

CS & IT ENGINEERING

Operating Systems

File System And Device Management



Lecture No. 2



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TOPICS TO BE
COVERED

**Page Replacement
Techniques**

Ref. String : $\langle \underline{7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1} \rangle$

I. FIFO :
3F : 15
4F : 10

$L = 20$
 $K = 6$

Max : $20(L) [Z=1]$
Min : $6(K) [Z \geq K]$

III. L.R.U (Least Recently used)
Sel. Criteria : ToR

II: optimal Replacement:

In the event of P. Fault
select that page as
victim which will not be
for long time in future
references;

3F : 9
4F : 8

Practically Non-
Implementable

7
3
2

3 Frames

3F : 12
4F : 8 ↓

IV. M.R.U (Most recently used)
Sel. Criteria : ToR

3 Frames : 16
4 Frames : 12

Ref. String: $\langle \underline{7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1} \rangle$

V: COUNTING ALGO'S:

- a) LFU: [Least frequently used]
- b) MFU [Most " " " "]

Sel. Criteria: C.O.R

3 Frames:

- a) LFU: 13
- b) MFU: 15

7
0
4

3 Frames

VI: LIFO:

Sel. Criteria: T.O.L

3F \rightarrow 12

LRU \sim optimal

Ref. String: $\langle \underline{1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5} \rangle$

I. FIFO:

3F : 9
4F : 10

↑
Belady's Anomaly

"Belady's Anomaly"

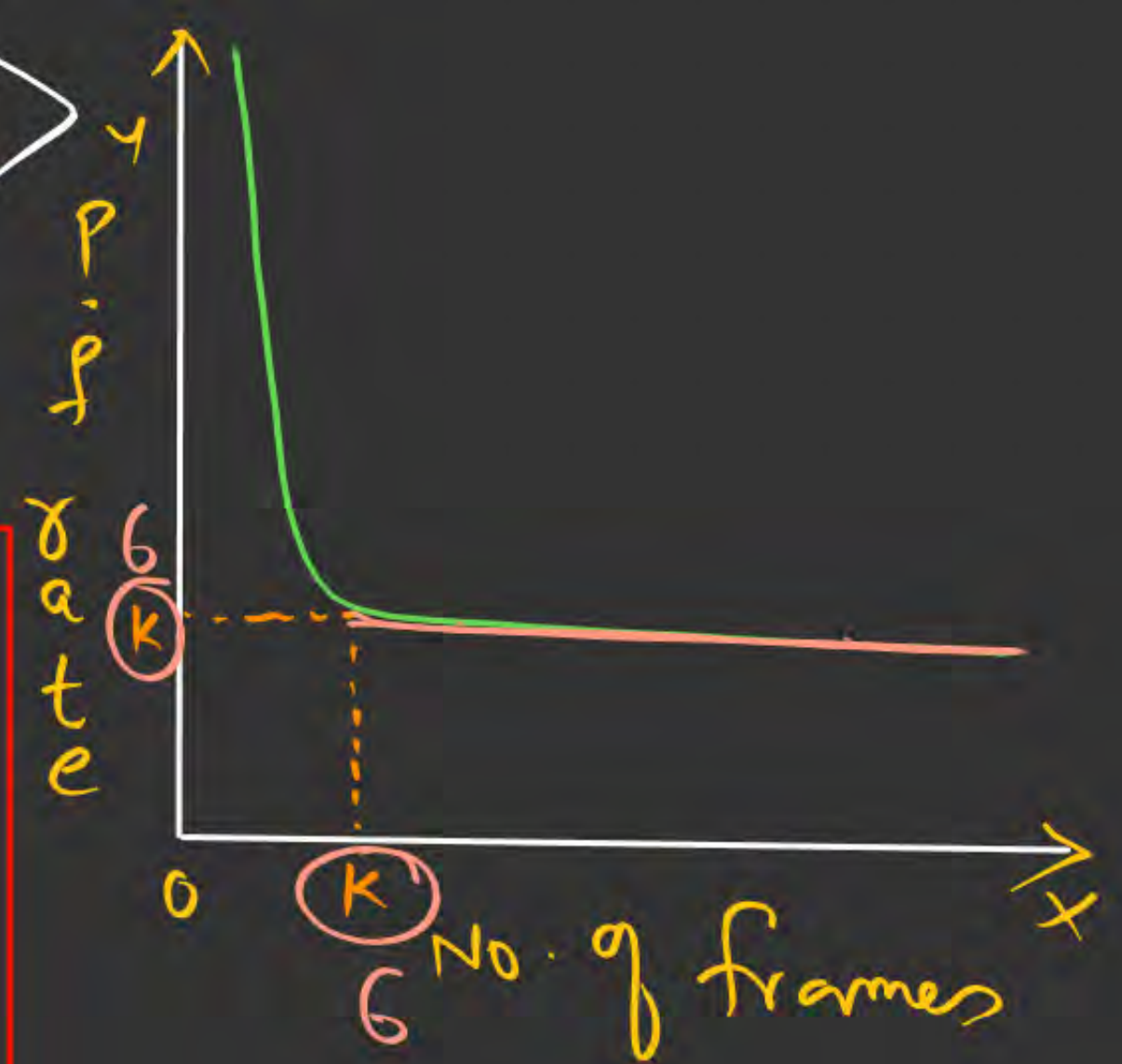
For Few Ref. Strings, with the Increase in no. of frames, Page fault also some-times increases

