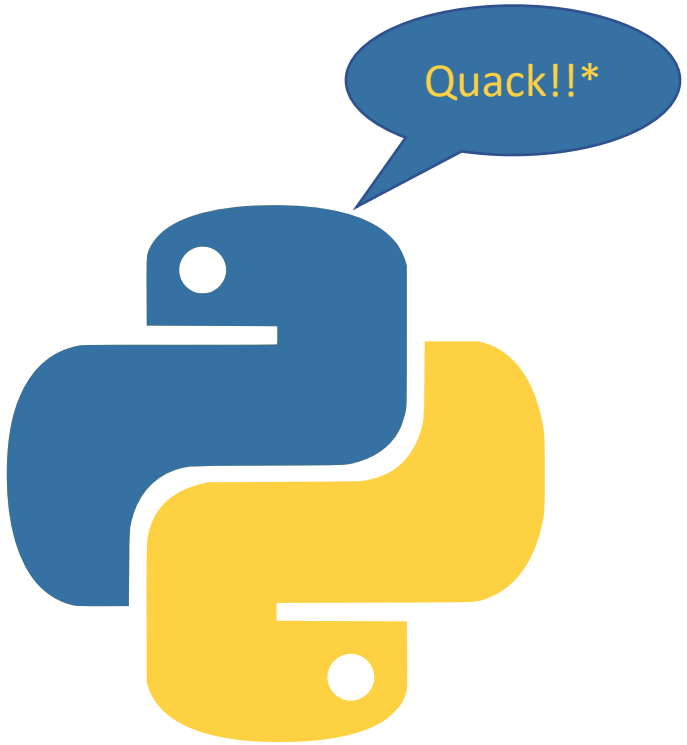
Object Oriented Programming
in Python



* That’s actually a spoiler, you have been alerted.

Introduction

Is OOP useful ? Definitely yes !!!

It allows you to write :

Shorter code

Versatile libraries

Clearer code

Easy to use libraries

Easy to use Graphical User Interfaces (GUI)

Easily extendable libraries

“Elegant“ code

A short overview of the history of OOP

> 1960s	Firstly introduced in Simula
> 1970s	Fully implemented in Smalltalk
> 1980s	Becomes popular thanks to C++
> 1990s	Very popular languages as python and Java rely on the use of OOP
> 2000 to present	OOP is used in Javascript, C# New paradigms start to develop (Go, Rust, Dart …)

Some programming languages (as Java) strongly rely on OOP

Python hello world program

```python
if __name__ == '__main__':
    print("Hello Wordl !)
```

Java hello world program

```java
public class HelloWorld {
    public static void main(String[] args) {
        System.out.println("Hello, World!");
    }
}
```

What is OOP ?

It is a programming strategy/paradigm using entities called “objects”.

Despite the fact that some examples found in real life are not objects in python can be really useful !!

Translation:

Glass breaking hammer

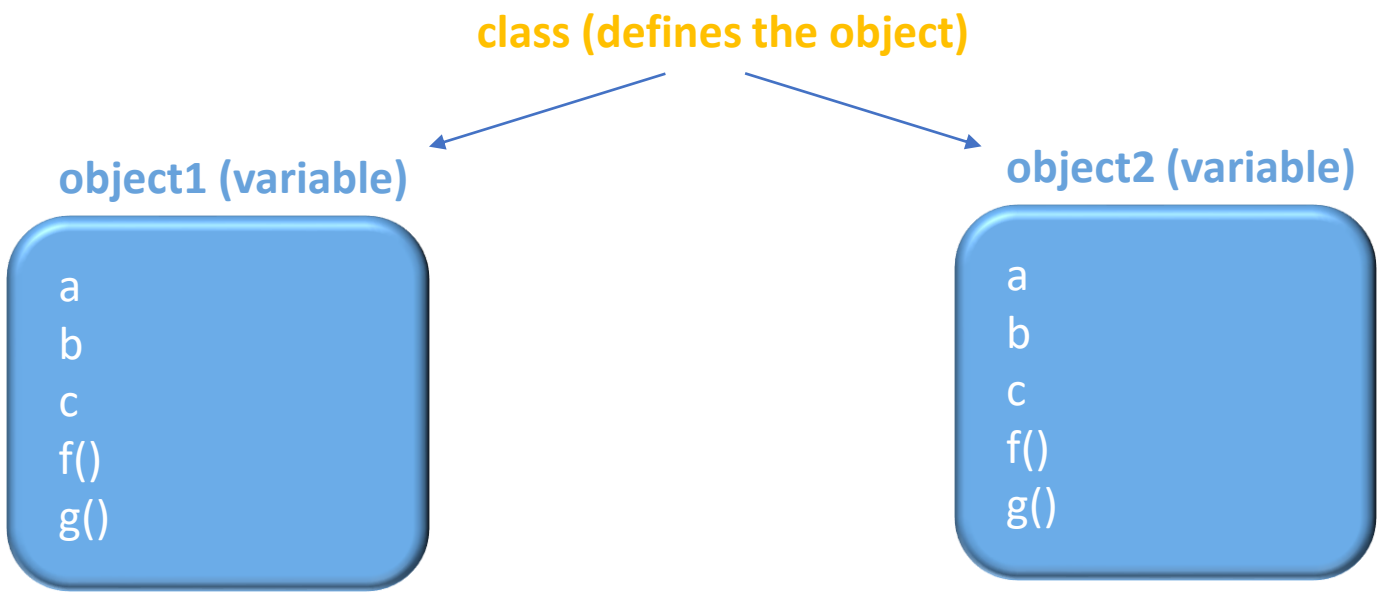
Break the glass to take the hammer

Memory Management in Python

What is the definition of an object in OOP?

In python an object is an abstract entity that contains variables and methods (functions).

The fact that it contains “its own things (variables and functions)” is called **“encapsulation”**



In python everything is an object including literals !!
(use dir() or type() if you do not believe me)

