CS 111 Midterm exam

PATEL; DEVEN VIMAL

TOTAL POINTS

90 / 100

QUESTION 1

1 Dirty bits 10 / 10

✓ **- 0 pts Correct**

- 10 pts No answer

- 5 pts Incorrect in explaining why dirty bit improves performance

- 5 pts Incorrect in explaining how dirty bit improves performance

- 2 pts Did not link performance increase to less disk I/O

QUESTION 2

2 ABI and system call interface 7 / 10

- 0 pts The subset relationship is clearly stated in the answer.

- 10 pts No answer

✓ **- 3 pts Wrote down some sentences related to question, but didn't clearly mention system call interface is a subset of ABI.**

- 1 pts More close to the answer but still missing clearly mentioning the subset relationship.

QUESTION 3

3 Shared libraries 10 / 10

✓ **- 0 pts Correct**

- 10 pts No answer

- 4 pts Missing details: multiple processes accessing the shared global data at the same time would be a problem.

QUESTION 4

4 System calls and trap instructions 10 / 10

✓ **- 0 pts Correct**

- 10 pts No answer

- 2 pts Did not mention transition of processor from unprivileged mode to privileged mode

- 2 pts Did not mention OS runs appropriate code for the system call

- 2 pts Did not explain usage of trap handler

- 2 pts Did not mention OS will determine what trap was caused by trap instruction

- 2 pts Did not mention associated parameters preset by user application are saved

QUESTION 5

5 Working sets and page stealing 10 / 10

✓ **- 0 pts Correct**

- 10 pts No answer

- 5 pts Incorrect description of working set.

- 5 pts Incorrect description of page stealing algorithms.

- 3 pts insufficient description of page stealing algorithms.

- 3 pts Insufficient description of working sets.

- 2 pts Important element is that page stealing takes pages from processes whose working sets are too large and gives them to processes whose working sets are too small.

- 3 pts Goal of a working set is not to maximize the number of pages in memory, but to figure out the right number to have there.

- 2 pts Working set has nothing to do with TLB.

- 1 pts Just because a working set is large doesn't mean it isn't using its pages.

- 2 pts working set is not really about preventing thrashing, since that can occur even with properly implemented working sets.

- 3 pts Important to note that working sets are associated with processes and are controlled by their behavior.

- 3 pts Page stealing is used to build proper

working sets, not vice versa.

- 2 pts Processes don't voluntarily release page frames. That's why it's called stealing.

- 2 pts Page table usually bigger than the working set.

- 0 pts Click here to replace this description.

QUESTION 6

6 Scheduling algorithm metrics 10 / 10

✓ **- 0 pts Correct**

- 10 pts No answer

- 2 pts Maximizing jobs completed does not necessarily translate to maximum throughput, by most definitions.

- 8 pts Fairness not guaranteed by non-preemptive scheduling. Starvation not necessarily avoided, either.

- 1 pts SJF has nothing to do with number of pages.

- 5 pts Insufficient explanation of why metric is maximized.

- 3 pts Not for all non-preemptive algorithms. Turnaround time won't be optimized for non-preemptive FIFO, for example. Question asked about non-preemptive algorithms in general, not just one example of such an algorithm.

- 5 pts Turnaround time is not necessarily optimized. It's time of job arrival till time of job completion. With non-preemptive scheduling, one long-running job can kill the turnaround time of many other jobs.

- 0 pts As stated in the test instructions, nothing on the back of the page is graded.

- 5 pts Won't necessarily optimize time to completion. A long running job will not be interrupted, causing other short jobs to incur long times to completion. If you interrupted the long job for the short ones, average time to completion would improve.

- 10 pts Did not specify a metric.

- 4 pts "Minimizing context switches" isn't a performance metric, though doing so is likely to improve some metrics.

- 3 pts Insufficient explanation of why metric is maximized.

- 10 pts Response time may not be optimized with non-preemptive scheduling, since one long-running job can kill the response time of many other jobs.

