Multithreading in Python

multithreading is a way of achieving multitasking. In multithreading, the concept of **threads** is used.

a **process** is an instance of a computer program that is being executed. Any process has 3 basic components:

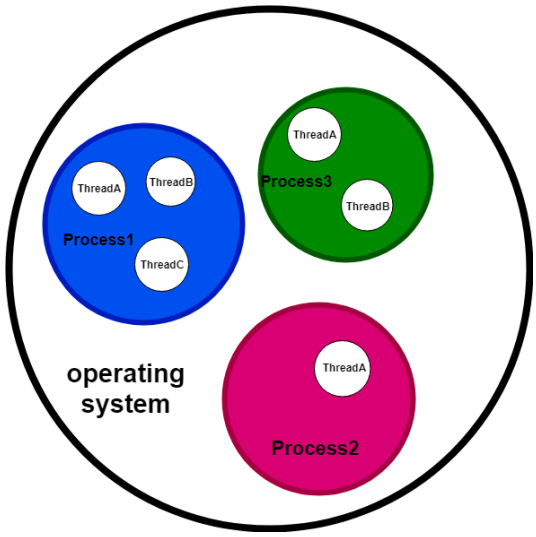
- An executable program.
- The associated data needed by the program (variables, work space, buffers, etc.)
- The execution context of the program (State of process)

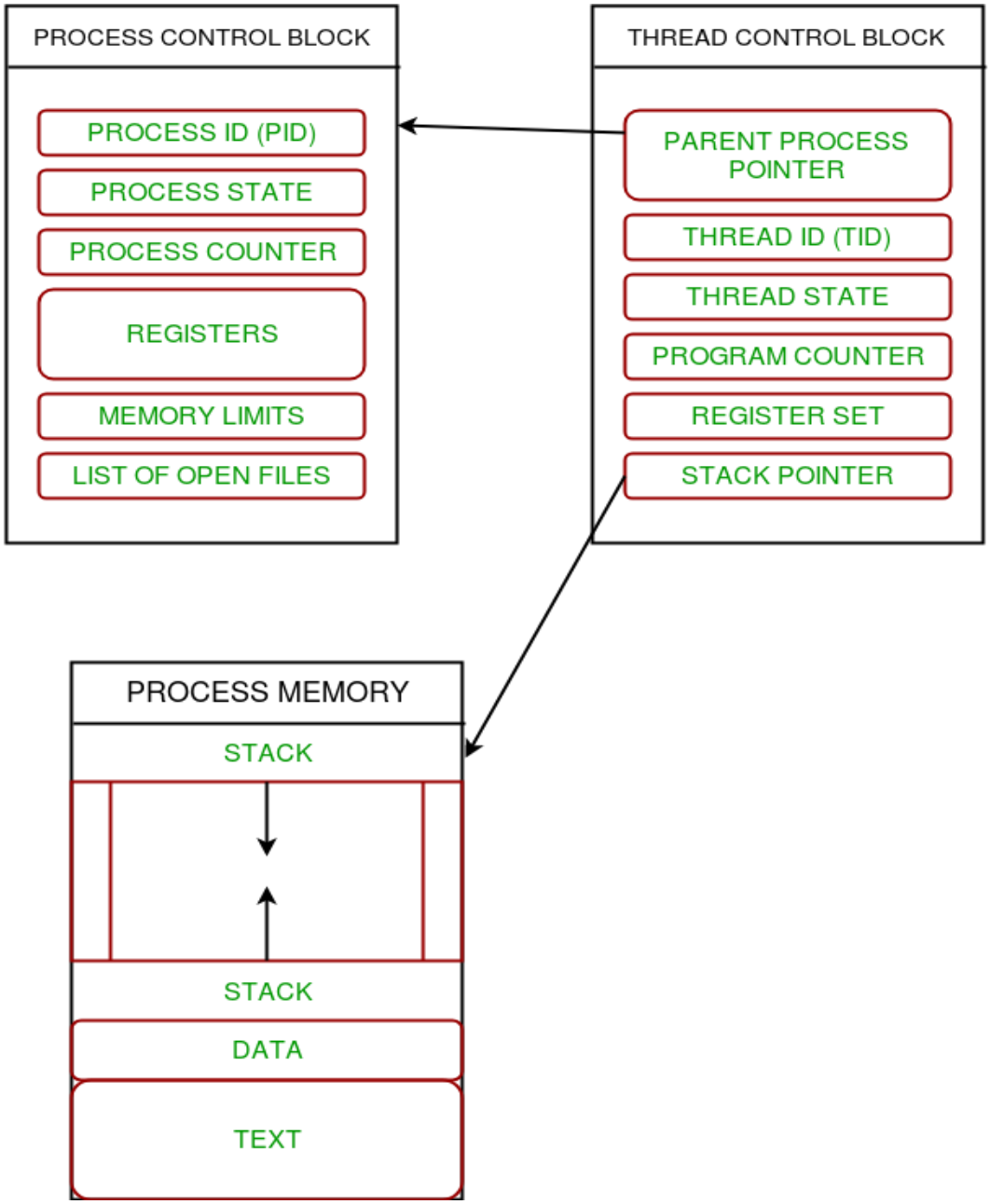
A **thread** is an entity within a process that can be scheduled for execution. Also, it is the smallest unit of processing that can be performed in an OS (Operating System).

