TUTORIAL NINE

Virtual Memory (Part 2)

1. Consider a demand-paged virtual memory system with M page frames. Assume initially all frames are empty. Given a page reference string with length L and N distinctive page numbers (N < L),

   a) What are the lower and upper bounds of page faults that may be generated by such a reference string if the FIFO page replacement algorithm is used?

   b) Will you have different answers if the LRU (Least-Recently-Used), instead of FIFO, page replacement algorithm is used?

2. Suppose that a process is allocated four page frames in a demand-paged virtual memory system. The time of loading and the time of last access are as shown in the table below.

Frame #	Page #	Time Loaded	Time Last Accessed
0	1	60	161
1	0	130	160
2	3	26	162
3	2	20	163

   Given the above memory state before the fault and the remaining page reference string of the process: 4, 0, 0, 0, 2, 4, 2, 1, 0, 3, 2, answer the following two questions.

   a) Calculate how many page faults will be generated if Least-Recently-Used (LRU) algorithm is used. Show your workings.

   b) Assuming that the size of the working set window is four, calculate the number of page faults that would occur if only the pages in the working set were loaded into the memory instead of using a fixed allocation of four frames. Show your workings.

3. Consider a demand-paging system with the following time-measured utilizations:

   CPU utilization 20%
   Paging disk 97.7%
   Other I/O devices 5%

   Which (if any) of the following will (probably) improve CPU utilization?

   a. Install a faster CPU.
   b. Install a bigger paging disk.
   c. Increase the degree of multiprogramming.
   d. Decrease the degree of multiprogramming.
   e. Install more main memory.
   f. Install a faster hard disk or multiple hard disks.
   g. Increase the page size.