Main Memory

[12 points] Logical and Physical Address Spaces

The Lehman College CMP memory architecture design team has a dilemma. The team is considering several different memory configuration variations for an upcoming machine design. Consider the following designs (All memory accesses are in terms of bytes, and all are using paging techniques):

Characteristic	**Design 1**	**Design 2**	**Design 3**
Physical Memory Address Width	8 bit	16 bit	32 bit
Logical Address Width	12 bit	20 bit	24 bit
Page/Frame size in bytes	16 bytes	32 bytes	64 bytes
Page Table Type	**Single**	**Single**	**Single**

a) [6 points] For each design, list the maximum number of pages each process can access in logical address space.

b) [6 points] For each design, list the maximum number of frames in physical memory.

Answer the questions regarding the page table of one process specified below. Assume 4K pages.

Virtual Page	Frame Number	Valid Bit	Reference Bit	Dirty Bit
0	3	v	0	1
1	-	i	0	0
2	0	v	1	1
3	-	i	0	0
4	9	v	1	0
5	-	i	0	0
6	-	i	0	0
7	12	v	0	0

(a) (2pts) How many pages of this process are resident in physical memory? What happens when one of the other pages is accessed?

(b) (2pts) What physical memory address is accessed when the process accesses the virtual address 17199?

(10 points) Assuming a 1-KB page size , What are the page numbers and offsets for the following address references (provided as decimal numbers)
2375

256

16311

16385

30000

(3 points) What is a translation look-aside buffer? What is contained in each entry it contains? What does it do?

Mass Storage

(20 points) In class, we discussed various disk scheduling algorithms. Write a method that simulates shortest seek time first (SSTF) disk scheduling algorithm. Your method takes two parameters, a list of requests of integer values and the position of the disk head and return the total amount of head movements. You can use any data structure .

(15 points) Suppose that a disk drive has 100 cylinders, numbered 0 to 99. The drive is currently serving a request at cylinder 20, and the previous request was at cylinder 21. The queue of pending requests, in FIFO
order, is:
10, 22, 20, 2, 40, 6, and 38 .

In all the cases, the Head pointer is initially at cylinder 20.

Draw a picture of the representing head movements and starting from the current head position, calculate total distance (in cylinders) for the disk arm movements to satisfy all the pending requests for each of the following disk-scheduling algorithms

a) FCFS

b) SSTF

c) SCAN

Virtual Memory

(9 points) What is thrashing? How might it be detected? How might one recover from it once detected?

(5 points) Describe the optimal page replacement algorithms.

(10 points) Consider the following page reference string:

0 2 1 3 0 1 4 0 1 2 3 4.

How many page faults occur for the following page replacement algorithms assuming three frames? As we did in class, you must include a sketch showing pages resident in memory and those replaced over time, the number of page faults, and any interesting observations

LRU replacement

Optimal replacement

(9 points) Consider the following page reference string:

0 2 1 3 0 1 4 0 1 2 3 4.

How many page faults occur for the following page replacement algorithms assuming three, four and five frames? As we did in class, you must include a sketch showing pages resident in memory and those replaced over time, the number of page faults, and any interesting observations

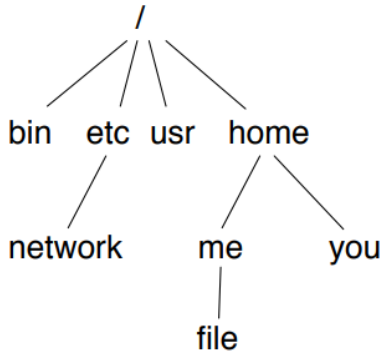
FIFO replacement

(6 points) What is a Belady's anomaly? Does any of your solution to the above question (FIFO replacement) exhibit Belady's anomaly? Explain.

(10 points) What are page faults? Under what circumstances do page faults occur? Describe in detail the actions taken by the operating system when a page fault occurs.

File System Interface

Consider the following file system



(2 Points) Specify the absolute path to the file and the relative path name form the directory network

(3 points) What are three types of objects that comprise the file system interface?

(4 points) Joe has a directory called /user/joe/cmp426 on his desktop machine, but he can't find it after mounting his corporate NFS server directory at /user/joe. How can he get access to that directory? Explain your answer.

(2 points) What are the two fundamental ways of accessing a file?

What is a volume?

(2 points) What is the most common way of structuring directories?

(c) (2pts) Suppose there is a reference to virtual page 6 by the process and that there is no free frame. If we use a Not Recently Used page replacement strategy, which page would be selected for 5 replacement? What operation(s) would need to occur before freeing that page?

In class, we discussed copy-on-write for memory pages shared among multiple processes. We cannot apply this same concept blindly to process creation using Unix fork(), but instead are forced to copy some parts immediately while other parts can be delayed.
What is copy on write?

Knowing the components of general processes, which parts must be copied immediately, and which parts can be delayed and copied-on-write?

This question refers to processes, not caching. When we create a new process, we must copy the stack space and registers, but need not copy the entire address space immediately. This is because often a call to fork creates a new address space into which a new process is immediately loaded, making the initial copy a waste of time and space because it is immediately overwritten. An example of this is when a command shell starts up a new process, first doing a fork to create a new copy of itself, but then replacing that copy with the new process which was executed on the command line. b. Why is copy-on-write potentially better than copying the entire process immediately upon creation? It can save time and space during the process creation (as mentioned above), avoiding the duplicate effort of making a copy, then immediately overwriting it.

* * * * HAVE A GOOD SUMMER * * * *