

CS 367: Homework 5 - Page Tables, TLBs, Caches

Due Monday November 14 (001) or Tuesday November 15 (003), on paper, at start of class.

Late penalty is 25% per day. (You are not expected to edit this document; please write your solutions on paper or type up your solutions in a new file).

Questions

General Page Table Questions (21%)

1. (6pts) What's the difference between a virtual and physical address?
2. (5pts) Where would each kind of address (VA, PA) be used? (programs, pieces of hardware, etc)
3. (5pts) What is the maximum number of pages a process can have?
4. (5pts) When we say that a virtual address generates a page fault, what do we really mean? What is the solution to this problem?

Page Table and VA → PA calculations (39%)

Assume a process uses 8-bit virtual addresses where 3 bits are the virtual page number. The page table is given below.

VPN	Valid?	PPN
000	1	000 1101
001	1	000 1111
010	0	011 0011
011	1	101 1000
100	1	100 1111
101	0	100 1101
110	1	100 1011
111	1	001 0101

1. (3pts) How many of the process's pages are currently in memory?
2. (3pts) How many bits does a physical address have here?
3. (3pts) What is the size of a page here? (# addressable bytes in it)
4. (5x6pts each) Calculate physical addresses (PA's) from the following virtual addresses, or indicate that a page fault would occur. Answer in hexadecimal.
 1. VA = 0001 0100 = 0x14
 2. VA = 0101 1000 = 0x58
 3. VA = 1001 1111 = 0x9F
 4. VA = 1010 0011 = 0xA3
 5. VA = 1101 1111 = 0xDF

TLBs (40%)

Consider Figure 9.20 from our text (3rd ed: p.822; 2nd ed: p.796). Be sure to note the specifics of this chart (the bulleted list beginning two pages earlier), especially how virtual addresses are 14 bits wide, physical addresses 12 bits wide, and the fact that we're addressing a single byte (your answers are single bytes if found).

1. (5pts) Does it make sense for both the TLB to miss and for the page table to miss? Why, or why not?
2. (5pts) Is it possible for the TLB to have a hit for a particular VPN, but the page table have the valid bit = 0 for that same VPN's page table entry? Why, or why not?
3. (5x6pts each) Use the following virtual addresses to calculate the physical address, and then find the actual byte that is stored at that location when possible. For each VA, you must:
 - state if the TLB was a hit or miss
 - state if the page table was a hit or miss (when used)
 - state if the cache was a hit or miss (when used)
 - give the single-byte answer for successful lookups

Since our VA's are not a multiple of 4 bits, we're using `o` as part of our hexadecimal representations to indicate `b00` when possible.

1. VA = 0xo36A
2. VA = 0xo733
3. VA = 0xo23B
4. VA = 0xo024
5. VA = 0xo056