Fall 2024 COMP 3511 Homework Assignment #2

Handout Date: October XX, 2024, Due Date: October XX, 2024

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Please read the following instructions carefully before answering the questions:

- You must finish the homework assignment **individually**.
- This homework assignment contains **three** parts: (1) multiple choices, (2) short answer and (3) CPU scheduling
- **Homework Submission:** Please submit your homework to **Homework #2** on **Canvas**.
- TA responsible for HW2:

1. (30 points) Multiple Choices

Write your answers in the boxes below:

MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9	MC10
D	B	A	C	B	B	C	D	B	A

(1) Which of the following resources cannot be shared across all the threads in the same process P?

A) The global variables.

B) An open file in P.

C) The text.

D) The stack memory.

Answer: D

(2) Which of the following statements on pipe communication is TRUE?

A) Named pipes are automatically deleted after the communication ends.

B) Communications are uni-directional for ordinary pipes

C) Named pipes cannot be used among a parent and child process.

D) Ordinary pipes can be used by communicating processes on different machines.

Answer: B

(3) If an application is 50% parallel and 50% serial, which of the following values is a possible speedup when moving the application from one core to four cores, according to Amdahl's Law?

A) 1.6

B) 2.0

C) 2.4

D) 2.8
Answer: A

(4) Which of the following statements is NOT TRUE between user threads and kernel threads?
A) User threads are only visible to programs
B) A user thread needs to be mapped a kernel thread before execution
C) Many-to-one mapping has been widely adopted by modern OS
D) OS manages kernel threads including allocating the required resources
Answer: C
Explanation: See slides 4.22 - Few systems currently use this model

(5) Which of the following process scheduling algorithm may lead to starvation?
A) FIFO
B) Shortest Job First
C) Round Robin
D) None of the above
Answer: B
Explanation: See slides 5.24

(6) Which of the following process scheduling is considered non-preemptive?
1. Switches from running to waiting
2. Switches from running to ready
3. Switches from waiting to ready
4. Process terminates
A) 1 and 2
B) 1 and 4
C) 2 and 3
D) 1, 2 and 3
Answer: B
Explanation: See slides 5.6

(7) Which of the following statement about the time quantum in RR algorithm is TRUE?
A) The time quantum can be as small as possible to achieve high average response time
B) The RR algorithm never suffers from convoy effect no matter how to set the time quantum
C) The average job turn-around time of RR might be worse than FCFS no matter how we set the time quantum
D) None of the above
Cancel the question
Explanation:
A: If the time quantum is too small, context switching overhead increases, which can negatively impact performance and average response time. (high response time is typo, should change to better)

B: If time quantum is too large, the RR falls back to FCFS and suffers from convoy effects
C: The average job turn-around time in RR can be better or worse than FCFS depending on the time quantum and the specific workload.

(8) Which of the following statement on MLFQ scheduling is TRUE?
A) It is fair in the sense that all CPU-bound processes can make progress
B) It might deliver better performance than RR
C) Its performance resembles SJF and SRTF scheduling without the need to estimate the next CPU burst time
D) All of the above
Answer: D

(9) Under symmetric multiprocessing, or SMP, what is the advantage of using per-core ready queue, i.e., each CPU core has its own ready queue(s)?
A) It provides better CPU utilization in all cases
B) It naturally provides processor affinity
C) It makes CPU scheduling easier
D) None of the above
Answer: B
Explanation: See slides 5.45

(10) Which of the following statement of rate-monotonic and EDF scheduling is TRUE?
A) A static priority is assigned in rate-monotonic scheduling
B) The rate-monotonic scheduling algorithm follows a non-preemption method
C) EDC scheduling uses static priority
D) Both rate-monotonic and EDF scheduling require processes to be periodic
Answer: A
Explanation: See slides 5.49-5.52

2. (30 points) Please answer the following questions in a few sentences
(1) (5 points) Why is a thread referred to as a lightweight process?
Answer: A thread is an instance of execution represented by a thread ID, a program counter (PC), a register set, and a stack, which is referred to as a light-weight process. As the creation of a thread is easier, faster and less resource-consumed, in which a thread shares code, data and others such as files with other threads within a process.

(2) (5 points) Please describe data parallelism and task parallelism.
Answer:
Data parallelism – distributes subsets of the data across multiple cores, same operation on each core. (2.5 points)
Task parallelism – distributing threads across cores, each thread performing unique operation. (2.5 points)

(3) (5 points) Explain the concept of context switching and further explain why the overhead is more if switching to a thread belong to other processes?

