Memory Management

Practice Problems Set

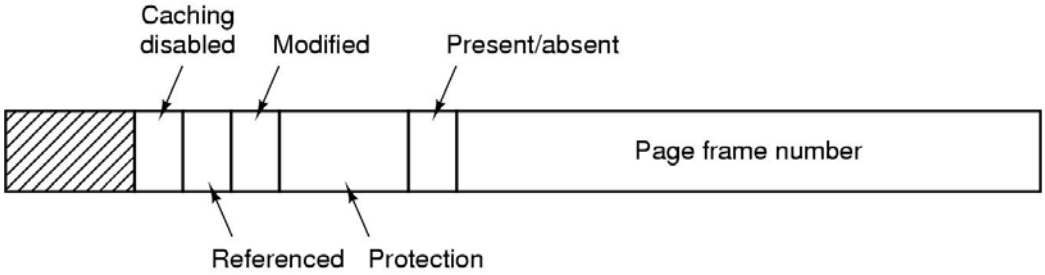
This problem set is optional. However, together with the other problem sets posted, it will be used as source and inspiration for tests.

1. A computer whose processes have 1024 pages in their address space keeps its page tables in memory. The overhead required for reading a word from the page table is 500nsec. To reduce this overhead, the computer has TLB, which holds 32 (virtual page, physical page frame) pairs, and can do a lookup in 100nsec. What hit rate is needed to reduce the mean overhead to 200 nsec?

2. Assume a paging system with 3 frames allocated to a process; it uses a demand page fetch strategy and the process begins executing with no page in memory. When page replacement is needed, the frame is selected from one of the 3 frames allocated to the process. Show which pages will be in these 3 frames as the process executes with the following page reference string with (a) optimal page replacement; (b) LRU page replacement: 1,2,3,5,3,2,1,4,3,5,2,4,6,4,2,1,5

3. What is the difference between a virtual address and a physical address?

4. Consider a paged logical address space (composed of 32 pages of 2KB each) mapped into a 1-MB physical memory space.
    a. What is the format of the processor's logical address space?
    b. What is the length and the width of the page table? Consider the following format of a page entry:



    c. What is the effect on the page table if the physical memory space is reduced by half?

5. In the old computer architecture VAX[1], user page tables are located at virtual addresses in the system space. What is the advantage of having user page tables in virtual rather than main memory? What is the disadvantage?

[1] ***V**irtual **A**ddress e**X**tension*, named so both because the VAX was seen as a 32-bit extension of the older 16-bit PDP-11 a

6. A process references five pages A, B, C, D, E in the following order:

   A; B; C; D; A; B; E; A; B; C; D; E

   Assume that the replacement algorithm is first-in-first-out and find the number of page transfers during this sequence of references starting with an empty main memory with three page frames. Repeat for four page frames.

7. A process contains 8 virtual pages on disk and is assigned a fixed allocation of 4 pages in main memory. The following page trace occurs:

   1, 0, 2, 2, 1, 7, 6, 7, 0, 1, 2, 0, 3, 0, 4, 5, 1, 5, 2, 4, 5, 6, 7, 6, 7, 2, 4, 2, 7, 3, 3, 2, 3

   a. Show the successive pages residing in the four frames using the LRU replacement policy. Compute the hit ratio in main memory. Assume that the frames are initially empty.
   b. Repeat (a) for FIFO policy.
   c. Compare the two hit ratio and comment on the effectiveness of using FIFO to approximate LRU with respect to this particular trace.

8. What is the difference between simple paging and virtual memory paging?

9. What information is typically found in a page entry? Briefly describe each element.

10. What is the difference between a page and a frame?

11. Paging can exist in a system without virtual memory, in which case it is called simple paging. In that case, the logical address space generated by the processor must fit in the physical memory.

    Consider such a simple paging system with the following parameters: 2^{32} bytes of physical memory; page size of 2^{10} bytes; 2^{16} pages of logical address space.

    a. How many bits are in a logical address?
    b. How many bytes in a frame?
    c. How many bits in the physical address specify the frame?
    d. How many entries in the page table?
    e. How many bits in each page table entry? Assume each page entry includes a present/absent bit.

12. A process has four page frames allocated to it. (All the following numbers are decimal, and everything is numbered starting from zero.) The time of the last loading

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nd because it was a commercial pioneer in using virtual memory to manage this larger address space. VAX was developed in the mid-1970s by Digital Equipment Corporation (DEC). DEC was later purchased by Compaq, which in turn was purchased by Hewlett-Packard.

of a page into each page frame, the last access to the page in each page frame, the virtual page number in each page frame, and the referenced (R) and modified (M) bits for each page frame are as shown (the times are in clock ticks from the process start at time 0 to the event).

Virtual Page Number	Page Frame	Time Loaded	Time Referenced	R Bit	M Bit
2	0	60	161	0	1
1	1	130	160	1	0
0	2	26	162	1	0
3	3	20	163	1	1

A page fault to virtual page 4 has occurred at time 164. Which page frame will have its contents replaced for each of the following memory management policies? Explain why in each case.

- FIFO (first-in-first-out)
- LRU (least recently used)
- Optimal (Use the following reference string.)
- Given the aforementioned state of memory just before the page fault, consider the following virtual page reference string: 4,0,0,0,2,4,2,1,0,3,2. How many page faults would occur if the working set policy with LRU were used with a window size of 4 instead of a fixed allocation? Show clearly where each fault would occur.