**Matthew Austin**

**Assignment 5**

**CIS355** – Spring Term 2018

**Point Value**: 100 points

**Assignment Due Date**: **In class Thursday, April 19, 2018**

**Short answers**

1. What is virtual memory **(2 points)?** What is the purpose of virtual memory **(2 points)?** Where is the virtual memory stored? (**1 points**)
   1. Virtual Memory is a storage allocation scheme in which secondary memory can be addressed as though it were part of main memory
   2. Virtual Memory uses hardware and software to allow a computer to compensate for physical memory shortages by temporarily transferring data from random access memory (RAM) to disk storage
2. Under what circumstances do page faults occur **(5 points)?** Describe the actions taken by the OS when a page fault occurs. Please use 1, 2, 3, … to indicate the order of the actions taken by the OS. (**10 points**)
   1. A page fault occurs when an access to a page that has not been brought into main memory takes place.
   2. 1.) The operating system verifies the memory access, aborting the program if it is invalid.

2.) If it is valid, a free frame is located and I/O is requested to read the needed page into the free frame.

3.) Upon completion of I/O, the process table and page table are updated and the instruction is restarted.

1. Considering the following page reference string:

7, 2, 3, 1, 2, 5, 3, 4, 6, 7, 7, 1, 0, 5, 4, 6, 2, 3, 0, 1

Assuming demand paging with three frames, how many page faults would occur for the following replacement algorithms

**LRU (10 points):** 18

**FIFO (10 points):** 17

**OPT: (10 points):** 13

1. In addition to LRU, there is a similar page replacement algorithm called Least Frequently Used (LFU). Under LFU, when the memory is full and a new page will be brought into memory, the page with the least reference frequency will be replaced. Describe a situation in which a least frequently used (LFU) page replacement algorithm generates fewer page faults than the least recently used (LRU) page replacement algorithm**? (10 points)**
   1. Consider the following sequence of memory accesses in a system that can hold four pages in memory: 1 1 2 3 4 5 1. When page 5 is accessed, the least frequently used page-replacement algorithm would replace a page other than 1, and therefore would not incur a page fault when page 1 is accessed again
2. A given system provides three frames to a program. The system uses single-layer paging (one page table) stored in memory but also has a TLB. TLB hit rates are 88%. Assume a TLB access takes 20ns, a memory access requires 200ns, and a page fault costs 8,000,000ns. Provide the amount of time a program with the reference string below spends accessing memory when using second chance FIFO. (**20 points**) Fault count: 13

Reference String: 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1

|  |  |  |
| --- | --- | --- |
| 0 | 1 | 7 |

(20+200)+(20+200)+(20+200)+(20+200+8,000,000)[7 is replaced]+(20+200)+(20+200+8,000,000)[1 is replaced]+(20+200)+(20+200+8,000,000)[3 is replaced]+(20+200)+(20+200+8,0000)[0 is replaced with 3]+(20+200+8,000,000)[4 is replaced with 0]+(20+200)+(20+200)+(20+200+8,000,000)[3 replaced with 1]+(20+200)+(20+200)+(20+200+8,000,000)[0 replaced with 7]+(20+200+8,000,000)[2 replaced with 0]+(20+200)

**64004180ns or 64.00418ms or 1.0667minutes**

1. Please explain what is a reference bit in the second chance algorithm? **(5 points)** What is the modified/dirty bit in the enhanced second chance algorithm? **(5 points)**
   1. The Second Chance algorithm works the same as FIFO, but instead of instantly paging out the page it checks for the set referenced bit and if it is set. If it is not set the page is swapped out. If it is set the reference bit is cleared and the page is put at the back of the queue. A reference bit is a page that a process referenced actively in the past T seconds.
   2. In the enhanced second chance algorithm hardware keeps a modify/dirty bit, besides the reference bit
      1. 1: page is modified
      2. 0: page is the same as the copy on disk
2. We use 5-bit logical addresses which allows 32 possible locations. The higher 3 bits are used for the page number and the lower 2 bits are used for the page offset. What is the size of a frame? **(5 points)** How many pages are in the page table? **(5 points)** The number of frames is 215 (225 / 210 = 215). The amount of pages in the page table is 232 / 210 = 222pages