In simple words, a **thread** is a sequence of such instructions within a program that can be executed independently of other code. A thread contains all this information in a **Thread Control Block (TCB)**:

- **Thread Identifier:** Unique id (TID) is assigned to every new thread
- **Stack pointer:** Points to thread's stack in the process. Stack contains the local variables under thread's space.
- **Program counter:** a register which stores the address of the instruction currently being executed by thread.
- **Thread state:** can be running, ready, waiting, start or done.
- **Thread's register set:** registers assigned to thread for computations.
- **Parent process Pointer:** A pointer to the Process control block (PCB) of the process that the thread lives on.

Consider the diagram below to understand the relation between process and its thread:



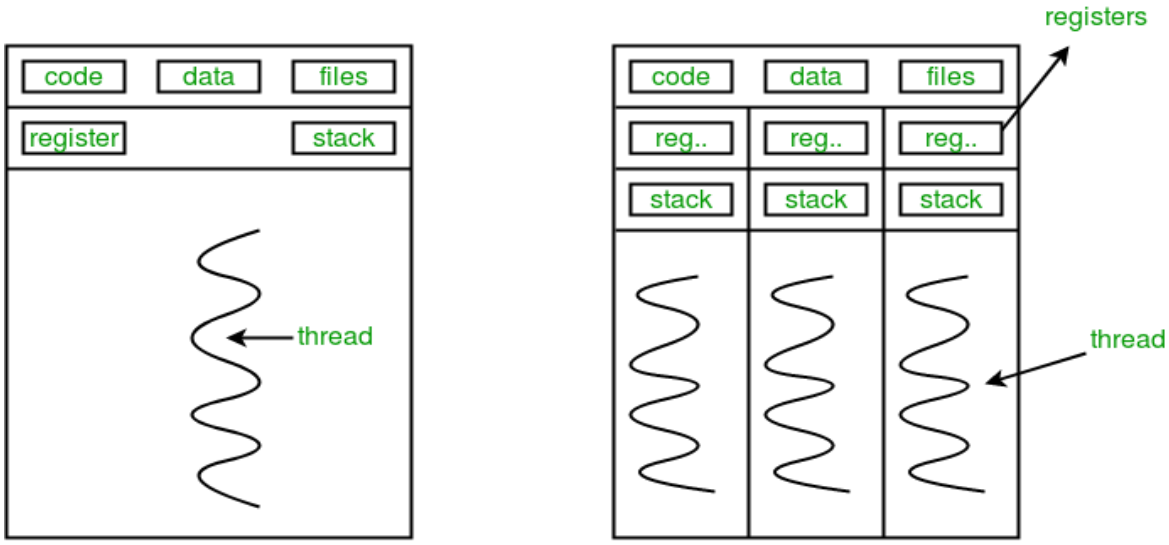


Multithreading

Multiple threads can exist within one process where:

- Each thread contains its own **register set** and **local variables (stored in stack)**.
- All thread of a process share **global variables** and the **program code**.

Consider the diagram below to understand how multiple threads exist in memory:



single-threaded process multithreaded process

Multithreading is defined as the ability of a processor to execute multiple threads concurrently.

*In a simple, single-core CPU, it is achieved using frequent switching between threads. This is termed as **context switching**. In context switching, the state of a thread is saved and state of another thread is loaded whenever any interrupt (due to I/O or manually set) takes place. Context switching takes place so frequently that all the threads appear to be running in parallel (this is termed as **multitasking**).*

Multi thread in python

In Python, the **threading** module provides a very simple and built in for producing multiple threads in a program.

