CSC 112: Computer Operating Systems
Lecture 8

Memory System II: Paging
Exercises ANS

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Q1. Inverted Page Table

- Q: A computer system has a 32-bit virtual address space, 4 KB pages, and 512 MB of physical memory.
  a) How many entries are in a conventional single-level page table?
  b) How many entries are in an inverted page table?

ANS:

- a) 4 KB page size = 2^12 bytes, so 32-12 = 20 bits for the page number.
  Number of entries in a conventional page table = 2^20, for each process.
- b) 512 MB physical memory = 2^29 bytes. Each frame is 4 KB = 2^12 bytes.
  Number of frames = 2^29/2^12=2^17.
  So, the inverted page table has 2^17 entries, for the whole system.

Q2. Inverted Page Table

- Q: For a system with a 64-bit virtual address space and 256 MB physical memory, compare the memory requirements for a conventional page table and an inverted page table with 4 KB pages.

ANS:

- Conventional page table:
  Number of virtual pages = 2^64/2^12=2^52 entries.
  This is extremely large and impractical to store in memory.
- Inverted page table:
  Number of physical frames = 2^28/2^12=2^16 entries.
  Much smaller and manageable.

Q1. Page Replacement

- Consider cache size of 3 frames, and following reference stream of virtual pages:
  - 5, 3, 5, 1, 2, 5, 4, 6, 1
- Fill in the table for FIFO, LRU, and OPT page replacement algorithms, and give the number of page faults for each algorithm.

Ref	5	3	5	1	2	5	4	6	1
F1									
F2									
F3									

Q1. Page Replacement ANS

Ref	5	3	5	1	2	5	4	6	1
Frame 1	5	5	5	5	5	5	4	4	4
Frame 2		3	3	3	2	2	2	2	1
Frame 3				1	1	1	1	6	6

FIFO: 6 page faults

Ref	5	3	5	1	2	5	4	6	1
Frame 1	5	5	5	5	5	5	5	5	1
Frame 2		3	3	3	2	2	2	6	6
Frame 3				1	1	1	4	4	4

LRU: 6 page faults

Ref	5	3	5	1	2	5	4	6	1
Frame 1	5	5	5	5	5	5	4	4	4
Frame 2		3	3	3	2	2	2	6	6
Frame 3				1	1	1	1	1	1

OPT: 5 page faults
(When referencing 4 and 6, you can replace any page, as long it page 1 is not replaced, since only it will be referenced again in the future)

Q2. Page Replacement

- Consider cache size of 3 frames, and following reference stream of virtual pages:
  - 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 1, 2, 0
- Fill in the table for FIFO, LRU, and OPT page replacement algorithms, and give the number of page faults for each algorithm.

Ref	7	0	1	2	0	3	0	4	2	3	0	3	1	2	0
F1															
F2															
F3															

Q2. Page Replacement ANS

Ref	7	0	1	2	0	3	0	4	2	3	0	3	1	2	0
F1	7	7	7	2	2	2	2	4	4	4	0	0	0	0	0
F2		0	0	0	0	3	3	3	2	2	2	2	1	1	1
F3			1	1	1	1	0	0	0	3	3	3	3	2	2

FIFO: 12 page faults

Ref	7	0	1	2	0	3	0	4	2	3	0	3	1	2	0
F1	7	7	7	2	2	2	2	4	4	4	0	0	0	2	2
F2		0	0	0	0	0	0	0	0	3	3	3	3	3	0
F3			1	1	1	3	3	3	2	2	2	2	1	1	1

LRU: 12 page faults

Ref	7	0	1	2	0	3	0	4	2	3	0	3	1	2	0
F1	7	7	7	2	2	2	2	2	2	2	2	2	2	2	2
F2		0	0	0	0	0	0	4	4	4	0	0	0	0	0
F3			1	1	1	3	3	3	3	3	3	3	1	1	1

OPT: 8 page faults

Q2. Page Replacement References

- Page replacement Algorithms | FIFO | Example | OS | Lec-26 | Bhanu Priya, Education 4u
  - https://www.youtube.com/watch?v=16kaPQtYo28
- Page replacement Algorithms | LRU | Example | OS | Lec-27 | Bhanu Priya, Education 4u
  - https://www.youtube.com/watch?v=u23ROrlSK_g
- Page replacement Algorithms | OPTIMAL | Example | OS | Lec-28 | Bhanu Priya, Education 4u
  - https://www.youtube.com/watch?v=jeJIKKQcqpU
  - Note that the reference stream is slightly different from FIFO and LRU videos