Decorators

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www.python.org/dev/peps/pep-0318/

Course overview

Basic programming
Advanced / specific python
Libraries & applications

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10 handins
1 final project (last 1 month)

Python decorators are just syntatic sugar

Python

```python
@dec2
@dec1
def func(arg1, arg2, ...):
    pass
```

≡

Python

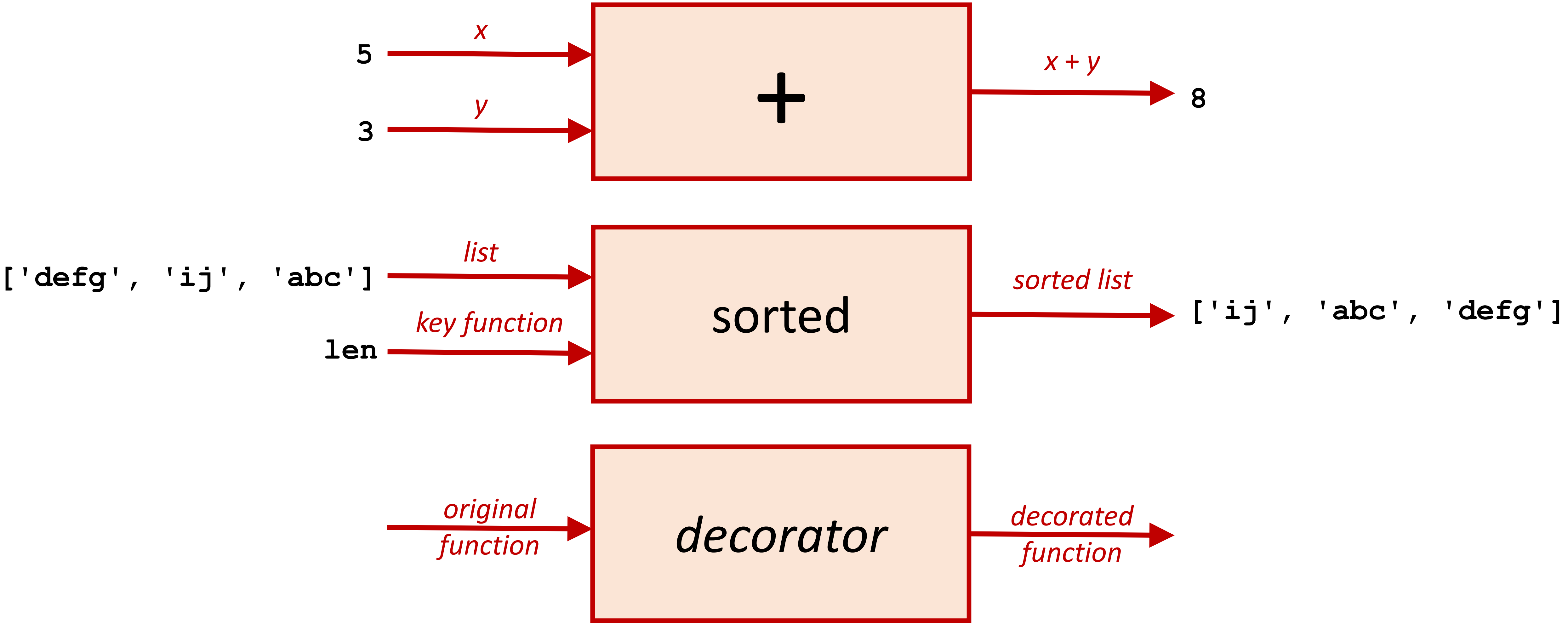
```python
def func(arg1, arg2, ...):
    pass

func = dec2(dec1(func))
```

'pie-decorator' syntax

dec1, dec2, ... are functions (decorators) taking a *function as an argument* and *returning a new function*