II. Optimal Replacement

3F : 7

4F : 6

↓
No Belady's Anomaly

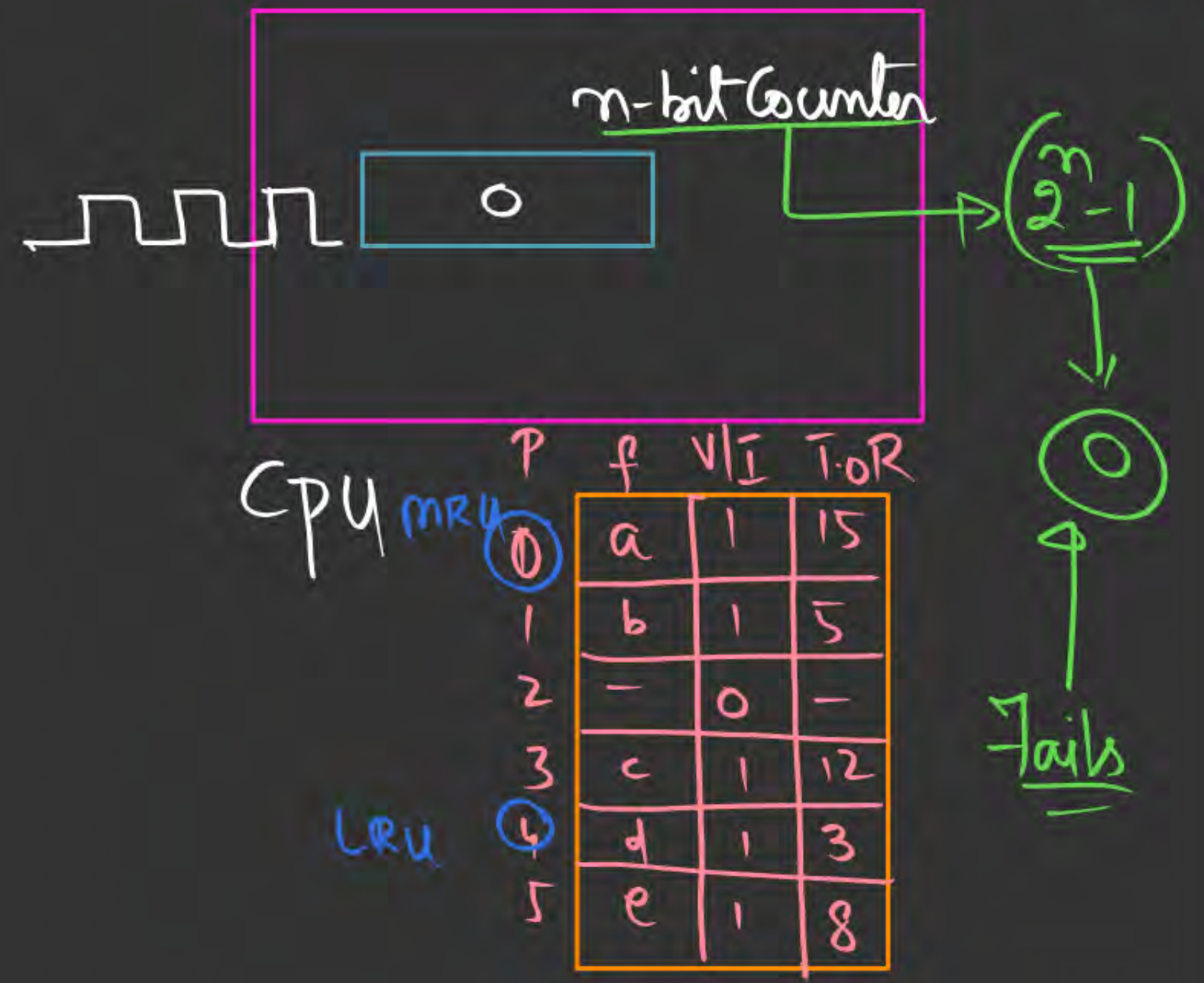


only FIFO & FIFO based Algo suffers from Belady's Anomaly

