

The German University in Cairo

Operating Systems

Threads and Scheduling

A report submitted by:

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Description:

This milestone mainly focused on implementing four threads in C using the pthreads library as the goal of this milestone was to recreate a part of the operating system functionalities which is the scheduling in executing different needed operations, which was represented using the four created threads being executed using different scheduling algorithms. Each thread has a minimum of three print statements, and it outputs its thread ID to identify itself. Furthermore, different scheduling algorithms are tested to observe how they affect the thread execution.

The predefined scheduling algorithms are FIFO(First in, First Out), RR(Round Robin) , and OTHERS.

What we faced in this milestone and how we resolved it:

During the execution of our code, we encountered inconsistencies in the output across different devices, operating systems, and system loads.

This made it extremely difficult for our software to have the required functionality and dependability. At first, we tried applying scheduling policies without identifying thread affinities or specifying CPU sets in an attempt to reduce these inconsistencies. However, despite these efforts, the output remained inconsistent, leading us to explore alternative solutions. After some research, we discovered that the threads needed to execute on a single CPU core to maintain the correct order of execution. To implement this, we assigned all threads to a single CPU core using CPU set affinity. We continued investigating the issue's underlying causes because the program was still unable to generate the desired results after this modification. After further research, we discovered that running the program with elevated privileges, using the sudo command, was necessary. This gave us the necessary privileges to set the thread scheduling policies and CPU affinities effectively, resolving the inconsistencies in the output of our code. By implementing CPU set affinity and running the program with elevated privileges, we successfully fixed the inconsistencies in our code's output. This experience highlights the importance of considering system-level factors and privileges when optimizing code performance across different environments.

Summary of Milestone 1 steps:

1. We created functions for each thread we need where each function has 3 print statements (total of 4 functions + main).
2. We generated thread ids for each of our four threads in the main procedure.
3. Using the CPU_ZERO and CPU_SET functions, we then managed which CPU cores are used by our threads and assigned them a single core.
4. Establish and set the pthread properties.
5. Use the sched_setscheduler function to establish the desired scheduling policy.
6. In the main method, we used pthread_setaffinity_np to ensure the main thread is running on the same CPU core as the other 4 threads, and then create each thread.
7. We calculated the start time of and the end time of each thread using the clock_gettime function
8. Next, we used the pthread_join function to wait for the threads to finish in order to synchronize our program.
9. Elapsed time = End time – Start time
10. Finally, we cleaned up and released the resources associated with the thread attributes object using the pthread_attr_destroy function (Note: this does not affect any threads that were created using this attributes object. It only releases the resources associated with the attributes object itself).

Results of our code:

```
● mariemmobarak@LAPTOP-ESHNJRHF:~$ gcc yarab.c -o hi
● mariemmobarak@LAPTOP-ESHNJRHF:~$ sudo ./hi fifo
Start time 1: 30222.357600
First thread id: 140516579825216
Time taken thread 1 is: 1.447576 seconds
Start time 2: 30223.805499
Second thread id: 140516571432512
Time taken thread 2 is: 1.350734 seconds
Start time 3: 30225.156335
Third thread id: 140516563039808
Time taken thread 3 is: 1.357140 seconds
Start time 4: 30226.513625
Fourth thread id: 140516554647104
Time taken thread 4 is: 1.337691 seconds
Total time taken: 5.493141
```

1. Using fifo: each thread executed in the order it was created, which indicates that FIFO is working correctly as shown in the image above.

```
● mariemmobarak@LAPTOP-ESHNJRHF:~$ gcc yarab.c -o hi
● mariemmobarak@LAPTOP-ESHNJRHF:~$ sudo ./hi rr
Start time 1: 29345.987975
Start time 2: 29346.080051
Start time 3: 29346.180067
Start time 4: 29346.280088
Second thread id: 140086322959936
End time thread 2 is: 29351.174810 seconds
First thread id: 140086331352640
End time thread 1 is: 29351.390624 seconds
Third thread id: 140086314567232
End time thread 3 is: 29351.398093 seconds
Fourth thread id: 140086306174528
End time thread 4 is: 29351.403137 seconds
Did not display time taken per thread because it is not accurate due to execution time of the core of round robin/other algorithm is being alternated between the threads.
Total time taken: 5.415162
```

2. Here we ran our code using round robin, where all threads started simultaneously, the end times were not in the same order due to the quantum/processing privileges given to each thread which indicates that our scheduling policy was working correctly.

3. Lastly, we tested the other scheduling policy, where it uses the default system's scheduling algorithm and no strict policy or time slicing rules are used, which indicates that our output was the expected output.

```

mariemobarak@LAPTOP-ESHQJRH:~$ gcc yarab.c -o hi
mariemobarak@LAPTOP-ESHQJRH:~$ sudo ./hi other
Start time 4: 29405.180429
Start time 3: 29405.190111
Start time 2: 29405.200126
Start time 1: 29405.210063
Third thread id: 140185852040768
End time thread 3 is: 29410.311424 seconds
Fourth thread id: 140185843648064
End time thread 4 is: 29410.412749 seconds
Second thread id: 140185860433472
End time thread 2 is: 29410.431161 seconds
First thread id: 140185868826176
End time thread 1 is: 29410.564761 seconds
Did not display time taken per thread because it is not accurate due to execution time of the core of round robin/other algorithm is being alternated between the threads.
Total time taken: 5.354699

```

Kpi Findings:

The following shows the total time taken in seconds for all four threads to finish executing and the average time in seconds of the 10 runs.

Scheduling Policy	1st run	2nd run	3rd run	4th run	5th run	6th run	7th run	8th run	9th run	10th run	Average
FIFO	0.512923	0.506132	0.509329	0.509522	0.505969	0.510597	0.506632	0.512724	0.509242	0.510201	0.5093271
RR	0.517149	0.516208	0.513934	0.521542	0.520792	0.517316	0.514846	0.513889	0.513790	0.513521	0.5162987
OTHER	0.480934	0.471103	0.482200	0.469143	0.490503	0.483146	0.473997	0.470836	0.473080	0.483826	0.4778768

We calculated the total time taken by the threads using the start time which is the time the first thread starts executing and the end time which is the time the last remaining thread finishes executing. Based on the averages, the other scheduling algorithm proved to be the most efficient since it resulted in the shortest average execution time among the three scheduling algorithms.