Homework 5 — due on Thursday 2 November 2000

Total number of points available on this homework is 110. Full credit is equivalent to 100 points.

1. (10 pts) Consider a process with a logical address space of 16 pages of 1024 words each, mapped onto a physical memory of 64 frames.
   (a) How many bits are there in the logical address?
   (b) How many bits are there in the physical address?
2. (10 pts) Consider a paging system with the page table stored in memory.
   (a) If a memory reference takes 150 nanoseconds, how long does a paged memory reference take?
   (b) If we add associative registers (a TLB), what percentage of page table references need to hit in the TLB to get an effective access rate of 155 nanoseconds?
3. (15 pts) Consider a segmented memory system with free memory "holes" of size 500K, 200K, 100K, 300K, and 450K (in order). How would each of First-Fit, Best-Fit, and Worst-Fit place processes of size 212K, 420K, 150K, and 350K (in order), and what would be the remaining hole sizes? Which makes the most efficient use of memory for this example?
4. (15 pts) For First-Fit, Best-Fit, and Worst-Fit, how long does it take to find a free segment on average with
   (a) an unsorted list of free segments, and
   (b) a list sorted by size.
5. (35 pts) Consider the following paged segmentation scheme.

Segment Table

Segment Number	Page Table
0	2
1	0
2	1

Page Table 0

Virtual Page	Page Frame	Valid	Read Only?
0	10	Y	N
1	17	N	N
2	89	Y	N
3	90	Y	N
4	29	Y	N
5	47	N	N
6	55	Y	N
7	32	Y	N
8	36	Y	N
9	9	Y	N

- "Valid?" is set to "Y" if the page is in memory.
- "Read Only?" is set to "N" if the page is writable.

Page Table 1

Virtual Page	Page Frame	Valid	Read Only?
0	3	N	N
1	22	N	N
2	73	Y	N
3	74	Y	N
4	85	Y	N
5	29	Y	N
6	63	Y	N
7	93	Y	N
8	83	Y	N
9	15	Y	N
10	27	Y	N
11	34	Y	N

Page Table 2

Virtual Page	Page Frame	Valid	Read Only?
0	33	Y	Y
1	46	Y	Y
2	54	N	Y
3	6	Y	Y
4	99	N	Y
5	67	Y	Y
6	21	Y	Y

- Assume a page size of 1000 bytes using base 10 integer addresses (not realistic, but it makes the math easier). Thus, the first page of virtual memory runs from virtual address 0 through virtual address 999. (All accesses to memory are for 4-byte words.)
- The maximum number of page table entries is 100 (0 to 99).
- Each process is separated into at most 3 segments (1 segment each for code, heap allocated data, and the stack).
- If the page is invalid ("Valid = N"), assume the page fault causes the OS to load the faulting page into the given page frame number; for example, an access to virtual page 2 in page table 2 causes a page fault where the OS loads virtual page 2 into page frame 54.

(a) (10 pts) How many integer digits do we need for the segment number, page number, and offset?

(b-f) What physical address do the following virtual addresses access? (Assume any missing digits are leading zeroes.) Indicate if the access generates an error (invalid segment, invalid page, or protection violation) or a page fault.

(b) (5 pts) Read from virtual address 211333

(c) (5 pts) Write to virtual address 5345

(d) (5 pts) Read from virtual address 1810627

(e) (5 pts) Read from virtual address 104806

(f) (5 pts) Read to virtual address 200097

6. (25 pts) Implementors of programming languages Scheme and ML have expressed a desire that trap conditions related to virtual memory (page fault, write to a read-only page), should not be handled by the operating system, but instead by specialized routines within the run-time support of the programming language. What could be the reason? Provide a detailed answer.