Attributes And Methods

•Outside of a class the attribute or method MUST be preceded by the name of the reference to the object:

•**Format**:

<Reference name>.<method or attribute name>

•**Example**:

```
aFoo.fun2()
aFoo.x
```

Important Recap: Accessing Attributes And Methods (2)

- Inside the methods of a class the attribute or method MUST be preceded by the keyword 'self':
- **Format**:

  <self>.<method or attribute name>

- **Example**:

```
self.fun1()
self.x
```

After This Section You Should Now Know

- How to define an arbitrary composite type using a class
- What are the benefits of defining a composite type by using a class definition over using a list
- How to create instances of a class (instantiate)
- How to access and change the attributes (fields) of a class
- How to define methods/call methods of a class
- What is a 'self' parameter and why is it needed
- What is a constructor (__init__ in Python), when it is used and why is it used
- How to write a method with default parameters
- The benefits and the process of creating a list of references to objects
- How to divide your program into different modules