CPU Scheduling Project

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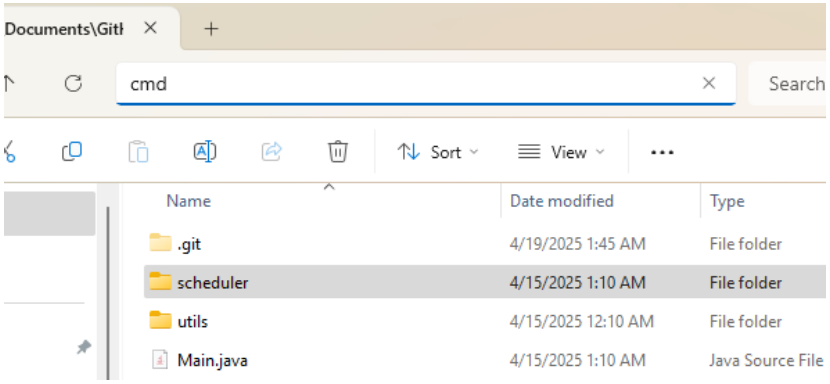
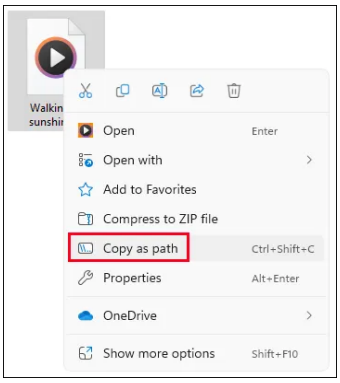
How to run the program

1) Navigate to the folder containing the files. This can be done with “cd” at the Command Prompt or by navigating to the files inside File Explorer and typing “cmd” in the place where it shows the file path. Or just use the built-in terminal if your code editor has one (Ex: VSCode). While you are in File Explorer, copy the path of the csv file.





2) [Optional] For those using an earlier version of JDK than 11, you will have to run “$ java main.java” in Command Prompt. In newer JDK versions, Java supports source-file mode, rendering this step unnecessary.

3) In Command Prompt, type “$ java Main.java <copied path of csv> [ime quantum integer]. This runs the program.

CPU scheduling is the process by which the operating system determines which process should be executed by the CPU at any given moment. Since a CPU can only handle one process at a time (on a single core), an effective scheduling algorithm is essential for maximizing CPU utilization and minimizing idle time.

Round Robin (RR) is a preemptive scheduling algorithm that assigns each process a fixed time quantum. If a process does not complete within that time slice, it is preempted and placed at the end of the ready queue, allowing other processes to execute. This ensures fair allocation of CPU time among all processes.

To prevent starvation of lower-priority processes, aging is employed. Aging gradually increases the priority of waiting processes over time, ensuring they eventually get CPU time even in the presence of higher-priority processes. In a priority-based system, processes with higher priority values are selected before those with lower ones.

In our implementation, the scheduling system is broken down into several key classes:

- Main.java: This class serves as the entry point of the program and initiates execution by calling the execute() method of the scheduler.
- FileParser.java: Responsible for reading process data from a CSV file using FileReader and BufferedReader, and converting each line into a Process object.
- Process.java: A data model that stores information for each process, including process ID, arrival time, burst time, remaining time, priority, and timestamps. It also contains methods to calculate waiting time and turnaround time.
- PriorityRoundRobinScheduler.java: The core of the scheduling logic. It implements Round Robin scheduling with priority queues and aging. The class maintains a set of ready queues sorted by priority, manages context switching based on a user-inputted time quantum, and updates CPU time based on process execution and idle time. The execute() method runs the scheduler, manages process arrivals, and outputs performance metrics such as CPU utilization, throughput, average waiting time, and average turnaround time.

This project demonstrates how combining Round Robin scheduling with priority & aging mechanisms allows for a fair and efficient process management strategy that balances responsiveness with priority handling.

