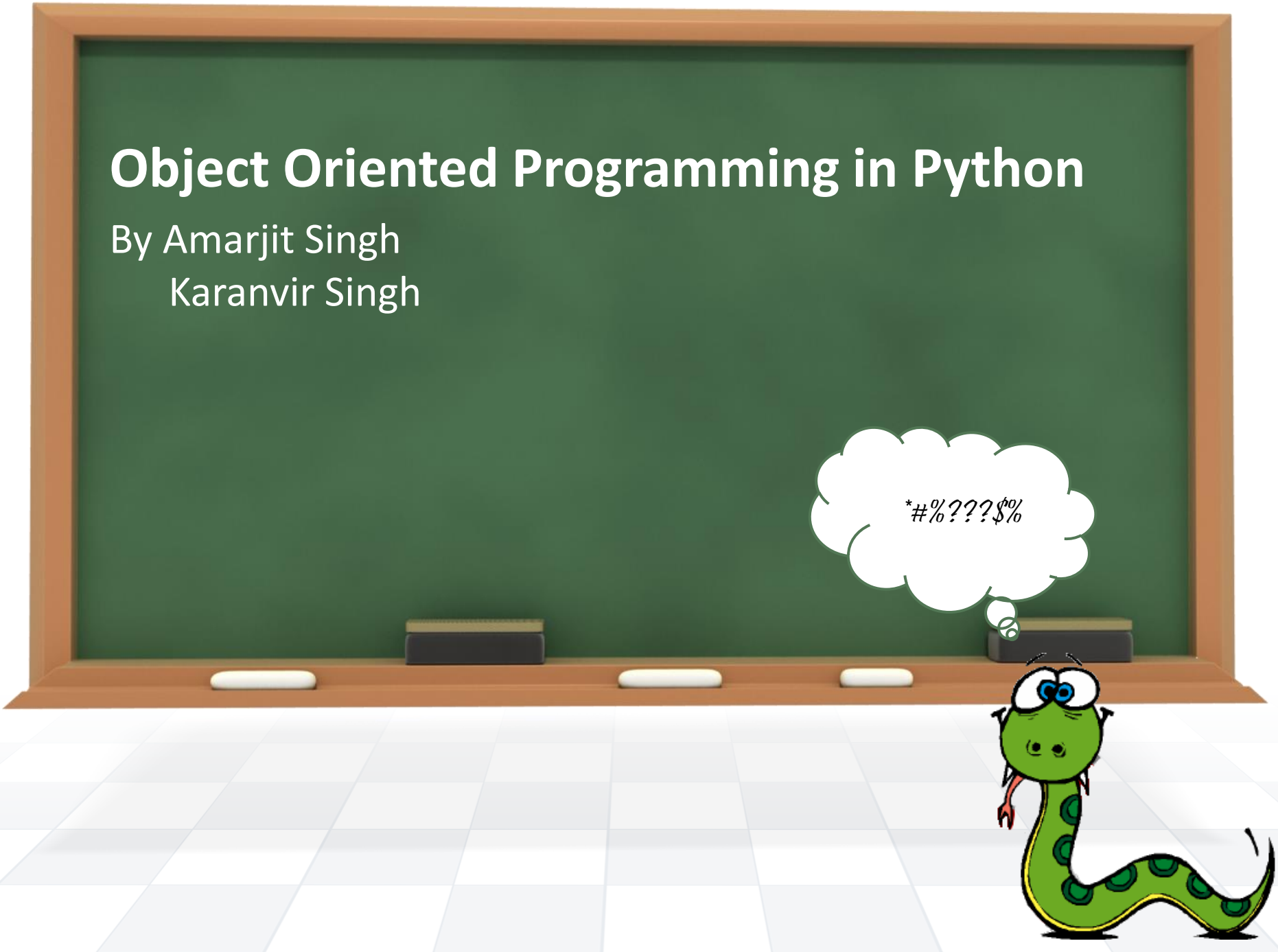
Object Oriented Programming in Python

By Amarjit Singh
Karanvir Singh



