# Lab 7 Scheduling
# Course: Operating Systems

**Exercise 1 : Suppose that the following processes arrive for execution at the times indicated. Each process will run for the amount of time listed. In answering the questions, use non-preemptive scheduling, and base all decisions on the information you have at the time the decision must be made.**

| Process | Arrival time | Burst time |
|---|---|---|
| P1 | 0.0 | 8 |
| P2 | 0.4 | 4 |
| P3 | 1.0 | 1 |

**a) What is the average turnaround time for these processes with the FCFS scheduling algorithm?**

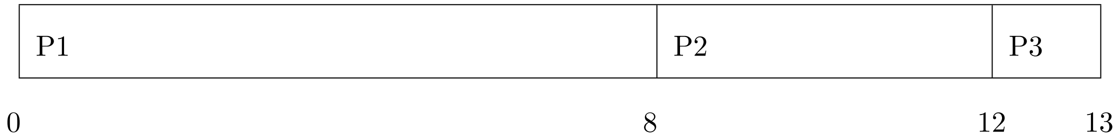

Table 1: Gantt chart - FCFS

- Turnaround time of process one is $T_{TT1} = 8 - 0 = 8$
- Turnaround time of process two is $T_{TT2} = 12 - 0.4 = 11.6$
- Turnaround time of process three is $T_{TT3} = 13 - 1 = 12$

The average turnaround time is $\overline{T} = (8 + 11.6 + 12) \div 3$

**b) What is the average turnaround time for these processes with the SJF scheduling algorithm?**

| P1 | P3 | P2 |
|---|---|---|

0 8 9 13

Table 2: Gantt chart - SJF - V1

- Turnaround time of process one is $T_{TT1} = 8 - 0 = 8$
- Turnaround time of process three is $T_{TT3} = 9 - 1 = 8$
- Turnaround time of process two is $T_{TT2} = 13 - 0.4 = 12.6$

The average turnaround time is $\overline{T} = (8 + 8 + 12.6) \div 3$

**c) The SJF algorithm is supposed to improve performance, but notice that we chose to run process P1 at time 0 because we did not know that two shorter processes would arrive soon. Compute what the average turnaround time will be if the CPU is left idle for the first 1 unit and then SJF scheduling is used. Remember that processes P1 and P2 are waiting during this idle time, so their waiting time may increase. This algorithm could be called future-knowledge scheduling.**

| Ø | P3 | P2 | P1 |
|---|---|---|---|

0 1 2 6 14

Table 3: Gantt chart - SJF - V2

- Turnaround time of process three is $T_{TT3} = 2 - 1 = 1$
- Turnaround time of process two is $T_{TT2} = 6 - 0.4 = 5.6$
- Turnaround time of process one is $T_{TT1} = 14 - 0 = 14$

The average turnaround time is $\overline{T} = (1 + 5.6 + 14) \div 3$

**Exercise 2 : The processes are assumed to have arrived in the order P1, P2, P3, P4, P5, all at time 0. Draw four Gantt charts that illustrate the execution of these processes using the following scheduling algorithms: FCFS, SJF, non-preemptive priority (a larger priority number implies a higher priority), and RR (quantum = 1). Calculate the average waiting time and turnaround time of each scheduling algorithm.**

| Process | Burst time | Priority |
|---|---|---|
| P1 | 8 | 4 |
| P2 | 6 | 1 |
| P3 | 1 | 2 |
| P4 | 9 | 2 |
| P5 | 3 | 3 |

### a) The First-Come, First-Served Scheduling (FCFS)

| | | | | |
|---|---|---|---|---|
| P1 | P2 | P3 | P4 | P5 |

0 8 14 15 24 27

Table 4: Gantt chart - FCFS

- The average turnaround time is $\overline{T} = (8 + 14 + 15 + 24 + 27) \div 5$
- The average waiting time is $\overline{T} = (0 + 8 + 14 + 15 + 24) \div 5$

### b) Shortest Job First Scheduling (SJF)

| | | | | |
|---|---|---|---|---|
| P3 | P5 | P2 | P4 | P1 |

0 1 4 10 18 27

Table 5: Gantt chart - SJF

- The average turnaround time is $\overline{T} = (1 + 4 + 10 + 18 + 27) \div 5$
- The average waiting time is $\overline{T} = (0 + 1 + 4 + 10 + 18) \div 5$

### c) Non-preemptive Priority Scheduling

| | | | | |
|---|---|---|---|---|
| P1 | P5 | P4 | P3 | P2 |

0 8 11 20 21 27

Table 6: Gantt chart - non-preemptive priority

- The average turnaround time is $\overline{T} = (8 + 11 + 20 + 21 + 27) \div 5$
- The average waiting time is $\overline{T} = (0 + 8 + 11 + 20 + 21) \div 5$

### d) Round Robin (RR)

| | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 1 | 2 | 4 | 5 | 1 | 2 | 4 | 5 | 1 | 2 | 4 | 1 | 2 | 4 | 1 | 2 | 4 | 1 | 4 | 1 | 4 | 4 |

Table 7: Gantt chart - non-preemptive priority

- The average turnaround time is $\overline{T} = (3 + 13 + 21 + 25 + 27) \div 5$
- The average waiting time is $\overline{T} = (17 + 15 + 2 + 18 + 10) \div 5$
  - The waiting time of P1 is $\overline{T} = 0 + 4 + 3 + 3 + 2 + 2 + 2 + 1 = 17$
  - The waiting time of P2 is $\overline{T} = 1 + 4 + 3 + 3 + 2 + 2 = 15$
  - The waiting time of P3 is $\overline{T} = 2$
  - The waiting time of P4 is $\overline{T} = 3 + 3 + 3 + 3 + 2 + 2 + 1 + 1 = 18$
  - The waiting time of P5 is $\overline{T} = 4 + 3 + 3 = 10$

## References

[1] Wikipedia. http://en.wikipedia.org, last access: 10/04/2019.

[2] Silberschatz, Galvin, and Gagne, Operating System Concepts.

[3] Tanenbaum, Modern Operating Systems.