

CMSC 311 Fall, 2006

Virtual Memory Worksheet

RTFP

Problem 1. (16 points):

The following problem concerns the way virtual addresses are translated into physical addresses.

- The memory is byte addressable.
- Memory accesses are to 4-byte words.
- Virtual addresses are 20 bits wide.
- Physical addresses are 16 bits wide.
- The page size is 4096 bytes.
- The TLB is 4-way set associative with 16 total entries.

In the following tables, **all numbers are given in hexadecimal**. The contents of the TLB and the page table for the first 32 pages are as follows:

| TLB | | | |
|-------|-----|-----|-------|
| Index | Tag | PPN | Valid |
| 0 | 03 | B | 1 |
| | 07 | 6 | 0 |
| | 28 | 3 | 1 |
| | 01 | F | 0 |
| 1 | 31 | 0 | 1 |
| | 12 | 3 | 0 |
| | 07 | E | 1 |
| | 0B | 1 | 1 |
| 2 | 2A | A | 0 |
| | 11 | 1 | 0 |
| | 1F | 8 | 1 |
| | 07 | 5 | 1 |
| 3 | 07 | 3 | 1 |
| | 3F | F | 0 |
| | 10 | D | 0 |
| | 32 | 0 | 0 |

| Page Table | | | | | |
|------------|-----|-------|-----|-----|-------|
| VPN | PPN | Valid | VPN | PPN | Valid |
| 00 | 7 | 1 | 10 | 6 | 0 |
| 01 | 8 | 1 | 11 | 7 | 0 |
| 02 | 9 | 1 | 12 | 8 | 0 |
| 03 | A | 1 | 13 | 3 | 0 |
| 04 | 6 | 0 | 14 | D | 0 |
| 05 | 3 | 0 | 15 | B | 0 |
| 06 | 1 | 0 | 16 | 9 | 0 |
| 07 | 8 | 0 | 17 | 6 | 0 |
| 08 | 2 | 0 | 18 | C | 1 |
| 09 | 3 | 0 | 19 | 4 | 1 |
| 0A | 1 | 1 | 1A | F | 0 |
| 0B | 6 | 1 | 1B | 2 | 1 |
| 0C | A | 1 | 1C | 0 | 0 |
| 0D | D | 0 | 1D | E | 1 |
| 0E | E | 0 | 1E | 5 | 1 |
| 0F | D | 1 | 1F | 3 | 1 |

Part 1 The Basics (8pts)

1. The box below shows the format of a virtual address. Indicate (by labeling the diagram) the fields (if they exist) that would be used to determine the following: (If a field doesn't exist, don't draw it on the diagram.)

- VPO* The virtual page offset
- VPN* The virtual page number
- TLBI* The TLB index
- TLBT* The TLB tag

19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0



2. The box below shows the format of a physical address. Indicate (by labeling the diagram) the fields that would be used to determine the following:

- PPO* The physical page offset
- PPN* The physical page number

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0



Part 2 Translation

For the given virtual addresses, indicate the TLB entry accessed and the physical address. Indicate whether the TLB misses and whether a page fault occurs.

If there is a page fault, enter “-” for “PPN” and leave part C blank.

Virtual address: 2DA49

- Virtual address format (one bit per box)

19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

| | | | | | | | | | | | | | | | | | | | |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| | | | | | | | | | | | | | | | | | | | |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|

- Address translation

| Parameter | Value |
|-------------------|-------|
| VPN | 0x |
| TLB Index | 0x |
| TLB Tag | 0x |
| TLB Hit? (Y/N) | |
| Page Fault? (Y/N) | |
| PPN | 0x |

- Physical address format (one bit per box)

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

| | | | | | | | | | | | | | | | |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| | | | | | | | | | | | | | | | |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|

Virtual address: 1F1F8

- Virtual address format (one bit per box)

19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

| | | | | | | | | | | | | | | | | | | | |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| | | | | | | | | | | | | | | | | | | | |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|

- Address translation

| Parameter | Value |
|-------------------|-------|
| VPN | 0x |
| TLB Index | 0x |
| TLB Tag | 0x |
| TLB Hit? (Y/N) | |
| Page Fault? (Y/N) | |
| PPN | 0x |

- Physical address format (one bit per box)

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

| | | | | | | | | | | | | | | | |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| | | | | | | | | | | | | | | | |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|