Objects: classes, instances and variables

MyFirstClass ← One Class

class_name

class_name is a class variable

Can be used to create several instances of the same class

obj1 → MyFirstClass → instance_name

obj2 → MyFirstClass → instance_name

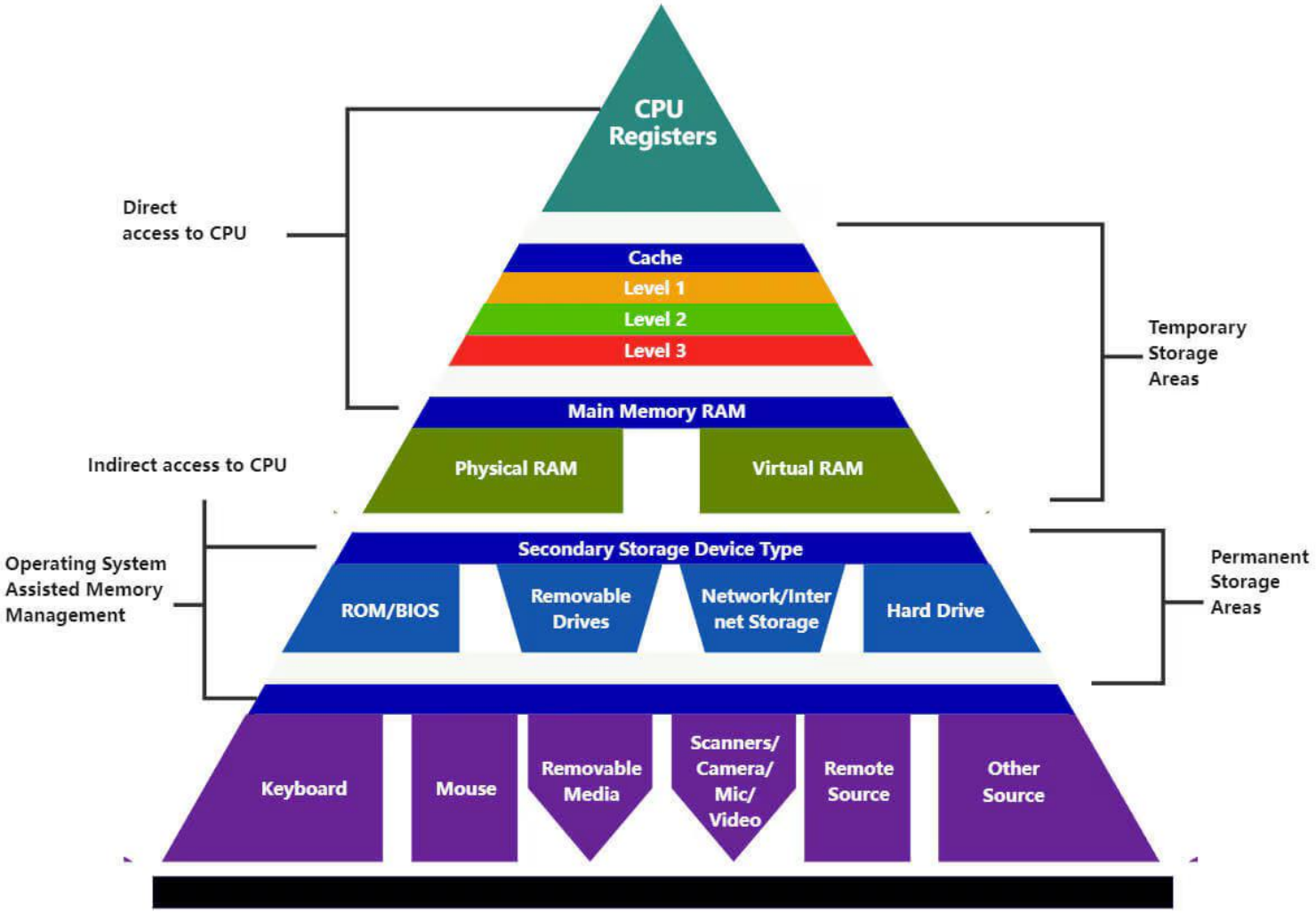
instance_name is an instance variable

Description of a Japanese umbrella

- It has a height and a radius
- It can be opened
- The point and handle have colors
- It is Japanese

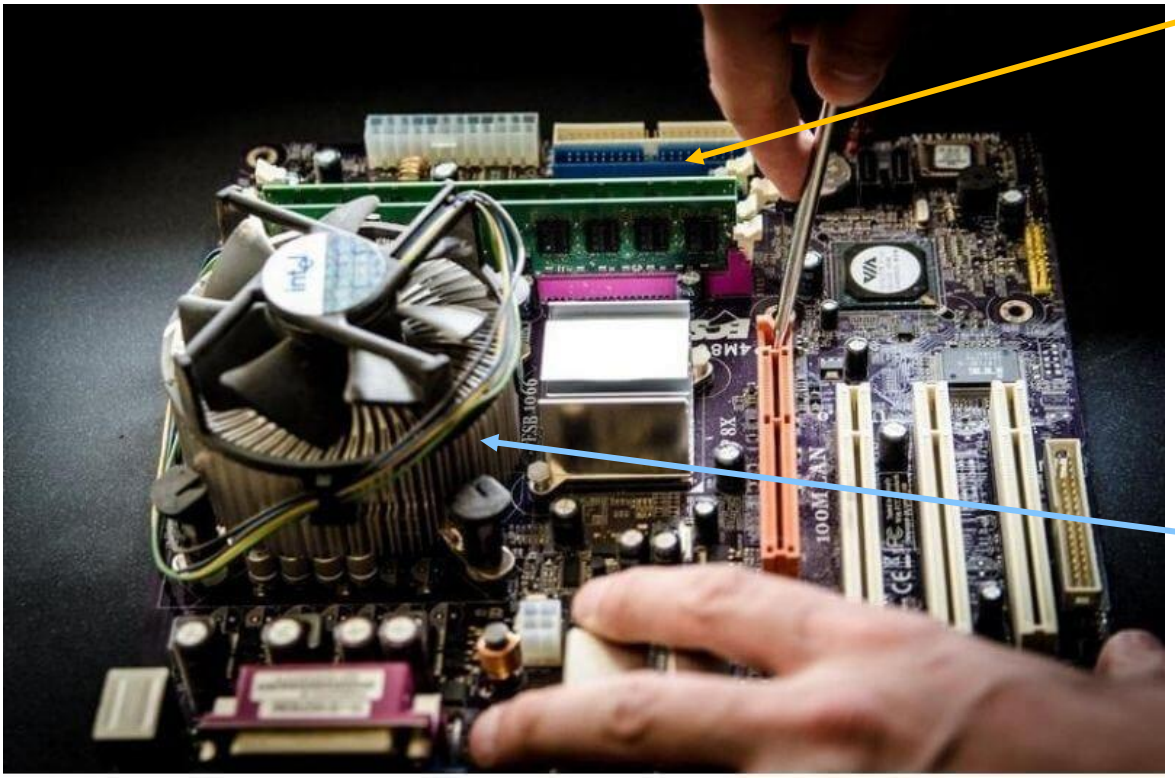
Different instances of the umbrella = The actual objects

(Very) basic memory management



Memory management in modern CPUs is complex: I will use a simplified model !

Basic memory management



Random Access Memory (RAM)

Heap memory

Used for objects and global variables

CPU Unit

Stack memory

Microprocessor

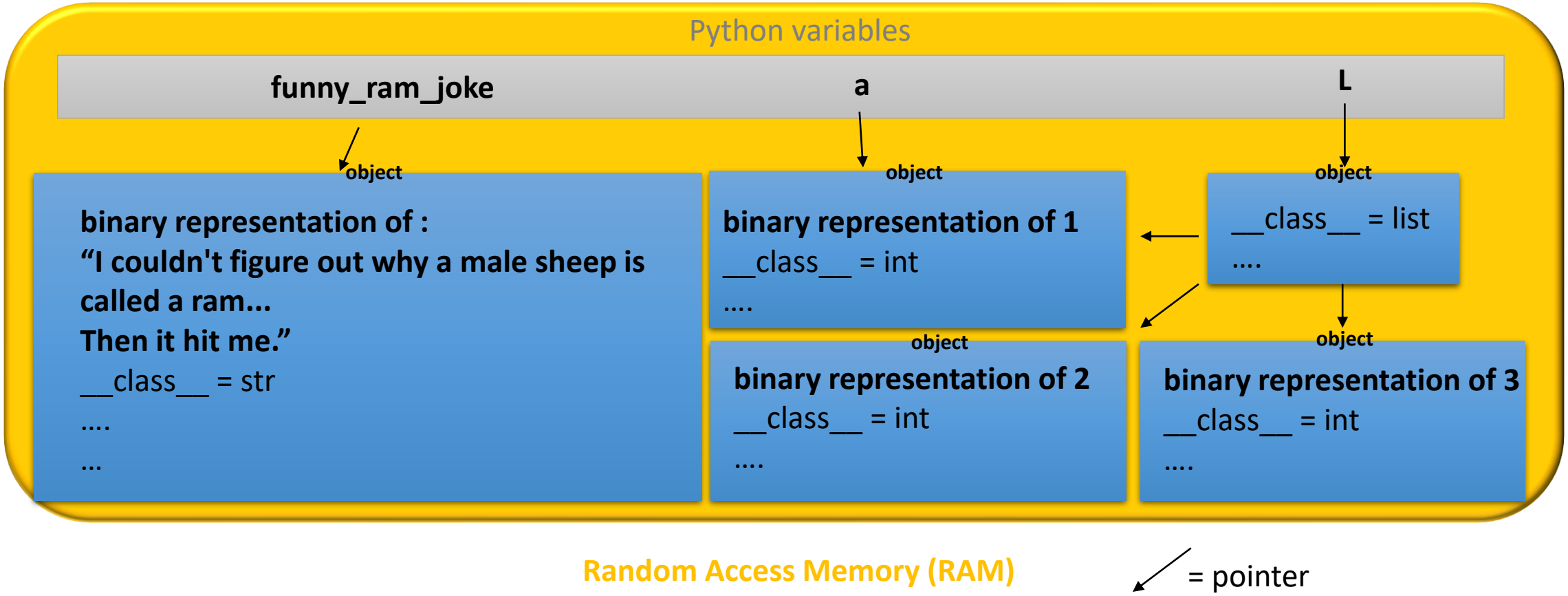
Used for local variables
and return values

Avoid using global variables in your programs !!!

