CSci 402 - Operating Systems

Alternate Final Exam

Fall 2021

(7:00:00pm - 7:40:00pm, Monday, December 13)

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 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) this model is used in the old days when a user space program didn't know that the kernel was multithreaded
(5) in this model, a user thread does not need to trap into the kernel to lock or unlock a mutex

Answer (just give numbers): _____

(Q2) (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) thread Y may wake up inside **thread_switch()** but go to sleep again insdie **thread_switch()** without returning from **thread_switch()**
(3) thread Y will return from the **thread_switch()** function inside **mutex_lock()** but thread X is still the owner of mutex **m**
(4) since thread Y is the new mutex owner, thread Y will call **mutex_lock()** again and will successfully lock mutex **m**
(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 **scheduler activations model**?

(1) in scheduler activations model, if a user thread makes a system call, another user thread in in the user process cannot make a system call
(2) scheduler activations model does not schedule threads in the kernel; instead, it schedules processes in the kernel
(3) it's difficult to make time-slicing work well in scheduler activations model
(4) scheduler activations model is not popular because its insecure to let user-space schedulers to make scheduling decisions
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q4) (2 points) Which of the following statements are correct about the **free block list** in **S5FS**?

(1) the head and tail of the free block list in S5FS are stored in the superblock
(2) the on-disk data structure for the free block list in S5FS is basically a singly-linked list
(3) each node in the free block list in S5FS can contain at most 99 disk block pointers
(4) free inodes are used to keep track of free disk blocks in S5FS
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q5) (2 points) Which of the following statements are correct about the **inverted page table** scheme?

(1) in an inverted page table scheme, a hash function is used, whose input is a combination of process ID and physical page number
(2) the main advantage of using a inverted page table scheme is its lookup speed
(3) in an inverted page table scheme, the page table used by each process looks like an "inverted tree"
(4) in an inverted page table scheme, a hash function is used, whose input is a combination of thread ID and virtual page number
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q6) (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) a chain of shadow objects is maintained in a singly-linked list in weenix
(2) if a virtual memory segment is read-only, its first mmobj must be a shadow object
(3) a shadow object holds pages that were copy-on-write but have never been modified
(4) if a virtual memory segment is shared-mapped, you must use a shadow object for its first mmobj
(5) if a virtual memory segment is privately mapped and read-writable, you must use a shadow object for its first mmobj

Answer (just give numbers): _____

(Q7) (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)	9	5	6	5	-
wt (hrs)					

(Q8) (2 points) Let's say that you are using a **rate-monitonic scheduler** to schedule 4 periodic tasks with $T_1 = 0.5$, $P_1 = 3.5$, $T_2 = 1$, $P_2 = 4$, $T_3 = 0.5$, $P_3 = 4.5$, 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).

(Q9) (2 points) Which of the following statements are correct about **extents** used in file systems in Windows?

(1) FAT32 extents has both external fragmentation and internal fragmentation while NTFS extents does not have external fragmentation
(2) it's a good idea to "defrag" the disk to improve performance for a file system that uses extents
(3) NTFS uses disk maps instead of extents to improve performance over FAT32
(4) FAT32 extents is optimized for random access
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q10) (2 points) Which of the following statements are correct about thread implementation strategies?

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

Answer (just give numbers): _____

(Q11) (2 points) Let's say that you have a 32-bit virtual address and it's divided into 14 bits of **tag**, 5 bits of **key**, and 13 bits of **offset**. If your processor's **translation lookaside buffer (TLB)** uses a 4-way associative cache structure, (a) how many **cache lines** does this TLB have, and (b) how many **bits** of **tags** can be stored in the **entire TLB**? Please give either a numerical answer or a simple numerical expression.

(Q12) (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 8 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:8" for iteration 1 since A is the "winner" of iteration 1 and the winning pass value is 8.) 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)	18	28	12
2				
3				
4				
5				
6				
7				

(Q13) (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 a special user space application
(3) a terminal driver typically runs in kernel while a pseudo-terminal driver typically runs in user space
(4) typically, pseudo-terminal driver and terminal driver are both user space drivers
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q14) (2 points) Which of the following statements are correct about the naive spin lock implementation vs. the **"better" spin lock implementation**?

(1) the naive spin lock and the "better" spin locks are functionally equivalent, i.e., they achieve the same functionality
(2) both the naive spin lock and the "better" spin lock do busy-waiting
(3) using the "better" spin lock can lock the spin lock faster than the naive spin lock if the spin lock is currently available
(4) using the "better" spin lock can lock the spin lock faster than the naive spin lock if the spin lock is currently unavailable
(5) no matter which spin lock implementations you use, the impact on system performance is the same if the spin lock is currently unavailable

Answer (just give numbers): _____

(Q15) (2 points) Which of the following statements are correct about the **round-robin (RR) / time-sliced** scheduler?

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

Answer (just give numbers): _____

(Q16) (2 points) Which of the following statements are correct about the **one-level** thread implementation model?

(1) **pthread_create()**, implemented in the user space, must be implemented as a system call
(2) **pthread_mutex_lock()**, implemented in the user space, must trap into the kernel to lock a mutex
(3) **pthread_join()**, implemented in the user space, must be implemented as a system call
(4) if **futex** is used to implement locks in user space, every **futex** operation that deals with a lock must trap into the kernel because threads are implemented in the kernel
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q17) (2 points) Which of the following statements are correct about the **FIFO** scheduler?

(1) for the FIFO scheduler, average waiting time depends on the ordering of jobs at the run queue
(2) the FIFO scheduler is inherently unfair to short jobs
(3) it appears to be a fair scheduling policy
(4) "starvation" at the scheduler is not possible for the FIFO scheduling policy
(5) the FIFO scheduler has the largest variance in waiting time among all scheduling disciplines

Answer (just give numbers): _____

(Q18) (2 points) Which of the following statements are correct about **paravirtualization**?

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

Answer (just give numbers): _____