Programming in Python[1]

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Lecture II: Fundamentals

Fundamental concepts of Python

The programmer describes computational processes in terms of:

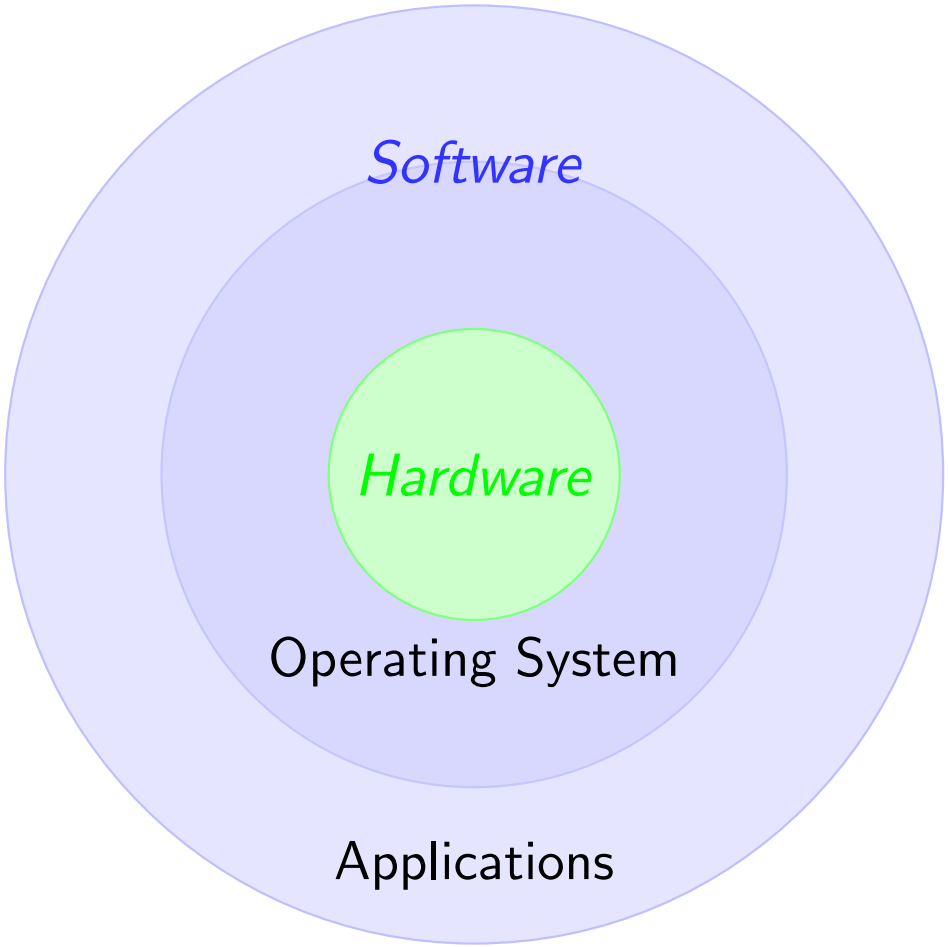
objects : all the entities manipulated by the program, each has an identity (can be distinguished) and a value, that is an element in a specific type (a set of values together with the operations that make sense on them)

basic types : integers (`int`), floats, strings (`str`), functions; they can be composed in more complex types

variables : names used to refer to objects; the same name can refer to different objects during the same process

special commands : the only way to change the execution environment (i.e., the "virtual machine" provided by the operating system) is to use system calls; syscalls change from system to system (e.g., Linux vs. Windows), but Python wraps them and they appear like the functions written by the programmers (e.g., `print`), even if they could not be programmed in Python.

The onion model



- Operating System: it is the only program interpreted directly by the hardware; other pieces of software get interpreted by the virtual machine provided by it.
- Applications: programs (e.g., the python interpreter or python programs) executed within the protected environment created by the operating system.

What we want to do

- Programming means to instruct an (automatic) interpret with a precise description of a computational process.
- (In fact, the only way to make a description precise is to specify exactly the interpreter)
- We use a software interpreter, itself a program interpreted by the operating system (the stack of interpreters can be much deeper).
- Our interpret (Python3) manipulates objects taken from types (that define which manipulations are possible), referred by variables, with special commands to ask the services provided by the operating system.

Assignment

This is the fundamental statement for imperative programming:

- A name, known as variable, is needed to refer to objects.
  `professor = "Mattia"`
- = is not symmetrical, read it as becomes: Left-hand-side is always a variable, right-hand-side is an object, that can be either a literal or anything referred by another variable.
- A variable can change its value with another, following, assignment. Thus, the same variable may refer to different objects.
  `professor = "Violetta"`
- Basic objects (numbers, strings, Boolean values) are immutable (the variable change, not the object; different objects have always different identity)
- Tracking a program means to track the values of all the variables of a program during its execution.

Type hints

Since Python 3.4 it is possible (and indeed desirable, especially for novices) to hint any reader of a program about the type of a variable.

- A variable has always a type (a string in this case) `professor = 'Mattia'`
- Type hints make clear the intention of the programmer (can be checked by external programs) `professor: str = 'Mattia'`
- Assigning to an object of another type is still possible (there is no syntax error raised), but it should be regarded with suspicion `professor = True`

Basic operations

- Binary operators: `5 + 2`, they compute a new object by using the two objects on which they apply;
- Unary operators: `-(-5)`;
- Functions: `max`, they compute a new object by using an arbitrary number of objects (in general 0–..., `max` takes at least 1) passed as parameters (or arguments) when the function is called (`max(3, 6, something_else)`); sometimes the object computed is `None`;
- Syntactically appear as functions, but *commands* like `print("Hello!")` are actually used to request side effects in the executing environment.

Official Python docs (3.11)

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- "Hedgehog" strategy: study the problem in depth, e.g., if objects are numbers you can exploit arithmetic.

```
x = x + y
y = x - y
x = x - y
```

Basic types

`bool` `False`, `True` Logical operations

`int` `1`, `-33`, `1_000_000` ... Arithmetic operations, no upper or lower limit

`float` `1.0`, `.1`, `1.2e34` ... Arithmetic operations, limited but you have `float('infinity')` (and `float('nan')`)

```
sys.float_info(max=1.7976931348623157e+308
↪   , max_exp=1024, max_10_exp=308,
↪  min=2.2250738585072014e-308,
↪  min_exp=-1021, min_10_exp=-307,
↪  dig=15, mant_dig=53,
↪  epsilon=2.220446049250313e-16,
↪  radix=2, rounds=1)
```

`str` `'aaaa\nthis is on a new line'`, `"bbb'b\"b"` ... Concatenation, alphabetical ordering, replication, ...

Homework

Finish chapters 1, 1E, 2, 2X, 3, 4.
It shouldn't take more than a couple of hours, but exercising continuously is crucial.