Objects, pointers, variables and RAM

```
funny_ram_joke = ‘’’I couldn't figure out why a male sheep is called
a ram...
Then it hit me.’’’
a = 1
L = [1, 2, 3]
```

Variables in python store a reference (point) to objects.
(passing by reference paradigm)

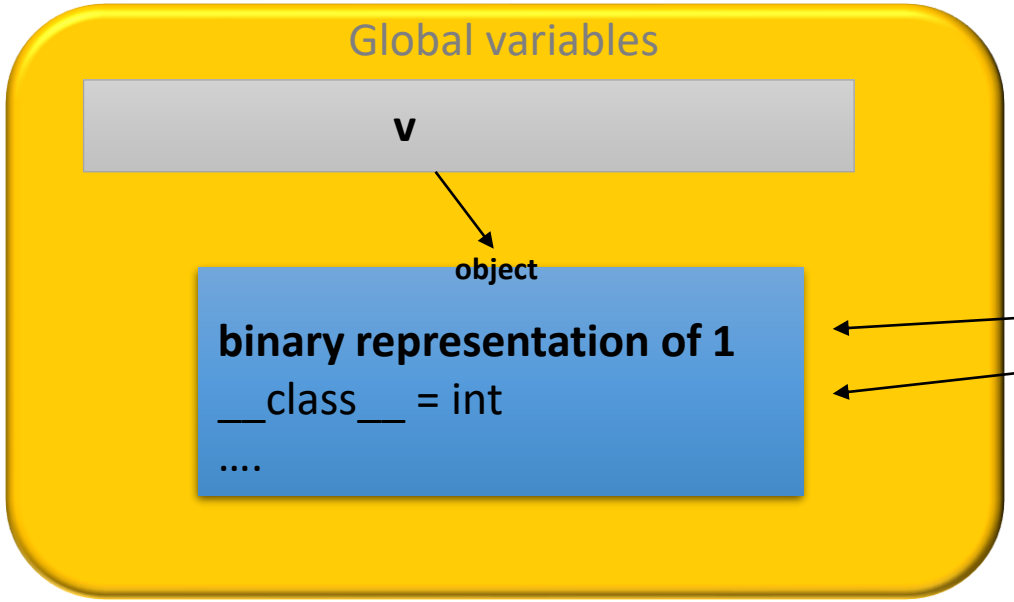


Local ang global variables

```
def f(a):
  b = a
v = 1
f(v)
```

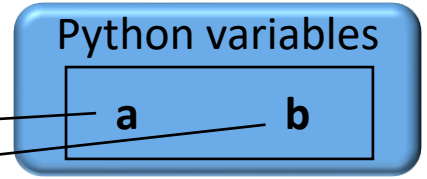
Global variable are stored in the RAM

Local variable are stored in the stack



Random Access Memory (RAM)

This variable are destroyed when the function returns



Stack Memory

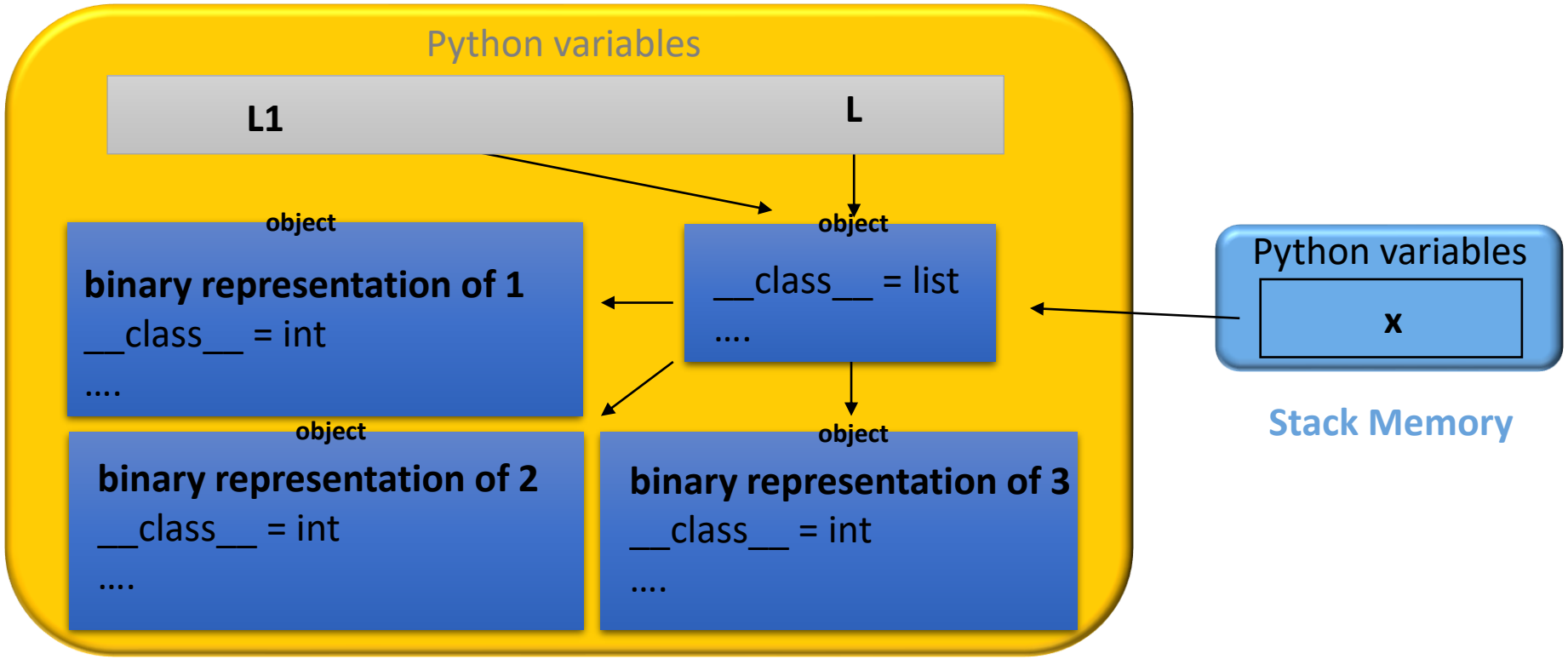
Assignment and collateral effects

Code

Assignment

```
L = [1, 2, 3]
L1 = L
def f(x):
    pass
f(L)
```

Collateral effects possible: all variables pointing the same objects are affected if you modify it using one of them



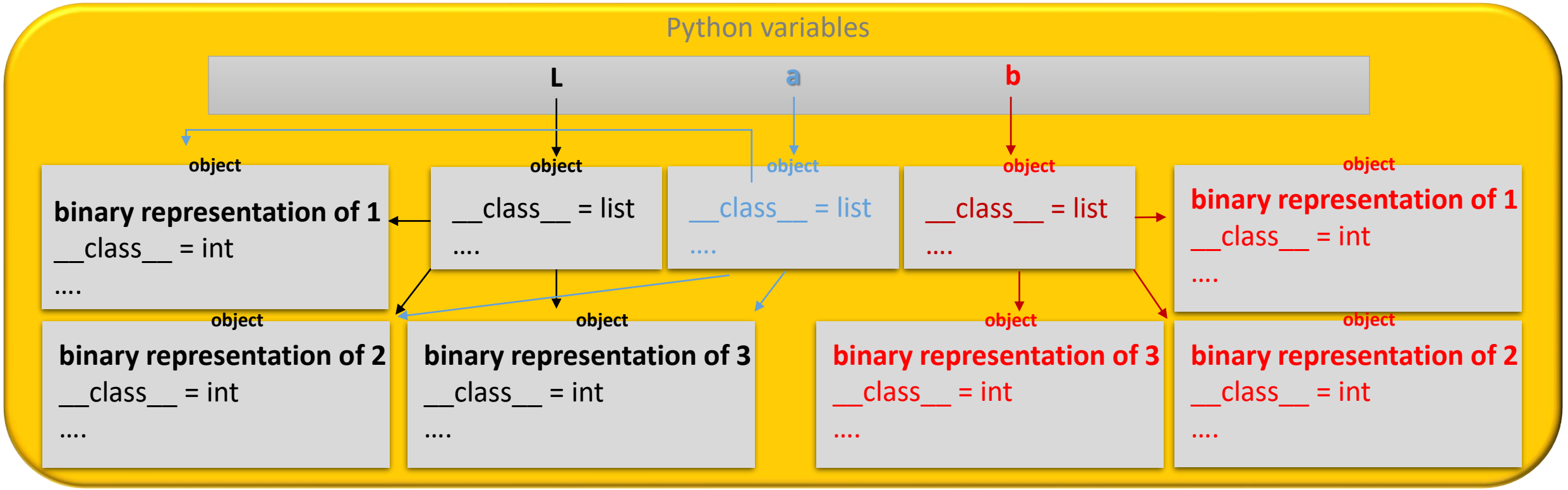
Copy and deep copy Code

(shallow) copy and deep copy

```
import copy

L = [1, 2, 3]
a = copy.copy(L)
b = copy.deepcopy(L)
```