Answer: Context switching is the process by which a computer's CPU switches from executing one process or thread to another. This involves saving the state of the currently running process or thread and restoring the state of the next process or thread to be executed. (2 points)

When switching between threads of the same process, the address space remains the same. Only the thread-specific data, such as the thread's stack pointer and registers, need to be updated. In contrast, when switching between threads of different processes, the CPU must switch the entire address space, which has more overhead. (3 points)

(4) (5 points) Please describe the pros and cons of one-to-one thread mapping scheme.

Answer: Pros: One-to-one thread mapping scheme provides the maximum concurrency, and it also allows multiple threads to run in parallel on multiprocessor or multicore systems. (2.5 points)

Cons: The number of threads per process sometimes can be restricted due to overhead since kernel threads consume resources such as memory, I/O, etc. (2.5 points)

(5) (5 points) Please describe the concept of CPU utilization, waiting time, turnaround time, response time and throughput.

Answer:

CPU utilization - fraction of the time that CPU is busy. (1 point)

Waiting time - amount of time a process waiting on the ready queue. (1 point)

Turnaround time – the amount of time to execute a particular process, measured by CPU burst time, I/O burst time and waiting time. (1 point)

Response time – the amount of time it takes from when a request is submitted until the first response is produced. (1 point)

Throughput – number of processes or jobs completed per time unit. (1 point)

(6) (5 points) Please describe the advantages in MLFQ scheduling.

Answer:

(1) It does not need to know the next CPU burst time in advance such as SJF or SRTF but achieves similar performance as SJF or SRTF. (3 points)

(2) It produces better response time than RR, or it can handle interactive jobs nicely. (1 point)

(3) It is fair by making progress on all processes, short or long CPU burst times. (1 point)

3. (40 points) CPU Scheduling.

(1) (20 points) Consider the following single-thread process, arrival times, and CPU process requirements:

Process	Arrival Time	Burst Time
P_1	0	8
P_2	3	10

P_3	7	11
P_4	12	4
P_5	13	1

- We consider 4 algorithms: FCFS, RR, SJF, SRTF (preemptive).
- The time quantum of the Round-Robin (RR) is 4.
- Assume that context switch overhead is 0.
- When a process arrives, it is immediately eligible for scheduling, e.g., process 2 that arrives at time 2 can be scheduled during time unit 2.
- Whenever there is a tie among processors (same arrival time, same remaining time, etc), they are inserted into the ready queue in the ascending order of process id. That is, if process 1 and process 2 arrive at the same time, process 1 is inserted first, and process 2 second in the ready queue.

For each scheduling algorithm, draw the Gantt charts depicting the sequence of the process execution, and calculate the average turnaround time and average waiting time.

Answer:

(5 points) FCFS:

Time: 0 8 18 29 33 34

| P1 | P2 | P3 | P4 | P5 |

Average turnaround time = 17.4

Average waiting time = 10.6

(5 points) RR:

Time: 0 4 8 12 16 20 24 25 29 31 34

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

Average turnaround time = 18.2

Average waiting time = 11.4

(5 points) SJF:

Time: 0 8 18 19 23 34

| P1 | P2 | P5 | P4 | P3 |

Average turnaround time = 13.4

Average waiting time = 6.6

(5 points) SRTF:

Time: 0 8 12 13 14 17 23 34

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

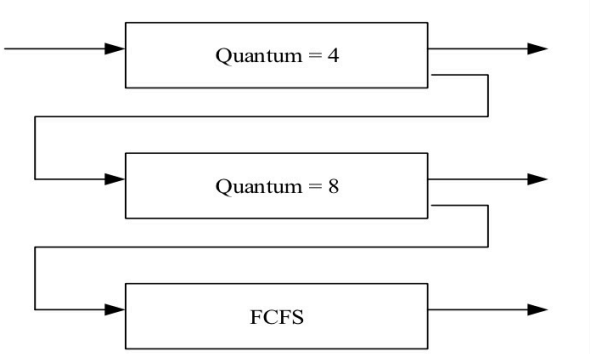
Average turnaround time = 12.2

Average waiting time = 5.4

(2) (20 points) **Multi-Level Feedback Queue**

Draw Gantt charts for a MLFQ scheduling and compute the average turnaround time and the average waiting time. The three queues are defined as follows.

1) Q0: RR with time quantum 4
2) Q1: RR with time quantum 8
3) Q2: FCFS



Process	Arrival Time	Burst Time
P1	0	6
P2	1	3
P3	8	6
P4	13	6
P5	16	3
P6	20	2

Answer:

(10 points) Gantt Chart:

[0-4] P1
[4-7] P2
[7-8] P1
[8-12] P3
[12-13] P1
[13-17] P4
[17-20] P5
[20-22] P6
[22-24] P3
[24-26] P4

(5 points) Average Waiting Time: 4.67
(5 points) Average Turnaround Time: 9.00