Test results:

List of processes

PID	Arrival Time	Burst Time	Priority
1	0	11	1
2	1	14	3
3	0	19	4
4	2	9	1
5	3	1	4
6	4	13	10
7	6	6	5
8	17	21	6

Time Quantum: [input]

Aging Threshold at: 7

Context Switching time at: 1

Test 1 [2] (Most inefficient as the context switching time to time quantum ratio is 1:2)

Executing Process ID: 1 (Priority 1) for 2 units.
Executing Process ID: 4 (Priority 1) for 2 units.
Executing Process ID: 1 (Priority 1) for 2 units.
Executing Process ID: 4 (Priority 1) for 2 units.
Executing Process ID: 1 (Priority 1) for 2 units.
Executing Process ID: 4 (Priority 1) for 2 units.
Executing Process ID: 1 (Priority 1) for 2 units.
Executing Process ID: 4 (Priority 1) for 2 units.
Executing Process ID: 2 (Priority 1) for 2 units.
Executing Process ID: 1 (Priority 1) for 2 units.
Executing Process ID: 4 (Priority 1) for 1 units.
Executing Process ID: 3 (Priority 1) for 2 units.
Executing Process ID: 2 (Priority 0) for 2 units.
Executing Process ID: 5 (Priority 0) for 1 units.
Executing Process ID: 1 (Priority 0) for 1 units.
Executing Process ID: 2 (Priority 0) for 2 units.
Executing Process ID: 3 (Priority 0) for 2 units.
Executing Process ID: 2 (Priority 0) for 2 units.
Executing Process ID: 7 (Priority 0) for 2 units.
Executing Process ID: 3 (Priority 0) for 2 units.
Executing Process ID: 2 (Priority 0) for 2 units.
Executing Process ID: 7 (Priority 0) for 2 units.
Executing Process ID: 3 (Priority 0) for 2 units.
Executing Process ID: 2 (Priority 0) for 2 units.
Executing Process ID: 7 (Priority 0) for 2 units.
Executing Process ID: 3 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 2 (Priority 0) for 2 units.
Executing Process ID: 3 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 3 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 3 (Priority 0) for 2 units.
Executing Process ID: 6 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 3 (Priority 0) for 2 units.
Executing Process ID: 6 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 3 (Priority 0) for 1 units.
Executing Process ID: 6 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 6 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 6 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 6 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 6 (Priority 0) for 1 units.
Executing Process ID: 8 (Priority 0) for 2 units.
Executing Process ID: 8 (Priority 0) for 1 units.

=== Final Metrics ===

PID	Prio	Waiting Time	Turnaround	Completion
4	1	21	30	32
5	0	36	37	40
1	0	31	42	42
7	0	60	66	72
2	0	66	80	81
3	0	94	113	113
6	0	122	135	139
8	0	106	127	144

Total Context Switching Time: 50 units

CPU Utilization: 65.28%
Throughput: 0.06 processes/unit time
Average Waiting Time: 67.00
Average Turnaround Time: 78.75

Test 2 [5]

```
Executing Process ID: 1 (Priority 1) for 5 units.
Executing Process ID: 4 (Priority 1) for 5 units.
Executing Process ID: 1 (Priority 1) for 5 units.
Executing Process ID: 4 (Priority 1) for 4 units.
Executing Process ID: 1 (Priority 1) for 1 units.
Executing Process ID: 2 (Priority 1) for 5 units.
Executing Process ID: 3 (Priority 1) for 5 units.
Executing Process ID: 2 (Priority 1) for 5 units.
Executing Process ID: 5 (Priority 1) for 1 units.
Executing Process ID: 3 (Priority 0) for 5 units.
Executing Process ID: 2 (Priority 0) for 4 units.
Executing Process ID: 3 (Priority 0) for 5 units.
Executing Process ID: 7 (Priority 0) for 5 units.
Executing Process ID: 3 (Priority 0) for 4 units.
Executing Process ID: 7 (Priority 0) for 1 units.
Executing Process ID: 8 (Priority 0) for 5 units.
Executing Process ID: 8 (Priority 0) for 5 units.
Executing Process ID: 8 (Priority 0) for 5 units.
Executing Process ID: 8 (Priority 0) for 5 units.
Executing Process ID: 8 (Priority 0) for 1 units.
Executing Process ID: 6 (Priority 1) for 5 units.
Executing Process ID: 6 (Priority 1) for 5 units.
Executing Process ID: 6 (Priority 1) for 3 units.
```

```
=== Final Metrics ===
PID     Prio    Waiting Time    Turnaround      Completion
4       1       12              21              23
1       1       14              25              25
5       1       41              42              45
2       0       41              55              56
3       0       54              73              73
7       0       63              69              75
8       0       63              84              101
6       1       100             113             117
Total Context Switching Time: 23 units

CPU Utilization: 80.34%
Throughput: 0.07 processes/unit time
Average Waiting Time: 48.50
Average Turnaround Time: 60.25
```