No collateral effects possible with deep copy (just placebo ☺) but the operation is much slower

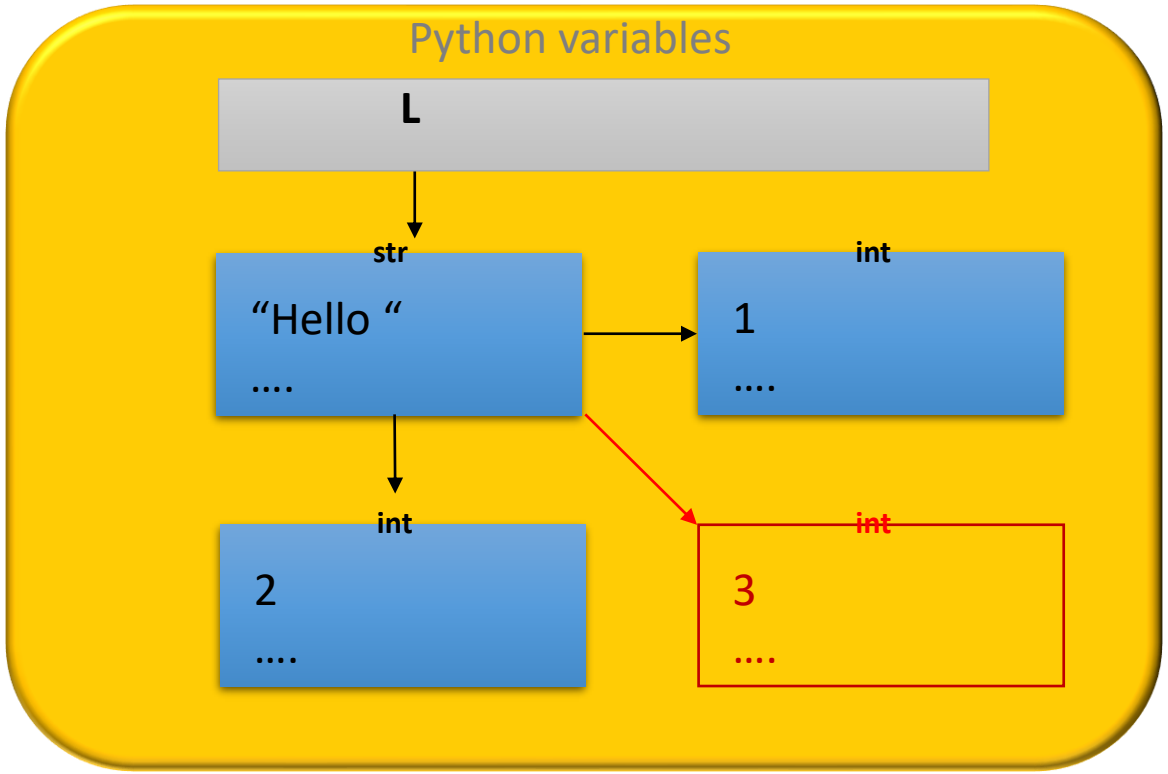


Random Access Memory (RAM)

Mutable and immutable objects

Mutable objects cannot be modified

```
L= [1, 2]
L.append(3)
```



Random Access Memory (RAM)

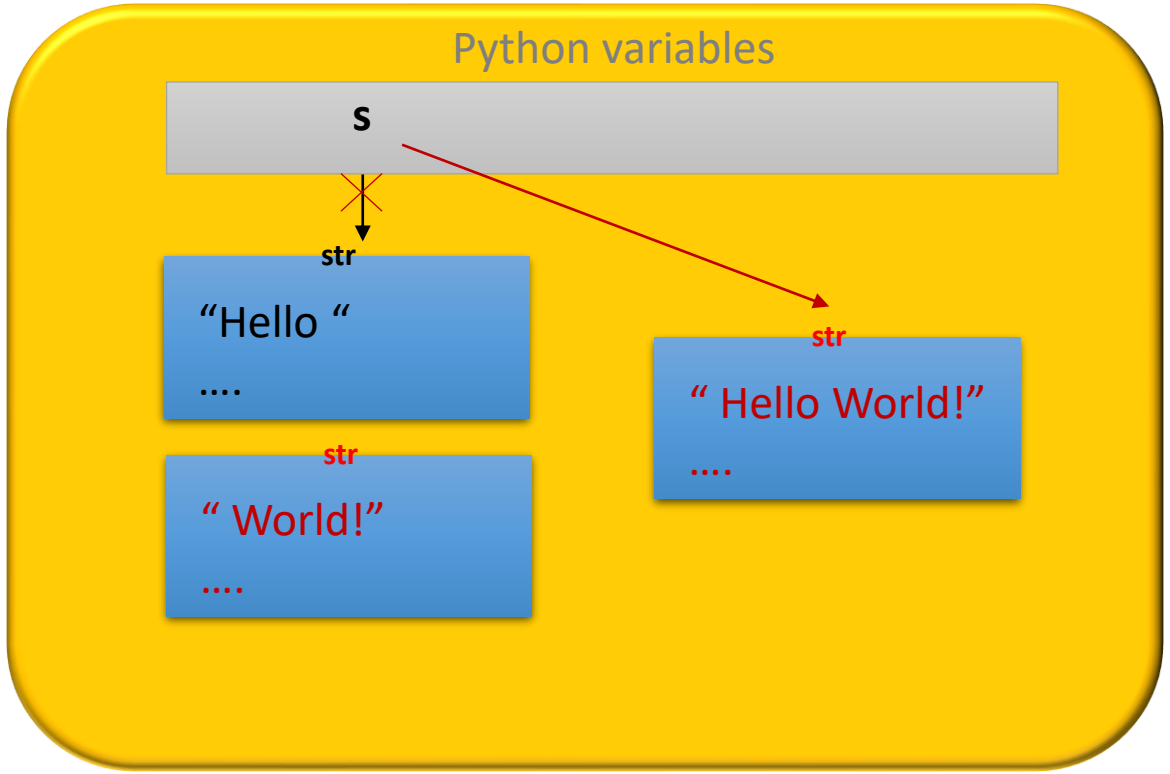
Object is modified "in place"

No copy needed and that's quick !

