CSci 402 - Operating Systems

Final Exam (PM Section)

Fall 2021

(11:00:00am - 11:40:00am, Friday, December 10)

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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 what happens when an appplication running inside a virtual machine makes a system call?

(1) the system call will eventually get turned into an upcall to reach the guest OS
(2) the system call would trap into the VMM first
(3) the system call will eventually be emulated by the VMM
(4) the system call will first be intercepted by the dynamic linker inside the VMM
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q2) (2 points) Which of the following statements are **correct** about **microkernel**?

(1) one main differences between a message port and a Unix pipe is that you can assign names to Unix pipes
(2) access control in a microkernel system typically is based on user IDs and group IDs just like a traditional Unix system
(3) almost all microkernel implementations have good performance
(4) in the design of the microkernel architecture, device drivers cannot be moved into user space
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q3) (2 points) Which of the following statements are correct about the **NOR** vs. **NAND** flash memory technologies?

(1) a NOR flash is more suitable to be used in a file system than a NAND flash
(2) for writing, a NAND flash is page-erasable but not block-erasable
(3) a NAND flash is byte-addressable
(4) a NOR flash is byte-addressable
(5) for a NAND flash, the smallest addressable unit for reading is a page

Answer (just give numbers): _____

(Q4) (2 points) Which of the following statements are correct about **physical vs. virtual addresses** on a 32-bit machine?

(1) there is a system call a user thread can call to ask the OS to convert a user space virtual address into physical address
(2) a thread uses physical addresses when it first got created in the kernel and switch to use virtual addresses when it runs in the user space for the first time
(3) a device driver uses physical addresses to execute code but use virtual address to access data on a device
(4) a user thread can use physical addresses if it makes a system call and turns into a kernel thread
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q5) (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)	8	5	6	8	-
wt (hrs)					

(Q6) (2 points) Which of the following statements are correct about **vfork()**?

(1) **fork()** is usually faster than **vfork()**
(2) if **vfork()** is used, the parent process and the child process can never run "concurrently" even if the programmer's code is perfect
(3) **fork()** and **vfork()** are equivalent
(4) **vfork()** is best used by expert programmers because it's tricky to use it correctly
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q7) (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 9 tickets, thread C 5 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 "A:4" for iteration 1 since A 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	(4)	17	23	31
2				
3				
4				
5				
6				
7				

(Q8) (2 points) Which of the following statements are correct about **futex**?

(1) the best place to use a futex is inside the kernel
(2) futex is considered "fast" because if the futex is available, a user thread can lock it quickly in user space without making a system call
(3) if a futex is currently **locked** and not being released, a thread calling `futex_lock()` must enter the kernel to wait for the lock to be released
(4) futex is designed to work only in multi-CPU systems and will not work in single-CPU systems
(5) in order for a futex to function correctly when there are multiple CPUs, the kernel is required to be a non-preemptive kernel

Answer (just give numbers): _____

(Q9) (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 an inode's **disk map** contains non-null block numbers in the first 12 entries and the last entry is null?

(1) 200 MB
(2) 960 KB
(3) 24 MB
(4) 96 MB
(5) 100 KB

Answer (just give numbers): _____

(Q10) (2 points) A correct implementation of **straight-threads synchronization** for a single CPU system 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 mutex **m1** and thread Y owns a different mutex **m2**. Which of the following statements are correct about what would happen if thread Y calls **mutex_lock(m1)**?

(1) thread X will enter **mutex_unlock()** immediately and thread Y will return from mutex_lock() immediately with mutex **m1** locked
(2) thread Y will go to sleep in the run queue
(3) thread X will enter **thread_switch()** and thread Y will return from **thread_switch()** immediately
(4) thread Y will go to sleep in **m1**'s mutex queue
(5) thread Y will enter **thread_switch()** and thread X will return from **thread_switch()** immediately

Answer (just give numbers): _____

(Q11) (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 **VMM**, the sensitive instruction will get emulated by the VMM
(2) when a sensitive instruction is executed in the **virtual user mode** inside the **virtual machine**, the sensitive instruction will get emulated by the VMM
(3) when a sensitive instruction is executed in the **privileged mode** of the **real machine**, it should cause a trap into the VMM
(4) when a sensitive instruction is executed in the **virtual privileged mode** inside the **virtual machine**, it should get delivered to the guest OS
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q12) (2 points) Let's say that you are using a **rate-monitonic scheduler** to schedule 4 periodic tasks with $T_1 = 0.5$, $P_1 = 4.5$, $T_2 = 1$, $P_2 = 5$, $T_3 = 0.5$, $P_3 = 5.5$, and $T_4 = 1$, $P_4 = 6$. Let's say that you schedule all 4 period tasts 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-monitonic 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).

(Q13) (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 0x0000d 0x0803a-0x08049
0x08049000-0x0804d000  r-x  PRIVATE 0xcfe0c004 0x0000e 0x08049-0x0804d
0x0804d000-0x08062000  rw-  PRIVATE 0xcfe0c064 0x0000b 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).

(Q14) (2 points) Which of the following statements are correct about the **popf machine instruction** in a **traditional Intel x86 processor**, i.e., non-Vanderpool?

(1) executing `popf` in the user mode will not cause a trap while executing it in the privileged mode will cause a trap
(2) `popf` behaves differently when it is executed in the user mode and in the privilege mode
(3) executing `popf` will not cause a trap in either user mode or privileged mode
(4) executing `popf` in the user mode causes a trap while executing it in the privileged mode does not
(5) `popf` is a privileged instruction and not a "sensitive instruction"

Answer (just give numbers): _____

(Q15) (2 points) Which of the following is correct about **management of page frames**?

(1) in Linux, user pages can be found in all three physical memory "zones"
(2) if the idea of "working set" is fully implemented in the OS, thrashing can be prevented
(3) if "local allocation" is used in the OS, thrashing can still happen
(4) in Linux, a dirty and inactive page frame must be freed/deallocated after it has been "cleaned" (i.e., content written back to disk)
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q16) (2 points) Which of the following statements are correct about **paravirtualization**?

(1) a paravirtualized OS is indistinguishable from the real OS in the sense that it can also run on the hardware the real OS was designed to run on
(2) VMware is well-known for its paravirtualization patent
(3) one way to implement paravirtualization is to to fix the hardware so that an OS can run inside a virtual machine without modification
(4) inside a commercial paravirtualized OS, usually there are no device drivers
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q17) (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) VMM is also known as "hypervisor"
(3) VMM is a terminal device that's used to interact with a virtual machine
(4) VMM is a user space program that runs inside a virtual machine
(5) when virtual machine is used, the guest OS runs in the user mode of the real machine

Answer (just give numbers): _____

(Q18) (2 points) Which of the following statements are correct about having a **monolithic kernel**?

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

Answer (just give numbers): _____