CSci 402 - Operating Systems

Final Exam (DEN Section)

Fall 2022

(9:00:00am - 9:40:00am, Monday, December 12)

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(This exam is open book and open notes.
Remember what you have promised when you signed your
Academic Integrity Honor Code Pledge.)

Time: 40 minutes

_____-
Name (please print)

Total: 38 points

_____-
Signature

Instructions

1. This is the first page of your exam. The previous page is a title page and does not have a page number. Since this is a take-home exam, no need to sign above since you won't submit this file.
2. Read problem descriptions carefully. You may not receive any credit if you answer the wrong question. Furthermore, if a problem says *"in N words or less"*, use that as a hint that N words or less are expected in the answer (your answer can be longer if you want). Please note that points may get *deducted* if you put in wrong stuff in your answer.
3. If a question doesn't say `weenix`, please do not give `weenix`-specific answers.
4. Write answers to all problems in the **answers text file**.
5. For non-multiple-choice and non-fill-in-the blank questions, please show all work (if applicable and appropriate). If you cannot finish a problem, your written work may help us to give you partial credit. We may not give full credit for answers only (i.e., for answers that do not show any work). Grading can only be based on what you wrote and cannot be based on what's on your mind when you wrote your answers.
6. Please do *not* just draw pictures to answer questions (unless you are specifically asked to draw pictures). Pictures will not be considered for grading unless they are clearly explained with words, equations, and/or formulas. It's very difficult to draw pictures in a text file and you are not permitted to submit additional files other than the answers text file.
7. For problems that have multiple parts, please clearly *label* which part you are providing answers for.
8. Please ignore minor spelling and grammatical errors. They do not make an answer invalid or incorrect.
9. During the exam, please only ask questions to *clarify* problems. Questions such as "would it be okay if I answer it this way" will not be answered (unless it can be answered to the whole class). Also, you are suppose to know the definitions and abbreviations/acronyms of *all technical terms*. We cannot "clarify" them for you. We also will **not** answer any clarification-type question for multiple choice problems since that would often give answers away.
10. Unless otherwise specified and stated explicitly, multiple choice questions have one or more correct answers. You will get points for selecting correct ones and you will lose points for selecting wrong ones.
11. When we grade your exam, we must assume that you wrote what you meant and you meant what you wrote. So, please write your answers accordingly.

(Q1) (3 points) Let's say that you have four threads A, B, C, and D and you are using the basic **round-robin (RR) / time-slicing** scheduler with a very small time slice. At time zero, all four threads are in the run queue and their processing times are shown in the table below. Assuming that there are no future arrivals into the run queue, please complete the table below with the "waiting time" of all four threads and the "average waiting time" (AWT) of these four threads and write the results on your answer sheet. Please make it very clear which waiting time is for which thread and which one is the AWT. For non-integer answers, you can use fractions or decimals with two digits after the decimal point. Your answer must not contain plus or multiplication symbols. You must use the definition of "waiting time" given in lectures.

	A	B	C	D	AWT (1 pt)
T (hrs)	7	8	11	10	-
wt (hrs)					

(Q2) (2 points) Which of the following statements are correct about having a **monolithic kernel**?

(1) a monolithic kernel is typically more robust (i.e., crashes less often) because it's not broken into little pieces
(2) the main advantage of a monolithic kernel is performance
(3) the main disadvantage of a monolithic kernel is poor security
(4) the weenix kernel is a monolithic kernel
(5) a monolithic kernel encourages system programmers to write more elegant code

Answer (just give numbers): _____

(Q3) (2 points) Which of the following statements are correct about the **scheduler activations model**?

(1) in the scheduler activations model, the kernel does not schedule/assign CPUs to threads; instead, the kernel schedules/assigns CPUs to processes
(2) scheduler activations model is not popular because its insecure to let user-space schedulers to make scheduling decisions
(3) the down side of the scheduler activations model is that if a user thread makes a system call, another user thread in in the user process cannot make a system call until the first thread has returned from the kernel
(4) it's difficult to make time-slicing work well in scheduler activations model
(5) in scheduler activations model, multiple user threads in the same user process can be making system calls concurrently

Answer (just give numbers): _____

(Q4) (2 points) Which of the following are approaches used to **reduce page fault latency**?