Mutable and immutable objects

Immutable objects cannot be modified

```
s = “Hello”
s = s + “ World!”
```



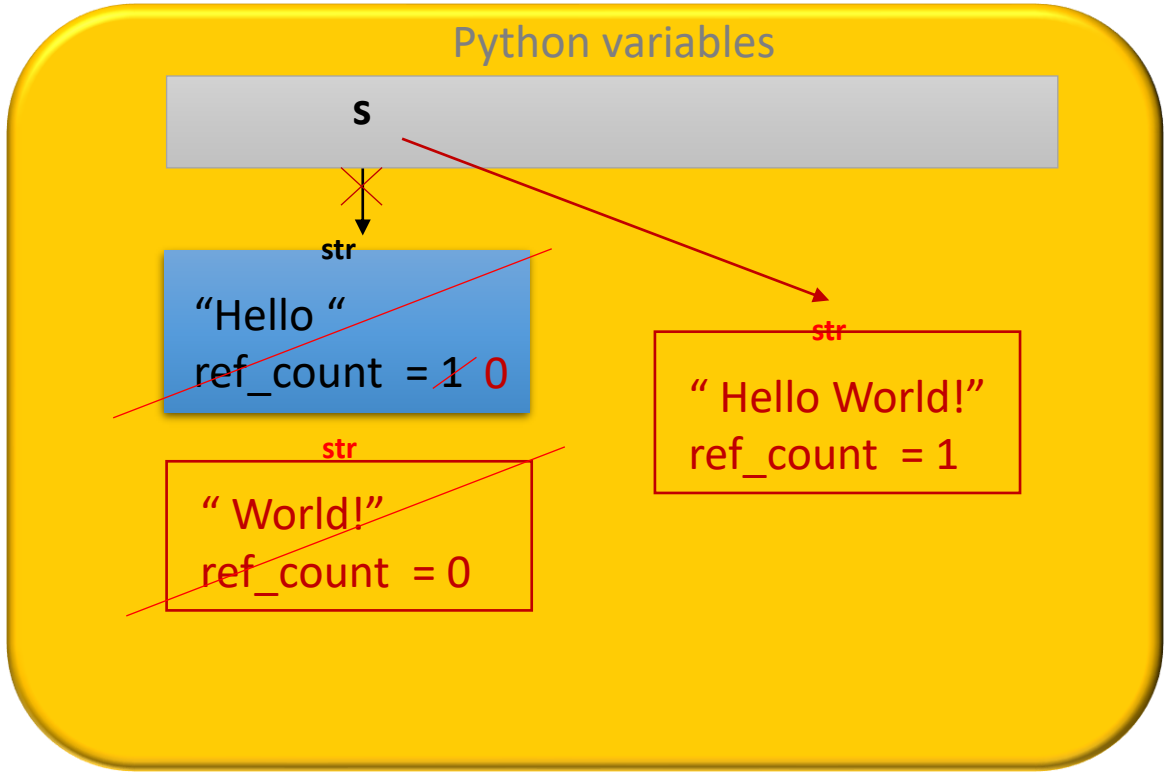
Examples: numbers, strings, tuples….
To modify strings you need to create new objects !!!
What happens to all the “old” unused objects in memory ?

Random Access Memory (RAM)

Smart pointers and the garbage collector

Python has smart pointers

```
s = “Hello”
s = s + “ World!”
```



Memory is automatically freed.

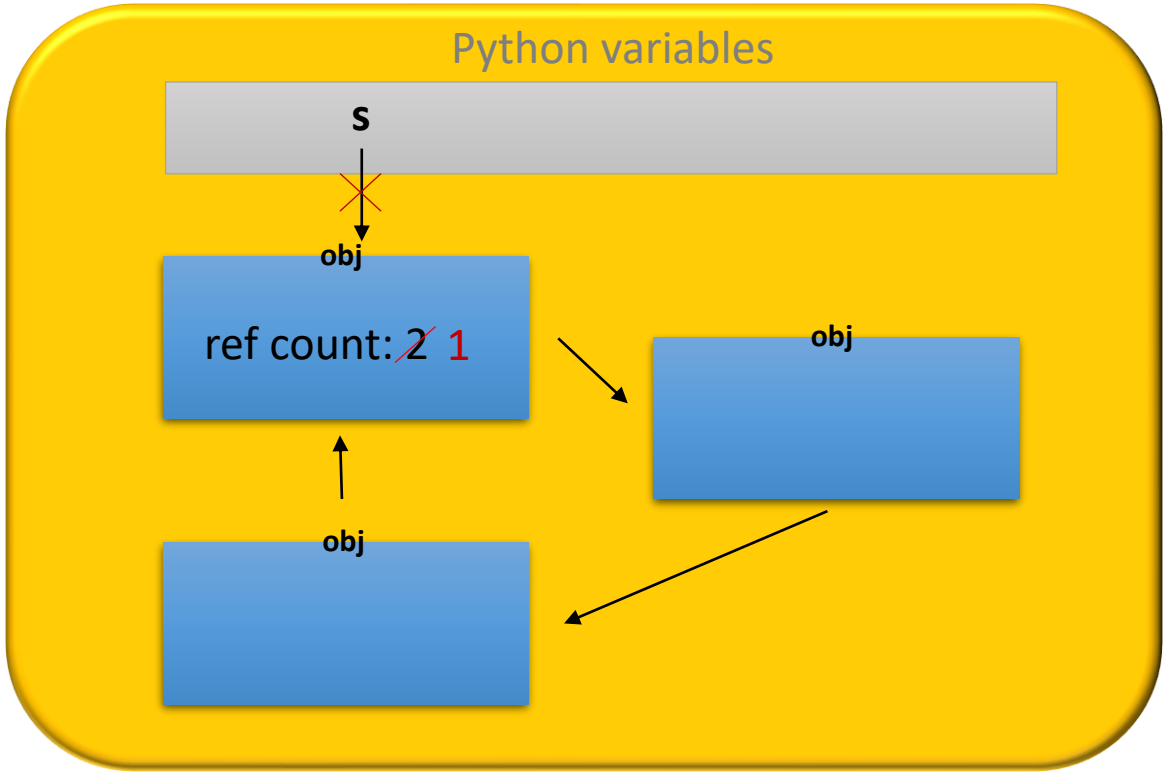
That’s smart !

Smart pointers and the garbage collector Code

```
del s
```

In some cases this does not work

(circular references)



Memory is not automatically freed

This is why python has a

GARBAGE COLLECTOR

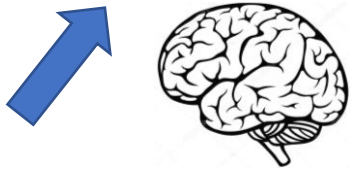
That periodically checks the memory for the presence of such cases and frees them if needed

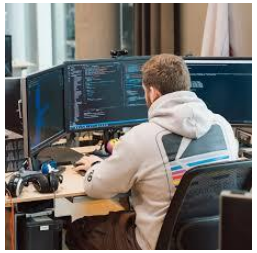
WHICH REDUCES PERFORMANCES

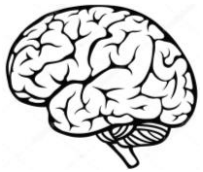
The smartness conservation principle

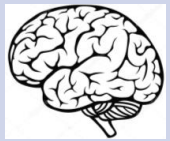
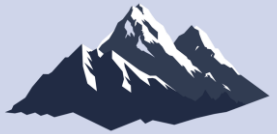
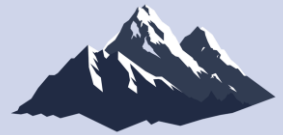
The quality of the final result is directly proportional to the amount of smartness used to produce it.

The Fazzini corollary (still top secret do not talk about it with anyone)







Pointer Smartness	Programmer Smartness	Program efficiency	Program stability
			
			
			

Section Summary

- **In python everything is accessed as an object**
- **Objects are stored in memory and automatically deleted when not needed anymore**
- **Memory management has a performance cost**
- **You can have (unwanted) collateral effects when copying and passing variables**

