MULTIPROCESSING IN PYTHON

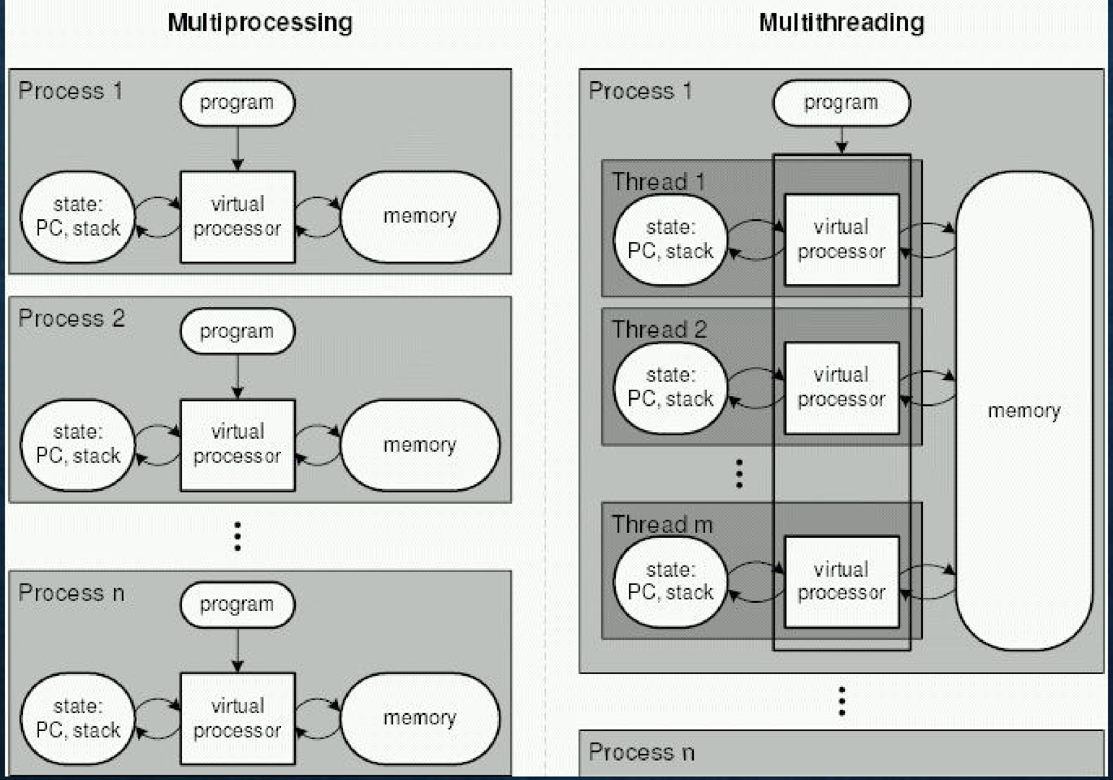
NEED FOR MULTIPROCESSING

- CPU’s with multiple cores have more or less become standard.
- Programs/applications should be able to take advantage.
- However, the default Python interpreter was designed with simplicity in mind and has a thread-safe mechanism, the so-called “GIL” (Global Interpreter Lock).
- In order to prevent conflicts between threads, it executes only one statement at a time (so-called serial processing, or single-threading).
- We will see how we can spawn multiple subprocesses to avoid some of the GIL’s disadvantages.

PROCESSES VS THREADS

- Depending on the application, two common approaches in parallel programming are either to run code via threads or multiple processes, respectively.
- Using threads will lead to conflicts in case of improper synchronization.
- A better approach is to submit multiple processes to completely separate memory locations. Every process will run completely independent from each other.
- While this has a lot of overload due to inter process communication, there are fewer synchronization issues.

PROCESSES VS THREADS



THE PROCESS CLASS

- multiprocessing is a built-in module that contains classes that can be used to run multiple processes at the same time.
- The most basic approach is to use the Process class.
- We will generate a random string using multiple processes.
- The results will be added to a queue and retrieved once all the sub processes are done.