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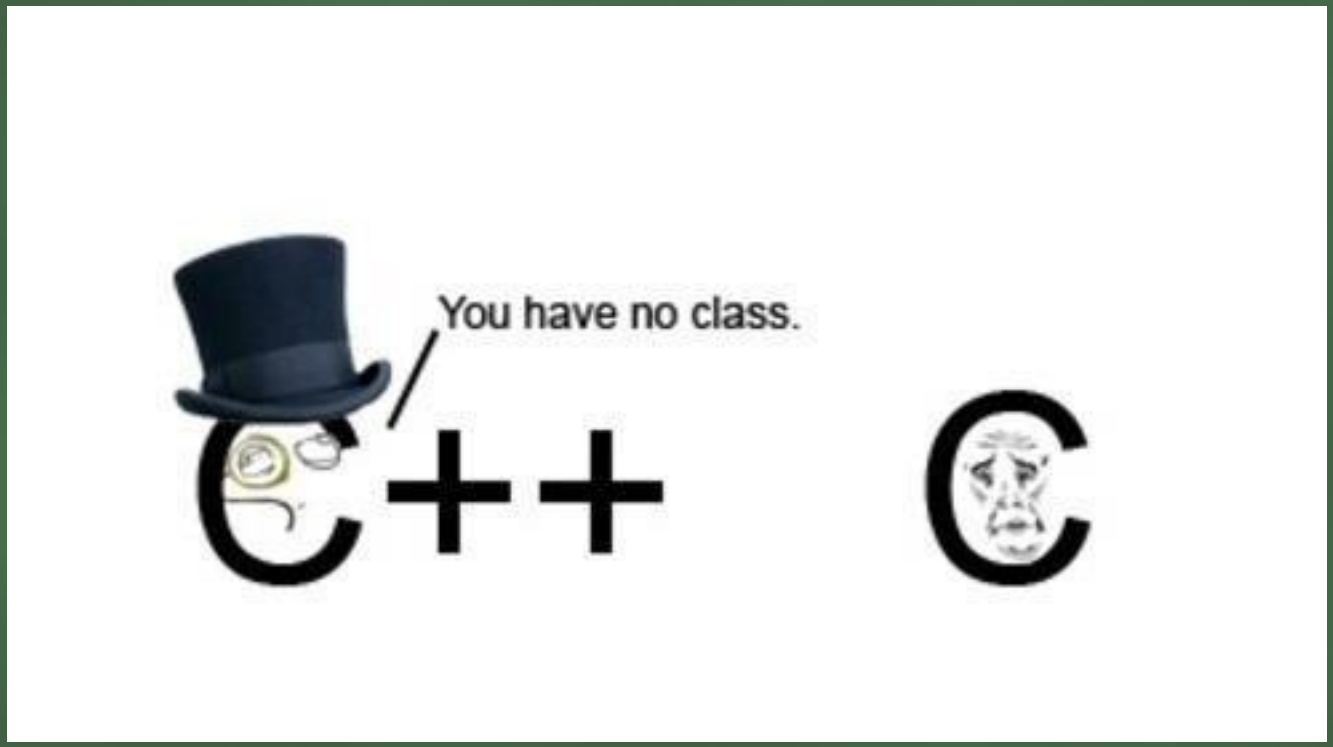
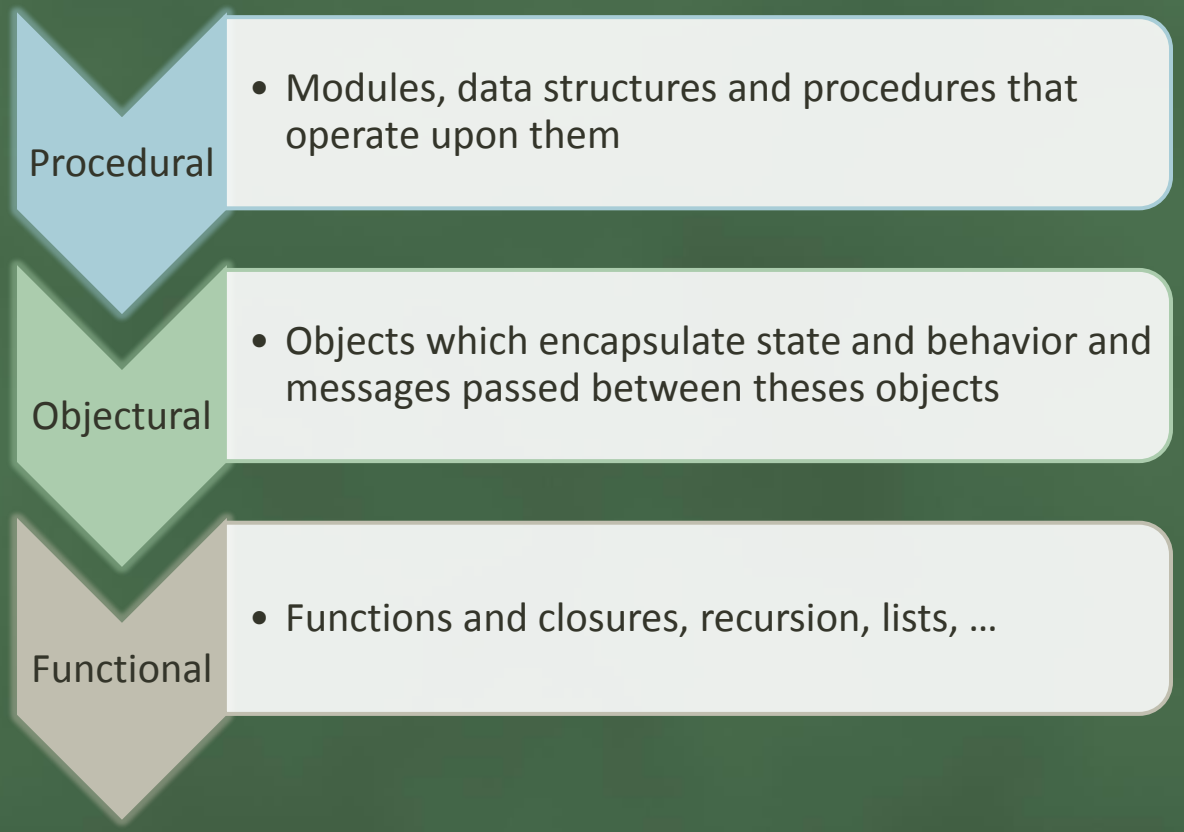


