CS 4310 Operating Systems
Exam 1
Max: 200 points
(10/24/2024)

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Read these instructions before proceeding.

- **Closed book. Closed notes. You can use calculator.**
- **You have 75 minutes to complete this exam**.
- **Important Notes:**
  - *During the exam, all students need to join the Zoom meeting*
  - *No questions will be answered during the exam about the exam questions. Write down your assumptions and answer the best that you can. In the last 15 minutes of the exam, if you have additional questions about submitting your exams, you can ask your questions on the Chat room of Zoom Meeting and your questions will be answered there.*
  - *Just in case you have trouble of submitting your exam here @Canvas, alternative way is to submit your completed exam to Prof. Young by emailing*
    gsyoung@cpp.edu
- **Turn in your completed exam in one PDF file including all pages here @Canvas.**

Possible ways to submit your exam:
(1) Print out the exam paper. Write your answers on the exam paper. Scan your completed exam papers or take photos of them. Then turn in **one PDF file** here @Canvas .
(2) Read the exam from the computer screen and answer questions on your own white papers (number your answers). Scan your exam answers or take photos of them. Then turn in **one PDF file** here @Canvas.
(3) Use your own way to prepare your completed exam in **one PDF file** and turn in here @Canvas.

Q.#1 (36)	Q.#2 (30)	Q.#3 (30)	Q.#4 (44)	Q.#5 (36)	Q.#6 (24)	Total (200)

1. (36 points)
Fill in the blanks (4 pts each)

(a) Operating System provides interface between software and ___hardware___ of a computer system.

(b) Two of the classical IPC (Inter-Process Communication) problems are the Sleeping Barber Problem and ___Dining Philosophers Problem___.

(c) One main feature of the third generation operating system is using ___multi-programming___ technique to save CPU time.

(d) ___Threads___ are processes in a process.

(e) A semaphore is accessed only through two standard atomic operations

___down___ and ___up___.

(f) To implement the process, operating system maintains each process's information in its _process control block .

(g) Give two benefits of thread (compared to process).

More efficient in terms of storage and sharing resources

Fast to create and switch

2. (30 points)

(a) **(12 points)** Briefly explain critical section problem.

Critical section problem deals with making sure that no two processes were ever in their critical regions at the same time to avoid race conditions

(b) **(18 points)** Briefly describe two solutions we covered in the class for solving the critical section problem.

The first solution is the busy waiting using test and set lock as a hardware solution. It would have a lock set to 0 and any process can set lock = 1 to enter critical section. When process finishes, set lock = 0 and another process can continue. The second is sleep and wakeup where one process goes into a critical section and put every other processes to sleep. Once the critical section is finished, it calls the wakeup function to let the sleeping process go to critical section.
Both of these solutions avoid race conditions

3. (30 points) (10 points each)

Disk requests come in to the disk driver for cylinders at time zero in the order of

17, 27, 4, 11, 31, 2, 36.

Starting position is 30. A seek takes 20 msec per cylinder moved.

How much seek time is needed for

(a) FCFS (First-come, first served)

Start Cylinder	Destination Cylinder	Seek time (ms)
30	17	260
17	27	200
27	4	460
4	11	140
11	31	400
31	2	580
2	36	680
Total Seek Time		2720

(b) SSF (Shortest Seek First)

Start Cylinder	Destination Cylinder	Seek time (ms)
30	31	20
31	36	100
36	27	180
27	17	200
17	11	120
11	4	140
4	2	40
Total Seek Time		800

(c) Elevator Algorithm (initially moving upward)

Start Cylinder	Destination Cylinder	Seek time (ms)
30	31	20
31	36	100
36	27	180
27	17	200
17	11	120
11	4	140
4	2	40
Total Seek Time		800

4. (44 points)

(a) (24 points) A RAID can fail if **four** or more of its drives crash within a short time interval. Suppose that the probability of one drive crashing in a given hour is P.
What is the probability of a k-drive RAID failing in a given hour?

P (k-drive failing in given hour) = 1 – (P(no drive failed) + P (exactly one drive failed) + P (exactly two drive failed) + P(exactly three drive failed))
$= 1 - ((1-P)^k + k*P(1-P)^{k-1} + k(k-1)*P^2(1-P)^{k-2} + k(k-1)(k-2)*P^3(1-P)^{k-3})$

(b) (20 points) Consider a computer system that has cache memory, main memory (RAM) and disk, and the operating system uses virtual memory. It takes 2 nsec to access a word from the cache, 8 nsec to access a word from the RAM, and 40 ms to access a word from the disk. If the cache hit rate is 70% and main memory hit rate (after a cache miss) is 90%, what is the average time to access a word?

40 ms = 40,000,000 ns

Average Access Time =
0.7 * 2 (cache hit)
+ 0.3 * 0.9 * 8 (in RAM, not cache)
+ 0.3 * 0.1 * 40,000,000 (on disk)

= 1,200,003.56 ns

5. (36 points) (12 points each)

Given a set of five processes (All are 100 % CPU-bound).

Process	CPU-Time	Priorities	Arrival Time
P_1	7	3	0
P_2	3	5	0
P_3	5	1	0
P_4	4	4	0
P_5	1	2	0

Draw the corresponding Gantt chart (illustrating the execution of the processes) and calculate the average turnaround time for the schedule using the following three scheduling algorithms. Ignore process switching overhead.

(a) First-Come-First-Serve (run in order of P_1, P_2, P_3, P_4, P_5):

P1	P2	P3	P4	P5

0 20

Average turnaround time = (7 + 10 + 15 + 19 + 20) /5 = 14.2 unit of time

(b) Priority Scheduling (with 5 being the highest priority):

P2	P4	P1	P5	P3

0 20

Average turnaround time = (3 + 7 + 14 + 15 + 20) /5 = 11.8 unit of time

(c) Round Robin (with time quantum = 3):

P1 (4)	P2 (d)	P3 (2)	P4 (1)	P5 (d)	P1 (1)	P3(d)	p4(d)	P1(d)

0 20

Average turnaround time = 6 + 13 + 18 + 19 + 20) /5 = 15.2 unit of time

6. (24 points) (12 points each)
(a) Given a set of four processes (All are 100 % CPU-bound).

Process	CPU-Time	Arrival Time
P_1	8	0
P_2	2	0
P_3	5	0
P_4	3	0

Draw the Gantt chart and calculate the average turnaround time for the schedule using the Shortest-Job-First scheduling algorithm.

P2	P4	P3	P1

0 18

Average turnaround time = (2 + 5 + 10 + 18) / 4 = 8.75 unit of time

(b) Given a set of four processes (All are 100 % CPU-bound).

Process	CPU-Time	Arrival Time
P_1	9	0
P_2	4	4
P_3	1	2
P_4	3	1

Draw the Gantt chart and calculate the average turnaround time for the schedule using the ***Shortest-Remaining-Time-First*** preemptive scheduling algorithm.

P1	P4	P3(d3)	P4 (d5)	P2 (d9)	P1 (d17)

0 17

Average turnaround time = (3 + 5 + 9 + 17) / 4 = 8.5 unit of time