# Practice Quiz 3 – Memory Management

Wednesday November 23rd, 2016

## Question 1 – Base and Bounds

A computer system uses a simple base/bounds register pair to virtualize address spaces. In each of the traces below, your job is to fill in the missing values of virtual addresses, physical addresses, base, and/or bounds registers. In some cases, it is not possible to provide an exact value. If so, please specify a range (e.g. greater than 100), or value that is not a single number.

| Virtual Address → | Physical Address | | |
|---|---|---|---|
| 100 | 800 | | |
| 300 | 1000 | Base? | _____ |
| 799 | 1499 | | |
| 800 | [fault] | Bounds? | _____ |

| Virtual Address → | Physical Address | | |
|---|---|---|---|
| 400 | 2500 | Base? | _____ |
| 1700 | 3800 | | |
| 2001 | _____? | Bounds? | _____ |
| 3001 | 5101 | | |

| Virtual Address → | Physical Address | | |
|---|---|---|---|
| _____ | 1400 | Base? | 500 |
| _____ | 2200 | | |
| _____ | 2499 | Bounds? | 2000 |
| _____ | [fault] | | |

## Question 2 – Page Tables

Compute memory requirement for each of the following page table implementations.

Consider a computer with 64KB of physical memory, where the page size is 256 bytes.

For a single-level page table, how many pages are there? _____

How many bits are required for the virtual page number (VPN)? _____

How many bits are required for the offset, considering that we would like the ability to address any byte in a 256 byte page? _____

What is the total space requirement in bytes for this single level page table? _____

Now consider a two level page table. At the first level we have a page directory which divides the page space in half. Half of the VPN bits are used to index the page directory, while the other half support indexing a page table. The page directory provides references to page tables which refer to pages.

If we create and store 4 pages indexed by a page table in the second level, what is the total space requirement in bytes for this two-level page table? _____

**Question 3 – TLB Hit/Miss Ratio with LRU**

Consider a TLB with a 5-address capacity which utilizes the Last Recently Used (LRU) cache replacement policy. Given the following page requests, what is the ratio of cache hits to misses?

The 5-address TLB has the following initial state sorted newest to oldest:

| | |
|---|---|
| TLB0 | 7 |
| TLB1 | 9 |
| TLB2 | 3 |
| TLB3 | 5 |
| TLB4 | 1 |

**Cache arrival sequence:**

0 3 5 2 1 7 8 2 3 4

Hits: _____

Misses: _____

Ratio: _____