•Object Oriented Programming Basics

Programming Paradigms

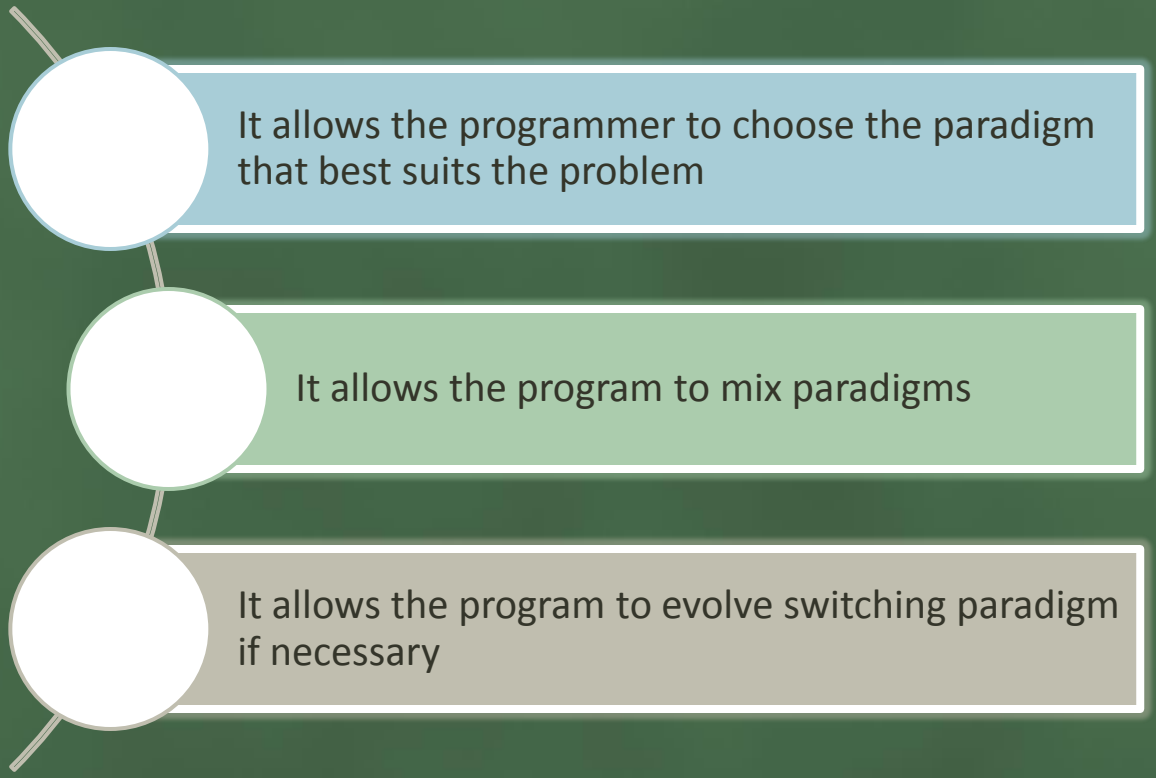
Before diving deep into the concept of Object Oriented Programming, let's talk a little about all the programming paradigms which exist in this world.



•Object Oriented Programming Basics

Programming Paradigms

Python is multiparadigm programming language



•Object Oriented Programming Basics

What is an Object?

A software item that contains variables and methods.

Object Oriented Design focuses on :-

Encapsulation

- dividing the code into a public interface, and a private implementation of that interface

Polymorphism

- the ability to overload standard operators so that they have appropriate behavior based on their context

Inheritance

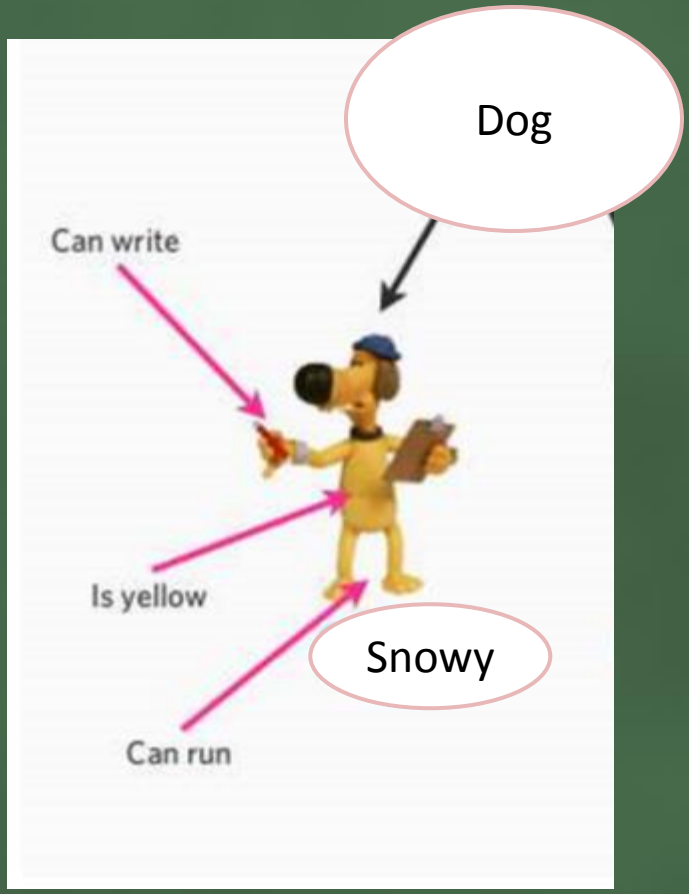
- the ability to create subclasses that contain specializations of their parents

•Object Oriented Programming Basics

What is a Class?

