COP 4600 – Midterm Examination - 2

Date: October 28, 2013

**Name: ………………………………………………………………………………………………………….**

Instructions:

* This exam is open book and open notes. Allotted time is 75 minutes.
* Note that the points add up to 100 + 10 bonus points.

# Problem 1 (10 pts)

Consider a logical address with a page size of 8 KB. How many bits must be used to represent the page offset in the logical address? Explain why (1 sentence).

*Answer 13, because 2^13 = 8192, 8KB*

# Problem 2 (25 points)

A process contains eight virtual pages on disk and is assigned a fixed allocation of four page frames in the main memory. The following page trace occurs:

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

## a) Show the successive pages residing in the four frames using the LRU (least recently used) policy.

4 6 7 3 0 2 3H 1 0H 2H 3H 1H 7 6 3H 6H 3H 1H 0 2

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4 | 4 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 7 | 7 | 7 | 7 | 7 | 0 | 0 |
|  | 6 | 6 | 6 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 2 |
|  |  | 7 | 7 | 7 | 7 | 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|  |  |  | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

## b) Repeat for the FIFO policy.

4 6 7 3 0 2 3H 1 0H 2H 3H 1H 7 6 3 6H 3H 1H 0 2

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4 | 4 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
|  | 6 | 6 | 6 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
|  |  | 7 | 7 | 7 | 7 | 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
|  |  |  | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 |

## c) Repeat for the optimal algorithm

4 6 7 3 0 2 3H 1 0H 2H 3H 1H 7 6 3H 6H 3H 1H 0H 2

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4 | 4 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
|  | 6 | 6 | 6 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
|  |  | 7 | 7 | 7 | 7 | 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|  |  |  | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

## d) Calculate and compare the hit ratios. Comment on the results.

**LRU = 9 / 20**

**FIFO = 8 / 20**

**OPT = 10 / 20**

**Results are as expected, the optimal the best, followed by LRU and FIFO.**

# Problem 3 (20 pts)

Suppose the page table for a process A currently executing on the processor looks like the following. All numbers are decimal, everything is numbered starting from zero, and all addresses are memory byte addresses. The page size is **4096** bytes.

|  |  |  |  |
| --- | --- | --- | --- |
| Virtual page number | Valid bit  (1 =valid) | Modify bit  (1 = modified) | Page frame number |
| 0 | 1 | 0 | 10 |
| 1 | 1 | 1 | 11 |
| 2 | 0 | 0 | - |
| 3 | 1 | 0 | 3 |
| 4 | 0 | 0 | - |
| 5 | 1 | 1 | 1 |

## What physical address, if any, would each of the following virtual addresses correspond to:

712

is in page 0, offset 712 frame 10, so 40960 + 712 = 41672

5000

is in page 1, offset 5000-4096, maps to frame 11, 4096 \* 11 + (5000 - 4096) = 45960

## List the actions which will happen if the operating system allocates frame 10 to another process B

1 - page 0 to which frame 10 is allocated is set to invalid in A's page table

2 - if needed, the page will be brought in from the disk for B

3 - the appropriate page table line made valid in B's page table

4

5

## List the actions which will happen if the operating system allocates frame 11 to another process B

1 - the frame will be written to the disk as page 1 for process A

2 - page 1 will be set to invalid in A's page table

3 - if needed, the page will be brought in from the disk for B

4 - the appropriate page table line made valid in B's page table

5

## List the actions which will happen if the process A writes into page 2?

1 - page fault! write stopped

2 - the OS allocates a frame F for the page

3 -if the F is currently allocated to another process C, it is deallocated in the process's page table and written to the hard disk, if it is marked as modified

4 -page 2 in the page table of A is set to F, marked not modified and valid.

5 -write is resumed

6

# Problem 4 (15 pts)

Suppose a program is operating with execution-time binding with a relocation register. The physical address generated is 300. The relocation register is set to 100. What is the corresponding logical address? Explain why.

*Answer: 300 – 100 = 200*

*Physical address = Logical address + Relocation register*

# Problem 5 (10 pts)

An address generated by a CPU is referred to as a \_\_\_\_.

A) physical address

B) logical address

C) post relocation register address

D) Memory-Management Unit (MMU) generated address

*Ans: B*

The mapping of a logical address to a physical address is done in hardware by the \_\_\_\_\_\_\_\_.

A) memory-management-unit (MMU)

B) memory address register

C) relocation register

D) dynamic loading register

*Ans: A*

# Problem 6 (10 points)

How many philosophers may eat simultaneously in the Dining Philosophers problem **with 17 philosophers**? Explain why (3 sentences, maybe drawing).

*Answer:* ***At most*** *8 philosophers can eat, which would use 16 resources (chopsticks). However, to achieve this, you need to position the eating philosopher's one after another with only one case of two waiting ones being next to each other:*

*E1 W2 E3 E4 E5 W6 E7 W8 E9 W10 E11 W12 E13 W14 E15 W16 W17*

*If you don't follow this rule, you can have as little as 6 philosophers eating:*

*E1 W2 W3 E4 W5 W6 E7 W8 W9 E10 W11 W12 E13 W14 W15 E16 W17*

*Simply stating 8, without explaining the problem with the arrangements, is 7 points.*

# Problem 7 (20 points)

Create a model of the formation of a methane molecule CH4 using semaphores. Methane is made of one carbon atom and four hydrogen atoms . You need to implement three types of processes:

-one process for each hydrogen atom (assume that they are created regularly).

-one process for each carbon atom (assume that they are created regularly)

-a single process for the chemical bonding.

The hydrogen and carbon atoms wait until there are four hydrogen and one carbon atom available. Then, they are combined into a methane molecule and terminate their individual life as an atom. Show the pseudocode for the three types of processes.