CS & IT ENGINEERING

Operating Systems

Memory Management

Lecture No. 11

By- Dr. Khaleel Khan Sir

- Page Replacement Techniques
- Problem Solving
-

Page Replacement Techniques

l = 20 ; n = 6

Ref string: < 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1 >

As for graph if No. of frames Alloc = 6

① FIFO :

Criteria : T.O.L

3 Frames = 15 (75%)

4 Frames = 10 (50%) ↓

Ref. String: < 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1 >

A) 9 B) 8
C) 6 D) 10

2) Optimal Replacement: < replace that page which will not be used for the longest duration of time in future references >

→ Least P.F rate

3 Frames: 9

4 Frames: 8

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

Practically opt. replacement is NOT Implementable

Benchmark

Ref. String: < 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1 >

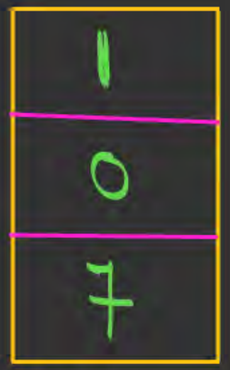
3) Least Recently used (LRU) < replace that page which has not been used for the longest duration of Time in the PAST >

Criteria: T.O.R

reference

3 Frames : 12

4 Frames : 8

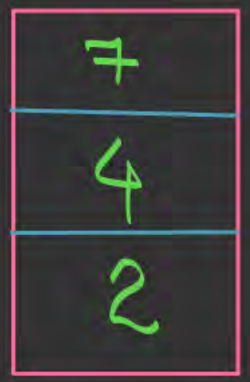


3 Frames

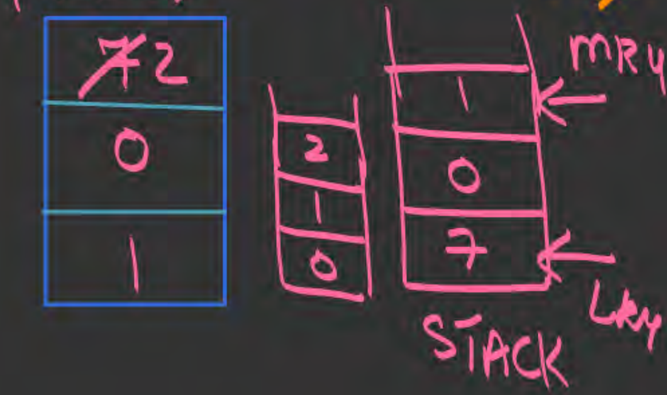
4) Most Recently used (MRU):

3F : 16

4F : 12 (?)



Stack method (TOR)



< 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1 >

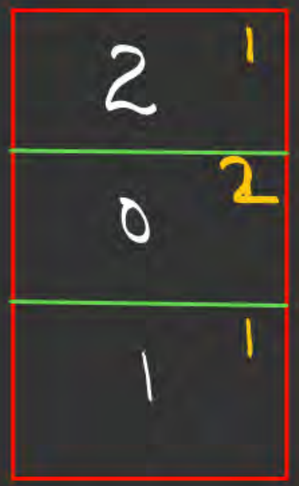
5) Counting Algo's

a) L.F.U [Least frequently used] = (13)

b) M.F.U [Most frequently used] = (15)

Sel. criteria: C.O.R

<Count of Reference>



3- Frames

Among all the Algo. optimal is having Least P.F rate

LRU ~ optimal

(Many OS Impl. either LRU or LRU Approximation)

Ref. string II: < 1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5 > $\ell = 12$, $n = \langle 5 \rangle$

MRU: (H/w) : LRU : 3/4 (1|8)