Classes(in classic oo) define what is common for a whole class of objects, e.g.: “Snowy is a dog” can be translated to “The Snowy object is an instance of the dog class.” Define once how a dog works and then reuse it for all dogs. Classes correspond to variable types(they are type objects).

At the simplest level, classes are simply namespaces.



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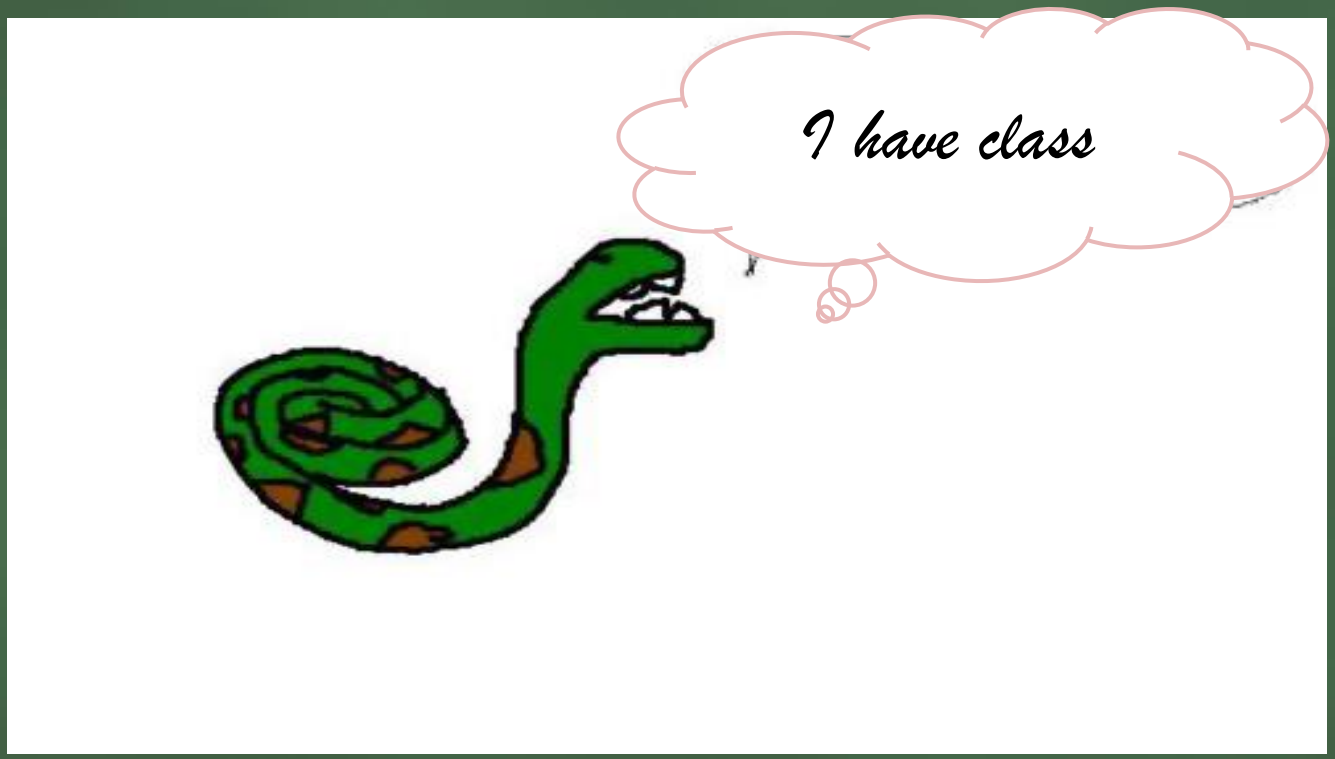

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Python Classes

- A class is a python object with several characteristics:
- You can call a class as it where a function and this call returns a new instance of the class
- A class has arbitrary named attributes that can be bound, unbound an referenced
- The class attributes can be descriptors (including functions) or normal data objects
- Class attributes bound to functions are also known as methods
- A method can have special python-defined meaning (they're named with two leading and trailing underscores)
- A class can inherit from other classes, meaning it delegates to other classes the look-up of attributes that are not found in the class itself

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Python Classes in Detail (I)

- All classes are derived from object (new-style classes).

```
class Dog(object):
pass
```

- Python objects have data and function attributes (methods)

```
class Dog(object):
        def bark(self):
        print "Wuff!“

snowy = Dog()
snowy.bark() # first argument (self) is bound to this Dog instance
snowy.a = 1 # added attribute a to snowy
```

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Python Classes in Detail (II)

- Always define your data attributes in __init__

```
class Dataset(object):
        def __init__(self):
                self.data = None

        def store_data(self, raw_data):
        ... # process the data
        self.data = processed_data
```

- Class attributes are shared across all instances.

```
class Platypus(Mammal):
        latin_name = "Ornithorhynchus anatinus"
```

