**ECE3700J Introduction to Computer Organization Homework 9**

**Assigned: November 28, 2023**

**Due: 2:00pm on December 5, 2023**

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1. (50 points) Virtual memory uses a page table to track the mapping of virtual addresses to physical addresses. The following is a stream of virtual byte addresses used to access memory.

Virtual addresses (in decimal): 12648, 45419, 46824, 16975, 40004, 12707, 52236

Assume 4 KB pages, a 4-entry fully associative TLB, and LRU replacement. If pages must be brought in from disk, increment to the next largest page number.

TLB:

|  |  |  |
| --- | --- | --- |
| Valid | Tag | Physical Page Number |
| 1 | 11 | 12 |
| 1 | 7 | 4 |
| 1 | 3 | 6 |
| 0 | 4 | 9 |

Page Table:

|  |  |
| --- | --- |
| Valid | Physical Page Number |
| 1 | 5 |
| 0 | Disk |
| 0 | Disk |
| 1 | 6 |
| 1 | 9 |
| 1 | 11 |
| 0 | Disk |
| 1 | 4 |
| 0 | Disk |
| 0 | Disk |
| 1 | 3 |
| 1 | 12 |

1. Given the virtual address stream, and the initial TLB and page table states shown above, show the final state of the system. Also list for each reference if it is a hit in the TLB, a hit in the page table, or a page fault. You may find the following table useful. (15 points)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Address | | VPN | Page Fault? | TLB hit? | TLB | | |
| Decimal | Hexadecimal | Valid | Tag | PPN |
| 12648 |  |  |  |  |  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| 45419 |  |  |  |  |  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| 46824 |  |  |  |  |  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| 16975 |  |  |  |  |  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| 40004 |  |  |  |  |  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| 12707 |  |  |  |  |  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| 52236 |  |  |  |  |  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

You may also want to keep track of the changes of the Page Table.

1. Repeat question (1), but this time use 16 KB pages instead of 4 KB pages. (15 points)
2. What would be some of the advantages and disadvantages of having a larger page size? (5 points)
3. Show the final contents of the TLB if it is 2-way set associative. (15 points)