THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER SCIENCE
CSC2202 - OPERATING SYSTEMS
FINAL EXAM
Thursday 29th November, 2018

Time: 09:00 - 12:00HOURS
Duration: 3 HOURS
Venue: P207

INSTRUCTIONS

- This paper has a total of SEVEN(7) questions
- You must answer a total of FIVE(5) questions
- All questions carry equal marks (20 marks each)
- Clearly number all your answers
- Use the marks as a guide to the detail required in your answers while keeping your answers concise and relevant

Question 1 [20 marks]

1. (a) (5 points) What is the difference between a program (an executable file) and a process and how is a program transformed into a process?

   (b) (3 points) Professor Theu is playing with kittens. He throws out a yarn ball and the kittens all race to fetch it, but only one succeeds. There are 12 kittens. After playing with the ball for a moment, the kitten brings the yarn ball back, returns it to Professor Theu and gets a treat. Which of deadlock, race condition, or starvation can occur? Please explain

   (c) (4 points) Explain how a scheduling algorithm could produce good throughput, but poor response time. Then explain how a scheduling algorithm could produce good response time, but poor throughput.

   (d) (3 points) Why don't we typically allow user level processes to disable interrupts?

   (e) (5 points) Explain how you would enhance a multi-level feedback queue scheduler to support user specified process priorities. That is, a user has a way to indicate that some processes are more important than other processes.

Question 2 [20 marks]

2. Answer the following questions in a few sentences as necessary.

   (a) (4 points) Typically a system call returns exactly once from an invocation. Name two Linux system calls that violate this behavior, and explain briefly how they violate the behavior.

   (b) (6 points) Let's assume you have exactly three page frames and they contain the pages A, B, and C. Construct a page reference sequence of 10 page accesses, including A, B, C and any other pages you want demonstrating that MIN produces a better hit rate than does LRU. Include the hit rates for each algorithm.

   (c) (2 points) A system is designed with the condition that no thread holding lock A can acquire lock B. What problem is this system designed to prevent?

   (d) (2 points) Why does modern virtual memory support require hardware support?

   (e) (2 points) Why on earth does the MIPS have a Random register? How would you use it?

   (f) (4 points) A MIPS instruction stores a value from a general purpose register into memory. List as many different ways as possible that this instruction could cause an exception.

Question 3 [20 marks]

3. For each of the problems described below, indicate which of the following synchronization primitives is BEST suited for it. Explain briefly why you chose the primitive you did.

   1. Counting semaphore
   2. Lock with Condition Variable
   3. Locks
   4. Readers-Writers Locks
   5. Monitors

   (a) (4 points) You have a bushel of apples. There are a pile of worms nearby. The bad news is that both you and the worms want to eat the apples. The good news is that the worms are willing to use whatever synchronization primitive you want. The worms don't mind if there are other worms or people eating the apple while they are munching away, but you are a bit squeamish and refuse to eat an apple while any worms are eating it (you are however, not so squeamish as to pass up an apple that currently has no worms, even if had worms in the past).

(b) (4 points) You notice that the person you'd like to ask out on a date is wearing a mood ring. You decide that it's best to ask the person out when the mood ring is either blue or purple. Once again you find yourself in the fortunate situation that the mood ring contains an embedded controller capable of issuing appropriate synchronization operations before it changes color (and of course, you know how to use synchronization primitives as well). What synchronization primitive do you want to share with the mood ring to help you get a date?

(c) (4 points) Professor Kumar has four cats and two hamsters. Her friend Mary has eleven cats. Kumar invites Mary's eleven cats over for a playdate. Each cat is allowed to play with either hamster, but only one cat can play with a particular hamster at any one time. The cats are clever beasts and know how to use synchronization primitives. What primitive to you want to use to grant the cats access to the hamsters? L

(d) (4 points) You've been giving a set of self-synchronizing chairs. The set supports the operations: allocate_chair, free_chair, spin_all_chairs, throw_chair_down_stairs. The set was manufactured by a company all of whose employees aced CSC2202. What primitive do you suppose they used to implement the chair interfaces?