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Python Classes in Detail (III)

- Use super to call a method from a superclass.

```
class Dataset(object):
        def __init__(self, data=None):
                self.data = data

class MRIDataset(Dataset):
        def __init__(self, data=None, parameters=None):
                # here has the same effect as calling
                # Dataset.__init__(self)
                super(MRIDataset, self).__init__(data)
                self.parameters = parameters
mri_data = MRIDataset(data=[1,2,3])
```

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Python Classes in Detail (IV)

- Special methods start and end with two underscores and customize standard Python behavior (e.g. operator overloading).

```
class My2Vector(object):
        def __init__(self, x, y):
                self.x = x
                self.y = y
        def __add__(self, other):
                return My2Vector(self.x+other.x, self.y+other.y)
v1 = My2Vector(1, 2)
v2 = My2Vector(3, 2)
v3 = v1 + v2
```

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Python Classes in Detail (V)

- Properties allow you to add behavior to data attributes:

```
class My2Vector(object):
        def __init__(self, x, y):
                self._x = x
                self._y = y
        def get_x(self):
                return self._x
        def set_x(self, x):
                self._x = x
        x = property(get_x, set_x)
# define getter using decorator syntax
@property
        def y(self):
                return self._y
v1 = My2Vector(1, 2)
x = v1.x # use the getter
v1.x = 4 # use the setter
x = v1.y # use the getter
```

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Python Example (I)

```
import random

class Die(object): # derive from object for new style classes
"""Simulate a generic die."""“

        def __init__(self, sides=6):
                """Initialize and roll the die.
                sides -- Number of faces, with values starting at one
                (default is 6).
                """
                self._sides = sides # leading underscore signals private
                self._value = None # value from last roll
                self.roll()

        def roll(self):
                """Roll the die and return the result."""
                self._value = 1 + random.randrange(self._sides)
                return self._value
```

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Python Example (II)

```
        def __str__(self):
                """Return string with a nice description of the die state."""
                return "Die with %d sides, current value is %d." %
                (self._sides, self._value)

class WinnerDie(Die):
        """Special die class that is more likely to return a 1."""
        def roll(self):
                """Roll the die and return the result."""
                super(WinnerDie, self).roll() # use super instead of
                Die.roll(self)

                if self._value == 1:
                        return self._value
                else:
                        return super(WinnerDie, self).roll()
```

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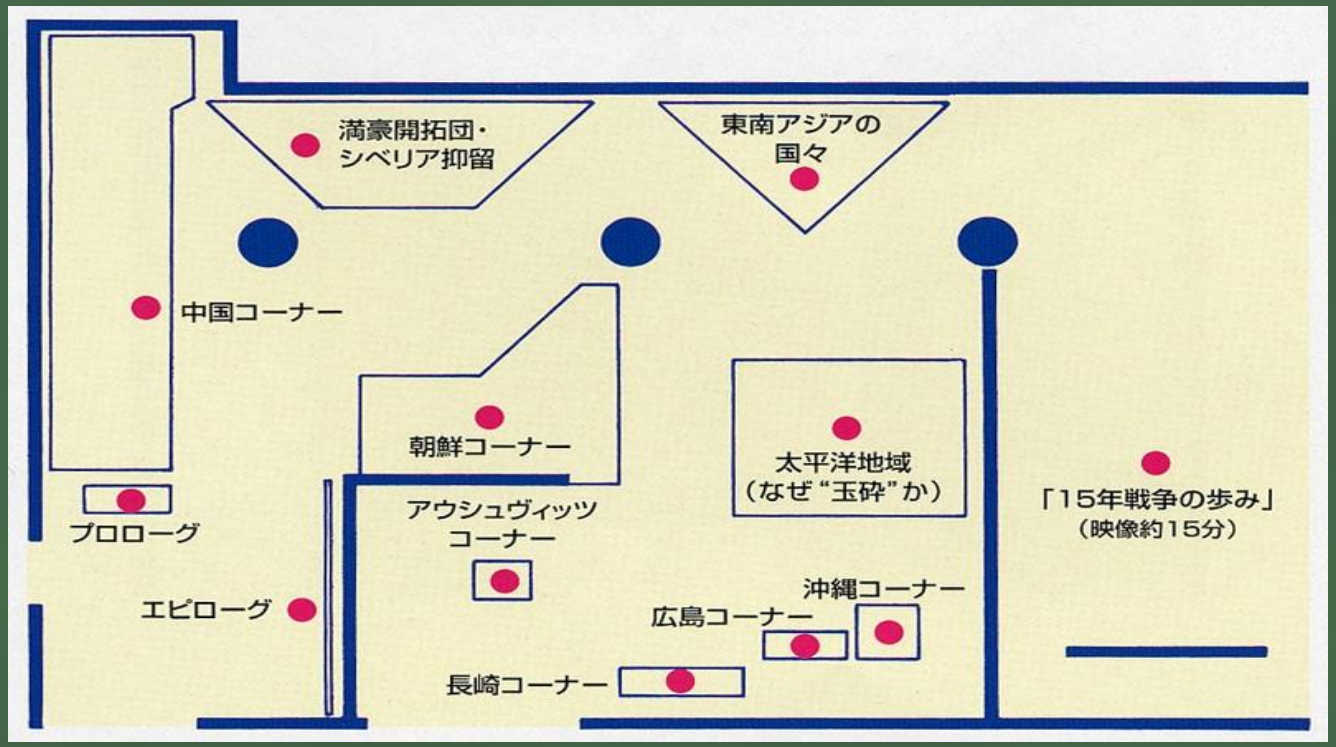
Python Example (III)

```
>>> die = Die()
>>> die._sides # we should not access this, but nobody will stop us
6
>>> die.roll
<bound method Die.roll of <dice.Die object at 0x03AE3F70>>
>>> for _ in range(10):
...         print die.roll()
2 2 6 5 2 1 2 6 3 2

>>> print die # this calls __str__
Die with 6 sides, current value is 2.
>>> winner_die = dice.WinnerDie()
>>> for _ in range(10):
...         print winner_die.roll(),
2 2 1 1 4 2 1 5 5 1
>>>
```

