

# Cloud Computing and Cloud Native Systems

ECE 573

## Homework 4

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# Table of Contents

<b>Solutions.....</b>	<b>1</b>
<b>1    Given Information.....</b>	<b>1</b>
<i>1.1    Question 1.....</i>	<i>1</i>
<i>1.2    Question 2.....</i>	<i>3</i>

## List of Tables

Table 1: Turnaround time for FCFS.	3
Table 2: Turnaround time for SJF.	4
Table 3: Turnaround time for LJF.	4
Table 4: Turnaround time for RR.	4

## Solutions

### 1 Given Information

In this homework we will study task scheduling for resource management. Suppose at time 0, a set of tasks arrive in the following order with their expected execution times:

1. Task A: 6 seconds
2. Task B: 8 seconds
3. Task C: 4 seconds
4. Task D: 10 seconds
5. Task E: 5 seconds

It is obvious we can schedule them one by one and complete all of them in 33 seconds.

However, scheduling them to complete in different orders will result in very different completion times for individual tasks. Here we will consider the following scheduling policies that determine the order to schedule each task.

- First-Come-First-Served (FCFS): tasks are scheduled in the order of arrival, i.e. A, B, C, D, E.
- Shortest Job First (SJF): tasks with shorter expected execution times are scheduled first, i.e. C, E, A, B, D.
- Longest Job First (LJF): tasks with longer expected execution times are scheduled first, i.e. D, B, A, E, C.
- Round Robin (RR): time slices are assigned to tasks following their order of arrival in rounds. A task at the end of the time slice, if not completed, is scheduled for the next round. Assume a fixed time slice of 3 seconds.

#### 1.1 Question 1

**Q:** For each scheduling policy (RR, FCFS, SJF, and LJF), determine the completion time for each task.

The completion time of each task is as given below:

1. Round Robin (RR): Tasks are carried out in rounds using 3-second time slices.
  - a. Round 1:
    - i. Time 0 to 3s: Task A (3s done, 3s remaining)
    - ii. Time 3 to 6s: Task B (3s done, 5s remaining)

- iii. Time 6 to 9s: Task C (3s done, 1s remaining)
    - iv. Time 9 to 12s: Task D (3s done, 7s remaining)
    - v. Time 12 to 15s: Task E (3s done, 2s remaining)
  - b. Round 2:
    - i. Time 15 to 18s: Task A (3s done, Task completes)
    - ii. Time 18 to 21s: Task B (3s done, 2s remaining)
    - iii. Time 21 to 22s: Task C (1s done, Task completes)
    - iv. Time 22 to 25s: Task D (3s done, 4s remaining)
    - v. Time 25 to 27s: Task E (2s done, Task completes)
  - c. Round 3:
    - i. Time 27 to 29s: Task B (2s done, Task completes)
    - ii. Time 29 to 32s: Task D (3s done, 1s remaining)
  - d. Round 4:
    - i. Time 32 to 33s: Task D (1s done, Task completes)
- 2. First-Come-First-Served (FCFS): Tasks are completed based on the arrival in a first come first service order.
  - a. Time 0 to 6s: Task A completes (at 6s; time elapsed: 6s).
  - b. Time 6 to 14s: Task B completes (at 14s; time elapsed: 8s).
  - c. Time 14 to 18s: Task C completes (at 18s; time elapsed: 4s).
  - d. Time 18 to 28s: Task D completes (at 28s; time elapsed: 10s).
  - e. Time 28 to 33s: Task E completes (at 33s; time elapsed: 5s).
- 3. Shortest Job First (SJF): Tasks are completed based on the ascending order of the time required for their completion. In this case, it is C(4s) -> E(5s) -> A(6s) -> B(8s) -> D(10s).
  - a. Time 0 to 4s: Task C completes (at 4s).
  - b. Time 4 to 9s: Task E completes (at 9s).
  - c. Time 9 to 15s: Task A completes (at 15s).
  - d. Time 15 to 23s: Task B completes (at 23s).
  - e. Time 23 to 33s: Task D completes (at 33s).
- 4. Longest job first (LJF): Tasks are completed based on the descending order of the time required for their completion. In this case, it is D(10s) -> B(8s) -> A(6s) -> E(5s) -> C(4s).
  - a. Time 0 to 10s: Task D completes (at 10s).
  - b. Time 10 to 18s: Task B completes (at 18s).