THE PROCESS CLASS

- Here, rand_string is a function with 2 parameters, length and a Queue, that generates a random string of a given length and adds it to the queue.
- We set up a Queue to store the results in.
- We create a list of processes where
  - target is the function to be executed.
  - args is the tuple of parameters to be passed into the function
- We then start off each process. This generates a process and makes it execute the assigned function using the given parameters.
- Once the processes are started off, we wait for them to complete and report their results. This is done using the join() function.
- The results can then be extracted from the queue.

```
output = mp.Queue()

processes = [mp.Process(target=rand_string,

                   args=(5, output)) for x in range(4)]


for p in processes:

    p.start()


for p in processes:

    p.join()

results = [output.get() for p in processes]
```

THE POOL CLASS

- Another and more convenient approach for simple parallel processing tasks is provided by the Pool class.
- Pool creates a “pool” of processes first, and then we can allocate tasks to each of them.
- We need to know how many processes we’ll need before we set up the Pool.
- There are four methods that are particularly interesting:
  - Pool.apply
  - Pool.map
  - Pool.apply_async
  - Pool.map_async

THE POOL CLASS

- Here, square is a function that takes in a parameter and returns the square of that number.
- The Pool class sets up a number of processes, specified through the processes keyword argument.
- We can then either apply or map the results.
- Both the apply and map functions lock the main program to make sure the results are in order.
- We do not have to start or join these processes. The Pool class handles that.

```
pool = mp.Pool(processes=4)
results = [pool.apply(square, args=(x,)) for
                x in range(1,7)]
print(results)
```

```
pool = mp.Pool(processes=4)
results = pool.map(square, range(1,7))
print(results)
```

THE POOL CLASS

- If we want to make maximum use of multiprocessing, we should let processes proceed out of order.
- This is especially necessary for embarrassingly parallel applications, where the processes do not have to communicate.
- To do this, we can use the async variants of the map and apply functions of the Pool class.
- However, we have to explicitly get the answers from the results queue.
- The results may be out of order.

```
pool = mp.Pool(processes=4)

results = [pool.apply_async(cube, args=(x,)) for

             x in range(1,7)]

output = [p.get() for p in results]

print(output)
```

USING THREADS

- Processes are very memory intensive, since they carry a lot of information with them.
- Threads are lightweight processes, which are created within a process. It is easier to share information between threads.
- However, due to the Global Interpreter Lock, python does not actually do multithreading. The threads are run one at a time, but they do not wait for synchronization, making the program ultimately faster.
- The threading module (built –in), helps us manage threads.

USING THREADS

- We need to define a function that each thread will run
- Each thread has a unique name. We can get it using the current thread’s getName function.
- The current thread is returned by the currentThread function.
- We want a return statement even if the function does not return anything.

```
def worker(val):
    global num
    num+=val
    print ("No! This is Patrick!",val,
            threading.currentThread().getName())
    print(num)
    return
```

USING THREADS

- The simplest way to use a Thread is to instantiate it with a target function and call start() to let it begin working.
- We create an empty list, then create each thread and add the threads to the list.
- Then, we start off the threads.
- If we use join, it forces the threads to execute in order.

```
thread1 = [ ]
for i in range(2000):
    t = threading.Thread(target = worker,
        args=(i,))
    thread1.append(t)
    t.start()
    t.join()
```

THREADS, CONCURRENCY AND SYNCHRONIZATION

- If we let the threads execute out of order, then we could have race conditions.
- Two threads could read the global variable, do their own calculations and then write their own answers to the global variable.
- This would result in one of the calculations being ignored.
- Joining the threads would result in getting the right answer, but then we are not making use of the threads and the multiprogramming model.
- A better way to do this would be to use concurrency techniques like locks. However, these are somewhat beyond the purview of the class.
- If you would like additional information, please let me know.