Design Patterns & Python



•Design Patterns & Python

What is a Design Pattern?

Design Patterns are concrete solutions for reoccurring problems.

They satisfy the design principles and can be used to understand and illustrate them.

They provide a NAME to communicate effectively with other programmers.

Iterator Pattern

- The essence of the Iterator Factory method Pattern is to "Provide a way to access the elements of an aggregate object sequentially without exposing its underlying representation.".

Decorator Pattern

- The decorator pattern is a design pattern that allows behavior to be added to an existing object dynamically.

Strategy Pattern

- The strategy pattern (also known as the policy pattern) is a particular software design pattern, whereby algorithms behavior can be selected at runtime.

Adapter Pattern

- The adapter pattern is a design pattern that translates one interface for a class into a compatible interface

Iterator Pattern

•Iterator Pattern

Problem

- How would you iterate elements from a collection?

```
>>> my_collection = ['a', 'b', 'c']
>>> for i in range(len(my_collection)):
...         print my_collection[i],
a b c
```

- But what if my_collection does not support indexing?

```
>>> my_collection = {'a': 1, 'b': 2, 'c': 3}
>>> for i in range(len(my_collection)):
...         print my_collection[i],
# What will happen here?
```

- This violates one of the design principles!

•Iterator Pattern

Description

- store the elements in a collection (iterable)
- manage the iteration over the elements by means of an iterator
- object which keeps track of the elements which were already delivered
- iterator has a next() method that returns an item from the
- collection. When all items have been returned it raises a
- Stop Iteration exception.
- iterable provides an __iter__() method, which returns an iterator
- object.

•Iterator Pattern

Example (I)

```
class MyIterable(object):
"""Example iterable that wraps a sequence."""
        def __init__(self, items):
                """Store the provided sequence of items."""
                self.items = items

        def __iter__(self):
                return MyIterator(self)

class MyIterator(object):
        """Example iterator that is used by MyIterable."""
        def __init__(self, my_iterable):
                """Initialize the iterator.
                my_iterable -- Instance of MyIterable.
        """
                self._my_iterable = my_iterable
                self._position = 0
```

•Iterator Pattern

Example (II)

```
def next(self):
        if self._position < len(self._my_iterable.items):
                value = self._my_iterable.items[self._position]
                self._position += 1
                return value
        else:
                raise StopIteration()

# in Python iterators also support iter by returning self
def __iter__(self):
        return self
```

•Iterator Pattern

Example (III)

- First, lets perform the iteration manually:

```
iterable = MyIterable([1,2,3])
iterator = iter(iterable) # or use iterable.__iter__()
try:
while True:
item = iterator.next()
print item
except StopIteration:
pass
print "Iteration done."
```

- A more elegant solution is to use the Python for-loop:

```
for item in iterable:
print item
print "Iteration done."
```

- In fact Python lists are already iterables:

```
for item in [1,2,3]:
        print item
```

Decorator Pattern

•Decorator Pattern

Problem (I)

```
class Beverage(object):

        # imagine some attributes like temperature, amount left,..
        .
        def get_description(self):
                return "beverage“

        def get_cost(self):
                return 0.00

class Coffee(Beverage):

        def get_description(self):
                return "normal coffee"
        def get_cost(self):
                return 3.00
class Tee(Beverage):

        def get_description(self):
                return "tee"
        def get_cost(self):
                return 2.50
```

•Decorator Pattern

Problem (II)

```
class CoffeeWithMilk(Coffee):

        def get_description(self):
                return super(CoffeeWithMilk, self).get_description() + ", with milk“

        def get_cost(self):
                return super(CoffeeWithMilk, self).get_cost() + 0.30

class CoffeeWithMilkAndSugar(CoffeeWithMilk):

# And so on, what a mess!
```

•Decorator Pattern

Description

We have the following requirements:

- adding new ingredients like soy milk should be easy and work with all beverages,
- anybody should be able to add new custom ingredients without touching the original code (open-closed principle),
- there should be no limit to the number of ingredients.