(1) use a FIFO page replacement policy
(2) use a pageout daemon
(3) increase the size of translation lookaside buffers
(4) lazy evaluation
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q5) (2 points) Which of the following statements are correct about virtual machine (VM) and virtual machine monitor (VMM)?

(1) when virtual machine is used, the OS of the real machine is often referred to as the guest OS
(2) another name for virtual machine is "hypervisor"
(3) VMM is a user space program that runs inside a virtual machine
(4) when virtual machine is used, the guest OS runs in the user mode of the real machine
(5) VMM is a terminal device that's used to interact with a virtual machine

Answer (just give numbers): _____

(Q6) (2 points) Which of the following statements are correct about **real-time** systems and threads?

(1) a real-time thread in the kernel is a thread that can schedule itself to run on the CPU at a specific time without the help of the scheduler
(2) a real-time thread in the kernel is a thread that makes timer-related system calls
(3) there is not much difference between a soft real-time system and a hard real-time system
(4) a real-time thread in the kernel is a thread that must start running on the CPU before a deadline
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q7) (2 points) Let's say that the address space of a user space in **weenix** looks like the following:

```
      VADDR RANGE      PROT  FLAGS    MMOBJ    OFFSET    VFN RANGE
0x0803b000-0x0804b000  rw-  PRIVATE 0xcfe0c034 0x00008 0x0803b-0x0804b
0x0804b000-0x0804f000  r-x  PRIVATE 0xcfe0c004 0x00009 0x0804b-0x0804f
0x0804f000-0x08064000  rw-  PRIVATE 0xcfe0c064 0x0000b 0x0804f-0x08064
```

If you get a page fault with vaddr = 0x0805b886, what **pagenum** would you use to lookup a page frame when you are handling a page fault? Please just give an integer value answer (no partial credit for this problem).

(Q8) (2 points) Let's say that you are using a **rate-monotonic scheduler** to schedule 4 periodic tasks with $T_1 = 0.5$, $P_1 = 4.5$, $T_2 = 1$, $P_2 = 5.5$, $T_3 = 0.5$, $P_3 = 7$, and $T_4 = 1$, $P_4 = 6$. Let's say that you schedule all 4 periodic tasks to start a time = 0. Since the total utilization is too large to guarantee that all jobs will meet their deadlines, the only way to know is to simulate the **rate-monotonic scheduler**. How many seconds into the simulation would be the first time all 4 jobs would start executing at exactly the same time again? Please just give a numeric answer (no partial credit for this problem).

(Q9) (2 points) Which of the following statements are correct about using **base and bounds** registers in a **segmented virtual memory** scheme?

(1) by adding some hardware in MMU, the basic base and bounds scheme can be extended to speed up directory lookup
(2) by adding some hardware in MMU, the basic base and bounds scheme can be extended to reduce the size of page tables
(3) by adding some hardware in MMU, the basic base and bounds scheme can be extended to make a memory segment read-only
(4) by adding some hardware in MMU, the basic base and bounds scheme can be extended to provide crash resiliency
(5) by adding some hardware in MMU, the basic base and bounds scheme can be extended to allow a memory segment to be swapped out to a storage device

Answer (just give numbers): _____

(Q10) (2 points) Which of the following statements are correct for a **forward-mapped (multilevel) page tables** in an **x86 CPU**, where a 32-bit virtual address is divided into a 10-bit page directory number, a 10-bit page table number, and a 12-bit offset?

(1) compare to a basic (two-level) page table scheme, address translation is faster when a multilevel page table scheme is used
(2) the size of a page directory table and the size of a second-level page table is the same as the size of a physical memory page
(3) the size of a a page directory entry is the same as the size of a second-level page table entry
(4) since every user space program must have at least 3 memory segments, at least 3 entries in the user portion of a page directory table must be valid
(5) the basic (two-level) page table scheme is more space efficient than the multilevel page table scheme

Answer (just give numbers): _____

(Q11) (2 points) In `sys_open()` in **weenix**, it calls `copy_from_user()` and then `user_strdup()` to **copy** the first argument to the `open()` system call into a string with a kernel space virtual address and then pass the kernel space virtual address to `do_open()`. Why can't `sys_open()` just pass the first argument of the `open()` system call directly to `do_open()`?