(e) (4 points) Every CSC2111 student was so excited about the Test 2 results that they wanted to schedule a meeting with Professor Kabemba. Naturally, she required proper synchronization to do so. What primitive did she pick?

Question 4 [20 Marks]

4. (a) (2 points) What other hardware mechanism can be used on a uniprocessor to achieve mutual exclusion?

(b) (3 points) What are the three main purposes of an operating system?

(c) (2 points) List two reasons why an operating system designer might choose not to have user threads map 1:1 with kernel threads.

(d) (3 points) For each of the following traps, indicate whether the trap is synchronous or asynchronous with respect to a user-level program.

i. System Call

ii. Exception

iii. Interrupt

(e) (2 points) Why might it be advantageous to keep a process running on the same processor on which it last ran (this is called processor affinity)?

(f) (4 points) Imagine that you've been asked to build an operating system for a simple embedded processor. The processor has no virtual memory and no memory translation unit. What functionality must you build into your process loader if you wish to have multiple programs resident in memory?

(g) (4 points) In a system with virtual memory, how can you share memory between two processes?

Question 5 [20 marks]

5. The Stoopid architecture has a 12bit, segmented, virtual address space. The top three bits of an address identify a segment. The next four identify a page number and the last five are offsets.

segnumber(3)	pgnumber(4)	offset(5)

(a) (2 points) How large (in bytes) are pages in this architecture?

(b) (8 points) You are told that the architecture has a TLB, but that they haven't quite worked out the details of a) what each TLB entry looks like, and b) how many TLB entries they should include. Propose a TLB entry design then make (and justify) a suggestion for how many TLB entries they should have

(c) (4 points) Assume that the architecture supports paging. How many entries would you expect to find in a page table?

(d) (6 points) Stoopid Inc. has asked you to come in and consult for them. They know that NULL pointers are an endless source of bugs. They are trying to decide whether they can/should make the hardware guarantee that NULL pointers always cause faults or leave it to the operating system to enforce that.

i. Would it be possible for the hardware to guarantee that an access to the memory location referenced by a pointer whose value is NULL always generates faults? (How?)

ii. If the hardware designers either can't or don't provide that support, how would you design your operating system to make sure that accesses to the location referenced by a NULL pointer always generates a fault?

Question 6 [20 marks]

6. (a) For each of the following pairs of terms, identify the context(s) in which they occur. Then define each term and clarify the key difference(s) between the two terms.

i. (3 points) "host OS" and "guest OS"

ii. (3 points) "page" and "frame"

iii. (3 points) "reference bit" and "dirty bit"

iv. (3 points) "disk partition" and "file system volume"

v. (3 points) "host OS" and "guest OS"

(b) (5 points) When multiple processes need to cooperate, there is a choice between shared memory and inter-process communication (IPC). Compare and contrast these two techniques. Make sure to clarify the role of the operating system in each.

Question 7 [20 marks]

7. (a) (5 points) Every file in a filing system has a set of attributes (read only, date created etc.) Assume a filing system allows an attribute of temporary, meaning the creating process only uses the file during the time it is executing and has no need for the data thereafter. Assume the process is written correctly, so that it deletes the file at the end of its execution. Do you see any reason for an operating system to have temporary file attribute? Give your reasons.

(b) (5 points) An operating system supplies system calls to allow you to COPY, DELETE and RENAME a file.
Discuss the differences between using COPY/DELETE and RENAME to give a file new name?

(c) (5 points) An operating system only allows a single directory hierarchy but allows arbitrary long filenames. Could you simulate something approximating a hierarchical file system? Give your reasons.

(d) (5 points) When a file is removed, the blocks it occupies are simply placed back onto the free list. Can you see any problems with this? If so, how would you overcome them and what problems, if any, would now exist and how would you resolve these?

END OF EXAM

Omnium Optimi!!!