CSci 402 - Operating Systems

Alternate Final Exam

Summer 2021

(7:00:00pm - 7:40:00pm, Tuesday, August 3)

Instructor: Bill Cheng

Teaching Assistant: (N/A)

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

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

Answer (just give numbers): _____

(Q2) (2 points) Which of the following statements are correct about virtual machine monitor (VMM)?

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

Answer (just give numbers): _____

(Q3) (2 points) Which of the following statements are correct about **directed processing**?

(1) the "signals" mechanism in Unix is less general than the Windows APC mechanism
(2) in "directed processing", a kernel thread is used to execute code for a user process without going into the user space
(3) the "signals" mechanism in Unix is a form of "directed processing"
(4) in "directed processing", a user thread is used to execute code inside the kernel
(5) the "signals" mechanism in Unix is more general than the Windows APC mechanism because it uses an upcall

Answer (just give numbers): _____

(Q4) (2 points) Which of the following statements are correct about the basic (two-level) virtual memory scheme where a virtual address is divided into a virtual page number (say 20 bits) and an offset (say 12 bits) on a 32-bit machine?

(1) during the lifetime of a user process, the mapping of virtual pages to physical pages stays the same
(2) when performing a virtual to physical address translation, the least-significant 12-bits of the virtual address (i.e., the offset) must equal to the least-significant 12-bits of the translated address
(3) an entry in a page table contains a 20-bit physical page number no matter how much physical memory is present
(4) a physical address is obtained by adding a physical page number with the 12-bit offset
(5) virtual page number is just an array index into a page table which has 2^{20} entries

Answer (just give numbers): _____

(Q5) (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 **x86 processors**?

(1) in Intel's solution, the hypervisor runs in "ring 0"
(2) in Intel's solution, the `popf` instruction is disabled so that it won't cause any problem
(3) in VMware's solution is a compile-time solution, i.e., sensitive instructions are replaced with hypercalls when kernel is compiled
(4) with paravirtualization, 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): _____

(Q6) (2 points) Which of the following statements are correct about the **round-robin (RR) / time-sliced** scheduler?

(1) with this scheduler, "starvation" at the scheduler cannot occur
(2) it generally has a smaller average waiting time than SJF scheduling
(3) time-slice values should be as large as possible to improve average waiting time
(4) time-slice values should be as small as possible to improve average waiting time
(5) it generally has a smaller variance in waiting time than SJF scheduling

Answer (just give numbers): _____

(Q7) (2 points) which of the following statements are correct about the **N x 1 (two-level)** thread implementation model?

(1) in this model, when a user thread makes a system call and gets blocked inside the kernel, other threads in the same process can still run as long as they don't make system calls
(2) in this model, when one user thread wants to give up the processor to switch to another user thread in the same process, it must make a system call
(3) in this model, thread creation and destruction still have to be implemented as system calls
(4) in this model, it's not necessary to trap into the kernel when locking and unlocking mutexes
(5) this model is used in the old days when the kernel didn't know about multithreading in user space programs

Answer (just give numbers): _____

(Q8) (2 points) Let's say that you are using **extensible hashing** to speed up directory lookup. If $h_3(''proc.c'') = 5$, which of the following are possible values of $h_5(''proc.c'')$?

(1) 29
(2) 51
(3) 43
(4) 37
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q9) (2 points) Which of the following statements are correct about **paravirtualization**?

(1) the paravirtualized guest OS cannot run directly on the real machine hardware
(2) compared with full virtualization, it is more difficult for paravirtualization to deal with "problematic" sensitive instructions
(3) the guest OS cannot tell if it's running on the real machine hardware or inside a virtual machine
(4) only limited amount of changes can be made to the guest OS when paravirtualization is used
(5) one main adadvantage of paravirtualization is performance

Answer (just give numbers): _____

(Q10) (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 6 ticket, thread B 5 tickets, thread C 7 tickets, and thread D 6 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 "B:4" for iteration 1 since B is the "winner" of iteration 1 and the winning pass value is 4.) 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	6	7	(4)	9
2	6			
3		7		
4				9
5			34	
6	41			
7				454

(Q11) (2 points) Which of the following statements are correct about **crash resiliency** in file systems?

(1) a major problem with "soft update" is hierarchical dependency among modified disk blocks
(2) journaling is not available to file systems that uses "extents"
(3) to provide crash resiliency in Linux file systems, ext3 uses journaling while ext4 does not use journaling
(4) to provide crash resiliency in Linux file systems, "shadow paging" is preferred over transaction-based approaches
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q12) (2 points) Which of the following statements are correct about **backing store**?

(1) pages in a shadow object must have its backing store in swap space
(2) read-only mapping of a file must have its backing store in swap space
(3) read-write shared mapping of a file must have its backing store in swap space
(4) read-write private mapping of a file must have its backing store in swap space
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q13) (2 points) Which of the following statements are correct about **shadow objects** if we want **copy-on-write** and **fork()** to work together correctly?

(1) if a virtual memory segment is read-only, its first mmobj must be a shadow object
(2) a shadow object holds pages that were copy-on-write but have never been modified
(3) if a virtual memory segment is shared-mapped, you must use a shadow object for its first mmobj
(4) a chain of shadow objects is maintained in a double-linked circular list in weenix
(5) if a virtual memory segment is privately mapped and writable, you must use a shadow object for its first mmobj

Answer (just give numbers): _____

(Q14) (2 points) Which of the following statements are **correct** about **microkernel**?

(1) almost all microkernel implementations have good performance
(2) access control in a microkernel system typically is based on user IDs and group IDs just like a traditional Unix system
(3) in the design of the microkernel architecture, even device drivers can be moved into user space
(4) one main differences between a message port and a Unix pipe is that a message port can be named
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q15) (2 points) Which are the reasons the **line-disciplining code** is made into a separate **module**?

(1) modularity: make the code suitable to be moved into usre space or be kept inside the kernel
(2) performance: make the terminal device appear to be more responsive
(3) modularity: separate the device dependent part from the device independent part in dealing with terminal devices
(4) protection: hardware manufacturers should not be trusted to access kernel data structures
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q16) (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
0x0803a000-0x08049000   rw-  PRIVATE 0xcfe0c034 0x0000e 0x0803a-0x08049
0x08049000-0x0804d000   r-x  PRIVATE 0xcfe0c004 0x0000f 0x08049-0x0804d
0x0804d000-0x08062000   rw-  PRIVATE 0xcfe0c064 0x0000a 0x0804d-0x08062
```

If you get a page fault with vaddr = 0x0805c668, 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).

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(Q17) (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)	4	5	6	5	-
wt (hrs)	16	19	20	19	18.5

(Q18) (2 points) Which of the following statements are **correct** about **executing sensitive instructions** in an IBM 360 **virtual machine**?

(1) when a sensitive instruction is executed in the **privileged mode** of the **real machine**, it should cause a trap into the VMM
(2) when a sensitive instruction is executed in the **VMM**, it should causes an additional trap into the VMM itself
(3) when a sensitive instruction is executed in the **virtual privileged mode** (inside a **virtual machine**), it should cause a trap into the VMM
(4) when a sensitive instruction is executed in the **virtual user mode** of the **virtual machine**, it should cause a trap into the VMM
(5) none of the above is a correct answer

Answer (just give numbers): _____