Test 3 [10]

```
Executing Process ID: 1 (Priority 1) for 10 units.
Executing Process ID: 4 (Priority 1) for 9 units.
Executing Process ID: 1 (Priority 0) for 1 units.
Executing Process ID: 3 (Priority 2) for 10 units.
Executing Process ID: 2 (Priority 1) for 10 units.
Executing Process ID: 5 (Priority 1) for 1 units.
Executing Process ID: 3 (Priority 1) for 9 units.
Executing Process ID: 2 (Priority 0) for 4 units.
Executing Process ID: 7 (Priority 1) for 6 units.
Executing Process ID: 8 (Priority 2) for 10 units.
Executing Process ID: 8 (Priority 2) for 10 units.
Executing Process ID: 8 (Priority 2) for 1 units.
Executing Process ID: 6 (Priority 3) for 10 units.
Executing Process ID: 6 (Priority 3) for 3 units.
```

```
=== Final Metrics ===
PID     Prio    Waiting Time    Turnaround      Completion
4       1       10              19              21
1       0       12              23              23
5       1       43              44              47
3       1       38              57              57
2       0       47              61              62
7       1       57              63              69
8       2       55              76              93
6       3       91              104             108
Total Context Switching Time: 14 units

CPU Utilization: 87.04%
Throughput: 0.07 processes/unit time
Average Waiting Time: 44.13
Average Turnaround Time: 55.88
```

Test 4 [25]

Executing Process ID: 1 (Priority 1) for 11 units. Executing Process ID: 4 (Priority 1) for 9 units. Executing Process ID: 3 (Priority 2) for 19 units. Executing Process ID: 2 (Priority 1) for 14 units. Executing Process ID: 5 (Priority 1) for 1 units. Executing Process ID: 7 (Priority 2) for 6 units. Executing Process ID: 8 (Priority 3) for 21 units. Executing Process ID: 6 (Priority 5) for 13 units.	=== Final Metrics === PID Prio Waiting Time Turnaround Completion 1 1 1 12 12 4 1 11 20 22 3 2 23 42 42 2 1 42 56 57 5 1 55 56 59 7 2 54 60 66 8 3 50 71 88 6 5 85 98 102 Total Context Switching Time: 8 units CPU Utilization: 92.16% Throughput: 0.08 processes/unit time Average Waiting Time: 40.13 Average Turnaround Time: 51.88

Test 5 [93] (No change as both 25 & 93 are greater than the largest burst in the csv)

Executing Process ID: 1 (Priority 1) for 11 units. Executing Process ID: 4 (Priority 1) for 9 units. Executing Process ID: 3 (Priority 2) for 19 units. Executing Process ID: 2 (Priority 1) for 14 units. Executing Process ID: 5 (Priority 1) for 1 units. Executing Process ID: 7 (Priority 2) for 6 units. Executing Process ID: 8 (Priority 3) for 21 units. Executing Process ID: 6 (Priority 5) for 13 units.	=== Final Metrics === PID Prio Waiting Time Turnaround Completion 1 1 1 12 12 4 1 11 20 22 3 2 23 42 42 2 1 42 56 57 5 1 55 56 59 7 2 54 60 66 8 3 50 71 88 6 5 85 98 102 Total Context Switching Time: 8 units CPU Utilization: 92.16% Throughput: 0.08 processes/unit time Average Waiting Time: 40.13 Average Turnaround Time: 51.88