CS5352 Advanced Operating Systems
Spring 2023

Midterm Exam

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Student Name: _____(Last, First)

R#: _____

Final Score: _____(Total: 30 points)

General Instructions:

- The maximum is 30 points, equivalent to 30% of your final score.
- There are **10** questions over 6 pages.
- This is a 70-minute close-book and close-note exam.
- You can use your calculator, not your computer and not your phone.
- Please explain your answer clearly and be concise. **Please show the steps how you obtain your result and make sure your handwriting is readable**.
- Good luck.

Example questions:

Question 1: Suppose that processes have 50% of I/O wait of the total time, each of them needs 10 seconds to complete (including CPU and I/O times), and they start simultaneously. We have a **single** CPU.

a) Suppose that we have 2 processes. What is the CPU utilization in this case if they run in concurrently? How long will the last one take to complete these 2 processes in the best case, average case, and worst case? Assume that they perform different types of I/0 (no conflicts)

b) To obtain the CPU utilization >=0.9 when running simultaneously, what is the minimum number of processes do we need? What is the CPU utilization in this case?

c) How many processes can complete in 20 seconds in **the best case** (assuming that there is no I/O conflicts)? Please draw your solution
What is the CPU utilization in this case?

d) How many processes can complete in 20 seconds in **the worst case** (assuming that there is no I/O conflicts)? Please draw your solution
What is the CPU utilization in this case?

Question 2: Cluster Computing

In a cluster center, we have 2 computing nodes and a master node which runs the scheduler. A user submits 5 jobs with the 50% I/O percentage. Each job requires 10 seconds to complete, including 5 seconds of CPU and 5 seconds of I/O time. The scheduler can decide how to split the jobs on 2 computing nodes:

- **A)** 3 jobs on the first computing node and 2 jobs on the second computing node
- **B)** 4 jobs on the first computing node and 1 job on the second computing node
- **C)** All 5 jobs on the first computing node and **no** jobs on the second computing node

Please answer the following questions:

1) What is the average CPU utilization of the cluster in Case **A**?
   How much time to complete all jobs?
2) What is the average CPU utilization of the cluster in Case **B**?
   How much time to complete all jobs?
3) What is the average CPU utilization of the cluster in Case **C**?
   How much time to complete all jobs?

Question 3: A computer provides each process with 32KB of address space divided into pages of 4KB. A particular program has a text size of 9 KB, a data size of 9 KB, and a stack size of 9KB bytes.
Each page must contain either text, data, or stack, not a mixture of two or three of them.
Please explain your answers.

a) Will this program fit in the address space? *(1 point)*
b) If the page size were 2KB, would it fit? *(1 point)*
c) If the page size were 1KB, would it fit? *(1 point)*

Question 4: A computer has 32-KB virtual memory and 4-KB pages.

a) How many entries are needed in the page table if traditional (one-level) paging is used?

b) If the physical memory is half size of virtual memory, many page frames are there in the physical memory?

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