•Decorator Pattern

Solution

```
class Beverage(object):

        def get_description(self):
                return "beverage“
        def get_cost(self):
                return 0.00

class Coffee(Beverage):
#[...]

class BeverageDecorator(Beverage):

        def __init__(self, beverage):
                super(BeverageDecorator, self).__init__() # not really needed here
                self.beverage = beverage

class Milk(BeverageDecorator):
        def get_description(self):
                #[...]
        def get_cost(self):
                #[...]
                coffee_with_milk = Milk(Coffee())
```

Strategy Pattern

•Strategy Pattern

Problem

```
class Duck(object):

        def __init__(self):
                # for simplicity this example class is stateless

        def quack(self):
                print "Quack!“

        def display(self):
                print "Boring looking duck.“

        def take_off(self):
                print "I'm running fast, flapping with my wings.“

        def fly_to(self, destination):
                print "Now flying to %s." % destination

        def land(self):
                print "Slowing down, extending legs, touch down."
```

•Strategy Pattern

Problem (I)

```
class RedheadDuck(Duck):

        def display(self):
                print "Duck with a read head.“

class RubberDuck(Duck):

        def quack(self):
                print "Squeak!“

        def display(self):
                print "Small yellow rubber duck."
```

- Oh man! The RubberDuck is able to fly!
- Looks like we have to override all the flying related methods.
- But if we want to introduce a DecoyDuck as well we will have to override all three methods again in the same way (DRY).
- And what if a normal duck suffers a broken wing?
- **Idea:** Create a FlyingBehavior class which can be plugged into theDuck class.

•Strategy Pattern

Solution (I)

```
class FlyingBehavior(object):
        """Default flying behavior."""
        def take_off(self):
                print "I'm running fast, flapping with my wings."
        def fly_to(self, destination):
                print "Now flying to %s." % destination
        def land(self):
                print "Slowing down, extending legs, touch down.“

class Duck(object):
        def __init__(self):
                self.flying_behavior = FlyingBehavior()
        def quack(self):
                print "Quack!"
        def display(self):
                print "Boring looking duck."
        def take_off(self):
                self.flying_behavior.take_off()
        def fly_to(self, destination):
                self.flying_behavior.fly_to(destination)
        def land(self):
                self.flying_behavior.land()
```

•Strategy Pattern

Solution (II)

```
class NonFlyingBehavior(FlyingBehavior):
        """FlyingBehavior for ducks that are unable to fly."""
        def take_off(self):
                print "It's not working :-("
        def fly_to(self, destination):
                raise Exception("I'm not flying anywhere.")
        def land(self):
                print "That won't be necessary.“

class RubberDuck(Duck):
        def __init__(self):
                self.flying_behavior = NonFlyingBehavior()
        def quack(self):
                print "Squeak!"
        def display(self):
                print "Small yellow rubber duck.“

class DecoyDuck(Duck):
        def __init__(self):
                self.flying_behavior = NonFlyingBehavior()
        def quack(self):
                print ""
        def display(self):
                print "Looks almost like a real duck."
```

Adapter Pattern

•Adapter Pattern

Problem

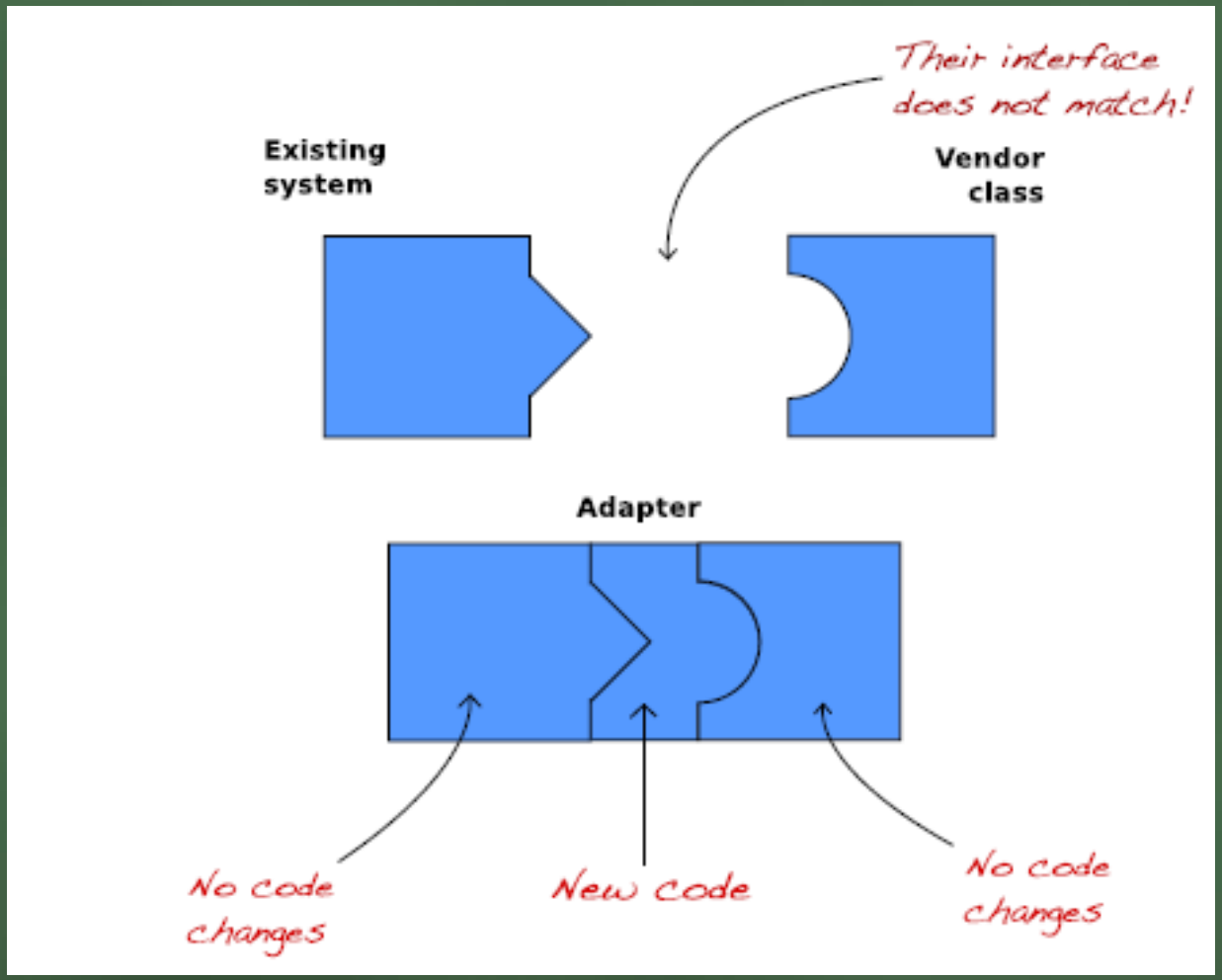
- Lets say we obtained the following class from our collaborator:

```
class Turkey(object):

        def fly_to(self):
                print "I believe I can fly...“

        def gobble(self, n):
                print "gobble " * n
```