Note: decorators are listed bottom up in order of execution

Recap functions



Contrived example : Plus one (I-II)

plus_one1.py

```
def plus_one(x):
    return x + 1

def square(x):
    return x ** 2

def cube(x):
    return x ** 3

print(plus_one(square(5)))
print(plus_one(cube(5)))
```

Python shell

```
| 26
| 126
```

Assume we *always* need to call `plus_one` on the result of `square` and `cube` (don't ask why!)

plus_one2.py

```
def plus_one(x):
    return x + 1

def square(x):
    return plus_one(x ** 2)

def cube(x):
    return plus_one(x ** 3)

print(square(5))
print(cube(5))
```

Python shell

```
| 26
| 126
```

We could call `plus_one` inside functions (but could be more `return` statements in functions)

Contrived example : Plus one (III-IV)

plus_one3.py

```
def plus_one(x):
    return x + 1

def square(x):
    return x ** 2

def cube(x):
    return x ** 3

square_original = square
cube_original = cube

square = lambda x: plus_one(square_original(x))
cube = lambda x: plus_one(cube_original(x))

print(square(5))
print(cube(5))
```

Python shell

```
| 26
| 126
```

Overwrite `square` and `cube` with decorated versions

plus_one4.py

```
def plus_one(x):
    return x + 1

def plus_one_decorator(f):
    return lambda x: plus_one(f(x))

def square(x):
    return x ** 2

def cube(x):
    return x ** 3

square = plus_one_decorator(square)
cube = plus_one_decorator(cube)

print(square(5))
print(cube(5))
```

Python shell

```
| 26
| 126
```

Create a decorator function `plus_one_decorator`

Contrived example : Plus one (V-VI)

plus_one5.py

```
def plus_one(x):
    return x + 1

def plus_one_decorator(f):
    return lambda x: plus_one(f(x))

@plus_one_decorator
def square(x):
    return x ** 2

@plus_one_decorator
def cube(x):
    return x ** 3

print(square(5))
print(cube(5))
```

Python shell

```
| 26
| 126
```

Use Python decorator syntax

plus_one6.py

```
def plus_one_decorator(f):
    def plus_one(x):
        return f(x) + 1

    return plus_one

@plus_one_decorator
def square(x):
    return x ** 2

@plus_one_decorator
def cube(x):
    return x ** 3

print(square(5))
print(cube(5))
```

Python shell

```
| 26
| 126
```

Create local function instead of using `lambda`

Contrived example : Plus one (VII)

plus_one7.py

```
def plus_one_decorator(f):
    def plus_one(x):
        return f(x) + 1
    return plus_one

@plus_one_decorator
@plus_one_decorator
def square(x):
    return x ** 2

@plus_one_decorator
@plus_one_decorator
@plus_one_decorator
def cube(x):
    return x ** 3

print(square(5))
print(cube(5))
```

Python shell

```
| 27
| 128
```

- A function can have an arbitrary number of decorators (also the same repeated)
- Decorators are listed bottom up in order of execution

Handling arguments

run_twice1.py

```
def run_twice(f):
    def wrapper():
        f()
        f()
    return wrapper
@run_twice
def hello_world():
    print('Hello world')
hello_world()
```

Python shell

```
| Hello world
| Hello world
```

"`wrapper`" is a common name for the function returned by a decorator

run_twice2.py

```
def run_twice(f):
    def wrapper(*args):
        f(*args)
        f(*args)
    return wrapper
@run_twice
def hello_world():
    print('Hello world')
@run_twice
def hello(txt):
    print('Hello', txt)
hello_world()
hello('Mars')
```

Python shell

```
| Hello world
| Hello world
| Hello Mars
| Hello Mars
```

`args` holds the arguments in a tuple given to the function to be decorated

Question – What does the decorated program print ?

decorator_quiz.py

```
def double(f):
    def wrapper(*args):
        return 2 * f(*args)
    return wrapper

def add_three(f):
    def wrapper(*args):
        return 3 + f(*args)
    return wrapper

@double
@add_three
def seven():
    return 7

print(seven())
```