- 2 pts Won't also optimize average time to completion, since long-running job can kill time to completion of many other jobs.

- 4 pts Throughput is typically defined as the amount of work produced by a system, not the number of jobs it completes. By the latter definition, non-preemptive scheduling doesn't optimize the metric, since you could finish many short jobs in the time it takes to finish one long job.

- 5 pts Not clear exactly what you mean by "process speed".

- 4 pts That's not the definition of mean response time. It's the average time to get some response from the system, not time to completion.

- 2 pts Not very clear description of chosen metric.

- 4 pts Non-preemptive scheduling is not likely to optimize number of deadlines met, since newly arrived jobs with short deadlines can't preempt a running job with a long deadline.

- 0 pts Not the usual definition of time to completion, but correct as described.

- 10 pts Round robin is not a non-preemptive algorithm

- 10 pts "operations/second->output" makes no sense. Output is not a metric.

- 6 pts Your assumptions are rarely true, and if not true, average time to completion is not optimized, by most definitions of that metric.

- 8 pts Incorrect description of throughput. Throughput is not the same as turnaround time, and turnaround time is not necessarily optimized by non-preemptive scheduling.

- 3 pts Metric you're looking for is throughput, not "turnout" or turnaround time.

- 5 pts Fairness not guaranteed (by any definition) for all types of non-preemptive scheduling, such as non-preemptive shortest job first.

- **2 pts** You're thinking of throughput, not total execution time.
- **10 pts** Round robin is not a metric, it's a scheduling algorithm, and not even a preemptive one.
- **0 pts** Click here to replace this description.

QUESTION 7

7 Worst fit and fragmentation 7 / 10

✓ **- 0 pts Correct**

- **3 pts** Worst fit algorithms fit allocation requests into the largest free chunk of memory available, assuming no perfect fit is available. The remainder of that chunk will be as large as possible, meaning it will be well suited to match later requests.
- **3 pts** A best fit algorithm will choose the free chunk closest and larger in size to the requested allocation, which implies that the leftover free memory returned to the free list is likely to be a small chunk, poorly suited to matching future requests.
- **4 pts** The definition of external fragmentation is scattering small, useless chunks of free memory throughout the free list, so best fit is more likely to cause external fragmentation than worst fit.
- **10 pts** wrong answer
- **10 pts** No answer

- 3 Point adjustment

did not provide details about how worst or best fit works

QUESTION 8

8 Page tables for fork vs. shared memory IPC 10 / 10

✓ **- 0 pts Correct**

- **10 pts** No answer
- **5 pts** Major difference is fork results in copy-on-write, while shared memory IPC doesn't.
- **1 pts** new process has its own page table, but its contents are the same.
- **3 pts** No discussion of fork page table issues.
- **1 pts** Stack isn't shared in shared memory IPC.
- **2 pts** Fork need not be followed by exec, leading to COW issues.
- **1 pts** IPC shared memory almost always read/write, at least by one of the processes.
- **2 pts** Data segment also likely to change after fork.
- **0 pts** Not well worded, but I think you have the right idea.
- **10 pts** So what's the difference?
- **10 pts** What is the difference in their page table behavior?
- **3 pts** Difference won't be in the TLB.
- **2 pts** Copy-on-write issue.
- **5 pts** Not a thread issue. Copy on write is the main relevant mechanism.
- **4 pts** Shared memory doesn't share page tables. Just entries in different page tables point to the same page frame.
- **3 pts** IPC is not about libraries, it's about data.

