CS & IT ENGINEERING

Operating System

Virtual Memory

Lecture - 04

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Recap of Previous Lecture

Topic Page Replacement Algorithm

Topic LRU, MRU Algorithms

Topic LIFO, Frequency Based Algorithms

Topics to be Covered

- Topic: Frame Allocation
- Topic: Thrashing
- Topic: Multilevel Paging

Topic : Question

[GATE-2014]

#Q. A main memory can hold 3 page frames and initially all of them are vacant. Consider the following stream of page requests :

2, 3, 2, 4, 6, 2, 5, 6, 1, 4, 6

If the stream uses FIFO replacement policy, the hit ratio h will be ?

2	2	2	6	6	6	1
	3	3	3	2	2	2
		4	4	4	5	5

A. 11/3

B. 1/11

C. 3/11

D. 2/11 ✓

Topic : Question

#Q. A virtual memory system has only 2-page frames which are empty initially. Using demand paging the following sequence of page reference is passed through this system.

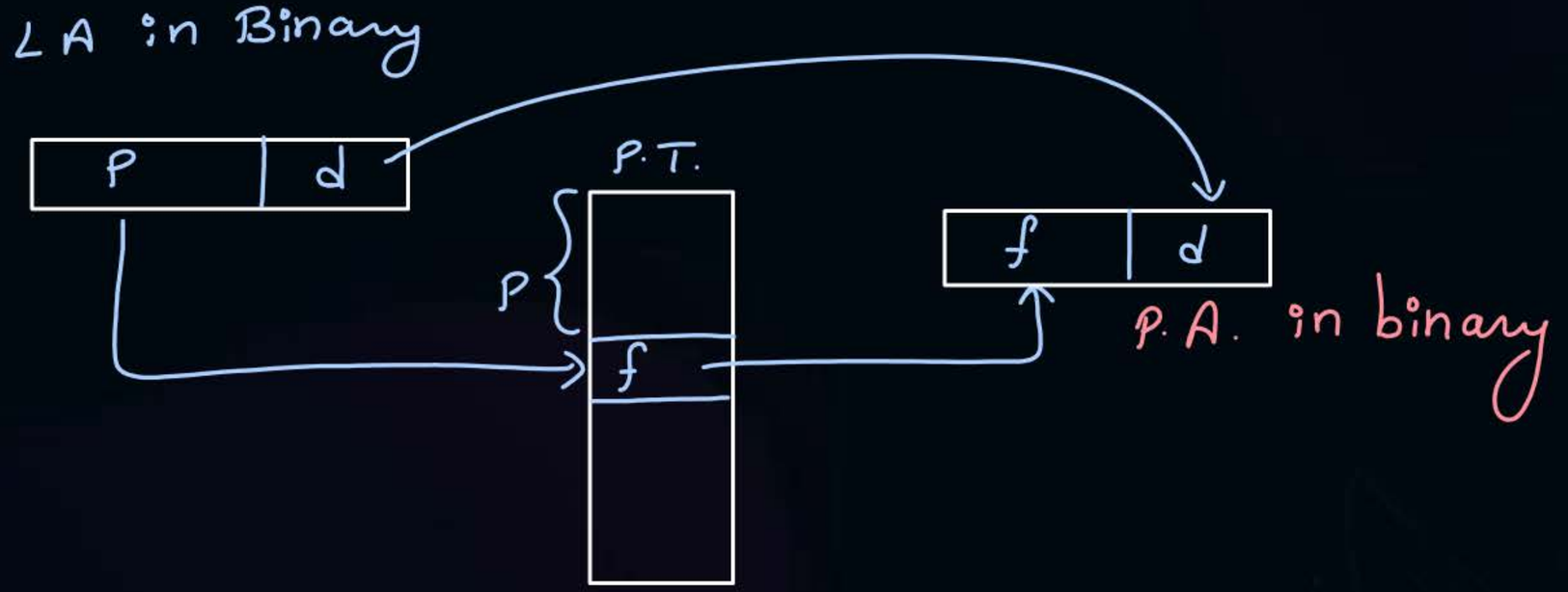
9, 8, 7, 8, 7, 9, 7, 9, 8, 9

Minimum possible number of page faults ? ⇒ 5

↳ optimal

9	9	7	7	8
	8	8	9	9

Topic : LA to PA translation in Decimal Numbers

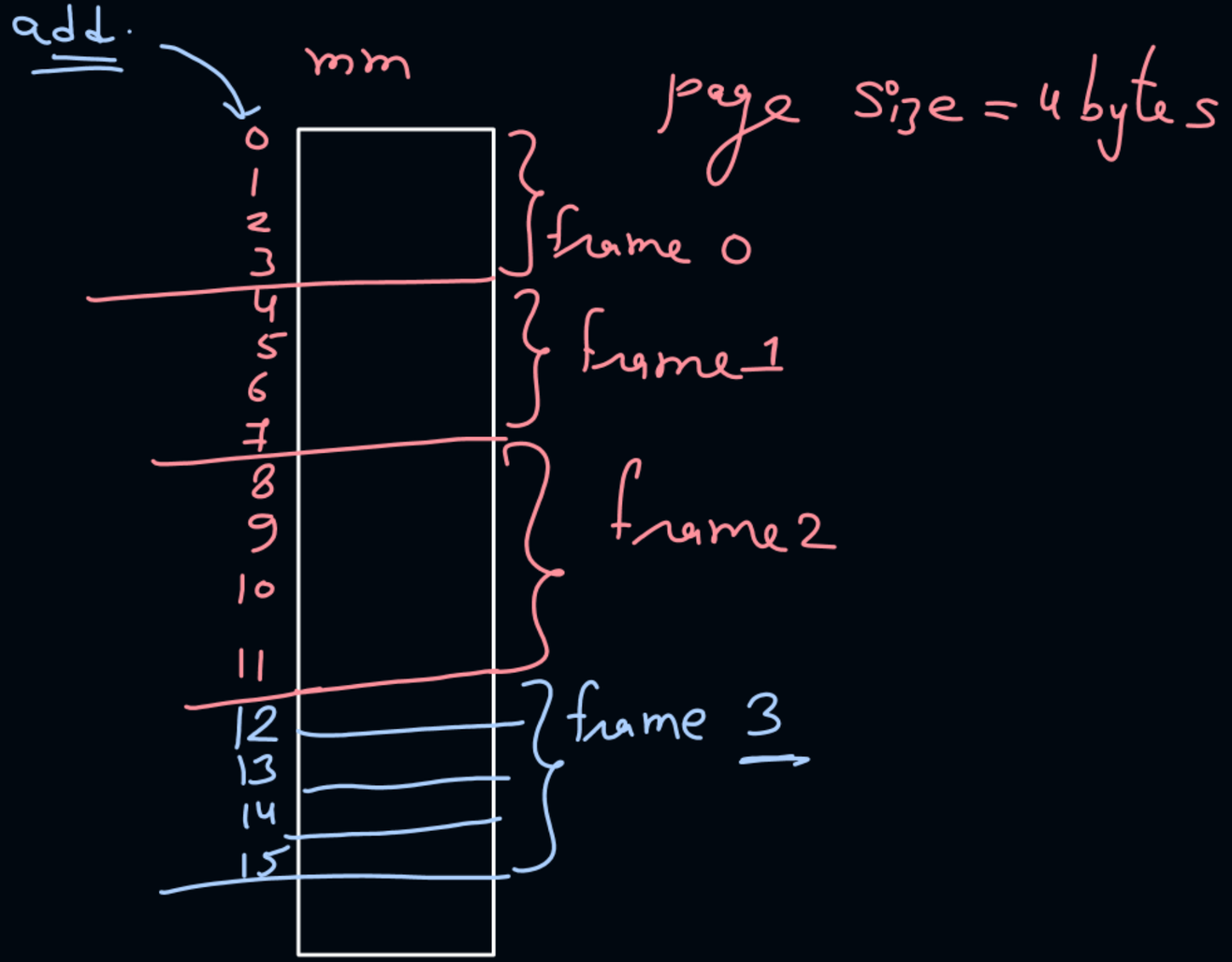


L.A. in decimal

$p = \left\lfloor \frac{L.A.}{\text{Page size}} \right\rfloor$

$d = L.A. \% \text{ page size}$

$PA = (f * \text{page size}) + d$


add.
mm
page size = 4 bytes
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
frame 0
frame 1
frame 2
frame 3

Topic : Question

GATE - 2024

2048 B

#Q. Consider a memory management system that uses a page size of 2KB. Assume that both the physical and virtual addresses start from 0. Assume that the pages 0, 1, 2 and 3 are stored in the page frames 1, 3, 2, and 0 respectively. The physical address (in decimal format) corresponding to the virtual address 2500 (in decimal format) is _____.

