CSci 402 - Operating Systems
Final Exam (DEN Section)
Spring 2021

(9:00:00am - 9:40:00am, Friday, May 7)

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

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

Answer (just give numbers): _____

(Q2) (2 points) Let's say that you are using **extensible hashing** to speed up directory lookup. If $h_3(''proc.c'') = 4$, which of the following are possible values of $h_5(''proc.c'')$?

(1) 20
(2) 36
(3) 44
(4) 12
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q3) (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 translation lookaside buffer
(2) a partial-line queue
(3) a completed-line queue
(4) a B tree and a hash table
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q4) (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 3 ticket, thread B 2 tickets, thread C 2 tickets, and thread D 4 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 "D:2" for iteration 1 since D is the "winner" of iteration 1 and the winning pass value is 2.) 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	8	7	5	(2)
2				
3				
4				
5				
6				
7				

(Q5) (2 points) In a **segmented virtual memory** system with **base and bounds** registers, the basic scheme uses **one pair of base and bounds registers in the MMU** for each of the 4 basic memory segments. Which of the following statements are correct about extending this basic scheme?

(1) to provide support for memory-mapped files, more pairs of base and bounds registers are required in the MMU
(2) to provide access protection to memory segments, a validity/present bit needs to be added to each pair of base and bounds registers
(3) to add support for "backing store", access protection bits are added to each pair of base and bounds registers
(4) there is nothing that needs to be added to the MMU to provide support for "backing store"
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q6) (2 points) Which of the following statements are correct about a **SJF (shortest job first)** scheduler?

(1) it appears to have a high throughput
(2) it's a scheduler that's inherently unfair to long jobs
(3) it generally has a smaller variance in waiting time than other schedulers
(4) "starvation" at the scheduler cannot occur with this scheduling policy
(5) compared with some other schedulers, this scheduler can have a large average waiting time for the jobs that are in run queue

Answer (just give numbers): _____

(Q7) (2 points) Which are the reasons the **line-disciplining code** is made into a separate **module**?

(1) protection: hardware manufacturers should not be trusted to access kernel data structures
(2) modularity: make the code for dealing with language-specific issues separate from the code to deal with hardware specific characteristics
(3) modularity: separate the device dependent part from the device independent part in handling the terminal device
(4) performance: make the terminal device appear to be more responsive
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q8) (2 points) Which of the following are bits inside a PTE (page table entry) in **weenix** (which runs on an x86 CPU)?

(1) a "present" bit
(2) a "user/kernel" bit
(3) a "private/shared" bit
(4) an "execute" bit
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q9) (2 points) Which of the following statements are **incorrect** about **undo journaling** and **redo journaling**?

(1) in redo journaling, you record "before images" in the log
(2) in undo journaling, you record "after images" in the log
(3) you record the same information into the log no matter if you are using undo journaling or redo journaling
(4) in undo journaling, you record "before images" in the log
(5) in redo journaling, you record "after images" in the log

Answer (just give numbers): _____

(Q10) (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
T (hrs)	7	3	5	3	-
wt (hrs)					

(Q11) (2 points) A **disk map** of a S5FS **inode** contains 13 disk block pointers. If a disk block is 1KB in size, which of the following are **possible file sizes** if a file's disk map contains non-null block numbers in the first 12 entries and the last entry is null in its **disk map**?

(1) 50 KB
(2) 80 MB
(3) 400 MB
(4) 7 MB
(5) 600 KB

Answer (just give numbers): _____

(Q12) (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 a new CPU mode
(2) with paravirtualization, all sensitive instructions are replaced with hypercalls only at run time and not at compile time
(3) in VMware's solution is a compile-time solution, i.e., sensitive instructions are replaced with hypercalls when kernel is compiled
(4) in Intel's solution, the `popf` instruction is disabled so that it won't cause any problem
(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?

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

Answer (just give numbers): _____

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

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

Answer (just give numbers): _____

(Q15) (2 points) Which of the following statements are correct about **pseudo-terminal driver** vs. **terminal driver**?

(1) for a pseudo-terminal, the input and output (on the device end) comes from and goes to an actual device
(2) for a pseudo-terminal, the input and output (on the device end) comes from and goes to an application
(3) typically, pseudo-terminal driver and terminal driver are both user space drivers
(4) a terminal driver typically runs in kernel while a pseudo-terminal driver typically runs in user space
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q16) (2 points) A correct implementation of **straight-threads** (i.e., no interrupt) **synchronization** on a single CPU is shown here:

```
void mutex_lock(mutex_t *m)
{
  if (m->locked) {
    enqueue(m->queue,
        CurrentThread);
    thread_switch();
  } else
    m->locked = 1;
}
```

```
void mutex_unlock(mutex_t *m)
{
  if (queue_empty(m->queue))
    m->locked = 0;
  else
    enqueue(runqueue,
        dequeue(m->queue));
}
```

Let's say that thread X owns the mutex **m** (i.e., has it locked). If thread X calls **mutex_unlock()** and the mutex queue is **not** empty, the thread at the head of the mutex queue (let's call it thread Y) is supposed to own the mutex next. The above code would dequeue thread Y from the mutex queue and enqueue thread Y to the run queue **without unlocking the mutex**. Referring to the above code, which of the following statements are correct about **the next time thread Y will run** in the CPU?

(1) even though thread Y is the new mutex owner, thread Y will still call **mutex_lock()** and may go to sleep again in **thread_switch()**
(2) since thread Y is the new mutex owner, thread Y will call **mutex_lock()** again and will successfully lock mutex **m**
(3) thread Y will return from the **thread_switch()** function inside **mutex_lock()** as the owner of mutex **m**
(4) thread Y go into zombie state before returning from **thread_switch()**
(5) it is possible that thread Y would wake up inside **thread_switch()** but go to sleep again insdie **thread_switch()** without returning from **thread_switch()**

Answer (just give numbers): _____

(Q17) (2 points) which of the following statements are correct about the **N x 1 (two-level)** thread implementation model?

(1) in this model, thread creation and destruction still have to be implemented as system calls
(2) this model is used in the old days when the kernel didn't know about multithreading in user space programs
(3) 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
(4) in this model, it's not necessary to trap into the kernel when locking and unlocking mutexes
(5) 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

Answer (just give numbers): _____

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

(1) Xen's I/O virtualization solution performs better than VMward's I/O virtualization solution
(2) in VMware's solution to I/O virtualization, most device drivers in the guest OS must be rewritten so that they can be supported
(3) I/O virtualization is not as big of a problem in building virtual machines for high performance servers because only a small number of devices need to be supported
(4) I/O virtualization in building virtual machines for desktop machines is challenging because it's virtually impossible for virtual machine vendors to support all devices
(5) 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

Answer (just give numbers): _____