Decorators
How to Silently Extend Classes (Part 2)

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Class Extensions through Decorators
What's a Decorator?

Decoration is a way to specify management code for functions and classes.

- Decorators themselves take the form of callable objects (e.g., functions) that process other callable objects.

Python decorators come in two related flavors:

- Function decorators do name rebinding at function definition time, providing a layer of logic that can manage functions and methods, or later calls to them.
- Class decorators do name rebinding at class definition time, providing a layer of logic that can manage classes, or the instances created by calling them later.

In short, decorators provide a way to insert automatically run code at the end of function and class definition statements.

Class Extensions through Decorators
Function Decorators

```
def decorator(F):          # on @ decoration
  def wrapper(*args):      # on wrapped function call
    # Use F and args and then call F(*args)
    print("I'm executing the call {0}{1} ...". \
          format(F.__name__, args))
    return F(*args)
  return wrapper


@decorator
def f(x,y):
  print("*** f({0}, {1})".format(x,y))

f(42, 7)
```

```
[23:30]cazzola@ulik:~/esercizi-pa>python3 fdecs.py
I'm executing the call f(42, 7) ...
*** f(42, 7)
```

```
class wrapper:
  def __init__(self, func):  # On @ decoration
    self.func = func
  def __call__(self, *args): # On wrapped calls
    # Use func and args and then call func(*args)
    print("I'm executing the call {0}{1} ...". \
          format(self.func.__name__, args))
    return self.func(*args)

@wrapper
def f2(x,y,z):
  print("*** f2({0}, {1}, {2})".format(x,y,z))

f2("abc",7, 'ß')
```

```
[23:31]cazzola@ulik:~/esercizi-pa>python3 fdecs.py
I'm executing the call f2('abc', 7, 'ß') ...
*** f2(abc, 7, ß)
```

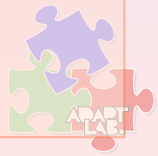
```
@decorator f(5,7) ≡ decorator(f)(5,7)
```

Note that, methods cannot be decorated by function decorators since the `self` would be associated to the decorator

Class Extensions through Decorators
Class Decorators

```
def decorator(cls):                                  # On @ decoration
  class wrapper:
    def __init__(self, *args):                       # On instance creation
      print("I'm creating {0}{1} ...".format(cls.__name__, args))
      self.wrapped = cls(*args)
    def __getattr__(self, name):                     # On attribute fetch
      print("I'm fetching {0}.{1} ...".format(self.wrapped, name))
      return getattr(self.wrapped, name)
    def __setattr__(self, attribute, value):         # On attribute set
      print("I'm setting {0} to {1} ...".format(attribute, value))
      if attribute == 'wrapped':                     # Allow my attrs
        self.__dict__[attribute] = value             # Avoid looping
      else:
        setattr(self.wrapped, attribute, value)
  return wrapper

@decorator
class C:                                 # C = decorator(C)
  def __init__(self, x, y): self.attr = 'spam'
  def f(self, a, b): print("*** f({0}, {1})".format(a,b))
```

```
[0:06]cazzola@ulik:~/esercizi-pa/decorators>python3
>>> from cdecorators import *
>>> x = C(6, 7)
I'm creating C(6, 7) ...
I'm setting wrapped to <cdecorators.C object at 0xb79eb26c> ...
>>> print(x.attr)
I'm fetching <cdecorators.C object at 0xb79eb26c>.attr ...
spam
>>> x.f(x.attr, 7)
I'm fetching <cdecorators.C object at 0xb79eb26c>.f ...
I'm fetching <cdecorators.C object at 0xb79eb26c>.attr ...
*** f(spam, 7)
```

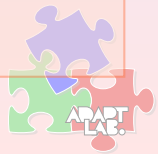


Class Extensions through Decorators
Decorators at Work: Timing

```
import time
class timer:
  def __init__(self, func):
    self.func     = func
    self.alltime = 0
  def __call__(self, *args, **kargs):
    start    = time.clock()
    result = self.func(*args, **kargs)
    elapsed = time.clock() - start
    self.alltime += elapsed
    print('{0}: {1:.5f}, {2:.5f}'.\
       format(self.func.__name__, elapsed, self.alltime))
    return result
@timer
def listcomp(N):
  return [x * 2 for x in range(N)]
@timer
def mapcall(N):
  return list(map((lambda x: x * 2), range(N)))
```

```
if __name__ == "__main__":
  result = listcomp(5)
  listcomp(50000)
  listcomp(500000)
  listcomp(1000000)
  print(result)
  print('allTime = {0}'.format(listcomp.alltime))
  print('')
  result = mapcall(5)
  mapcall(50000)
  mapcall(500000)
  mapcall(1000000)
  print(result)
  print('allTime = {0}'.format(mapcall.alltime))
  print('map/comp = {0}'.format(\
    round(mapcall.alltime / listcomp.alltime, 3)))
```

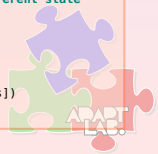
```
[21:06]cazzola@ulik:~/esercizi-pa>python3 timing.py
listcomp: 0.00000, 0.00000
listcomp: 0.03000, 0.03000
listcomp: 0.41000, 0.44000
listcomp: 0.85000, 1.29000
[0, 2, 4, 6, 8]
allTime = 1.29
mapcall: 0.00000, 0.00000
mapcall: 0.07000, 0.07000
mapcall: 0.71000, 0.78000
mapcall: 1.41000, 2.19000
[0, 2, 4, 6, 8]
allTime = 2.19
map/comp = 1.698
```



