

Question 3

For this question, I implemented the solution to the dining philosopher problem using OpenMP which takes the number of philosophers as input along with other parameters like minimum time and maximum time to think or eat. I also modified the Pthread implementation to this problem so that performance of both the implementations can be compared directly.

More information on the code and how to run is provided in the Readme and in the log file.

This program was run and tested on the **COE** system.

Part A:

Following are the places where I had to use Pthread/OpenMP APIs in my code.

- To spawn N threads/philosophers and initialize locks/forks.
- Put barrier at the start so that all philosophers start approximately at the same time.
- Locks/Forks for synchronization.
- Put barrier at the end so that a summary of the philosophers is provided after all philosophers have completed M iterations.
- Destroy threads/philosophers and locks/forks.

For my implementation, on one hand, it was easier to spawn threads using OpenMP compared to Pthreads. But on the other hand, I had more control on the attributes of the threads/philosopher while using Pthreads compared to OpenMP. The ease of writing code was more in OpenMP compared to Pthreads.

Implementing and accessing locks and barriers were similar for both Pthreads and OpenMP for my implementation. Semaphores and `omp_locks` were used as locks in my Pthread and OpenMP implementation respectively.

Part B:

- Below I have added the snapshot of the summary of philosophers, their thinking, waiting and eating duration for both the implementation.
- The thinking time and eating time were fixed to **50 milliseconds** so that it would be easy to compare both the implementations.

- Both the programs end once the cumulative number of plates of all the **5** philosophers reach **50**. The time elapsed for both the programs are also mentioned in the snapshot.
- Total eat duration, total think duration, and total wait duration for each philosopher is mentioned below each philosopher stats.

Total eat duration (for each philosopher) = number of plates eaten * eat duration.

Total think duration (for each philosopher) = number of time thought * think duration.

Total think duration (for each philosopher) = total time spent by the philosopher X to obtain both the forks

- Global eat duration, global think duration and global wait duration are the cumulative time spent by all the philosophers for eating, thinking and waiting respectively.

Observation:

- The time taken to reach 50 iterations are pretty same for both pthread and openmp implementation.
- In these experiments, all philosophers were given the same priority. The variation of time taken to eat and think is pretty similar across each philosopher. This variation is the same for both pthread and openmp implementation.
- We can observe that the wait duration varies for each philosopher in both the implementations. This is because all threads are not spawn at the same time and as a result few philosophers pick both the forks before their adjacent philosopher.
- Though there is variation in wait duration across each philosopher, the combined wait duration of all philosophers is pretty same for both the implementations.
- The shortest wait duration and longest wait duration across philosophers are similar in both the implementations.
- For a large number of threads(**1000**), pthread implementation is faster compared to OpenMP implementation.

Below I have added the snapshot of the summary of philosophers, their thinking, waiting and eating duration for both Pthread and OpenMP implementation for

- Number of philosophers: 5
- Number of philosophers: 1000

OpenMP implementation: Number of Philosophers: 5

```
Philosopher 4 stats
Philosopher 4 number of times thought: 10
Philosopher 4 number of plates eaten: 10
Philosopher 4 total eat duration: 500 ms
Philosopher 4 total wait duration: 452.826294 ms
Philosopher 4 total think duration: 500 ms
-----
Philosopher 1 stats
Philosopher 1 number of times thought: 11
Philosopher 1 number of plates eaten: 11
Philosopher 1 total eat duration: 550 ms
Philosopher 1 total wait duration: 251.644577 ms
Philosopher 1 total think duration: 550 ms
-----
Philosopher 0 stats
Philosopher 0 number of times thought: 10
Philosopher 0 number of plates eaten: 10
Philosopher 0 total eat duration: 500 ms
Philosopher 0 total wait duration: 402.907135 ms
Philosopher 0 total think duration: 500 ms
-----
Philosopher 3 stats
Philosopher 3 number of times thought: 12
Philosopher 3 number of plates eaten: 12
Philosopher 3 total eat duration: 600 ms
Philosopher 3 total wait duration: 151.313080 ms
Philosopher 3 total think duration: 600 ms
-----
Philosopher 2 stats
Philosopher 2 number of times thought: 12
Philosopher 2 number of plates eaten: 12
Philosopher 2 total eat duration: 600 ms
Philosopher 2 total wait duration: 202.050201 ms
Philosopher 2 total think duration: 600 ms
-----
Global eat duration: 2750.000000
Global wait duration: 1460.741333
Global think duration: 2750.000000
Total time elapsed: 1.457476
End of Execution
```

