Operating Systems (COMP2006)

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Computing Discipline
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Worksheet 7

1. Briefly describe the following terms
   - Virtual memory.
   - Thrashing.
   - Demand paging.
   - Page fault.
   - Page replacement.
   - Modify/dirty bit.
   - Valid/invalid bit.
   - Belady's anomaly.
   - Prepaging.
   - Working set model.
   - Lock bit.

2. When do page faults occur? Describe the actions taken by the OS when a page fault occurs

3. A certain computer provides its users with a virtual-memory space of 2^{32} bytes. The computer has 2^{18} bytes of physical memory. The virtual memory is implemented by paging, and the page size is 4096 bytes. A user process generates the virtual address 11123456H. Explain how the system establishes the corresponding physical location.

4. Suppose we have a demand-paged memory. The page table is held in registers. It takes 8 ms to service a page faults if an empty page is available or the replaced page is not modified, and 20 ms if the replaced page is modified. Memory access time is 100 ns. Assume that the page to be replaced is modified 70 percent of the time. What is the maximum acceptable page-fault rate for an effective access time of no more than 200 ns?

5. Consider the following page reference string:

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

   How many page faults would occur for the following replacement algorithms, assuming one, two, three, four, five, six, or seven frames? Remember that all frames are initially empty, so your first unique pages will all cost one fault each
   - LRU replacement
   - FIFO replacement
   - Optimal replacement

6. What cause thrashing? How does the system detect thrashing? Once it detects thrashing what can the system do to eliminate thrashing?

7. Consider a demand-paging system with a paging disk that has an average access and transfer time of 20 milliseconds. Addresses are translated through a page table in main memory with an access time of 1 microsecond per memory access. Thus, each memory reference through the page table takes two accesses. To improve this time, we have added an associative memory that reduces access time to one memory reference, if the page-table entry is in associative memory. Assume that 80% of the accesses are in the associative memory, and that, of the remaining 10 % (or 2% of the total) cause page faults. What is the effective access time?

8. An OS supports a paged virtual memory, using a central processor with a cycle time of 1 microsecond. It costs an additional 1 microsecond to access a page other than the current one. Pages have 1000 words, and the paging device is a drum that rotates at 3000 RPM and transfers 1 million words per second. The following statistical measurements were obtained from the system:
   (i) 1 percent of all instructions executed accessed a page other than the current page.
   (ii) Of the instructions that accessed another page, 80 percent accessed a page already in memory.
   (iii) When a new page was required, the replaced page was modified 50 percent of the time.
   (iv) Calculate the effective instruction time on the system, assuming that the system is running one process only, and that the processor is idle during drum transfers.

9. Consider a demand-paged computer system where the degree of multiprogramming is currently fixed at four. The system was recently measured to determine utilization of CPU and the paging disk. The results are one of the following alternatives. For each case, what is happening? Can the degree of multiprogramming be increased to increase the CPU utilization?

   - CPU utilization 13%; disk utilization 97%
   - CPU utilization 87%; disk utilization 3%
   - CPU utilization 13%; disk utilization 3%