① FIFO: Pure D.P

3 Frames: 9 ✓

4 Frames: 10 ✓ ↑

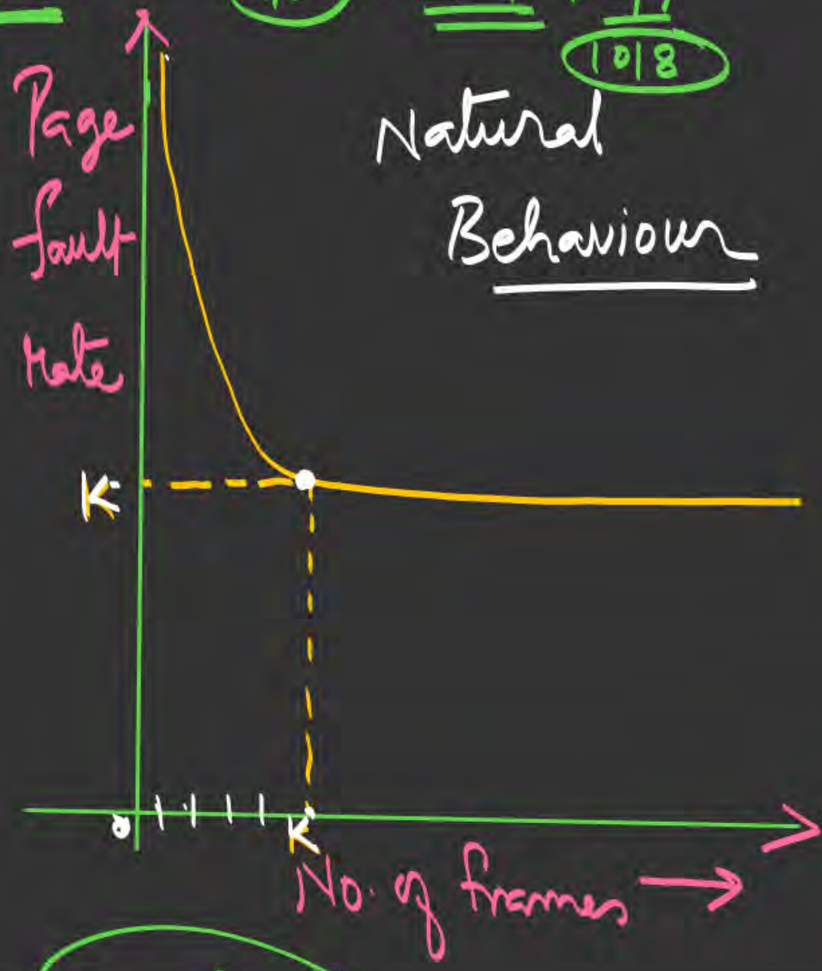
1	4	4	4	5	5	5		
2	2	1	1	1	3	3		
3	3	3	2	2	2	4		

Frames

② Optimal Replacement

3F → 7 ↓

4F → 6



Natural Behaviour

Belady's Anamoly:

< As the no. of frames allocated to the process increases, Page fault also Sometimes increases >

Sec. chance

Only FIFO & FIFO-Based Suffers from Bel. Anam.

II. * LRU Approximations

These Algo's are not really LRU, but they approximate to the behaviour of LRU

Reference bit (R)

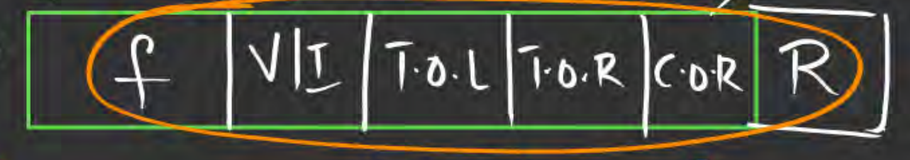
→ Each Page in the P.T will be associated with a Ref bit 'R';

a) Reference bit (R):

Criteria: 'R':

- 0 : Page is Not referred so far during present Epoch.
- 1 : Page has been referred atleast once during Present Epoch;

Index

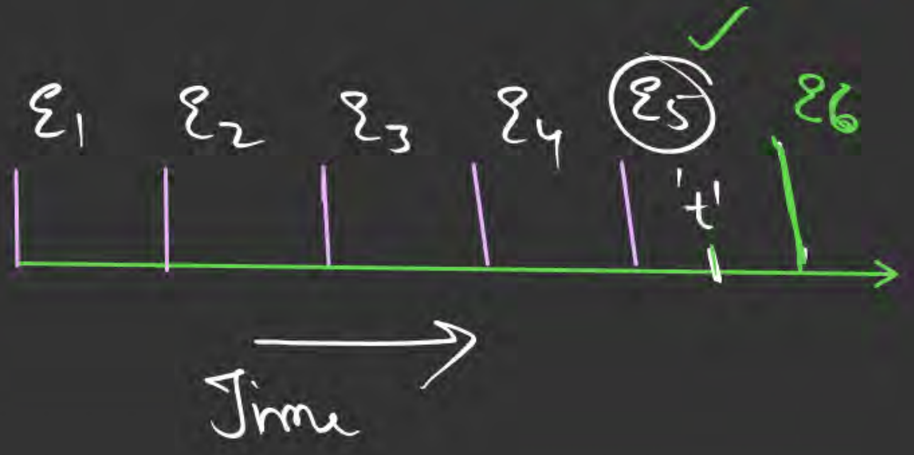


Attributes of Page

P	f	V/I	T.O.L	R	
0	a	1	2	1	
1	e	1	3	1	
2	d	1	0	1	
P.F 3	—	0	—	—	
4	c	1	4	1	
5	b	1	1	1	

Page-Table

Ref bit Algo fails



b) Additional Ref bits : < Each Page is associated with more than 1 - Ref bits (Say 8)

Current Epoch

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
P_i	1	0	0	1	0	1	1	1
P_j	0	0	1	1	1	0	1	1
P_k	0	0	1	1	0	1	1	1

P_e X : Cause P.F

When current Epoch gets over

⇓

(Shift left of R's)

c) Second-chance [clock Algo]

Criteria: [T·o·L + R]

When all Pages 'R' value is 1 then FIFO Page gets selected

Second chance ~ FIFO

Belady's Anamoly

P·T·E

P	f	V/I	T·o·L	R	
0	e	1	2	×0	
1	a	1	3	×0	
✓2	b	1	0	×0	
(3)	—	0	—	—	
4	c	1	1	×0	
5	d	1	4	×0	

(Page-Table)

THANK YOU!