LRU Implementation

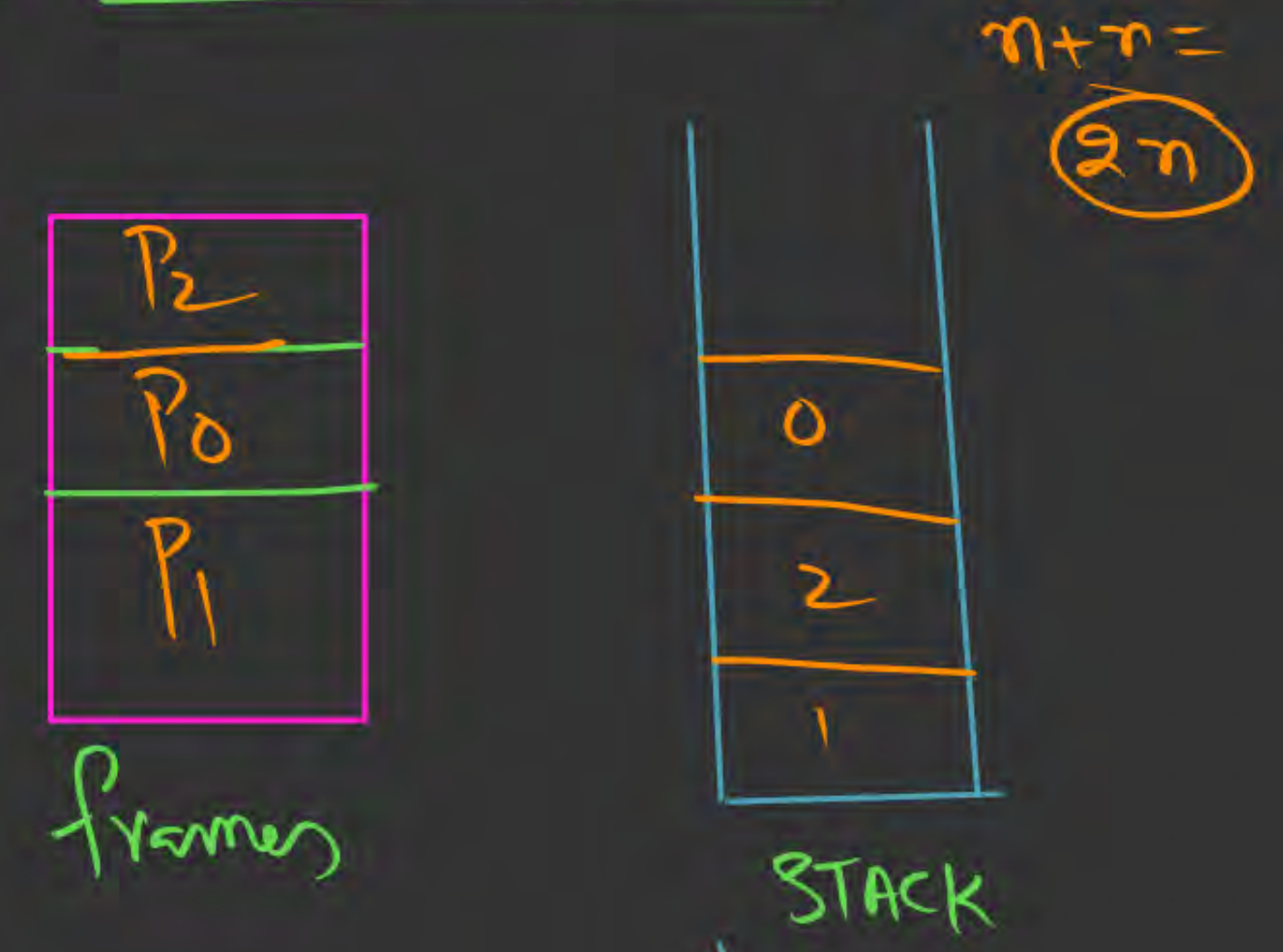
Ref String: < 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, ...

