Homework 2 - System Programming

Instructor for CS 241: Klara Nahrstedt
Deadline, May 3, midnight
Department of Computer Science
University of Illinois, Urbana Champaign

The homework 2 is an **individual effort activity!! (no pairs)**. Each student submits his/her own solution in the electronic form using the PDF format. **THERE ARE NO LATE SUBMISSIONS ACCEPTED, i.e., 0 POINTS AFTER MIDNIGHT!!!** The format should use 11pt or 12pt font. Each student submits his/her work to Illinois Compass in the same manner as he/she submitted machine problems:

1. Log into Illinois Compass (`http://compass.uiuc.edu`) and select cs241 from the *Course List*.
2. Select HW2 Handin from the CS 241 Home Page
3. Click the *Add Attachments* button in the *Submissions* section.
4. In the *Choose Files* window, click *My Computer*.
5. Select your PDF document in the file selection dialog.
6. Click *Submit*, then check *OK* in the confirmation alert.
7. On the *Confirmation* page, click *Continue*.

1 Problems on Input/Output (25 Points)

1. (9 Points) Although DMA does not use the CPU, the maximum transfer rate is still limited. Consider reading a block from the disk. Name three factors that might ultimately limit the transfer rate.

2. (10 Points) An alternative to interrupts is polling. What are the circumstances in which polling is better than interrupts? Give at least two circumstances.

3. (6 Points) Many disks contain an Error-Correcting Code (ECC) at the end of each sector. If the ECC is wrong, what actions might be taken and by which piece of hardware or software?

2 Problem on Basic Memory Management (30 Points)

1. (15 Points) In this problem you are to compare the storage needed to keep track of free memory using a *bitmap* method versus a *using linked list* method. The 128 MB memory is allocated in units of n bytes. For the linked list, assume that memory consists of an alternating sequence of segments and holes, each 64 KB. Also assume that each node in the linked list needs 32-bit memory address, a 16-bit length, and a 16-bit next-node field. How many bytes of storage is required for each method? Which one is better?

2. (12 Points) Consider the swapping system in which memory consists of the following hole sizes in memory order: 10KB, 4KB, 20KB, 18KB, 7KB, 9KB, 12KB, and 15 KB. Which hole is taken for successive segment requests of (a) 18KB, (b) 2KB, (c) 13 KB for the following policies: first fit, best fit, and worst fit? Specify clearly what is the list of holes after the allocation of the segment requests (a),(b) and (c) for each policy.

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

3 Problem on Virtual Memory Management (20 Points)

1. (5 Points) Let us assume processes with 1024 pages in their address spaces. Furthermore, we assume that each process keeps its page tables in the memory. The overhead required for reading a word from the page table is 5 nsec. To reduce this overhead, the computer has a TLB, which holds 32 (virtual page, physical page frame) pairs, and can do a look up in 1 nsec. What is the minimum hit rate needed to keep the mean overhead (of accessing the page table) to at most 2 nsec?

2. (5 Points) A machine has 48-bit virtual addresses and 32-bit physical addresses. Pages are 8KB. How many entries are needed for the page table? Provide the exact calculation how you determine the number of entries.

3. (10 Points) A computer has four page frames. The time of loading, time of last access, and the R (reference bit) and M (modified bit which can be dirty bit = 1 or clean bit = 0) are as shown below (the times are in clock ticks):

Page	**Loaded**	**Last reference**	R	M
0	126	280	1	1
1	230	256	0	1
2	140	270	0	0
3	110	285	1	1

Table 1: *Load Information*

   (a) Which page will FIFO replace?

   (b) Which page will LRU replace?

   (c) Which page will second chance replace?

   (d) Which page will be replaced using 'page classes' replacement?

   For each algorithm specify the evicted page and explain clearly why this page was evicted. (Note: If just the victim page will be specified, and no explanation will be given, points will be taken off.)

4 Problems on File Systems (25 Points)

1. (9 Points) Consider the i-node structure with 10 direct addresses and one indirect address. If the i-node contains 10 direct addresses of 4 bytes each and all disk blocks are 1024 Bytes (each block size is 1 KB), what is the largest possible file?

2. (16 Points) The beginning of a free space bitmap looks like this after the disk partition is first formated: 1000 0000 0000 0000 (the first block is used by the root directory). The system always searches for free blocks starting at the lowest numbered block, so after writing file A, which uses 6 blocks, the bitmap looks like this: 1111 1110 0000 0000. Show the bitmap after each of the following additional actions:

   (a) File B is written, using 5 blocks;

   (b) File A is deleted;

   (c) File C is written, using 8 blocks;

   (d) File B is deleted.