Duck Typing in Python

Author: Tommaso Puccetti

Università degli Studi di Firenze

21/12/2018

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** ;
- **Procedural programming**;
- **Objected oriented**.

Python's evaluation strategy

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**.

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)]
```

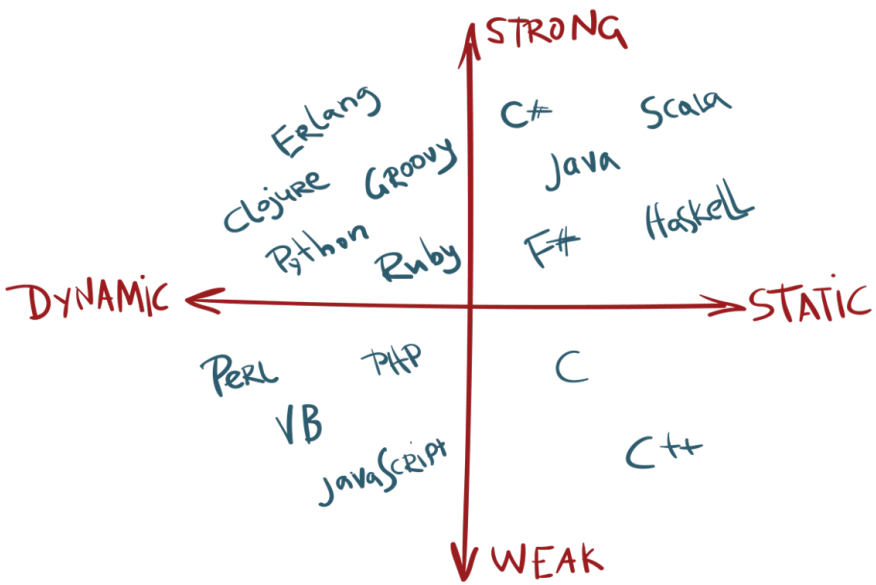
If we write the same code in **haskell** we get the *true* value:

```
elem 5 [5, 10, infiniteLoop 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

In **statically-typed languages** type-checking is done at compile time.

- **Advantages**:
  - There is a formal proof of **type-safety** wich guarantee the absence of run-time errors.;
  - Static typing 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

In reverse, in **dynamically-typed languages** type checking take place at run-time, during the execution of the code.

- **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. In a **strongly typed**: every expression must be well typed, wich means that only operations appropriate for that type are allowed;
2. **Weakly typed**:

Python type-checking

1. Python type-checking is **dynamic**:
   - **Variables are simply names pointing to objects**, only the object that a variable references has a type;
   - objects have a type but it is determined at runtime;
   - variables are not explicitly typed;
2. Python is also **strongly typed**.

Let's see the implications by some example.

Python's dynamic typing example (1)

```
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, having different types**. 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**.

```python
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 they do 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

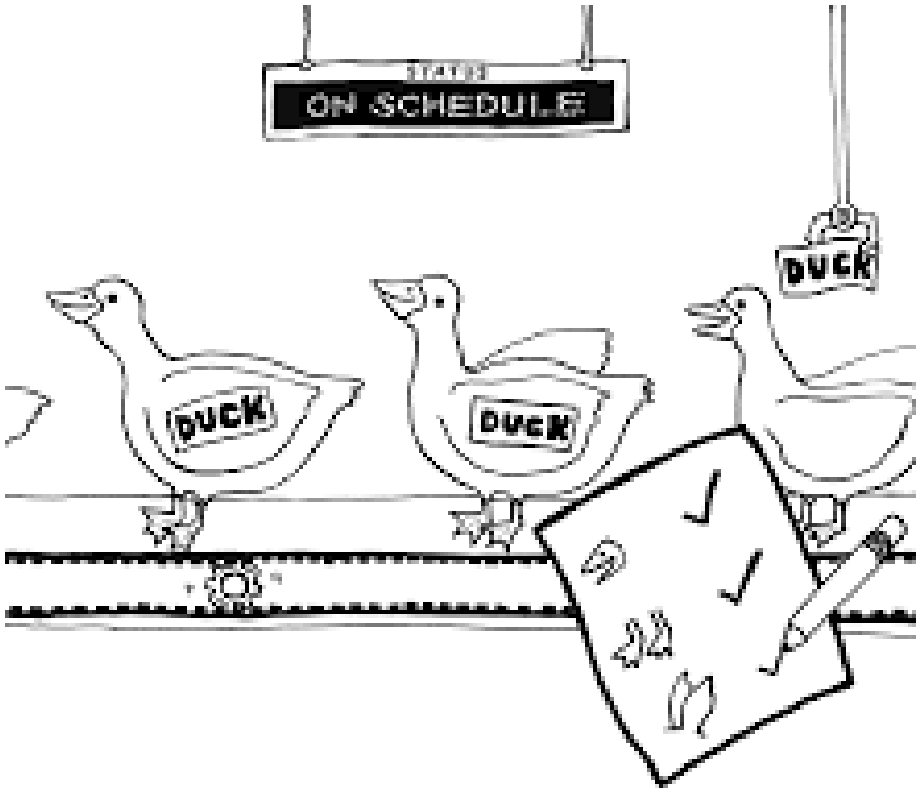
```
class Duck():
    def __init__(self, name, colour):
        self.name = name
        self.colour = colour
    def quack(self):
        return "Quaaack"
    def fly(self):
        return "The duck is flying"

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.

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 the type of an object is not checked at runtime. Instead the type checker looks for the presence of a given method or attribute.
- **The idea is that it doesn't actually matter what type my data is - just if i can do with it what i want.**

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 imitates a quack"
    def fly(self):
        return "The parrot is flying"

class Man():
    def quack(self):
        return "The man imitates 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):
        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)