- c. Time 18 to 24s: Task A completes (at 6s).
- d. Time 24 to 29s: Task E completes (at 5s).
- e. Time 29 to 33s: Task C completes (at 4s).

## 1.2 Question 2

**Q:** The turnaround time is defined as the time from task arrival to its completion. Calculate the average turnaround time for each scheduling policy. Is turnaround time a good measure for scheduling policies and which scheduling policy performs the best?

The turnaround time is calculated by adhering to the following steps:

1. Recording arrival time (all the tasks arrive at  $t=0s$ ).
2. Recording completion time for each task.
3. Calculating turnaround time (completion time - arrival time)

The steps for each for each of the scheduling policies is as follows:

1. First Come First Served (FCFS):

Sl No.	Tasks	Arrival Time	Completion Time	Turnaround time
1	A	0	6	$6 - 0 = 6s$
2	B	0	14	$14 - 0 = 14s$
3	C	0	18	$18 - 0 = 18s$
4	D	0	28	$28 - 0 = 28s$
5	E	0	33	$33 - 0 = 33s$
Average =		$\frac{(6 + 14 + 18 + 28 + 33)}{5} = 19.8s$		

Table 1: Turnaround time for FCFS.

2. Shortest Job First (SJF):

Sl No.	Tasks	Arrival Time	Completion Time	Turnaround Time
1	C	0	4	$4 - 0 = 4s$
2	E	0	9	$9 - 0 = 9s$
3	A	0	15	$15 - 0 = 15s$
4	B	0	23	$23 - 0 = 23s$
5	D	0	33	$33 - 0 = 33s$
Average =		$\frac{(4 + 9 + 15 + 23 + 33)}{5} = 16.8s$		

Table 2: Turnaround time for SJF.

3. Longest Job First (LJF):

Sl No.	Tasks	Arrival Time	Completion Time	Turnaround Time
1	D	0	10	$10 - 0 = 10s$
2	B	0	18	$18 - 0 = 18s$
3	A	0	24	$24 - 0 = 24s$
4	E	0	29	$29 - 0 = 29s$
5	C	0	33	$33 - 0 = 33s$
Average =		$\frac{(10 + 18 + 24 + 29 + 33)}{5} = 22.8s$		

Table 3: Turnaround time for LJF.

4. Round Robin (RR):

Sl No.	Tasks	Arrival Time	Completion Time	Turnaround Time
1	A	0	18	$18 - 0 = 18s$
2	B	0	29	$29 - 0 = 29s$
3	C	0	22	$22 - 0 = 22s$
4	D	0	33	$33 - 0 = 33s$
5	E	0	27	$27 - 0 = 27s$
Average =		$\frac{(18 + 29 + 22 + 33 + 27)}{5} = 25.8s$		

Table 4: Turnaround time for RR.

For several important reasons listed below, turnaround time is a useful metric for scheduling practices.

1. A Comprehensive Measure of Performance:
  - a. It records both execution and waiting times.
  - b. Provides a thorough overview of the job lifecycle from start to finish.
  - c. Indicates how efficiently the system processes jobs.
2. Metric for User Experience:
  - a. Corresponds directly to consumer happiness.
  - b. Indicates how long people really wait for tasks to be completed.
  - c. Aids in establishing reasonable goals for work completion.
3. Assessment of System Performance:
  - a. Enables the comparison of various scheduling strategies.
  - b. Uncovers job processing bottlenecks.
  - c. Aids in the optimization of resource allocation.
4. Evaluation of Fairness:
  - a. Demonstrates how various work durations are handled.
  - b. Highlights possible problems with hunger.
  - c. Exhibits a bias in scheduling for work kinds.

However, turnaround time has the following limitations:

- Does not take task priority into consideration.
- Interactive performance requirements might not be reflected.
- Disregards the use of system resources.

Among the other policies tested above the Shortest Job First (SJF) policy performs the best because of the following reasons:

- It reduces the total amount of time spent waiting on all jobs.
- Shorter jobs are finished more rapidly, which lessens their influence on the average.
- The overall system throughput is optimized.
- Tasks consume less time in the system overall.

The Shortest Job First (SJF) scheduling policy offers the best trade-off between task completion and average turnaround time, according to these evaluations, which also indicate how each scheduling algorithm influences task completion patterns and overall system performance.