Eric Paulz
CPSC 3300-002

Homework 8: Virtual Memory

1. Consider a computer with a paged logical address space with 8 pages and each page is 4 Kbytes. The logical address space is mapped into a 512-Kbyte of physical memory space. (30pts)

    i) Draw the fields in the logical and physical addresses and show the number of bits of each field.

    Logical Address

$\log_2 8$ = 3 bits (page number)	$\log_2 4096$ = 12 bits (offset)

    Physical Address

$\log_2 128$ = 7 bits (page frame)	$\log_2 4096$ = 12 bits (offset)

    ii) Draw the page table of a process and show the number of entries in the table and number of bits per entry.

frame #	valid-invalid bit
00	v
01	v
02	i
…	…
n	v

    iii) Populate the page table for process, namely A, which is currently running on the CPU. Several pages of process A is in the physical memory as follows:

	…
#frame 10	Page 2 of Process A
#frame 11	Page 4 of Process A
#frame 12	Page 1 of Process A
#frame 13	Page 7 of Process A
	…

2. Consider paged virtual memory systems. Assume a page size of 256 bytes (2^8), and that processes in this system can have a maximum virtual address space of 16K bytes (2^{14}). The system is currently configured with 8K (2^{13}) bytes of physical memory. (30pts)

    i) How many pages are in the virtual address space?
    $2^{14} / 2^8 = 2^6 = 64$ pages

    ii) How many page frames are in the physical address space?
    $2^{13} / 2^8 = 2^5 = 32$ frames

    iii) A user process generates the virtual address 12,345 (0011000000111001 in binary). Explain how the system establishes the corresponding physical address assuming that the hardware memory management unit and transfer lookaside buffer (TLB) is used.

Given the virtual address of 12,345, the processor examines the TLB. If there is a TLB hit, the frame number is retrieved and the real address is formed. If there is a TBL miss, the page number is used to index the process page table.

3. Consider a paged virtual memory system with a physical memory that can only contain 4 pages. Assume the execution of a program generates the following address trace

a b c d d f f e b e

where *a*, *b*, *c*, *d*, *e*, and *f* are the pages referenced and the page frames are initially empty. (40pts)

i) How many page faults occur with first-in-first-out Page Replacement?

Time	1	2	3	4	5	6	7	8	9	10
Request	*a*	*b*	*c*	*d*	*d*	*f*	*f*	*e*	*b*	*e*
	a	a	a	a	a	b	b	c	d	d
		b	b	b	b	c	c	d	f	f
			c	c	c	d	d	f	e	e
				d	d	f	f	e	b	b
Fault?	*	*	*	*		*		*	*	

= 7 faults

ii) How many page faults occur with LRU Page Replacement?

Time	1	2	3	4	5	6	7	8	9	10
Request	*a*	*b*	*c*	*d*	*d*	*f*	*f*	*e*	*b*	*e*
	a	a	a	a	a	b	b	c	d	d
		b	b	b	b	c	c	d	f	f
			c	c	c	d	d	f	e	b
				d	d	f	f	e	b	e
Fault?	*	*	*	*		*		*	*	

= 7 faults