V.A. $= (2500)_{10}$

$p = \left\lfloor \frac{2500}{2048} \right\rfloor = 1$

$d = 2500 \% 2048 = 452$

P.T.

0	1
1	3
2	2
3	0

$f = 3$

P.A. $= (3 * 2048) + 452$

$= \underline{6596}$ Ans.

Topic : Frame Allocation

How many frames to be allocated to one process.

Topic : Frame Allocation

- How many frames do we allocate per process?

Topic : Frame Allocation

How many frames do we allocate per process?

- If it is a single-user, single-tasking system, it's simple – all the frames belong to the user's process

Topic : Frame Allocation

2 Questions

- What is the minimum number of frames that a process needs?
- Is page replacement global or local?

Topic : Minimum Number of Frames

Every process must have enough pages to complete an instruction.

Topic : Frame Allocation

1. Equal Allocation → equal no. of frames are allocated to each process.
2. Proportional Allocation
   ↳ no. of frames allocated to a process is proportional to it's size.

ex:- 2 Processes
P1 ⇒ 12 Pages
P2 ⇒ 8 Pages

Total ⇒ 12 frames

equal

P1 ⇒ 6 frames
P2 ⇒ 6 frames

Proportional

$P1 = \frac{12}{12+8} * 12 \text{ frames} \cong 7 \text{ frames}$

$P2 = \frac{8}{12+8} * 12 \text{ frames} \cong 5 \text{ frames}$

Topic : Local Vs Global Allocation

for a page fault service the faulted page will replace page of same process.

for a page fault of a process P1, service can replace the page of another process also.

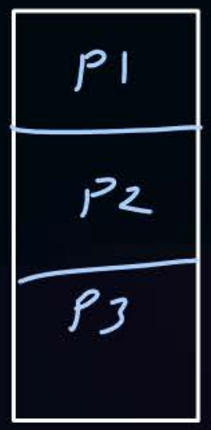
Topic : Local Allocation

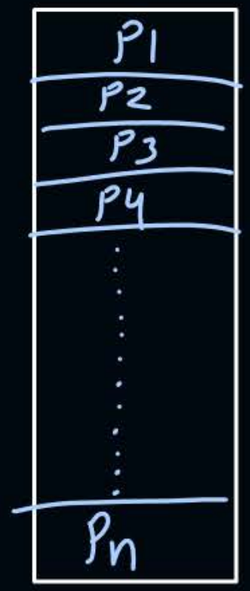
1. Local replacement requires that the page being replaced be in a frame belonging to the same process
2. The number of frames belonging to the process will not change
3. This allows processes to control their own page fault rate