(1) because x86 MMU uses segmentation and not paging
(2) because the `open()` system call must work properly even if the first argument contains a kernel space virtual address
(3) because user program can be maliciouis and pass a bad virtual address to the kernel to try to crash the kernel
(4) because the first argument of the `open()` system call may need a page fault to perform copy-on-write before it can be used by `do_open()`
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q12) (2 points) For a terminal, input characters may need to be processed/edited in some way before they reach the application. Which of the following **data structures** are used to solve this problem?

(1) a hash table that uses extensible hashing
(2) a B tree or a B+ tree
(3) a translation lookaside buffer
(4) a memory map and a page table
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q13) (2 points) Which of the following statements are correct about approaches to deal with the problem caused by the **popf** instruction so that a virtual machine can be built for the **x86 processor**?

(1) in Intel's solution, a new "processor mode" was added
(2) in Intel's solution, the `popf` instruction is disabled so that it won't cause any problem
(3) VMware's solution is a compile-time solution, i.e., some sensitive instructions are replaced with hypercalls when the kernel is compiled
(4) with paravirtualization, certain sensitive instructions are replaced with hypercalls at the time the kernel is compiled
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q14) (2 points) Which of the following are maintained in a **S5FS superblock**?

(1) checkpoint files
(2) root node of the B+ tree for locating all the inodes
(3) inode numbers of all the free inodes
(4) disk map
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q15) (3 points) Let's say that you have four threads A, B, C, and D and you are using **stride scheduling**. You have decided to give thread A 5 ticket, thread B 6 tickets, thread C 8 tickets, and thread D 12 tickets. The initial pass values that **you must used** for the four threads are shown below along with the "winner" of the iteration 1. Please run **stride scheduling** to fill out all the entries (pass values) in the table and keep track of the "winner" in each round. For **iterations 2 through 7**, please write on your answer sheet the "winner" and the winning pass value of that iteration. (For example, you would write "C:7" for iteration 1 since C is the "winner" of iteration 1 and the winning pass value is 7.) You must use the **smallest possible integer stride values** when calculating all the pass values. If you get the stride values wrong, you will not get any partial credit for this problem.

itr	A	B	C	D
1	14	27	(7)	21
2				
3				
4				
5				
6				
7				

(Q16) (2 points) Which of the following statements are correct about thread implementation strategies?

(1) one problem with the N x 1 model is priority inversion
(2) one main problem with the 1 x 1 model is that it's slow because system calls are slow
(3) one main problem with the N x 1 model is that it's slow because system calls are slow
(4) the scheduler activations model is a variation on the two-level model
(5) N x 1 model is preferred over 1 x 1 model because N x 1 model can achieve higher parallelism

Answer (just give numbers): _____

(Q17) (2 points) Which of the following statements are correct about using **base and bounds** registers in a **segmented virtual memory** scheme?

(1) the bounds register contains a "validity" bit to indicate if the value stored in the base register is valid or not
(2) the bounds register contains a virtual address
(3) the value in a bounds register must be an integer multiple of the size of a page
(4) the base register contains a physical address
(5) the base register contains a virtual address

Answer (just give numbers): _____

(Q18) (2 points) Which of the following statements are **correct** about **I/O virtualization**?

(1) in VMware's solution to I/O virtualization, most device drivers in the guest OS must be rewritten so that they can be supporte
(2) in Xen's solution to I/O virtualization, only a few device drivers in the guest OS has to be rewritten in order for Xen to use them
(3) I/O virtualization is not as big of a problem in building virtual machines for high performance servers since only a small number of devices need to be supported
(4) VMware's I/O virtualization solution performs better than Xen's I/O virtualization solution
(5) none of the above is a correct answer

Answer (just give numbers): _____