CSCI 3323 (Principles of Operating Systems), Fall 2016

Homework 4

Credit: 35 points.

1 Reading

Be sure you have read, or at least skimmed, sections 1 through 3 of Chapter 3.

2 Honor Code Statement

Please include with each part of the assignment the Honor Code pledge or just the word "pledged", plus one or more of the following about collaboration and help (as many as apply).[1] Text *in italics* is explanatory or something for you to fill in. For written assignments, it should go right after your name and the assignment number; for programming assignments, it should go in comments at the start of your program.

- This assignment is entirely my own work.
- This assignment is entirely my own work, except for portions I got from the assignment itself *(some programming assignments include "starter code")* or sample programs for the course *(from which you can borrow freely — that's what they're for)*.
- I worked with *names of other students* on this assignment.
- I got help with this assignment from *source of help — ACM tutoring, another student in the course, the instructor, etc.*
- I got significant help from *outside source — a book other than the textbook (give title and author), a Web site (give its URL), etc.. ("Significant" here means more than just a little assistance with tools — you don't need to tell me that you looked up an error message on the Web, but if you found an algorithm or a code sketch, tell me about that.)*
- I provided significant help to *names of students* on this assignment. *("Significant" here means more than just a little assistance with tools — you don't need to tell me about helping other students decipher compiler error messages, but beyond that, do tell me.)*

3 Problems

Answer the following questions. You may write out your answers by hand or using a word processor or other program, but please submit hard copy, either in class or in one of my mailboxes (outside my office or in the ASO).

1. (5 points) Consider a computer system with 10,000 bytes of memory whose MMU uses the simple base register / limit register scheme described in section 3.2 of the textbook, and suppose memory is currently allocated as follows:

[1]Credit where credit is due: I based the wording of this list on a posting to a SIGCSE mailing list. SIGCSE is the ACM's Special Interest Group on CS Education.

- Locations 0–1999 are reserved for use by the operating system.
- Process A occupies locations 5000–6999.
- Process B occupies locations 7000–8999.
- Other locations are free.

Answer the following questions about this system.

(a) What value would need to be loaded into the base register if we performed a context switch to restart process A?

(b) What memory locations would correspond to the following virtual (program) addresses in process A?

- 100
- 4000

2. (15 points) Consider a computer system using paging to manage memory; suppose it has 64K (2^{16}) bytes of memory and a page size of 4K bytes, and suppose the page table for some process (call it process A) looks like the following.

Page number	Present/absent bit	Page frame number
0	1	5
1	1	6
2	1	2
3	0	?
4	0	?
5	1	7
6	0	?
...	0	?
15	0	?

Answer the following questions about this system.

(a) How many bits are required to represent a physical address (memory location) on this system? If each process has a maximum address space of 64K bytes, how many bits are required to represent a virtual (program) address?

(b) What memory locations would correspond to the following virtual (program) addresses for process A? (Here, the addresses will be given in hexadecimal, i.e., base 16, to make the needed calculations simpler. Your answers should also be in hexadecimal. Notice that if you find yourself converting between decimal and hexadecimal, *you are doing the problem the hard way.* Stop and think whether there is an easier way!)

- 0x1420
- 0x2ff0
- 0x4008
- 0x0010

(c) If we want to guarantee that this system could support 16 concurrent processes and give each an address space of 64K bytes, how much disk space would be required for storing out-of-memory pages? Explain your answer (i.e., show/explain how you calculated it). Assume that the first page frame is always in use by the operating system and will never be paged out. You may want to make additional assumptions; if you do, say what they are.

3. (15 points) Now consider a bigger computer system, one in which addresses (both physical and virtual) are 32 bits and the system has 2^{32} bytes of memory. Answer the following questions about this system. (You can express your answers in terms of powers of 2, if that is convenient.)

   (a) What is the maximum size in bytes of a process's address space on this system?

   (b) Is there a logical limit to how much main memory this system can make use of? That is, could we buy and install as much more memory as we like, assuming no hardware constraints? (Assume that the sizes of physical and virtual addresses don't change.)

   (c) If page size is 4K (2^{12}) and each page table entry consists of a page frame number and four additional bits (present/absent, referenced, modified, and read-only), how much space is required for each process's page table? (You should express the size of each page table entry in bytes, not bits, assuming 8 bits per byte and rounding up if necessary.)

   (d) Suppose instead the system uses a single inverted page table (as described in section 3.3.4 of the textbook), in which each entry consists of a page number, a process ID, and four additional bits (free/in-use, referenced, modified, and read-only), and at most 64 processes are allowed. How much space is needed for this inverted page table? (You should express the size of each page table entry in bytes, not bits, assuming 8 bits per byte and rounding up if necessary.) How does this compare to the amount of space needed for 64 regular page tables?