Homework 6

Graded

Student

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Total Points

88 / 100 pts

Question 1

Virtual Memory Concepts **16** / 16 pts

1.1 **Memory Compaction** **4** / 4 pts

✔ **+ 4 pts** Correct

+ 0 pts Incorrect

1.2 **Paging and Segmentation** **4** / 4 pts

✔ **+ 4 pts** Correct

+ 0 pts Incorrect

1.3 **Base and Limit Register** **4** / 4 pts

✔ **+ 4 pts** Correct

+ 0 pts Incorrect

1.4 **External Fragmentation** **4** / 4 pts

✔ **+ 4 pts** Correct

+ 0 pts Incorrect

Question 2

Addresses and Page Tables **44** / 44 pts

2.1 **Virtual Address Layout** **4** / 4 pts

✔ **+ 4 pts** Correct (VPN)

+ 4 pts Correct

+ 0 pts Incorrect

2.2 **Virtual Address Layout** **4** / 4 pts

✔ **+ 4 pts** Correct (Offset)

+ 4 pts Correct

+ 0 pts Incorrect

2.3 **Virtual Address Layout** **4** / 4 pts

✔ **+ 4 pts** Correct (18)

+ 4 pts Answer plus the number in Q2.4 equals 32

+ 4 pts Correct

+ 0 pts Incorrect

2.4 **Virtual Address Layout** **4** / 4 pts

✔ **+ 4 pts** Correct (14)

+ 4 pts Correct

+ 0 pts Incorrect

2.5 **Physical Address Layout** **4** / 4 pts

✔ **+ 4 pts** Correct (PFN)

+ 4 pts Correct

+ 0 pts Incorrect

2.6 **Physical Address Layout** **4** / 4 pts

✔ **+ 4 pts** Correct (Offset)

+ 4 pts Correct

+ 0 pts Incorrect

2.7 **Physical Address Layout** **4** / 4 pts

✔ **+ 4 pts** Correct (10)

+ 4 pts Answer plus the number in Q2.8 equals 24

+ 4 pts Correct

+ 0 pts Incorrect

2.8 **Physical Address Layout** **4** / 4 pts

✔ **+ 4 pts** Correct (14)

+ 4 pts Same as the answer in Q2.4

+ 4 pts Correct

+ 0 pts Incorrect

2.9 **Page Table Entries** **6** / 6 pts

✔ **+ 6 pts** Correct (262144)

+ 3 pts Answered bit size of VPN (18)

+ 6 pts Fall-through error from Q2.3

+ 6 pts Correct

+ 0 pts Incorrect

2.10 **Page Frames** **6** / 6 pts

✔ **+ 6 pts** Correct (1024)

+ 3 pts Answered bit size of PFN (10)

+ 6 pts Fall-through error from Q2.4

+ 6 pts Correct

+ 0 pts Incorrect

2.11 **Work** **0** / 0 pts

✔ **+ 0 pts** Correct

Question 3

Page Faults **16** / 16 pts

3.1 **Offset Bits** **4** / 4 pts

- ✔ **– 0 pts** Correct (12)
- **– 0 pts** Correct
- **– 4 pts** Incorrect

3.2 **Address Translation** **8** / 8 pts

- ✔ **– 0 pts** Correct (0x919A22B)
- **– 0 pts** Correct
- **– 4 pts** Incorrect offset portion (22B, last three numbers; or wrong size)
- **– 4 pts** Incorrect PFN portion (919A, first four numbers; or wrong size)
- **– 8 pts** Incorrect

3.3 **Page Fault** **4** / 4 pts

- ✔ **– 0 pts** Correct (5AC92, 82BD3)
- **– 2 pts** Missing one / having one extra
- **– 4 pts** Missing one and having one extra at the same time
- **– 0 pts** Correct
- **– 4 pts** Incorrect

Question 4

Second Chance Replacement **12** / 24 pts

4.1 Structures Needed

Resolved **4** / 8 pts

– **0 pts** Correct

– **2 pts** Did not mention circular queue/circular queue-like function/FIFO (just need to mention one)

Ex: frame table or separate queue

– **2 pts** Did not mention referenced bit

✔ – **2 pts** Did not mention clearing referenced bit while going through queue

✔ – **2 pts** Did not mention selecting the first victim without a referenced bit set

– **8 pts** Blank/no answer

Regrade Request **Submitted on: Oct 25**

My entire second paragraph talks about how it clears the reference bit, and how the page has to be replaced (first victim). I feel like I should get the points back for this, even if the specific thing in the rubric wasn't directly stated, but it was indirectly said. Thank you!

Your answer is missing some key components. Although you say that we go through the pages in a FIFO manner, you didn't mention how we actually choose them! We select the first victim in FIFO order without a referenced bit set, clearing reference bits as we go. This is important!

Reviewed on: Nov 12

4.2 Advantages over FIFO

Resolved **0** / 8 pts

– **0 pts** Correct (explain that referenced allows pages accessed more frequently recently to not be evicted **OR** mention it reduces page faults)

– **4 pts** Accurate explanation of how Second Chance Replacement algo works without emphasizing its advantages over FIFO

✔ – **8 pts** Incorrect

– **8 pts** Blank/no answer

Regrade Request **Submitted on: Oct 25**

I believe this would be a valid explanation since it talks about how Second chance uses reference bits, and the process of using it. I also describe how the worst case would allow it to be FIFO, which is showing the time advantage it has over FIFO as it has a max bound on the time FIFO takes.

