

# CS 2200 Homework 7

## Fall 2018

### Instructions:

- Please print a copy of the assignment and hand write your answers. No electronic submissions are allowed. **Please print as one double-sided page. Do NOT staple multiple sheets together. There will be a 70 point penalty if you do not.**
- This is an individual assignment. You may discuss concepts but not the answers.
- Due Date: **10/24/18 – 6:00 PM** in recitation. Bring your BuzzCard. Show up on time.

Name: \_\_\_\_\_ GT Username: \_\_\_\_\_ Section: \_\_\_\_\_

### 1. Address Layouts

Our OS uses 32-bit virtual addresses, 24-bit physical addresses, and page sizes of 8KB. Draw the layout of **both** the virtual and physical addresses along with the size in bits.

### 2. Address Translation

Say we have virtual addresses of 32 bits, physical addresses of 28 bits, and a page size of 64 KB. Given the process's entire page table below, translate the virtual addresses into their respective physical addresses. Identify any page faults you may find by writing "page fault".

| VPN  | PFN | VALID |
|------|-----|-------|
| DEAD | 8DE | 1     |
| 49BB | 4F0 | 1     |
| FAAD | 57C | 0     |
| FACE | D85 | 1     |
| BB8D | 235 | 0     |
| DE2F | 123 | 1     |
| DEAF | B72 | 0     |
| BEAD | 6A1 | 1     |

| Virtual Address | Physical Address |
|-----------------|------------------|
| 0x49BBB1CD      |                  |
| 0xBB8D789E      |                  |
| 0xBEAD2CD3      |                  |
| 0xEF1201DD      |                  |

### 3. Page Replacement - Least Recently Used (LRU)

Consider a system with 4 page frames with each page associated with a 4-bit reference counter. The reference counter is a shift register, which is right shifted in each time slice and the MSB of the page(s) that are accessed in that time slice is (are) set to 1. Initially, none of the pages are in physical memory (i.e., all the physical frames are free).

To make this problem simple, we assume only one page is accessed in each time slice. This is indicated as the "VPN Ref#" (e.g., Page 5 is referenced in time slice 1, 4, and 8). At the end of the first time slice, only one page frame is in use (for VPN = 5) and its reference counter will read: 1000.

Fill in the table, and when a page has to be evicted to service the page fault, indicate which page is chosen as the victim.

| Time                      | 1        | 2 | 3 | 4 | 5 |
|---------------------------|----------|---|---|---|---|
| VPN Ref #                 | 5        | 2 | 3 | 5 | 4 |
| Victim                    | N/A      |   |   |   |   |
| List of frames & counters | 5 - 1000 |   |   |   |   |

| Time                      | 6 | 7 | 8 | 9 | 10 |
|---------------------------|---|---|---|---|----|
| VPN Ref #                 | 1 | 2 | 4 | 6 | 1  |
| Victim                    |   |   |   |   |    |
| List of frames & counters |   |   |   |   |    |

### 4. Memory Fragmentation

Define **internal** and **external fragmentation** and state one memory system in which each occur.