Using Objects in Python

Basic concepts

Encapsulation

Inheritance

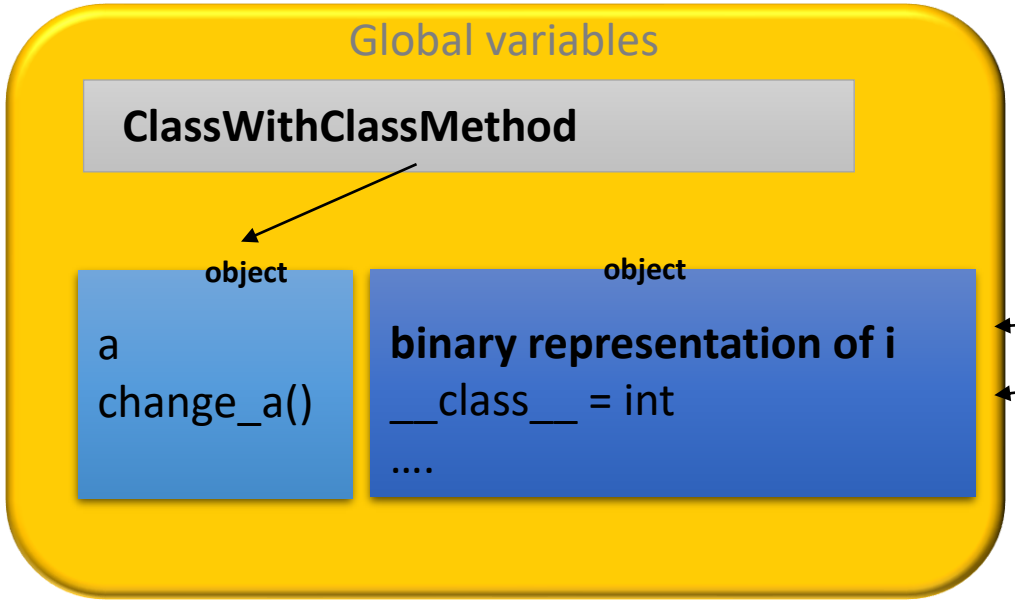
Basic concepts

Key Concepts

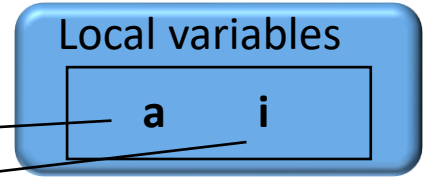
The best way (in my opinion) to manage object is

To consider that class functions (method) do not have any special way to access class members

```
class ClassWithClassMethod:
    a = 1
    def change_a(i:int) -> None:
        a = i
```



This variable are destroyed when the function returns



Stack Memory

Random Access Memory (RAM)

Class methods

You can use class methods by using class objects

```
class ClassWithClassMethod:
    a = 1
    def change_a(i:int) -> None:
        ClassWithClassMethod.a = i
```

To use class methods you need to use the @classmethod decorator

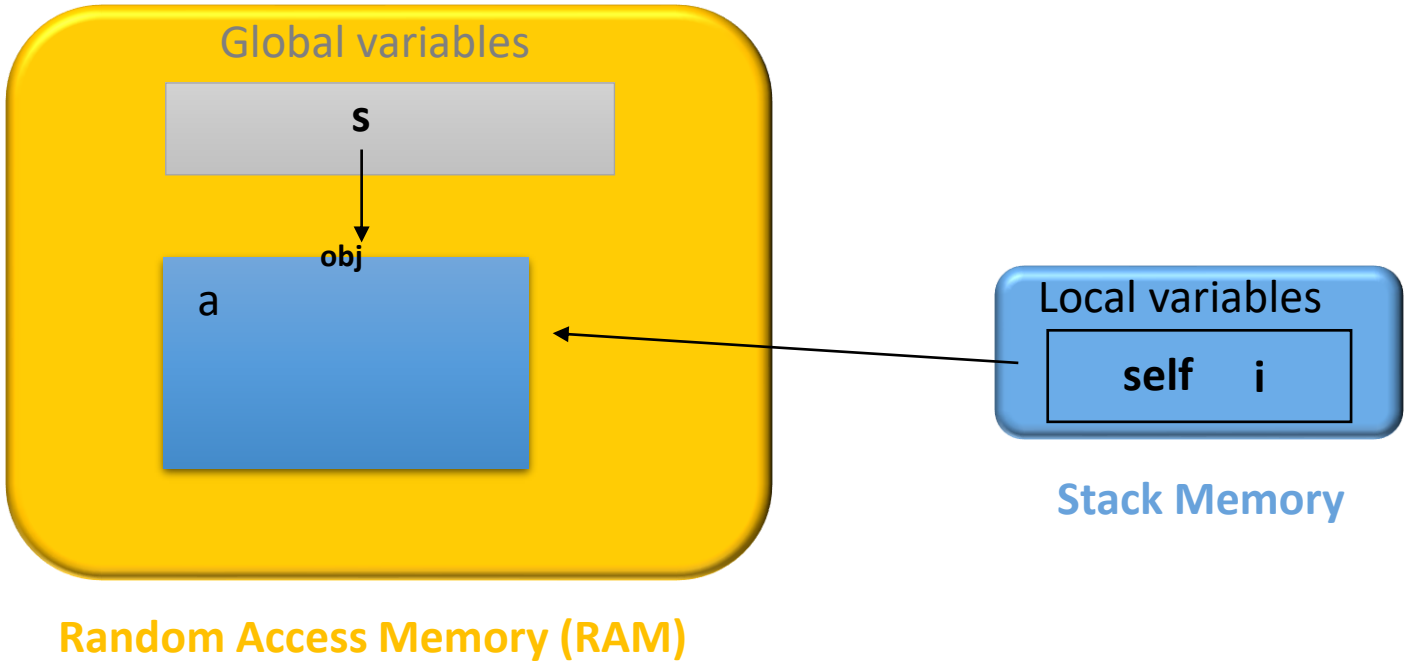
```
class ClassWithClassMethod:
    a = 1
    @classmethod
    def change_a(cls, i:int) -> None:
        cls.a = i
```

In general you will rarely need to use calls methods and members (you are allowed to forget this)

Accessing Instance variables Code

How can I access instance variables ?

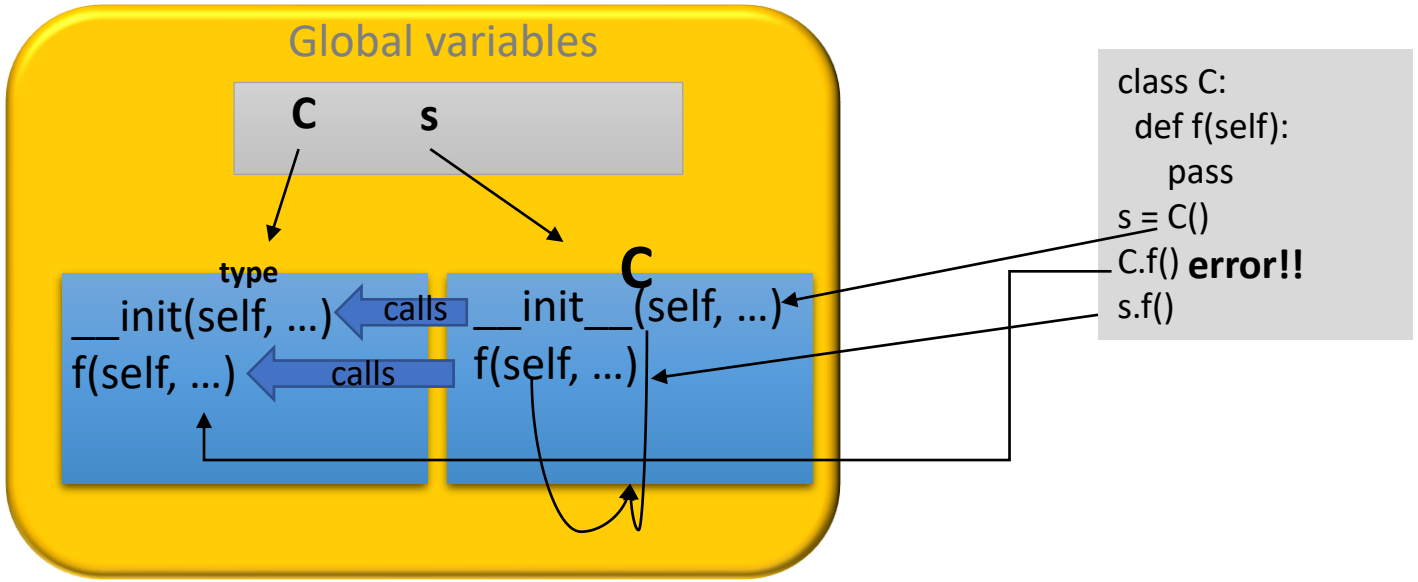
- **using variables**
- **using** `self` **in class members**



Class functions and instance methods

Class functions are automatically converted to instance methods

- **You can call a function f using the class**
- **When you call f from an instance of the class self is added as first argument**
- **__Init__ is called when an instance is created**



Random Access Memory (RAM)

Encapsulation

Encapsulation in OOP

The basic idea of encapsulation is

To use objects instances as self contained pieces of code and thus to avoid using global variables.

