

Homework 3

ECE 4310
Spring 2021
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10 Problems - 50 pts total

1 (10 pts) Explain the purpose of pages and frames as they relate to executing processes.

It divides physical memory into frames that can accommodate pages that processes can access virtually as a contiguous block when the physical memory is not contiguous.

2 (10 pts) A computer system has a 32-bit virtual address space with a page size of 32K, and 4 bytes per page table entry.

(a) How many pages are in the virtual address space?

Assuming page size is 32K bits, $2^{32} / (32 \times 1024) = 131072$ pages

(b) What is the maximum size of addressable physical memory in this system?

$2^{(4 \times 8)} \times 32 \times 1024 = 247$ bits

(c) If the average process size is 2GB, would you use a one-level, two-level, or three-level page table? Why?

As the process size is large, it is best to use two-level or three-level page table as less higher level pages need to be paged in because processes may not need to access an entire higher level page worth of memory.

3 (10 pts) Explain under which circumstances page faults occur and how they are resolved by the operating system.

Page fault occurs when the page containing instructions or data needed is not currently in the physical memory. Upon a page fault is raised, the operating system move the page needed from mass storage into the physical memory.

4 (10 pts) Consider the following page reference string:

7, 4, 2, 1, 1, 6, 7, 3, 3, 1, 6, 5, 1, 4, 3, 2, 2, 5, 6, 2

Using the FIFO, LRU, and Optimal page replacement algorithms with 3 frames, show the page load order and number of page faults that would occur.

FIFO: 15 page faults

7	7	7	1	1	1	1	3	3	3	3	5	5	5	5	2	2	2	2	2
	4	4	4	4	6	6	6	6	1	1	1	1	4	4	4	4	5	5	5
		2	2	2	2	7	7	7	7	6	6	6	6	3	3	3	3	6	6

LRU: 15 page faults

7	7	7	1	1	1	3	3	3	3	5	5	5	3	3	3	3	6	6	6
	4	4	4	4	6	6	6	6	1	1	1	1	1	1	2	2	2	2	2
		2	2	2	2	7	7	7	7	6	6	6	4	4	4	4	5	5	5

Optimal: 10 page faults

7	7	7	7	7	7	7	3	3	3	3	3	3	3	3	2	2	2	2	2
	4	4	4	4	6	6	6	6	6	6	5	5	5	5	5	5	5	6	6
		2	1	1	1	1	1	1	1	1	1	1	4	4	4	4	4	4	4

5 (10 pts) Explain thrashing as it relates to virtual memory and what affect it has on the operating system. Name at least 2 methods to reduce thrashing.

When the physical memory is not enough to hold the pages needed by processes running, pages would be constantly paged in and out of the memory. This is called thrashing, and because it needs to constantly access mass storage for the pages needed, it cause a decrease in operating system performance. Since it is a result of insufficient physical memory or high number of processes running or both, thrashing can be reduced by adding physical memory or reducing the number of processes running.

6 (10 pts) Explain why wear leveling is important with flash storage.

Unlike hard drive, instead of mechanical failure that usually result from access to any data like motor failure, the point of failure of flash storage is at each individual cells. By distributing writes evenly across the device, it reduces the chance of cells failing due to repeated access to a given cell.

7 (10 pts) Consider the following requests to read data from sectors of a hard drives, where the current position of the head is at sector 91 and the head is moving towards sector 0. What is the order in which the sectors in the queue would be services using the SCAN disk scheduling algorithm?

130, 37, 58, 105, 8, 11, 1, 140, 200, 6, 72, 81, 43, 104

Assuming starting at 91 and decreasing sectors:

81, 72, 58, 43, 37, 11, 8, 6, 1, (change direction), 104, 105, 130, 140, 200

8 (10 pts) You have been asked to design a high performing and highly redundant storage array with 48 TB of usable space for files. You' ve also been asked to minimize cost while keeping the requirements in place (high performing and highly redundant), if that' s possible. 8 TB hard drives cost \$200, 10 TB hard drives cost \$250, 12 TB hard drives cost \$300, and 14TB hard drives cost \$450. Explain which type of RAID you would choose and the quantity and types of drives you would use for your solution. Explain in Detail.

RAID 10 would be used as it provides both high performance and redundancy from striping and mirroring and less disks compare to RAID 50. 2 set of 48 TB storage is needed. As the costs of storage for any given arrangement of 48 TB are the same, 2 sets of 6 8TB hard drive costing \$2400 would be used since replacement after drive failure takes less time.

9 (10 pts) Compare and contrast polling I/O vs interrupt driven I/O in the following I/O related scenarios:

(a) Keyboard

As keyboard inputs are infrequent and slow it may be better served with interrupt I/O such that it does not waste CPU cycles polling when keyboard is not in use.

(b) Network

As network are relatively slow it may be better served with interrupt I/O for the same reason as above.

(c) Disk

As disk access can be relatively fast it may be better served with polling I/O

10 (10 pts) Explain why DMA is more efficient for performing I/O?

CPU can delegate the I/O access to DMA circuit and continue with other tasks in the meantime.