Homework 4 Solutions

ECE 426
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Gabriel Kuri

5 Problems - 50 pts total

1 (10 pts) Explain the purpose of pages and frames as they relate to executing processes.

Page tables allow a process to use non-contiguous blocks of physical memory by mapping page of logical memory to frame of physical memory through the use of a page table.

2 (10 pts) A computer system has a 32-bit virtual address space with a page size of 8K, and 4 bytes per page table entry.

(a) How many pages are in the virtual address space?

Number of pages is the address space divided by the page size: $\frac{2^{32}}{2^{13}} = 2^{19}$ addressable pages

(b) What is the maximum size of addressable physical memory in this system?

With 4 byte entries in the page table we can reference 2^{32} pages. Since each page is 2^{13}, the maximum addressable physical memory size is $2^{32} \times 2^{13} = 2^{45}$

(c) If the average process size is 1GB, would you use a one-level, two-level, or three-level page table? Why?

2 or 3 level page table due to the large amount of memory consumed per process.

3 (10 pts) Explain under which circumstances page faults occur and how they are resolved by the operating system.

Page faults occur when a process needs to access data or instructions which have not been loaded in to physical memory. The operating systems then pages in the data or instructions which caused the "page fault".

4 (10 pts) Consider the following page reference string:

7, 2, 3, 1, 2, 5, 3, 4, 6, 7, 7, 1, 0, 5, 4, 6, 2, 3, 0, 1

Using the FIFO, LRU, and Optimal page replacement algorithms with 3 frames, show the page load order and number of page faults that would occur.

FIFO (17 page faults): 7; 7 2; 7 2 3; 1 2 3; 1 5 3; 1 5 4; 6 5 4; 6 7 4; 6 7 1; 0 7 1; 0 5 1; 0 5 4; 6 5 4; 6 2 4; 6 2 3; 0 2 3; 0 1 3
LRU (18 page faults): 7; 7 2; 7 2 3; 1 2 3; 1 2 5; 3 2 5; 3 4 5; 3 4 6; 7 4 6; 7 1 6; 7 1 0; 5 1 0; 5 4 0; 5 4 6; 2 4 6; 2 3 6; 2 3 0; 1 3 0
OPT (13 page fauts): 7; 7 2; 7 2 3; 1 2 3; 1 5 3; 1 5 4; 1 5 6; 1 5 7; 1 5 0; 1 4 0; 1 6 0; 1 2 0; 1 3 0

5 (10 pts) Explain thrashing as it relates to virtual memory and what affect it has on the operating system. Name at least 2 methods to reduce thrashing.

Thrashing occurs when a particular process is constantly paging in and paging out the same chunk of code or data due to insufficient physical memory to hold them in RAM. This creates a severe performance penalty as the operating system has to constantly bring the code/data back in to RAM from disk for execution by the processor. We can eliminate thrashing by increasing the amount of physical RAM or reducing the number of processes currently consuming physical memory.