The advantages of encapsulation are:

- **Increasing performance by avoiding global variables**
- **Create code that is easy to use and to reuse**
- **Avoid errors due to conflicts of variable**

An object is a self-contained, easy to use, hassle-free, piece of code
The use of encapsulation alone makes OOP worthy !!!

Encapsulation in Python

The basic idea of encapsulation is

To define a “public” interface for the class user and a “private” implementation for the class writer

Public variables do not have restrictions on their name

Private variables and functions must begin with a _ the class user can use them but he really should not

Variable beginning with __ cannot be accessed, but the access can be forced by putting the class name in front of the variable (sometimes referred to as protected variables)

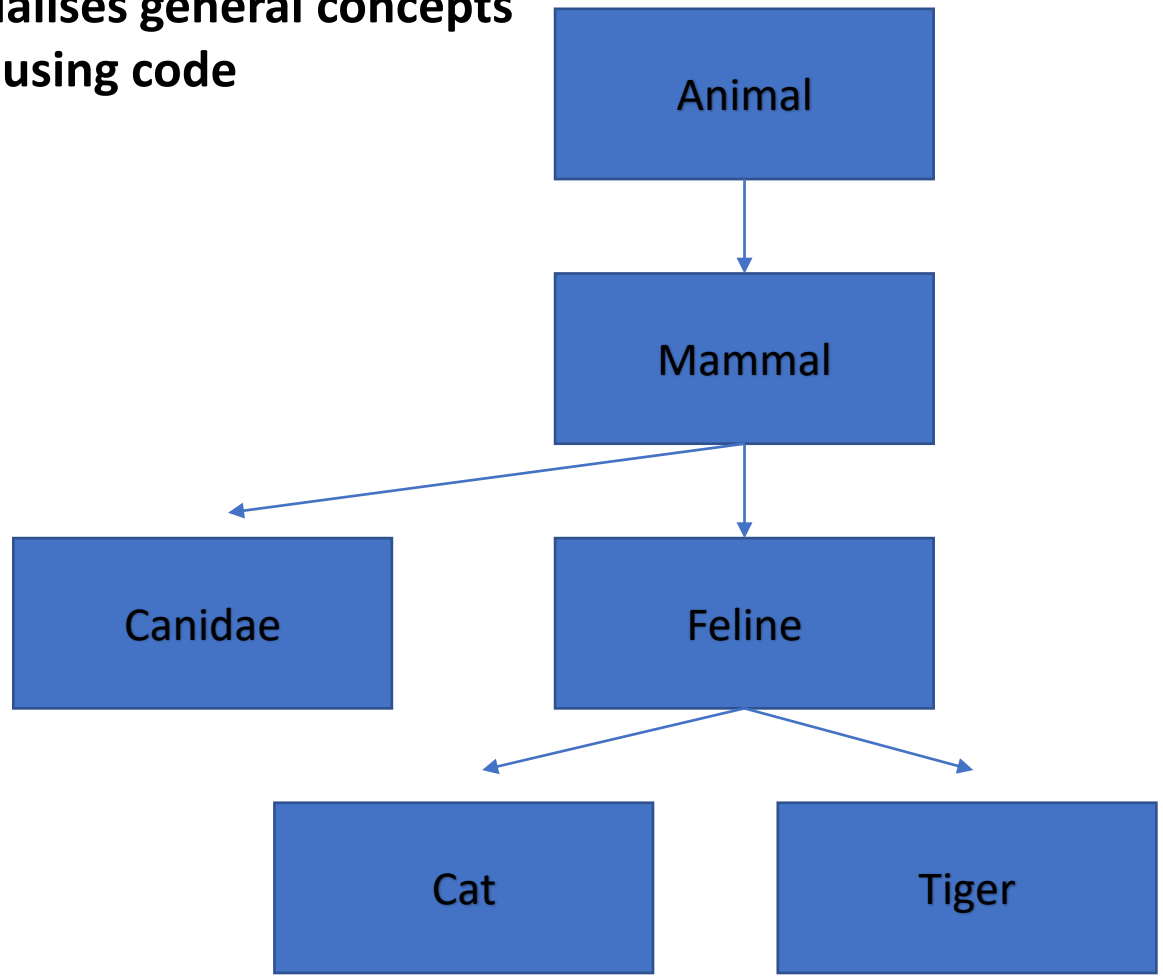
Any modification to the interface do not affect the user code !!!

Inheritance

Inheritance

The basic idea of inheritance is

To define a hierarchy of classes that specialises general concepts to more specific tasks and reusing code



You can easily extend functionality of a class written by someone else without knowing the implementation specifics (useful in GUIs !!)

You can write general functions that works on classes with belonging to the same category (with common ancestors) (a function Woking on all mammals).

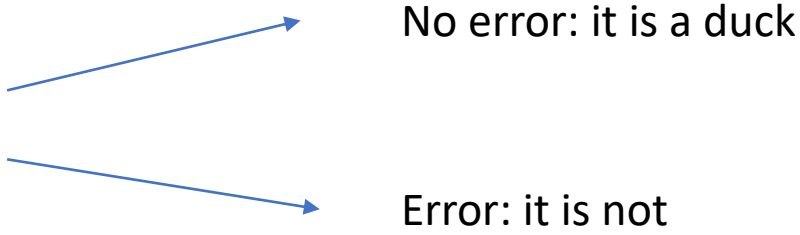
This is called POLYMORPHISM.

Polymorphism and Python

Simple Idea (duck typing)

If it quacks it is a duck !!!

```
def test_duck(f):
  f.quack
```



But it can generate a lot of errors at runtime

If the programmer is not aware !!!

Inheritance

The basic idea of inheritance is

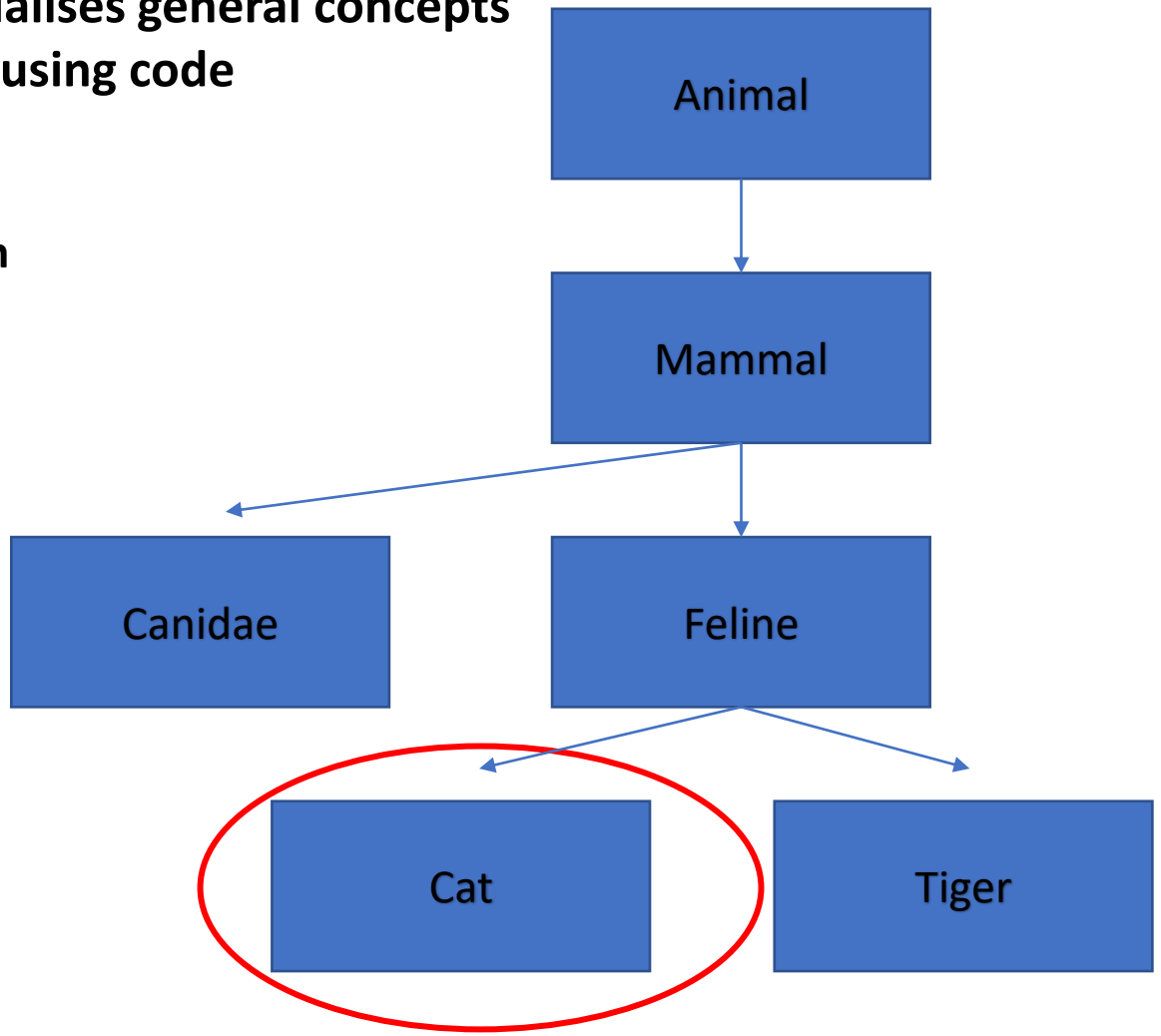
To define a hierarchy of classes that specialises general concepts to more specific tasks and reusing code