(i) Counter Method:



$$T.O.R = (\text{Counter_value})$$

(ii) STACK METHOD:

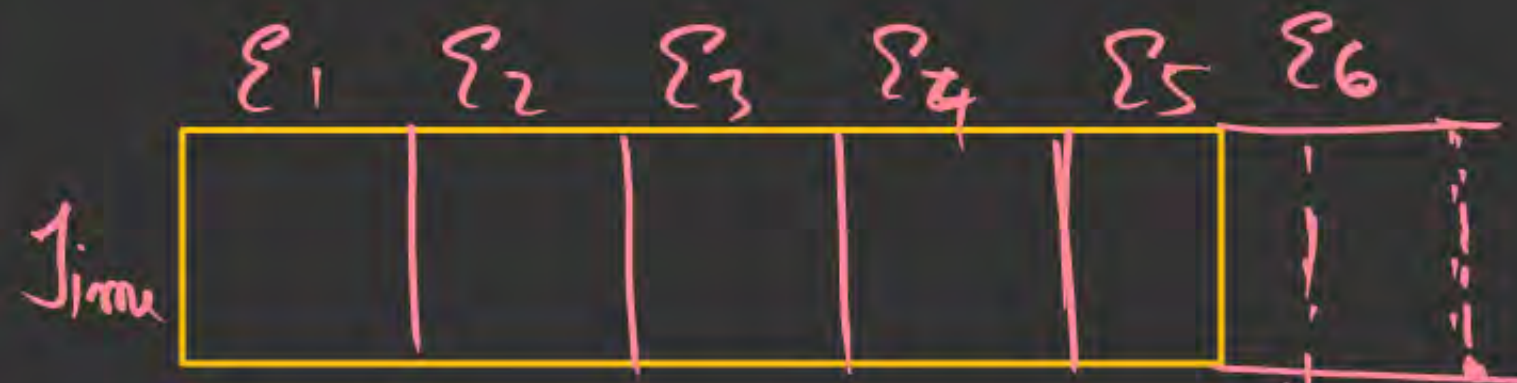


VII: LRU Approximations : Reference-Bit (R) based:

1) Reference Bit (R): Fail
 Criteria: R
 0: Page has not been referred so far during the Present Epoch;
 1: Page has been referred atleast once during Present Epoch;

P	f	VLI	TOL	R	M
0	a	1	4	1	0
1	b	1	6	1	1
2	c	1	3	0	1
3	-	0	-		
4	d	1	0	1	0
5	e	1	5	1	0
6	f	1	2	0	0

Page Table



2) Additional Ref. bits:

	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇	R ₈
P _i	1	0	1	1	1	1	1	1
P _j	0	0	0	1	1	1	1	1
P _k	1	1	1	0	1	1	1	1

x (P_l)

3) Second chance

clock Algo

Sel. Criteria: (TOL + R)

(FIFO-Based)

Belady's Anomaly

4) Enhanced Second chance Not Recently used (NRU)

0 : clean
1 : dirty

Sel criteria: $R + M \left(\frac{\text{Modified bit}}{\text{dirty bit}} \right)$

	R	M	
0	0	0	1
1	0	1	2
	1	0	3
	1	1	4

Q1) Consider a Process with a Ref String of length ' l ', in which ' k ' unique Pages occur.

Calculate the Lower Bound & Upper Bound of the No. of Page-faults, assuming ' z ' Frames are allocated.

