# Duck Typing in Python

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# Introduction

Python is an ***interpreted***, ***multi-paradigm*** language. It was initially designed by Guido van Rossum in 1991 and developed by Python Software Foundation. It supports:

- **Functional programming** (non pure);
- **Procedural programming**;
- **Objected oriented**.

# Python's semantic

Could be useful to first recall the difference between ***strict*** and ***lazy*** evaluation:

1. **Strict evaluation strategy**: the arguments of a function are fully evaluated to values before evaluating the function call (call by value);
2. **Non-strict or Lazy evaluation:** arguments are evaluated only if it is needed in the function body (*call by name*)

**Python**:

- implements **strict evaluation**;
- uses **whitespace indentation**, rather than curly brackets or keywords, to delimit blocks.

# Strict evaluation: example

In Python we never get *true* because it force the evaluation of the function wich contains an infinite loop in the body:

```
def infiniteLoop(x):
    while True:
        print("do something with x")
    return x

5 in [5, 10, infiniteLoop(5)]
```

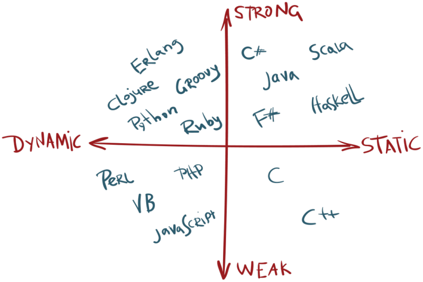
If we write the same code in **haskell** we get the *true* value:

```
elem 5 [5, 10, noreturn 5]
```

# Type-checking

**Type checking** is the process of verifying and enforces the typing rules of a language.

1. **Dynamic vs. Static**
2. **Weak vs. Strong**.



# Type-checking: static

**Statically-typed languages**: type-checking is done at compile time, in order to guarantee the absence of run-time errors.

- **Advantages**:
    - There is a formal proof of **type-safety**;
    - A large class of errors are caught earlier;
    - Types guide code development;
    - Types could be seen as documentation for the code.
- **Disadvantages**:
    - Static typing is a constraint on the program structure;
    - More code.

# Type-checking: dynamic

**Dynamically-typed languages:** dynamic type checking is the process of verifying type constraints at runtime, during execution.

- **Advantages**:
  - These languages are more flexible;
  - less code.
- **Disadvantages**:
  - Programs can fail at runtime due to type errors.
  - It forces runtime checks to occur for every execution of the program, at any step of evaluation. The result is **less optimized** code.

# Type-checking: strong and weak

1. **Strongly typed**: every expression is well typed;
   - **Advantages**:

# Python type-checking

1. Python type-checking is **dynamic**:
   - Variables have no type, only the object that a variable references has a type. **Variables are simply names pointing to objects**;
   - variables are not explicitly typed;
   - objects have a type but it is determined at runtime;
2. Python is also **strongly typed**.

Let's see the implications by some example.

# Python's dynamic typing example (1)

```python
if False:
    print(10+"ten")
else:
    print(10+10)
```

The first branch never execute, so the type checking ignore the type incongruency.
If we try to execute **separately** the first branch, the type check raise a type error:

```
TypeError: unsupported operand type(s) for +: 'int' and 'st.r.'
```

# Python's dynamic typing example (2)

Another consequnce is that programmers are **free to bind the same names (variables) to different objects with a different type**. Then the following statements are perfectly legal:

```
variable = 10
variable = "ten"
```

So long as you only perform operations valid for the type the interpreter doesn't care what type they actually are.

# Python's strong typing example

Python is not allowed to perform operations inappropriate to the type of the object:

```
print(10+"ten")
```

In a **weakly-typed** language, like PHP, the integer is forced to be a string and no type error is raised:

```
$temp = "ten";
$temp = $temp + 10; // no error caused
echo $temp;
```

The output will be "ten10".

# Annotations

Annotations were introduced in Python 3.0 and are the main way to add type hints to the code. We can annotate both **function** and **variable**.

```
import math

pi: float = 3.142

def circumference(radius: float) -> float:
    return 2 * math.pi * radius
```

Type hints and annotations ***do not add a real static typechecking*** in native Python so this should not effect the code performance.

# Annotations: why use it?

**From PEP 484**:
*" <...>using type hints for performance optimizations is left as an exercise for the reader"*.

**Advantages:**

- Type hints help document your code;
- Type hints improve IDEs and linters. This allows IDEs to offer better code completion and similar features.

**Disadvantages**

- Type hints take developer time and effort to add.
- Type hints introduce a slight penalty in start-up time.

# Object oriented

```python
class Duck():
    def __init__(self, name, colour):
        self.name = name
        self.colour = colour
    def quack(self):
        return "Quaaack"
    def fly(self):
        return "The duck is flying"

donald = Duck("Donald","white")

donald.name
donald.colour
donald.quack()
donald.fly()
```

# Object oriented: self

- The first argument of every class method is always a reference to the current instance of the class (***self***).
- The ***self*** world is the equivalent of ***this*** in **Java**. However Java do not requires to pass *this* explicitly as a first parameter of a method: it could be used straight in the body.
- However self **is not a reserved keyword** in Python, is just a strong convention.

