University of Newcastle
School of Electrical Engineering and Computing

COMP2240 - Operating Systems
Workshop 8
Topics: Memory Management & Disk and I/O Scheduling

1. Consider the following page-reference string: *a,b,d,c,b,e,d,b,d,b,a,c,b,c,a,c,f,a,f,d*. Assume that there are 3 frames available and that they are all initially empty. Complete a figure showing the frame allocation for each of the following page replacement policies:

a) First-in-first-out
b) Optimal
c) Least recently used

Then, find the relative performance of each policy with respect to page faults.

2. A process contains eight virtual pages on disk and is assigned a fixed allocation of four page frames 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 part (a) for the FIFO replacement policy.
c) Compare the two hit ratios and comment on the effectiveness of using FIFO to approximate LRU with respect to this particular trace.

3. Consider a disk drive with 4,000 cylinders, numbered from 0 to 1,999. The request queue has the following composition:

1045 750 932 878 1365 1787 1245 664 1678 1897

If the current position is 1167 and the previous request was served at 1250, compute the total distance (in cylinders) that the disk arm would move for each of the following algorithms: FIFO, SSTF, SCAN, C-SCAN, LOOK and C-LOOK scheduling.

4. Calculate how much disk space (in sectors, tracks, and surfaces) will be required to store 300,000 120-byte logical records if the disk is fixed sector with 512 bytes/sector, with 96 sectors/track, 110 tracks per surface, and 8 usable surfaces. Ignore any file header record(s) and track indexes, and assume that records cannot span two sectors.

5. A disk pack has the following specifications: it comprises 25 double sided disks; each surface of a disk has 480 tracks and a track has 20 blocks in it. Each block is of 2048 bytes, with an inter-block gap of 64 bytes.

Compute the total capacity of a track, the useful capacity of a track (excluding inter-block gap), the total capacity and useful capacity of a cylinder, the total capacity and useful capacity of the disk page, and the percentage of space wasted.

Supplementary problems:

S1. Disk-scheduling policies SSTF, SCAN, C-SCAN, LOOK and C-LOOK are not truly fair, that is, starvation can occur. Only FIFO/FCFS is fair.

a) Explain why this unfairness assertion is true.
b) Describe a scheme to ensure fairness (other than FIFO/FCFS).
c) Explain why fairness is an important goal in a time-sharing system.

S2. The UNIX kernel will dynamically grow a process's stack in virtual memory as needed, but it will never try to shrink it. Consider the case in which a program calls a C subroutine that allocates a local array on the stack that consumes 10 K. The kernel will expand the stack segment to accommodate it. When the subroutine returns, the stack pointer is adjusted and this space could be released by the kernel, but it is not released. Explain why it would be possible to shrink the stack at this point and why the UNIX kernel does not shrink it.

S3. Windows uses 2-MB large pages because it improves the effectiveness of the TLB, which can have a profound impact on performance. Why is this? Why are 2-MB large pages not used all the time?

S4. A certain editor has 100 KB of program text, 30 KB of initialized data, and 50 KB of BSS. The initial stack is 10 KB. Suppose that three copies of this editor are started simultaneously. How much physical memory is needed (a) if shared text is used, and (b) if it is not?

S5. Consider a disk drive that has *N* tracks numbered from 0 to (*N* - 1). Assume that requested sectors are distributed randomly and evenly across the tracks of the disk. We want to determine the average number of tracks traversed by a Seek operation. The problem can be partitioned as follows:

a) First, calculate the probability of a Seek operation of length *j* when the head is currently positioned over track *t*. *Hint: You need to determine the total number of combinations, recognising that all track positions for the destination of the Seek are equally likely, as are all starting positions of the disk head prior to the Seek.*
b) Next, calculate the probability of a Seek of length *k*. *Hint: This involves the summing over all possible combinations of movements of k tracks.*
c) Now, calculate the average number of tracks traversed by a seek, using the formula for expected value:

$$E[x] = \sum_{i=0}^{N} i \times \Pr[x = i]$$

d) Finally, show that for large values of *N* the average number of tracks traversed by a Seek approaches $\frac{N}{3}$. *(At least you know what answer you are trying to work toward!)*