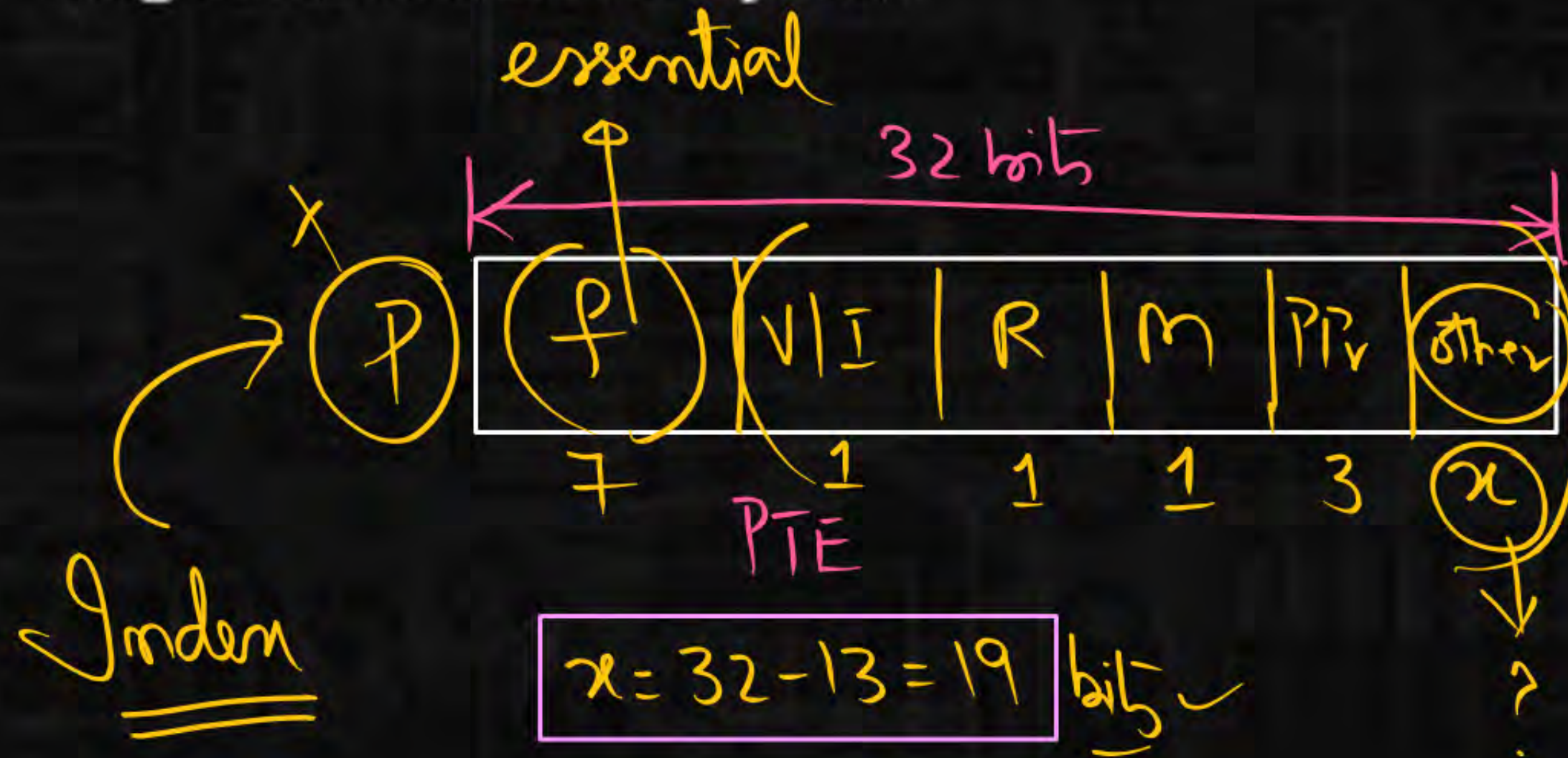
$$\textcircled{1} \text{ L.B : } k \quad [z \geq k]$$

$$\textcircled{2} \text{ U.B : } l \quad [z = 1]$$

Q.



Consider a System with $V.A.S = P.A.S = 2^{16}$ Bytes. Page Size is 512 Bytes. The size of Page Table entry is 32 bits. If the Page Table Entry contains besides other information 1 V/I bit, 1 Reference, 1 Modified bit, 3 bits for Page Protection. How many bits can be assigned for storing other attributes of the Page. Also compute Page Table Size in Bytes?



$$2^{16} / 2^9 = 2^7$$

$$P.T.S = N * e$$

$$= 128 \times 4B$$

$$= 512 \text{ Bytes}$$



Consider a virtual memory system with FIFO page replacement policy, for an arbitrary page access pattern, increasing the number of page frames in main memory will

- A. Always decrease the number of page faults.
- B. Always increase the number of page faults
- ☒ C. Sometimes increase the number of page faults
- D. Never affect the number of page faults.



A memory page containing a heavily used variable that was initialized very early and is in constant use is removed when

FIFO

- A. LRU page replacement algorithm is used
- ☒ B. FIFO page replacement algorithm is used
- C. LIFO page replacement algorithm is used
- D. None of the above

Q.

Consider a virtual memory system with FIFO page replacement policy, for an arbitrary page access pattern, increasing the number of page frames in main memory will

- A** Always decrease the number of page faults.
- B** Always increase the number of page faults
- C** Sometimes increase the number of page faults
- D** Never affect the number of page faults.



Recall that Belady's anomaly is that the page-fault rate may increase as the number of allocated frames increases. Now, consider the following statements:

✓ S1: Random page replacement algorithm (where a page chosen at random is replaced) suffers from Belady's anomaly

✗ S2: LRU page replacement algorithm suffers from Belady's anomaly

Which of the following is CORRECT?

A. S1 is true, S2 is true

C. S1 is false, S2 is true

✓ B. S1 is true, S2 is false

D. S1 is false, S2 is false