Let us consider a simple example using threading module:

```
# importing the threading module
import threading
def print_cube(num):
        """ function to print cube of given num """
        print("Cube: {}".format(num * num * num))
def print_square(num):
        """ function to print square of given num """
        print("Square: {}".format(num * num))

        # creating thread
t1 = threading.Thread(target=print_square, args=(10,))
t2 = threading.Thread(target=print_cube, args=(10,))

        # starting thread 1
t1.start()
        # starting thread 2
t2.start()

        # wait until thread 1 is completely executed
t1.join()
        # wait until thread 2 is completely executed
t2.join()

# both threads completely executed
print("Done!")
```

```
Square: 100

Cube: 1000

Done!
```

Let us try to understand the above code:

- To import the threading module, we do:
- `import threading`

- To create a new thread, we create an object of **Thread** class. It takes following arguments:
  - **target**: the function to be executed by thread
  - **args**: the arguments to be passed to the target function

  In above example, we created 2 threads with different target functions:

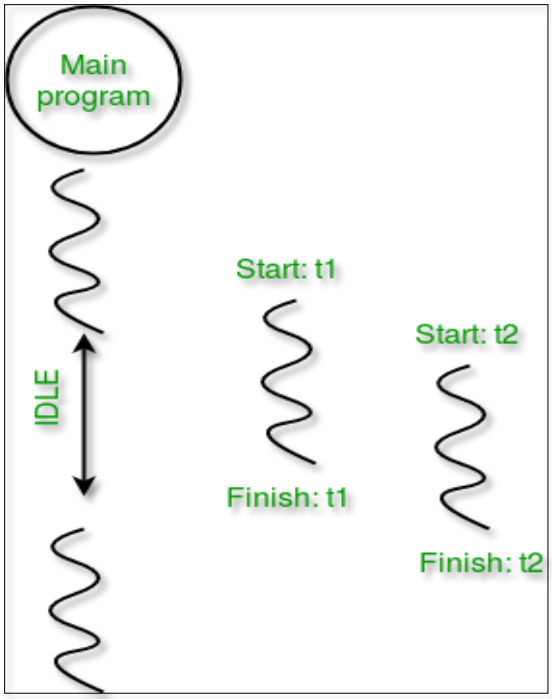
```
t1 = threading.Thread(target=print_square, args=(10,))

t2 = threading.Thread(target=print_cube, args=(10,))
```

- To start a thread, we use **start** method of **Thread** class.
- `t1.start()`
- `t2.start()`

- Once the threads start, the current program (you can think of it like a main thread) also keeps on executing. In order to stop execution of current program until a thread is complete, we use **join** method.
- `t1.join()`
- `t2.join()`

As a result, the current program will first wait for the completion of **t1** and then **t2**. Once, they are finished, the remaining statements of current program are executed.

Consider the diagram below for a better understanding of how above program works:



Consider the python program given below in which we print thread name and corresponding process for each task:

```
import threading
import os
def task1():
        print("Task 1 assigned to thread:",threading.current_thread().name)
        print("ID of process running task 1:",os.getpid())
def task2():
        print("Task 2 assigned to thread:",threading.current_thread().name)
        print("ID of process running task 2: {}".format(os.getpid()))
        # print ID of current process
print("ID of process running main program:",os.getpid())

        # print name of main thread
print("Main thread name",threading.main_thread().name)
# creating threads
t1 = threading.Thread(target=task1, name='t1')
t2 = threading.Thread(target=task2, name='t2')
# starting threads
t1.start()
t2.start()
# wait until all threads finish
t1.join()
t2.join()
```

```
ID of process running main program: 11758

Main thread name: MainThread

Task 1 assigned to thread: t1

ID of process running task 1: 11758

Task 2 assigned to thread: t2

ID of process running task 2: 11758
```

Let us try to understand the above code:

- We use **os.getpid()** function to get ID of current process.
- `print("ID of process running main program: ",os.getpid())`

  As it is clear from the output, the process ID remains same for all threads.

- We use **threading.main_thread()** function to get the main thread object. In normal conditions, the main thread is the thread from which the Python interpreter was started. **name** attribute of thread object is used to get the name of thread.
- `print("Main thread name:",threading.main_thread().name))=`

- We use the **threading.current_thread()** function to get the current thread object.
- `print("Task 1 assigned to thread:",threading.current_thread().name)`

The diagram given below clears the above concept: