Q1. What resources are used when a thread is created? How do they differ from those used when a process is created?

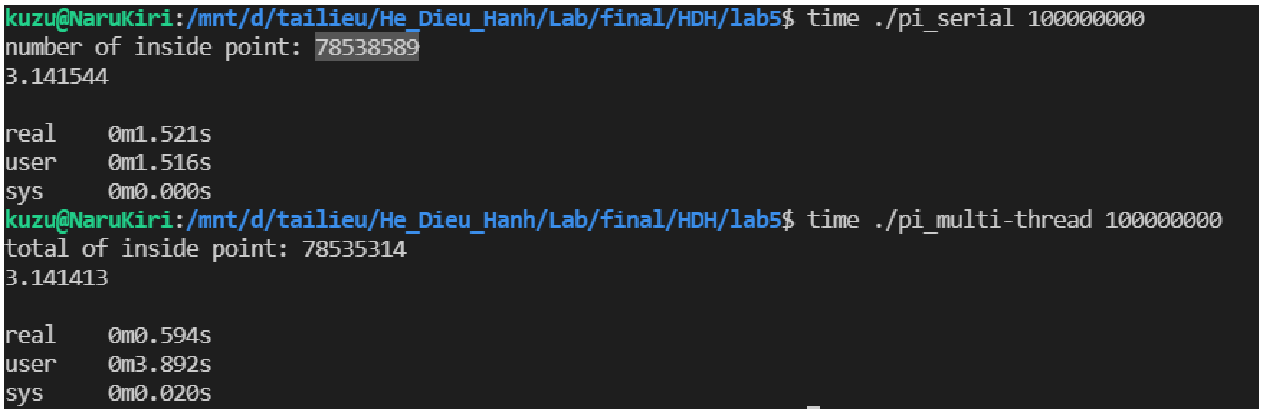
Because a thread is smaller than a process, thread creation typically uses fewer resources than process creation. Creating a process requires allocating a process control block (PCB), a rather large data structure. The PCB includes a memory map, list of open files, and environment variables. Allocating and managing the memory map is typically the most time-consuming activity. Creating either a user or kernel thread involves allocating a small data structure to hold a register set, stack, and priority. Further, all thread in the same process shares memory and resources of the process by default, and doing context-switch between threads is not costly as process. Overall, Thread creation consumes less time and memory than process creation.

Q2. Is it possible to have concurrency but not parallelism? Explain.

It's possible. Actually, concurrency and parallelism are two different concepts: concurrency allowing all the tasks to make process, each task perform for a small time and then give back CPU for other process. In contrast, a parallel system can perform more than one task simultaneously. That mean, with context-switching of process or thread, we can perform concurrency, creating the illusion of parallelism by rapidly switching between processes

Exercise

Problem 1



```
kuzu@NaruKiri:/mnt/d/tailieu/He_Dieu_Hanh/Lab/final/HDH/lab5$ time ./pi_serial 100000000
number of inside point: 78538589
3.141544

real    0m1.521s
user    0m1.516s
sys     0m0.000s
kuzu@NaruKiri:/mnt/d/tailieu/He_Dieu_Hanh/Lab/final/HDH/lab5$ time ./pi_multi-thread 100000000
total of inside point: 78535314
3.141413

real    0m0.594s
user    0m3.892s
sys     0m0.020s
```

Có thể thấy chương trình multi-thread tính pi chạy nhanh hơn so với chương trình serial tính pi, với cùng 1 lượng input.