

CIS11032 Logic Designing & Computer Organization

Lesson 08 Replacement Algorithms

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Lesson Learning Outcomes

At the completion of this lesson students should be able to,

- Understand how the cache replacement works in memory management.

COURSE OUTLINE

- Replacement Algorithms
- Belady's Anomaly

Cache Replacement Algorithms

- This is quite needed in in an operating system that uses Paging for Memory Management.
- These algorithms determine which page needs to be replaced when new page comes in.
- Cache Replacement Algorithms are as follows:
 - I. **First In First Out**
 - II. **Least Frequently Used**
 - III. **Least Recently Used**

Page Hit vs Page Fault

PAGE HIT

- When we want to load the page on the memory, and the page is *already available* on memory, then it is called page hit.

$$\text{Page Hit Ratio} = \frac{\text{No. of page hits}}{\text{Total Number of references}}$$

PAGE FAULT

- When we want to load the page on the memory, and the page is *not already on memory*, then it is called a page fault. The page fault is also called page miss.

$$\text{Page Fault Ratio} = \frac{\text{No. of page faults}}{\text{Total Number of references}}$$

First In First Out (FIFO)

- Simplest of all algorithms.
- On a page fault,
 - The frame that has been in memory the longest will be replaced.

Least Frequently Used (LFU)

- On a page fault,
 - The pages which would not be used for the longest duration of time in the future is replaced.
That is the page with the smallest frequency/count is replaced

Least Recently Used (LRU)

- On a page fault,
 - **The least recently used page would be replaced.**
It is similar to FIFO, but if a page is referenced (Page Hit occurs), the page is considered to have been entered latest, and placed at last in the queue to be removed.

EXAMPLE

Apply the above algorithms to the following cache entry and evaluate the best replacement algorithm. (No. of Pages = 3)

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

01. First In First Out Algorithm

7	0	1	2	0	3	0	4	2	3	0	3	2	1	2
7	7	7	2	2	2	2	4	4	4	0	0	0	0	0
	0	0	0	0	3	3	3	2	2	2	2	2	1	1
		1	1	1	1	0	0	0	3	3	3	3	3	2
F	F	F	F	H	F	F	F	F	F	F	H	H	F	F

Page Hits = 3
Page Faults = 12

$$\begin{aligned} \text{Hit Ratio} &= \frac{3}{15} \times 100 \\ &= 20\% \end{aligned}$$

$$\begin{aligned} \text{Fault Ratio} &= \frac{12}{15} \times 100 \\ &= 80\% \end{aligned}$$

EXAMPLE contd.

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

02. Least Frequently Used Algorithm

7	0	1	2	0	3	0	4	2	3	0	3	2	1	2
7	7	7	2	2	2	2	4	4	3	3	3	3	3	3
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	1	3	3	3	2	2	2	2	2	1	2
F	F	F	F	H	F	H	F	F	F	H	H	H	F	F

Page Hits = 5
Page Faults = 10

$$\begin{aligned} \text{Hit Ratio} &= \frac{5}{15} \times 100 \\ &= 33.33\% \end{aligned}$$

$$\begin{aligned} \text{Fault Ratio} &= \frac{10}{15} \times 100 \\ &= 66.66\% \end{aligned}$$

EXAMPLE contd.

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

02. Least Recently Used Algorithm

7	0	1	2	0	3	0	4	2	3	0	3	2	1	2
7	7	7	2	2	2	2	4	4	4	0	0	0	1	1
	0	0	0	0	0	0	0	0	3	3	3	3	3	3
		1	1	1	3	3	3	2	2	2	2	2	2	2
F	F	F	F	H	F	H	F	F	F	F	H	H	F	H

Page Hits = 5
Page Faults = 10

$$\begin{aligned} \text{Hit Ratio} &= \frac{5}{15} \times 100 \\ &= 33.33\% \end{aligned}$$

$$\begin{aligned} \text{Fault Ratio} &= \frac{10}{15} \times 100 \\ &= 66.66\% \end{aligned}$$

Belady's Anomaly

- Bélády's anomaly is a phenomenon in which,
Increasing the number of page frames results in an increase in the number of page faults for certain memory access patterns
- This is more common when using the first-in first-out (FIFO) page replacement algorithm.

Thank you