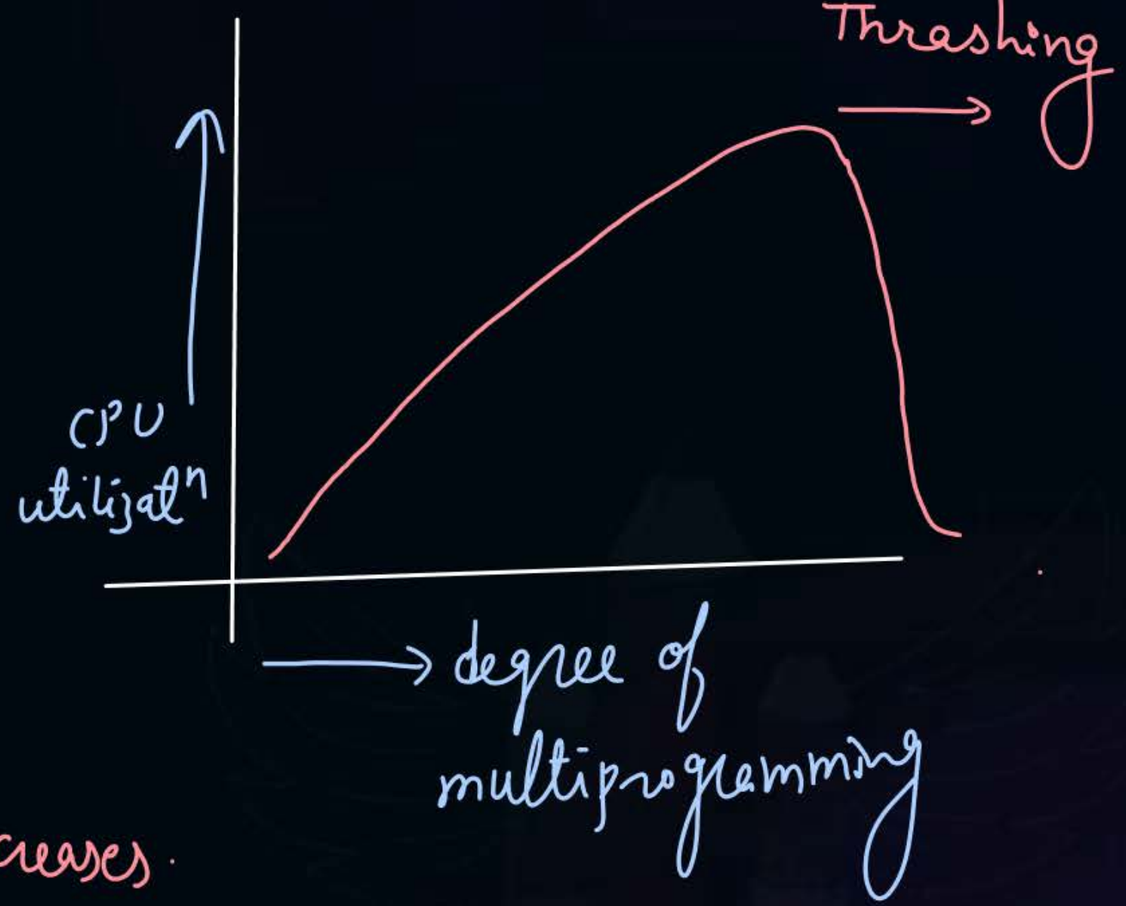
Topic : Global Allocation

1. The process can replace a page from a set that includes all the frames allocated to user processes
2. High-priority processes can increase their allocation at the expense of lower-priority processes
3. Global allocation makes for more efficient use of frames and their better throughput

Topic : Thrashing







when CPU spends more time on page fault service as compared to process execut^n; CPU utilizat^n decreases.