The class can access all variables of the superclasses as its own with the exception of variable beginning with __

Any function of a superclass can be called:

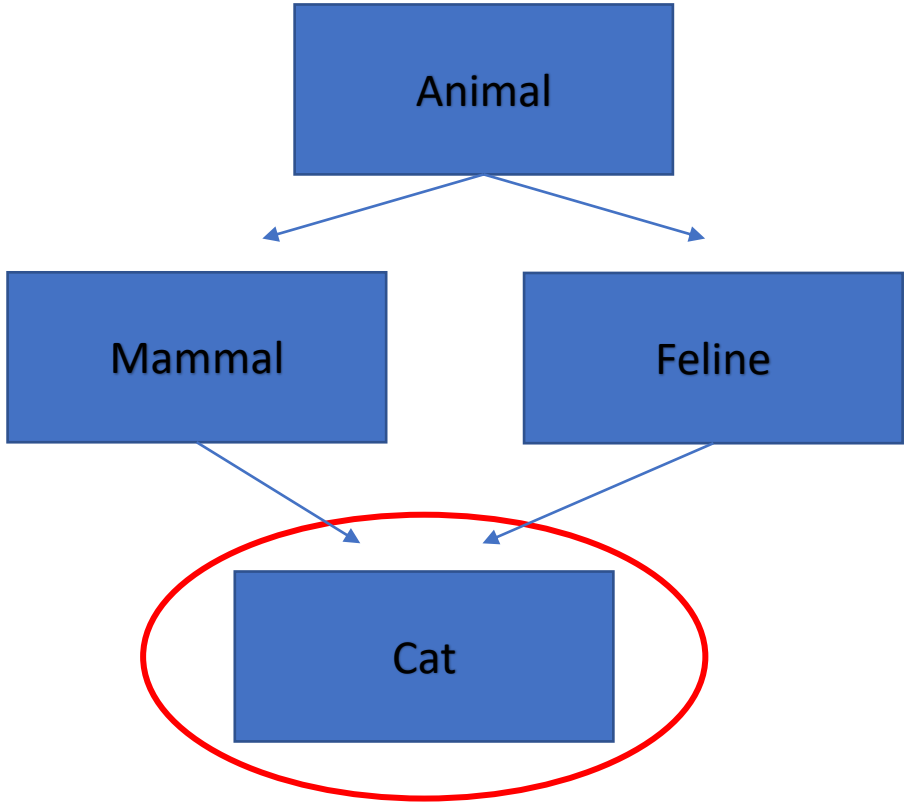
- **By using the class name:**
  ex. Feline.jump(), Feline.__init__()

- **By using super()**
  ex. super().jump(), super().__init__()



The diamond problem

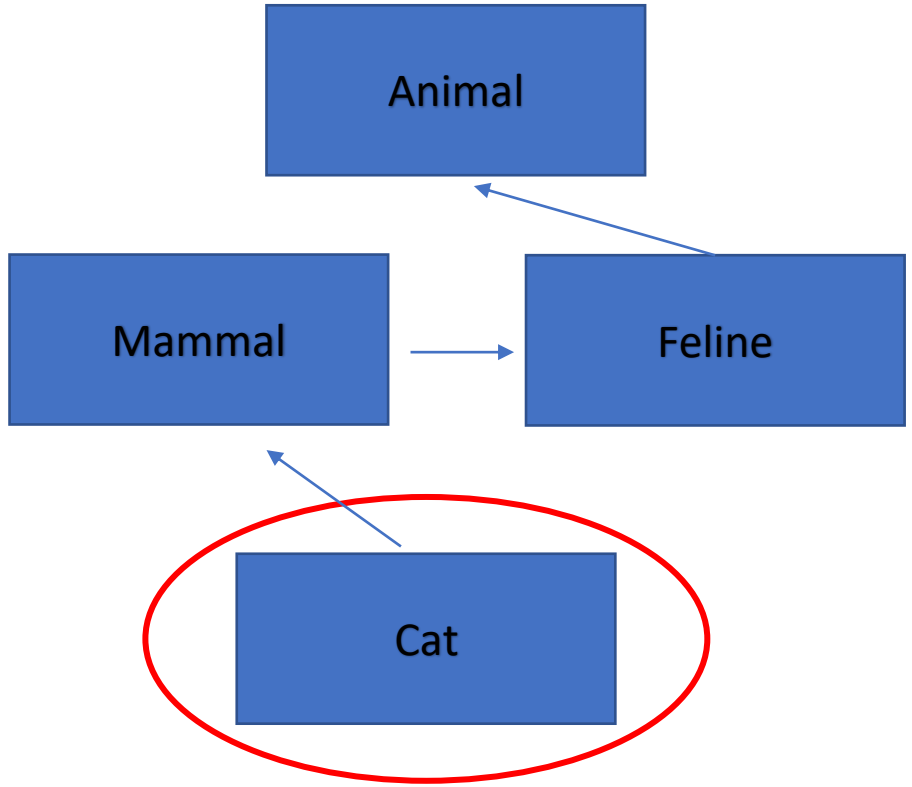
But in this case who is super referring to ?



MRO (method resolution order)

The general case is complex (recursive algorithm)
but in 99,9% of cases:

From left to right then from bottom to top



Iterators and generators

Iterators and iterables

If you can do that

```
obj = ObjectClass()
for i in obj:
  print(i)
```

ObjectClass is an iterable

An iterable is an object with a special method called __iter__
__iter__ returns an iterator

An iterator is an object with a special method called __next__
__next__ can do two things:

- **Return the next value in the sequence**

- **Raise a StopIteration exception to indicate the end of the sequence**

If StopIteration is never raised the iterator never stops !!!

Do not use it in for loops unless .....

Lazy containers

Iterators and iterables are called lazy containers

Because they generate the number only when needed

If you do not want to use classes you can use function generators

```
def fgen(max:int):
    i = 0
    while i < max:
        yield i
 return

for i in fgen():
  print(i)
```

The function creates an iterator

Returns i as next element in the sequence

The sequence ends when the function returns

And for simple cases you can use generator expressions

```
odd_gen = ( 2*n+1 for n in range (10) )
```

Generates a lazy iterator giving even numbers between 1 and 19

Callables and decorators

Functions are objects

A function is a special kind of object, called of type function that has a __call__ method.

A general object is said to be callable (and behaves as a function) if it has the __call__ method.

A function that takes a function as argument, modifies it and returns it is called a decorator

```
def decorate(f):
    print("I print this then I execute f")
    f()

def f():
    print("Hello")

decorated_f = decorate(f)
```

```
def decorate(f):
    print("I print this then I execute f")
    f()

@decorate
def f():
    print("Hello")
```

f and decorate_f are both decorated

This code can be shortened by using decorator syntax