- 7
- 10
- 14
- 17
- 20
- Don’t know

Example: Enforcing argument types

- Defining decorators can be (slightly) complicated
- Using decorators is easy

integer_sum1.py

```
def integer_sum(*args):
    assert all([isinstance(x, int) for x in args]),\
           'all arguments most be int'
    return sum(args)
```

Python shell

```
> integer_sum(1, 2, 3, 4)
| 10
> integer_sum(1, 2, 3.2, 4)
| AssertionError: all arguments most be int
```

integer_sum2.py

```
def enforce_integer(f):    # decorator function
    def wrapper(*args):
        assert all([isinstance(x, int) for x in args]),\
               'all arguments most be int'
        return f(*args)
    return wrapper

@enforce_integer
def integer_sum(*args):
    return sum(args)
```

Python shell

```
> integer_sum(1, 2, 3, 4)
| 10
> integer_sum(1, 2, 3.2, 4)
| AssertionError: all arguments most be int
```

Decorators can take arguments

```python
@dec(argA, argB, ...)
def func(arg1, arg2, ...):
    pass
```

≡

```python
def func(arg1, arg2, ...):
    pass
func = dec(argA, argB, ...)(func)
```

`dec` is a function (decorator) that takes a *list of arguments* and *returns a function* (to decorate `func`) that takes a *function as an argument* and *returns a new function*

Example: Generic type enforcing

print_repeated.py

```
def enforce_types(*decorator_args):
    def decorator(f):
        def wrapper(*args):
            assert len(args) == len(decorator_args), \
                   f'got {len(args)} arguments, expected {len(decorator_args)}'
            assert all([isinstance(x, t) for x, t in zip(args, decorator_args)]), \
                   'unexpected types'
            return f(*args)
        return wrapper
    return decorator

@enforce_types(str, int)  # decorator with arguments
def print_repeated(txt, n):
    print(txt * n)

print_repeated('Hello ', 3)
print_repeated('Hello ', 'world')
```

Python

```
@dec(argA, argB, ...)
def func(arg1, arg2, ...):
    pass
```

≡

Python

```
def func(arg1, arg2, ...):
    pass
func = dec(argA, argB, ...)(func)
```

Python shell

```
| Hello Hello Hello
| AssertionError: unexpected types
```

Example: A timer decorator

time_it.py

```
import time

def time_it(f):
    def wrapper(*args, **kwargs):
        t_start = time.time()
        result = f(*args, **kwargs)
        t_end = time.time()
        t = t_end - t_start
        print(f'{f.__name__} took {t:.2f} seconds')
        return result

    return wrapper

@time_it
def slow_function(n):
    sum_ = 0
    for x in range(n):
        sum_ += x
    print('The sum is:', sum_)

for i in range(6):
    slow_function(1_000_000 * 2 ** i)
```

Python shell

```
| The sum is: 499999500000
| slow_function took 0.27 sec
| The sum is: 1999999000000
| slow_function took 0.23 sec
| The sum is: 7999998000000
| slow_function took 0.41 sec
| The sum is: 31999996000000
| slow_function took 0.81 sec
| The sum is: 127999992000000
| slow_function took 1.52 sec
| The sum is: 511999984000000
| slow_function took 3.12 sec
```

Built-in `@property`

- decorator specific for class methods
- allows accessing `x.attribute()` as `x.attribute`,
  convenient if `attribute` does not take any arguments (also readonly)

rectangle1.py

```python
class Rectangle:
    def __init__(self, width, height):
        self.width = width
        self.height = height

#   @property
    def area(self):
        return self.width * self.height
```

Python shell

```
> r = Rectangle(3, 4)
> print(r.area())
| 12
```

rectangle2.py

```python
class Rectangle:
    def __init__(self, width, height):
        self.width = width
        self.height = height

    @property
    def area(self):
        return self.width * self.height
```

