CprE 308 Homework 2

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Problem 1. Address translation (5 points)

Suppose we are given a virtual address 16390. If we are using paging and the page size is 4KB, what are the *virtual page number* and *offset* of the given virtual address? Suppose virtual page numbers start with 0.

Note: 2^{10}=1024, 2^{11}=2048, 2^{12}=4096, 2^{13}=8192, 2^{14}=16384, 2^{15}=32768, 2^{16}=65536.

Problem 2. Multi-level page table (5 points)

Suppose a program has a 64-bit virtual address space, and the system uses a three-level page table. The virtual address has a 10-bit top level page table field (i.e., index for page global directory), 16-bit second level page table field (i.e., index for page middle directory), and 22-bit third level page table field, and an offset.

a) What is the page size?
b) What is the max number of virtual pages for this program?

Problem 3. Page Replacement Algorithms (10 points)

Suppose the physical memory has four page frames and they are occupied by four pages (0 - 3). The following table shows the timestamp when each page is loaded to the frame (i.e., the "Loaded" column), the timestamp when each page is last referenced (i.e., the "Last Ref." column), the recently referenced bit R in the corresponding page table entry.

Page	Loaded	Last Ref.	R
0	126	280	0
1	230	265	0
2	140	270	1
3	110	285	1

Suppose a page fault happens and the system needs to replace a page.

a) If the system uses First-In-First-Out (FIFO) algorithm, which page is replaced?

b) If the system uses Least-Recently-Used (LRU) algorithm, which page is replaced?

c) If the system uses Clock algorithm, and the pages are organized in a circular list of 0-->1-->2-->3->0, the clock hand currently points to page 1, which page is replaced?

d) If the system uses Clock algorithm, and the pages are organized in a circular list of 0-->1-->2-->3->0, the clock hand currently points to page 2, which page is replaced?