```
class ElectricEngine:
    def turn_on(self):
        return "zzzz"

class EngineV8:
    def turn_on(self):
        return "brooom"

electric = ElectricEngine()
fueled = EngineV8()

car1 = Car(fueled)
car2 = Car(electric)
print(car1.run())
print(car2.run())
```

Duck typing vs Static typing (3)

In statically-typed language, like Java, if we want to pass different objects to the Car contructor, they has to be **different implementation of a common interface**:

- we had to declare explicit an 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

- Due to the flexibility given by Duck typing is possible to add a function to a class, **at run-time**.
- In a **statically-typed** languages this behaviour is **not possible:** once a class is loaded by the classloader there's no way to modify the code.

Add method to a class: 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 imitates a quack"
    def fly(self):
        return "The parrot is flying"

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

Add method to a class: example (2)

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

v = [donald, charlie, john, jack]

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

Man.fly = fly
```

Add method to a class: example (3)

```
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 only to "john" istance 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)

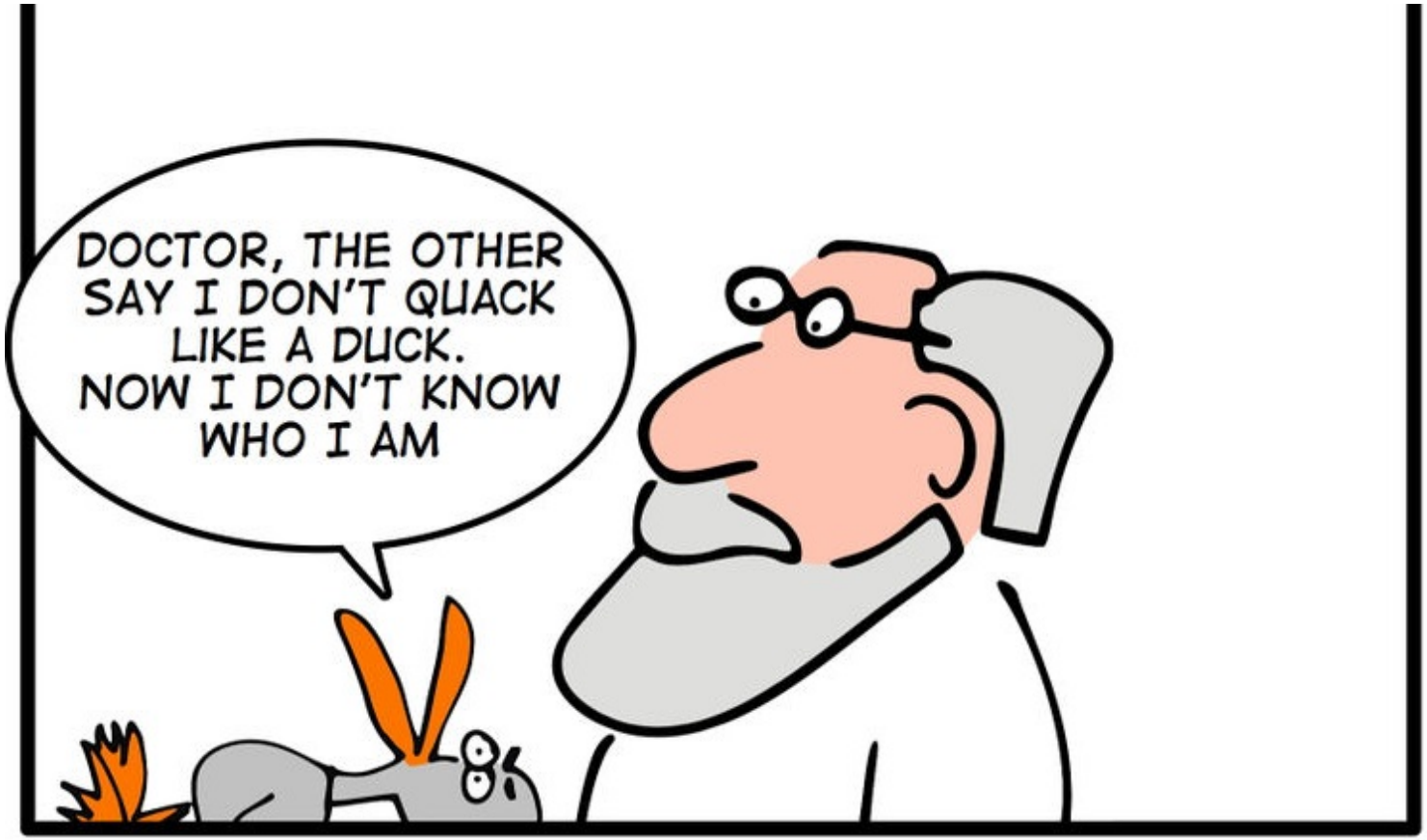
We still have an error but this time is caused by the istance "jack", proving that we added the method fly only to one istance of Man.

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

Duck typing is a handy way to have a **polymorphic** code without relying on abstract classes/interfaces:

- a statement calling a method on an object does not rely on the declared type of the object (at compile time)
- The object simply must supply an implementation of the method called, when called, at run-time.
- It gives flexibility to the language.
- Doesn't guarantee the absence of type error during run-time.


DOCTOR, THE OTHER SAY I DON'T QUACK LIKE A DUCK. NOW I DON'T KNOW WHO I AM