Class Extensions through Decorators
Decorators at Work: Tracer

```
def Tracer(aClass):                              # On @ decorator
  class Wrapper:
    def __init__(self, *args, **kargs):          # On instance creation
      self.fetches = 0
      self.wrapped = aClass(*args, **kargs)      # Use enclosing scope name
    def __getattr__(self, attrname):
      print('Trace: ' + attrname)                # Catches all but own attrs
      self.fetches += 1
      return getattr(self.wrapped, attrname)     # Delegate to wrapped obj
  return Wrapper

@Tracer
class Person:                                    # Person = Tracer(Person)
  def __init__(self, name, hours, rate):         # Wrapper remembers Person
    self.name = name
    self.hours = hours
    self.rate = rate
  def pay(self):                                 # Accesses outside class traced
    return self.hours * self.rate                # In-method accesses not traced
```

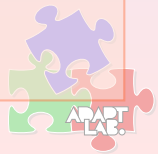
```
[12:59]cazzola@ulik:~/esercizi-pa/decorators>python3
>>> from tracer import *
>>> bob = Person('Bob', 40, 50)
>>> print(bob.name) # bob is a Wrapper to a Person
Trace: name
Bob
>>> print(bob.pay())
Trace: pay
2000
>>> sue = Person('Sue', rate=100, hours=60)
>>> print(sue.name) # sue is a different Wrapper
Trace: name
Sue
>>> print(sue.pay())
Trace: pay
6000
>>> print(bob.name)  # bob has different state
Trace: name
Bob
>>> print(bob.pay())
Trace: pay
2000
>>> print([bob.fetches, sue.fetches])
[4, 2]
```



Class Extensions through Decorators
Decorators at Work: Singleton

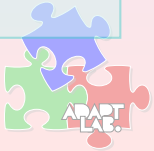
```
class singleton:
    def __init__(self, aClass):
        self.aClass = aClass
        self.instance = None
    def __call__(self, *args):
        if self.instance == None:
            self.instance = self.aClass(*args) # One instance per class
        return self.instance

@singleton                                  # Person = singleton(Person)
class Person:                               # Rebinds Person to onCall
     def __init__(self, name, hours, rate): # onCall remembers Person
        self.name = name
        self.hours = hours
        self.rate = rate
     def pay(self):
        return self.hours * self.rate

@singleton                          # Spam = singleton(Spam)
class Spam:                         # Rebinds Spam to onCall
    def __init__(self, val):        # onCall remembers Spam
        self.attr = val
```

```
[21:29]cazzola@ulik:~/esercizi-pa/decorators>python3
>>> from singleton import *
>>> bob = Person('Bob', 40, 10)
>>> print(bob.name, bob.pay())
Bob 400
>>> sue = Person('Sue', 50, 20)
>>> print(sue.name, sue.pay())
Bob 400
>>> X = Spam(42)
>>> Y = Spam(99)
>>> print(X.attr, Y.attr)
42 42
```



Class Extensions through Decorators
Decorators at Work: Privateness

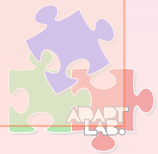
```
traceMe = False
def trace(*args):
    if traceMe: print('[' + ' '.join(map(str, args)) + ']')
def Private(*privates):                          # privates in enclosing scope
    def onDecorator(aClass):                     # aClass in enclosing scope
        class onInstance:                        # wrapped in instance attribute
            def __init__(self, *args, **kargs):
                self.wrapped = aClass(*args, **kargs)
            def __getattr__(self, attr):         # My attrs don't call getattr
                trace('get:', attr)              # Others assumed in wrapped
                if attr in privates:
                    raise TypeError('private attribute fetch: ' + attr)
                else:
                    return getattr(self.wrapped, attr)
            def __setattr__(self, attr, value):                 # Outside accesses
                trace('set:', attr, value)                      # Others run normally
                if attr == 'wrapped':                           # Allow my attrs
                    self.__dict__[attr] = value                 # Avoid looping
                elif attr in privates:
                    raise TypeError('private attribute change: ' + attr)
                else:
                    setattr(self.wrapped, attr, value)          # Wrapped obj attrs
        return onInstance                                       # Or use __dict__
    return onDecorator
```



Class Extensions through Decorators

Decorators at Work: Privateness (Cont'd)


```
[22:05]cazzola@ulik:~/esercizi-pa/decorators>python3
>>> from private import *
>>> traceMe = True
>>> @Private('data', 'size')
... class Doubler:
...         def __init__(self, label, start):
...             self.label = label                  # Accesses inside the subject class
...             self.data = start                   # Not intercepted: run normally
...         def size(self):
...             return len(self.data)               # Methods run with no checking
...         def double(self):                       # Because privacy not inherited
...             for i in range(self.size()):
...                 self.data[i] = self.data[i] * 2
...         def display(self):
...             print('{0} => {1}'.format(self.label, self.data))
>>> X = Doubler('X is', [1, 2, 3])
>>> print(X.label)                                  # Accesses outside subject class
X is
>>> X.display(); X.double(); X.display()            # Intercepted: validated, delegated
X is => [1, 2, 3]
X is => [2, 4, 6]
>>> print(X.size())                 # prints "TypeError: private attribute fetch: size"
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "private.py", line 19, in __getattr__
    raise TypeError('private attribute fetch: ' + attr)
TypeError: private attribute fetch: size
>>> X.data = [1, 1, 1]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "private.py", line 27, in __setattr__
    raise TypeError('private attribute change: ' + attr)
TypeError: private attribute change: data
```



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