How to integrate it with our Duck Simulator: turkeys can fly and gobble but they can not quack!

•Adapter Pattern

Description



•Adapter Pattern

Solution

```
class TurkeyAdapter(object):
        def __init__(self, turkey):
                self.turkey = turkey
                self.fly_to = turkey.fly_to #delegate to native Turkey method
                self.gobble_count = 3
        def quack(self): #adapt gobble to quack
                self.turkey.gobble(self.gobble_count)

>>> turkey = Turkey()
>>> turkeyduck = TurkeyAdapter(turkey)
>>> turkeyduck.fly_to()
I believe I can fly...
>>> turkeyduck.quack()
gobble gobble gobble
```

Adapter Pattern applies several good design principles:

- uses composition to wrap the adaptee (Turkey) with an altered interface,
- binds the client to an interface not to an implementation

More About Python

More About Python

Object models

Since Python2.2 there co-exist two slightly dierent object models in the language

Old-style (classic) classes : This is the model existing prior to Python2.2

New-style classes : This is the preferred model for new code

Old Style

```
>>> class A: pass
>>> class B: pass
>>> a, b = A(), B()
>>> type(a) == type(b)
True
>>> type(a)
<type 'instance'>
```

New Style

```
>>> class A(object): pass
>>> class B(object): pass
>>> a, b = A(), B()
>>> type(a) == type(b)
False
>>> type(a)
<class ' main .A'>
```

More About Python

New-style classes

- Defined in the type and class unification effort in python2.2
- (Introduced without breaking backwards compatibility)
- Simpler, more regular and more powerful
  - Built-in types (e.g. dict) can be subclassed
  - Properties: attributes managed by get/set methods
  - Static and class methods (via descriptor API)
  - Cooperative classes (sane multiple inheritance)
  - Meta-class programming
- It will be the default (and unique) in the future
- Documents:
  - Unifying types and classes in Python 2.2
  - PEP-252: Making types look more like classes
  - PEP-253: Subtyping built-in types
-

More About Python

The class statement

```
class classname(base-classes):
statement(s)
```

- classname is a variable that gets (re)bound to the class object after the class statement finishes executing
- base-classes is a comma separated series of expressions whose values must be classes
  - if it does not exists, the created class is old-style
  - if all base-classes are old-style, the created class is old-style
  - otherwise it is a new-style class1
  - since every type subclasses built-in object, we can use object to
  - mark a class as new-style when no true bases exist
- The statements (a.k.a. the class body) dene the set of class attributes which will be shared by all instances of the class

More About Python

Class-private attributes

- When a statement in the body (or in a method in the body) uses an identifier starting with two underscores (but not ending with them) such as __private, the Python compiler changes it to _classname__private
- This lets classes to use private names reducing the risk of accidentally duplicating names used elsewhere
- By convention all identifiers starting with a single underscore are
- meant to be private in the scope that binds them

```
>>> class C5(object):
... private = 23
>>> print C5.__private
AttributeError: class A has no attribute ' private'
>>> print C5. C5 private
23
```

More About Python

Descriptors

- A descriptor is any new-style object whose class supplies a special method named __get__
- Descriptors that are class attributes control the semantics of accessing and setting attributes on instances of that class
- If a descriptor's class also supplies method __set__ then it is called an overriding descriptor (a.k.a. data descriptor)
- If not, it is called non-overriding (a.k.a. non-data) descriptor
- Function objects (and methods) are non-overriding descriptors
- Descriptors are the mechanism behind properties, methods, static methods, class methods, and super (cooperative super-classes)
- The descriptor protocol also contains method __delete__ for unbinding attributes but it is seldom used

Thank You