QUESTION 9

9 Condition variables 6 / 10

- **0 pts** Correct
- **10 pts** No answer

✓ **- 4 pts A condition variable is used to determine if some specific pre-defined condition has or has not occurred.**

- **3 pts** If the condition does occur, one or more of the blocked processes will be unblocked and permitted to run.
- **3 pts** The condition variable allows a process to wait for a specific condition without requiring the process to use a busy loop to check for the condition's occurrence.
- **10 pts** wrong answer

QUESTION 10

10 TLB misses 10 / 10

✓ **- 0 pts Correct**

- **10 pts** No answer
- **3 pts** Missing case of invalid entry.
- **4 pts** Missing case of valid entry on disk.
- **3 pts** Missing case of valid entry in RAM.

- 1 pts Page fault is on non-present, not invalid.

- 3 pts Case with page on disk is present bit not set. Invalid bit is different.

- 4 pts Different cases for valid page on disk and valid page in RAM.

- 2 pts What happens for an invalid entry?

- 1 pts TLB is a cache of page table entries, not pages.

- 1 pts Per test instructions, text on the back of the page is not graded.

- 2 pts First step is to consult in-RAM page table.

- 1 pts Disk isn't searched, since page table contains disk location of non-present pages.

- 2 pts More details on not present case.

- 3 pts Spacial locality does not play into TLB miss handling.

- 3 pts Memory won't be searched. Either the page is present, not present, or not valid. Present pages have their PTE loaded, not present pages are fetched from disk, invalid pages cause an exception.

- 2 pts Page table entry itself will indicate if page is on disk. No need to invoke clock algorithm.

- 1 pts Dirty bit doesn't indicate whether a page is in memory or not. Present bit does. Dirty bit indicates if an in-memory page has been written.

- 1 pts Invalid case is not that the page cannot be found, but that its PTE is marked invalid.

- 1 pts How is it determined if a segmentation fault should occur?

- 2 pts Not present pages are in the page table. They're just marked as "not present."

Midterm Exam
CS 111, Principles of Operating Systems
Winter 2018

Name: Deven Patel

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This is a closed book, closed note test. Answer all questions.

Each question should be answered in 2-5 sentences. DO NOT simply write everything you remember about the topic of the question. Answer the question that was asked. Extraneous information not related to the answer to the question will not improve your grade and may make it difficult to determine if the pertinent part of your answer is correct. Confine your answers to the space directly below each question. Only text in this space will be graded. No question requires a longer answer than the space provided.

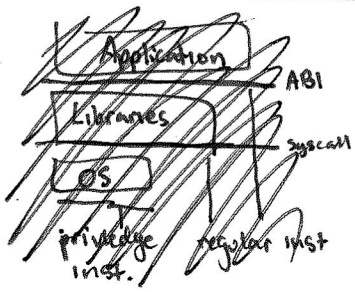
1. In a virtual memory system, why is it beneficial to have a dirty bit associated with a page?

In a virtual memory system,

Dirty bit indicates that a change was made in the RAM page and it is no longer the same as the equivalent page on disk (HDD or SSD usually). When dirty bit is set, it indicates that the page needs to be written to disk so when a page replacement algorithm needs to replace a page it can be set to ~~have some weight to~~ try and avoid these dirty bit pages since copying them to disk would be expensive in cycles and slow the system down. These pages are ~~usually~~ sometimes handled by preemptive page laundering which copies them to disk in clusters (for efficiency) in the background/when load isn't so high.

→ and since the bit is set the replacement alg. knows not to just erase them like they erase other pages that were not changed.

2. What is the relationship between a system's Application Binary Interface and its system call interface?



The Application Binary Interface binds APIs to the ISA. In some senses, A system call is an API/can be accessed by libraries which are APIs. An ABI binds these to the ISA so that so long as the OS/ISA on a system has the same ABI compliance as the system a program compiled with an ABI compliant linker is on, the programs binaries will run on that system as well. This makes it easy to distribute binaries to users without them needing to compile.

3. Why can't shared libraries include global data?

Shared libraries cannot include global data because shared libraries are shared by multiple processes. If they have global data, one process might change a variable (global) which another process needed in order to execute correctly. In some sense this is like a race condition since the order of execution (who gets/changes the global first) can change the outcome of a process so the process is non-deterministic.