Topic : How to Handle Thrashing

Topic : Locality Model

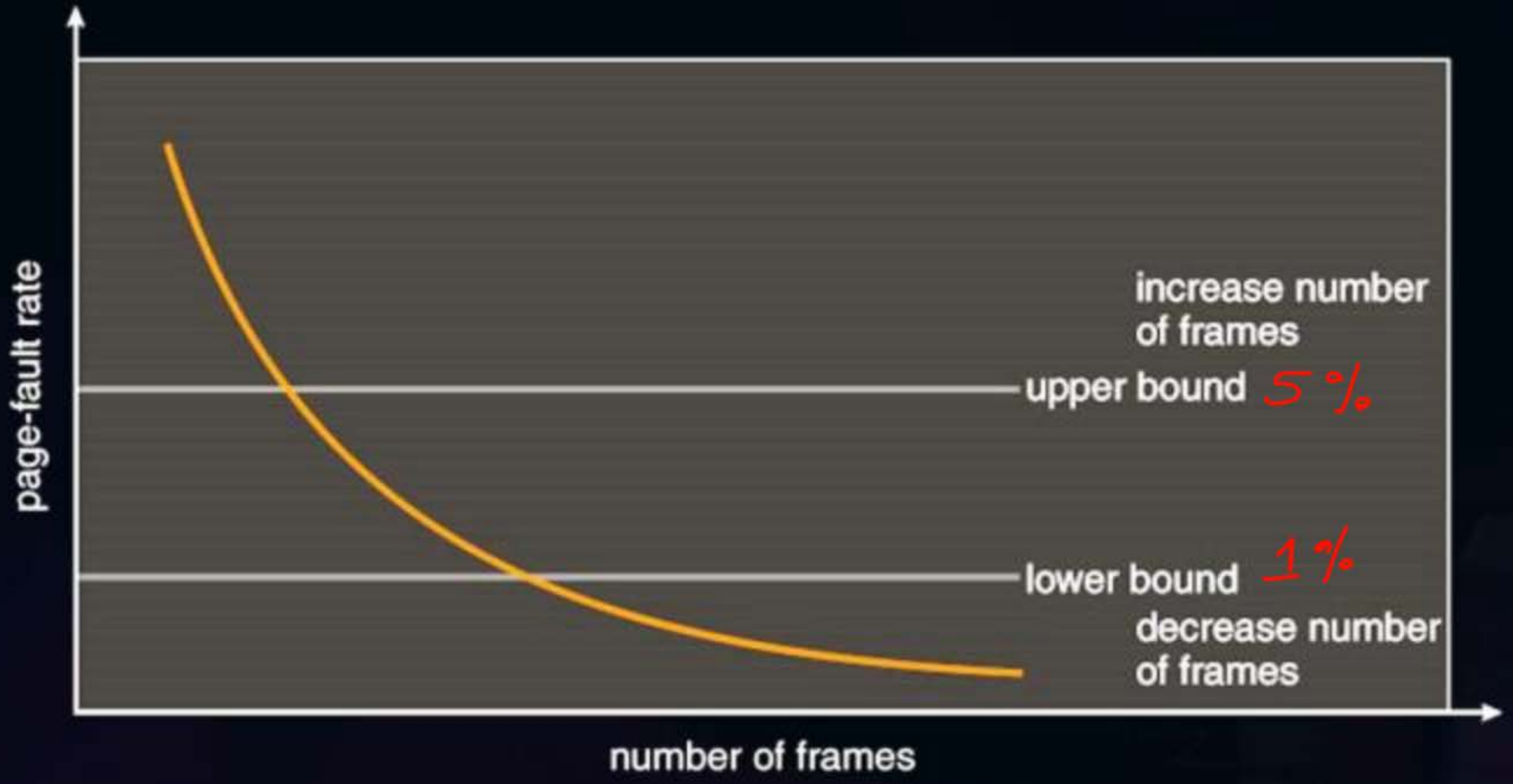
1. Working Set Model
2. Page Fault Frequency

Topic : Working Set

min. no. of pages to run process smoothly.

to run each process if it's current working set is in the memory then there will not be many page faults. ⇒ hence no thrashing

Topic : Page Fault Frequency



Topic : Let's Take a Simple Example

L.A.S.

Process Size = 32B

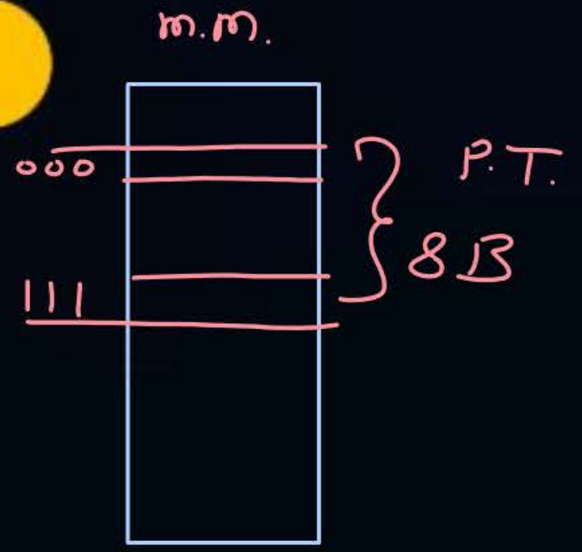
Page size = 4B

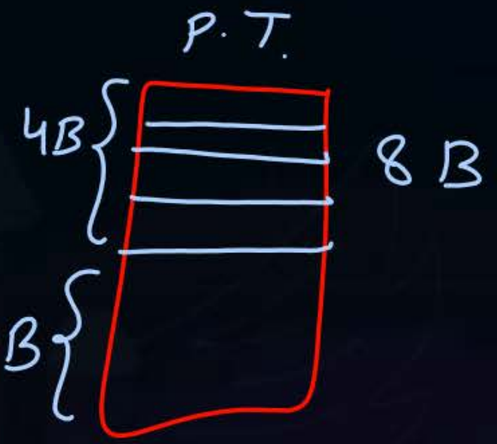
Page table entry size = 1B

Page Table Size = ?

$$\text{no. of pages} = \frac{32B}{4B} = 8$$

Page table size = 8 * 1B = 8 Bytes





when P.T. size is very large, then to store entire P.T. into mm together becomes difficult.

soln ⇓

Divide P.T. also into pages; distribute page table pages also on frames and keep only demanded P.T. pages into mm to utilise mm space.