# Object oriented: inheritance and polymorphism

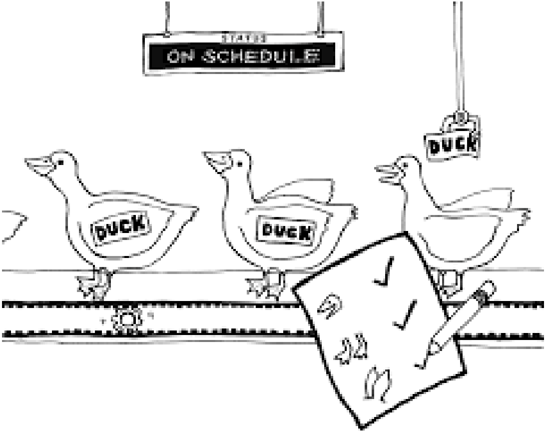
```python
class Person():
    def __init__(self, name, surname):
        self.name = name
        self.surname = surname
    def get_info(self):
        return self.name + " " + self. surname

class Teacher(Person):
    def __init__(self, name, surname):
        Person.__init__(self, name, surname)
    def get_info(self):
        return self.name + " " + self. surname + " is a teacher"

class Student(Person):
    def __init__(self, name, surname, id):
        Person.__init__(self, name, surname)
        self.id = id
    def get_info(self):
        return self.name + " " + self. surname + " is a student"
    def get_id(self):
        return self.id
```

# Duck typing

*If it looks like a duck, swims like a duck, and quacks like a duck, then it probably is a duck.*



# Duck typing: main idea

**Duck typing** is a concept related to dynamic typing in an object oriented language:

- Implementing duck typing you do not check types at all. Instead you check for the presence of a given method or attribute.
- **The idea is that it doesn't actually matter what type my data is - just whether or not i can do what i want with it.**

# Duck typing: example (1)

```
class Duck(Bird):
    def quack(self):
        return "Quaaack"
    def fly(self):
        return "The duck is flying"

class Parrot(Bird):
    def quack(self):
        return "The parrot parrots a quack"
    def fly(self):
        return "The parrot is flying"

class Man():
    def quack(self):
        return "The man parrots a quack too"
```

# Duck typing: example (2)

```
v = [Duck(), Parrot(), Man()]

for i in v:
    print(i.quack())
```

Even if the istance of Man is not a subtype of the Bird class the type-checker do not raise any type error. The output would be:

```
Quaaack
The parrot parrots a quack
The man parrots a quack too
```

# Duck typing: example (3)

```
for i in v:
    print(i.fly())
```

If we try to use the *fly()* method over the entire collection of objects an error is raised at runtime:

```
The duck is flying
The parrot is flying
Traceback (most recent call last):
File ."./.home./.tommaso./.git./.ducktyping.-.tpl./.code./.ducklist...py.",
line 23, in <module> print(i.fly())
AttributeError: Man instance has no attribute 'fly'
```

# Duck typing vs Static typing (1)

```
class Car:
    def __init__(self, engine):
        self.engine = engine
    def run():
        self.engine.turn_on()
```

- This is a classical example of **dependency injection**;
- Note that my Car does not depends on any concrete implementation of engine: i'm just using a dependency injected instance of something that responds to a *turn_on* message;
- I could say my class Car depends on an interface. But I did not have to declare it.

# Duck typing vs Static typing (2)

In statically-typed language, like Java, if we want to pass different implementation of Engine, to the contructor of the Car class we had to:

- declare explicit interface (*IEngine for example*);
- declare its implementation (EngineV8 or ElectricEngine);
- explicitly define my Car parameter to be an implementation of IEngine.

# Duck typing vs Static typing (3)

```
interface IEngine {
    void turnOn();
}

public class EngineV8 implements IEngine {
    public void turnOn() {
        // do something here
}}

public class Car {
    public Car(IEngine engine) {
        this.engine = engine;
        }
    public void run() {
        this.engine.turnOn();
        }
}
```

# Add method to a class: example (1)

Due to the flexibility given by Duck typing is possible to poke a function into a class:

```
class Man():
    def __init__(self, name):
        self.name = name
    def quack(self):
        return "The man parrots a quack too"

donald = Duck()
charlie = Parrot()
john = Man("John")
jack = Man("Jack")

v = [donald, charlie, john, jack]
```

# Add method to a class: example (2)

```
def fly(self):
    return "Takes a plane"

Man.fly = fly

for i in v:
    print(i.fly())
```

Every istance of the Man class, even if previously instantiated, now has the fly method.

```
The duck is flying
The parrot is flying
John takes a plane
Jack takes a plane
```

# Add method to a single instance of a class (1)

It is possible to add a method to a single istance of a class but we have a problem: **the function is not automatically bound** when it's attached directly to an istance.

```
        john.fly = fly

        for i in v:
            print(i.fly())

The duck is flying
The parrot is flying
Traceback (most recent call last):
File "/home/tommaso/git/ducktyping-tpl/code/pokelist.py", line 33,
in <module> print(i.fly())
TypeError: fly() takes exactly 1 argument (0 given)
```

# Add method to a single instance of a class (2)

To properly bound the method to "john" we had to use the module *types*:

```
import types

john.fly = types.MethodType(fly, john)

for i in v:
    print(i.fly())
```

# Add method to a single instance of a class (3)

We still have an error but this time is caused by the istance "jack", proving that we added the method fly only to one istance of Man.

```
The duck is flying
The parrot is flying
John takes a plane
Jack takes a plane
Traceback (most recent call last):
File ."./.home./.tommaso./.git./.ducktyping.-.tpl./.code./.pokelist...py.",
line 35, in <module>
print(i.fly())
AttributeError: Man instance has no attribute 'fly'
```

# Conclusion