4. Describe how a trap instruction is used to implement a system call in a typical operating system.

When a computer boots it sets up its trap table. When a process makes a systemcall, it traps into the OS with a trap instruction, and now the kernel is handling things. The trap table takes PC/PS and sends the flow to the appropriate level 1 handler. This handler saves registers etc. as needed on the kernel stack and goes to a system call dispatch table which selects a 2nd level trap handler based on the table. This handler takes care of the syscall then it goes back to the 1st level handler which returns the processes state and does a return-from-trap instruction. The process continues at the next instruction in user mode again because of the return-from-trap.

5. What is the relationship between the concept of working sets and page stealing algorithms?

Working set is ~~a~~ the set of pages a process needs to run effectively. Less pages and it slows down, more pages and the process only gets marginal diminishing returns. The working set is dynamically "chosen" by page stealing algorithm, like working set-clock algorithm. The idea is processes that fully utilize their pages will get more as needed and processes that don't will lose their pages to processes that need them.

fairness, Turnaround time, Throughput (ops/s), Lateness, Response time.

6. Name a performance metric that is likely to be maximizable using non-preemptive scheduling. Why is this form of scheduling useful to maximize this metric?

With non-preemptive scheduling one metric that can be maximized is throughput in operations/sec. This form of scheduling is useful to maximise this metric since there are no interupts (usually) or context switches which greatly slow things down cycles wise. The scheduler can just line the processes up and run them. As more processes come they can just be added to the back of the queue since order doesn't matter for this metric. This approach is usually seen in batch processing where we want to maximise this throughput metric.

7. Why does a worst fit algorithm for managing a free list handle external fragmentation better than a best fit algorithm?

A best fit algorithm checks the whole free list and finds a best fit and fills it. This algorithm can leave a lot of small free sections which no one can fit and thereby create external fragmentation between allocated sections.

Worst fit is better at first since it looks for the worst fit for some memory and this leaves big free sections, however, over time this algorithm also gets external fragmentation as the free list gets fuller and allocations start filling and freeing smaller sections. Best fit just fragments with tiny unusable free spaces a lot faster.

8. Both shared memory IPC and the processes' data areas after a Linux fork() operation would require the page tables of two processes to point to the same physical page frames. What would be different about the two cases (other than being caused by IPC vs. forking)?

One difference is that the shared memory pages can be written and read by numerous processes and they will all always point to the same physical space. With process's data area after fork, assuming copy on write, if one process wants to write to that data space it will need to copy the physical pages and then update its page table appropriately, and they will no longer be sharing. If there is not copy-on-write, these processes won't point to the same pages in the first place because the forked process would get its own copied pages by default.

9. What is the purpose of a condition variable?

The purpose of a condition variable is to solve the asynchonous completion problem without needing spin locks which waste cycles and are unfair. Condition variables make threads waiting for a resource sleep in a queue then wake the one at the front up when the current thread in the lock is done with it. that thread then can enter the critical zone and do whatever it needs to while holding the lock (There are more applications than just this one, but it is an example). They are more fair then spin locks, that is a key detail and can have better preformance and are typically correct. Progress depends on line waiting (as mentioned in lecture 8 notes).

10. In a system using demand paging, what operations are required when a TLB miss occurs? What are the possible outcomes of those operations?

In CISC systems when a TLB miss occurs there need to be hardware instructions that can go to the base of a page table and go down the page table searching for the correct entry then bring it into the TLB, or else page fault as mentioned below.

In RISC systems the OS manages the TLB miss. In this case it needs to trap into the OS and search the Page table for the correct PTE. If it is found and present it brings the entry in and replace an old entry. If it is not present it needs to page fault and go to disk and get it then search again and upon finding it bring it into the TLB. Another outcome of page fault if it is not found in disk is a signal that a process is trying to access something that doesn't exist or that it's not supposed to access.