Python shell

```
> r = Rectangle(3, 4)
> print(r.area)
| 12
```

Class decorators

Python

```python
@dec2
@dec1
class A:
  pass
```

≡

Python

```python
class A:
  pass

A = dec2(dec1(A))
```

Module `dataclasses` (Since Python 3.7)

- New (and more configurable) alternative to `namedtuple`

Python shell

```
> from dataclasses import dataclass
> @dataclass  # uses a decorator to add methods to the class
  class Person:
      name: str  # uses type annotation to define fields
      appeared: int
      height: str = 'unknown height'  # field with default value
> person = Person('Donald Duck', 1934, '3 feet')
> person
| Person(name='Donald Duck', appeared=1934, height='3 feet')
> person.name
| 'Donald Duck'
> person.height = '3.5 feet'
> Person('Mickey Mouse', 1928)
| Person(name='Mickey Mouse', appeared=1928, height='unknown height')
```

docs.python.org/3/library/dataclasses.html#module-dataclasses

Raymond Hettinger - Dataclasses: The code generator to end all code generators - PyCon 2018

@functools.total_ordering (class decorator)

student.py

```
import functools

@functools.total_ordering
class Student():
    def __init__(self, name, student_id):
        self.name = name
        self.id = student_id
    def __eq__(self, other):
        return (self.name == other.name and self.id == other.id)
    def __lt__(self, other):
        my_name = ', '.join(reversed(self.name.split()))
        other_name = ', '.join(reversed(other.name.split()))
        return (my_name < other_name
                or (my_name == other_name and self.id < other.id))
donald = Student('Donald Duck', 7)
gladstone = Student('Gladstone Gander', 42)
grandma = Student('Grandma Duck', 1)
```

Automatically creates <, <=, >, >= if at least one of the functions is implemented and == is implemented

Python shell

```
> donald < grandma
| True
> grandma >= gladstone
| False
> grandma <= gladstone
| True
> donald > gladstone
| False
```

class_decorator.py

```python
def add_lessequal(cls):
    '''Class decorator to add __le__ given __eq__ and __lt__.'''
    cls.__le__ = lambda self, other : self == other or self < other
    return cls  # the original class cls with attribute __le__ added

def add_lessequal(cls):  # alternative
    class sub_cls(cls):
        def __le__(self, other):
            return self == other or self < other

    return sub_cls  # new subclass of class cls

@add_lessequal  # Vector = add_lessequal(Vector)
class Vector:
    def __init__(self, x, y):
        self.x = x
        self.y = y

    def _length_squared(self):
        return self.x ** 2 + self.y ** 2

    def __eq__(self, other):
        # Required, otherwise Vector(1, 2) == Vector(1, 2) is False
        return self._length_squared() == other._length_squared()

    def __lt__(self, other):
        return self._length_squared() < other._length_squared()

#    def __le__(self, other):
#        return self._length_squared() <= other._length_squared()

#    def __le__(self, other):
#        return self == other or self < other
```

Python shell

```
> u = Vector(3, 4)
> v = Vector(2, 5)
> u.__eq__(v)
| False
> u.__ne__(v)
| True  # not u.__eq__(v)
> u.__lt__(v)
| True
> u.__gt__(v)
| NotImplemented  # special value
> u.__le__(v)
| True  # added by @add_lessequal
> u.__ge__(v)
| NotImplemented  # special value
> u == v
| False
> u != v
| True
> u < v
| True
> u > v  # v < u
| False
> u <= v
| True
> u >= v  # v <= u
| False
```

https://docs.python.org/3/reference/datamodel.html#basic-customization

Summary

- *@decorator_name*
- Pyton decorators are just syntatic sugar
- Adds functionality to a function without having to augment each call to the function or each return statement in the function
- There are decorators for functions, class methods, and classes
- There are many decorators in the Python Standard Library
- Decorators are easy to use
- ...and (slightly) harder to write