Your answer only mentions there is a reference bit but doesn't explain how it's used by second chance replacement algo. The advantages are not listed, and degenerating to FIFO is the worst case but doesn't explain why it performs better than FIFO.

Reviewed on: Nov 20

4.3 **Degenerates to FIFO** **8** / 8 pts

✔ **– 0 pts** Correct

– 4 pts Did not mention Second Chance Replacement uses a FIFO ordering for frames (can imply this)

– 4 pts Did not mention all referenced bits being set to the same value (0 or 1) causes FIFO degeneration; only one example needed

– 8 pts Blank/no answer

Q1 Virtual Memory Concepts
16 Points

For the questions below, answer true/false.

Q1.1 Memory Compaction
4 Points

Memory compaction is usually used with fixed-size partition memory allocation scheme.

- ○ True
- ◉ False

Q1.2 Paging and Segmentation
4 Points

Paging and Segmentation both use a table for virtual to physical mapping since they work in a similar way.

- ◉ True
- ○ False

Q1.3 Base and Limit Register
4 Points

There is no special advantage for the base and limit register solution over the bounds register solution for memory management.

- ○ True
- ◉ False

Q1.4 External Fragmentation
4 Points

Paged virtual memory can eliminate external fragmentation.

- (●) True
- ( ) False

Q2 Addresses and Page Tables
44 Points

Our operating system uses 32-bit virtual addresses, 24-bit physical addresses, and page sizes of 16 Kbytes.

For Q2.1-Q2.8, complete the layout of the virtual and physical addresses by labeling each field with the correct value, as well as denoting the bit size for each field.

Q2.1 Virtual Address Layout
4 Points

Fill in the layout below with the appropriate fields for the **VIRTUAL address**.

Label 1	Label 2

What part of the virtual address is `Label 1`?

VPN

Q2.2 Virtual Address Layout
4 Points

What part of the virtual address is `Label 2`?

Offset

Q2.3 Virtual Address Layout
4 Points

What is the bit size of `Label 1`?

18

Q2.4 Virtual Address Layout
4 Points

What is the bit size of Label 2?

14

Q2.5 Physical Address Layout
4 Points

Fill in the layout below with the appropriate fields for the **PHYSICAL address**.

Label 1	Label 2

What part of the physical address is Label 1?

PFN

Q2.6 Physical Address Layout
4 Points

What part of the physical address is Label 2?

Offset

Q2.7 Physical Address Layout
4 Points

What is the bit size of Label 1?

10

Q2.8 Physical Address Layout
4 Points

What is the bit size of `Label 2`?

14

Q2.9 Page Table Entries
6 Points

How many entries are there in the page table? Format your answer as a base 10 number (standard number). So if your answer is 2^4, write "16".

262144

Q2.10 Page Frames
6 Points

How many page frames does the memory system have? (assume there are no hardware limitations) Again, format your answer as a base 10 number (standard number).

1024

Q2.11 Work
0 Points

In order to receive partial credit for an incorrect answer for Q2.9 and Q2.10, please give your work below. **Incorrect answers with no work shown will receive 0 points.**

2.9: 2^18 = 262144

2.10: 2^10 = 1024

Q3 Page Faults
16 Points

Say we have virtual addresses of 32 bits, physical addresses of 28 bits, and a page size of 4Kbytes. Given the following page table entries from the process' page table, answer the following questions.

VPN	PFN	Valid?
5AC92	1C03	I
82BD3	AAA1	I
FEC18	EFAB	V
2AC82	919A	V

Q3.1 Offset Bits
4 Points

How many bits does the offset in an address have?

12

Q3.2 Address Translation
8 Points

You are given a virtual address of 0x2AC8222B. According to the table above, what is its corresponding physical address?

0x919A22B

Q3.3 Page Fault
4 Points

Which of the following VPNs is held by a Page Table Entry that may lead to a page fault?

- [x] 5AC92
- [x] 82BD3
- [ ] FEC18
- [ ] 2AC82

Q4 Second Chance Replacement

24 Points

Provide short answers to the following questions on the Second Chance page replacement algorithm.

Q4.1 Structures Needed

8 Points

What data structures and bookkeeping features are needed to implement Second Chance replacement algorithm? Explain how the algorithm selects a page for eviction.

The Second Chance replacement algorithm requires arrays representing frames to track pages in memory and a boolean array to track page access, along with the arrival time of a
virtual page into physical memory.

The algorithm uses the reference bit set by the hardware as an indication that the page deserves a second chance to stay in memory. Initially, the operating system clears the reference bits of all the pages. As the program executes, the hardware sets the reference bits for the pages referenced by the program. If a page has to be replaced, the memory manager chooses the replacement candidate in FIFO manner.

Q4.2 Advantages over FIFO

8 Points

What are the advantages of Second Chance Replacement algorithm over FIFO? Explain why it performs better in most cases.

True FIFO requires us to maintain a queue containing all frames. Second Chance only
requires a bit per frame. Second Chance, at worst, will become FIFO if we have a case where all the reference bits are set.

Q4.3 Degenerates to FIFO
8 Points

Second Chance replacement algorithm can degenerate to FIFO. Explain the circumstances in which this might occur.

The concept of Second Chance is if all the pages have their referenced bit set, on the second encounter of the first page in the list, that page will be swapped out, as it now has its referenced bit cleared. However, if all the pages have their reference bit cleared from the start then second chance algorithm simply becomes a FIFO.