Pthread implementation: Number of Philosophers: 5

```
-----
Philosopher 1 stats
Philosopher 1 number of times thought: 12
Philosopher 1 number of plates eaten: 12
Philosopher 1 total eat duration: 600 ms
Philosopher 1 total wait duration: 253.721725 ms
Philosopher 1 total think duration: 600 ms
-----
Philosopher 3 stats
Philosopher 3 number of times thought: 11
Philosopher 3 number of plates eaten: 11
Philosopher 3 total eat duration: 550 ms
Philosopher 3 total wait duration: 252.206512 ms
Philosopher 3 total think duration: 550 ms
-----
Philosopher 0 stats
Philosopher 0 number of times thought: 10
Philosopher 0 number of plates eaten: 10
Philosopher 0 total eat duration: 500 ms
Philosopher 0 total wait duration: 353.476013 ms
Philosopher 0 total think duration: 500 ms
-----
Philosopher 2 stats
Philosopher 2 number of times thought: 12
Philosopher 2 number of plates eaten: 12
Philosopher 2 total eat duration: 600 ms
Philosopher 2 total wait duration: 202.267914 ms
Philosopher 2 total think duration: 600 ms
-----
Philosopher 4 stats
Philosopher 4 number of times thought: 10
Philosopher 4 number of plates eaten: 10
Philosopher 4 total eat duration: 500 ms
Philosopher 4 total wait duration: 403.901276 ms
Philosopher 4 total think duration: 500 ms
-----
Global eat duration: 2750.000000
Global wait duration: 1465.573364
Global think duration: 2750.000000
Total time elapsed: 1.458577
End of Execution
```

OpenMP implementation: Number of Philosophers: 1000

```
Philosopher 452 stats
Philosopher 452 number of times thought: 1
Philosopher 452 number of plates eaten: 1
Philosopher 452 total eat duration: 50 ms
Philosopher 452 total wait duration: 849.216370 ms
Philosopher 452 total think duration: 50 ms
-----
Philosopher 486 stats
Philosopher 486 number of times thought: 1
Philosopher 486 number of plates eaten: 1
Philosopher 486 total eat duration: 50 ms
Philosopher 486 total wait duration: 979.181091 ms
Philosopher 486 total think duration: 50 ms
-----
Philosopher 550 stats
Philosopher 550 number of times thought: 1
Philosopher 550 number of plates eaten: 1
Philosopher 550 total eat duration: 50 ms
Philosopher 550 total wait duration: 901.024109 ms
Philosopher 550 total think duration: 50 ms
-----
Philosopher 487 stats
Philosopher 487 number of times thought: 1
Philosopher 487 number of plates eaten: 1
Philosopher 487 total eat duration: 50 ms
Philosopher 487 total wait duration: 929.263794 ms
Philosopher 487 total think duration: 50 ms
-----
Philosopher 451 stats
Philosopher 451 number of times thought: 1
Philosopher 451 number of plates eaten: 1
Philosopher 451 total eat duration: 50 ms
Philosopher 451 total wait duration: 899.176208 ms
Philosopher 451 total think duration: 50 ms
-----
Global eat duration: 52500.000000
Global wait duration: 112507.804688
Global think duration: 52500.000000
Total time elapsed: 1.225826
End of Execution
```

Pthread implementation: Number of Philosophers: 1000

```
Philosopher 893 stats
Philosopher 893 number of times thought: 1
Philosopher 893 number of plates eaten: 1
Philosopher 893 total eat duration: 50 ms
Philosopher 893 total wait duration: 200.755371 ms
Philosopher 893 total think duration: 50 ms
-----
Philosopher 807 stats
Philosopher 807 number of times thought: 2
Philosopher 807 number of plates eaten: 2
Philosopher 807 total eat duration: 100 ms
Philosopher 807 total wait duration: 117.847214 ms
Philosopher 807 total think duration: 100 ms
-----
Philosopher 70 stats
Philosopher 70 number of times thought: 1
Philosopher 70 number of plates eaten: 1
Philosopher 70 total eat duration: 50 ms
Philosopher 70 total wait duration: 302.503754 ms
Philosopher 70 total think duration: 50 ms
-----
Philosopher 34 stats
Philosopher 34 number of times thought: 2
Philosopher 34 number of plates eaten: 2
Philosopher 34 total eat duration: 100 ms
Philosopher 34 total wait duration: 150.330780 ms
Philosopher 34 total think duration: 100 ms
-----
Philosopher 71 stats
Philosopher 71 number of times thought: 1
Philosopher 71 number of plates eaten: 1
Philosopher 71 total eat duration: 50 ms
Philosopher 71 total wait duration: 244.702469 ms
Philosopher 71 total think duration: 50 ms
-----
Global eat duration: 52500.000000
Global wait duration: 44092.675781
Global think duration: 52500.000000
Total time elapsed: 0.506883
End of Execution
```