Topic : Page Table in Memory

8 Pages

Process
Page 000
Page 001
Page 010
Page 011
Page 100
Page 101
Page 110
Page 111

	Page Table
000	0101
001	1000
010	0100
011	1100
100	1010
101	0001
110	1111
111	0010

P.T. divided into 2 pages

outer P.T. (P.T. of P.T.)

0	0011
1	1001

000	0101
001	1000
010	0100
011	1100

PT Page 0

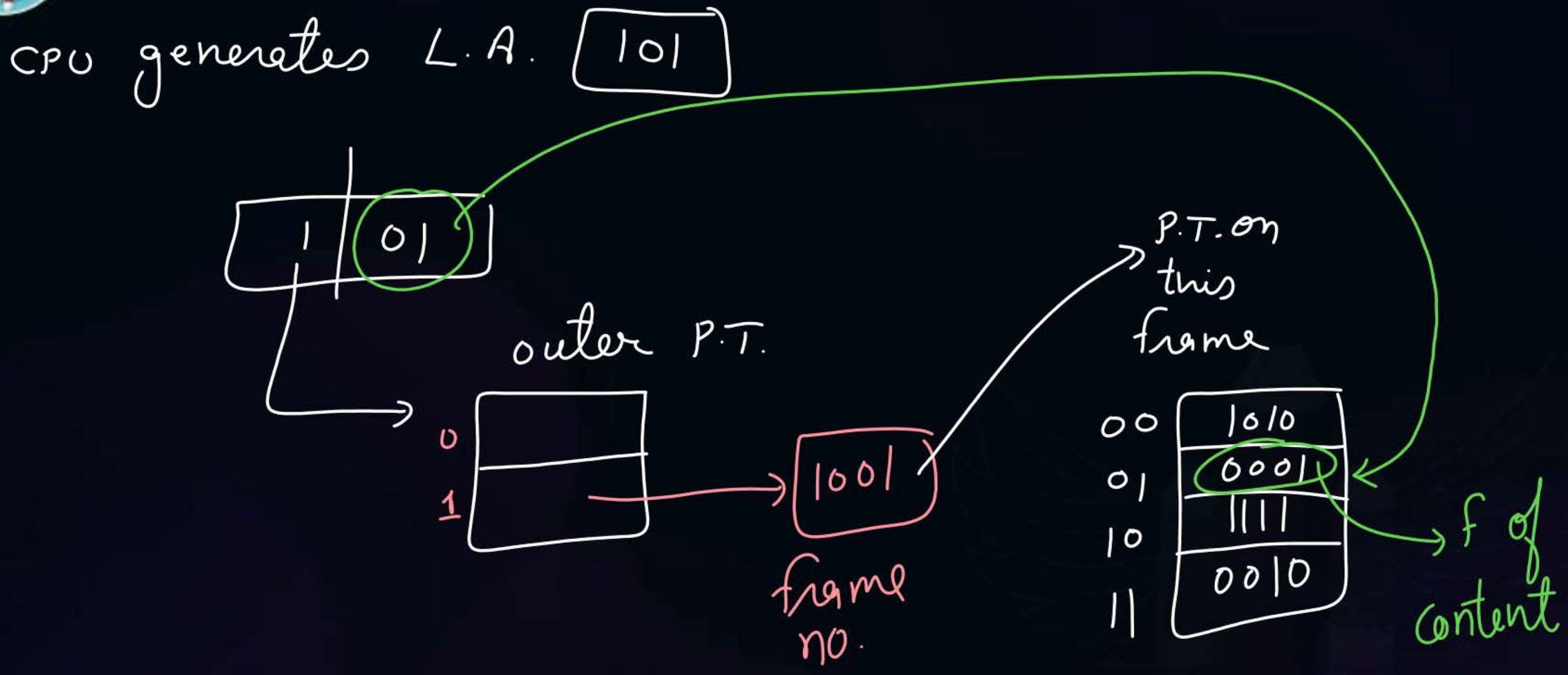
100	1010
101	0001
110	1111
111	0010

P.T. Page 1

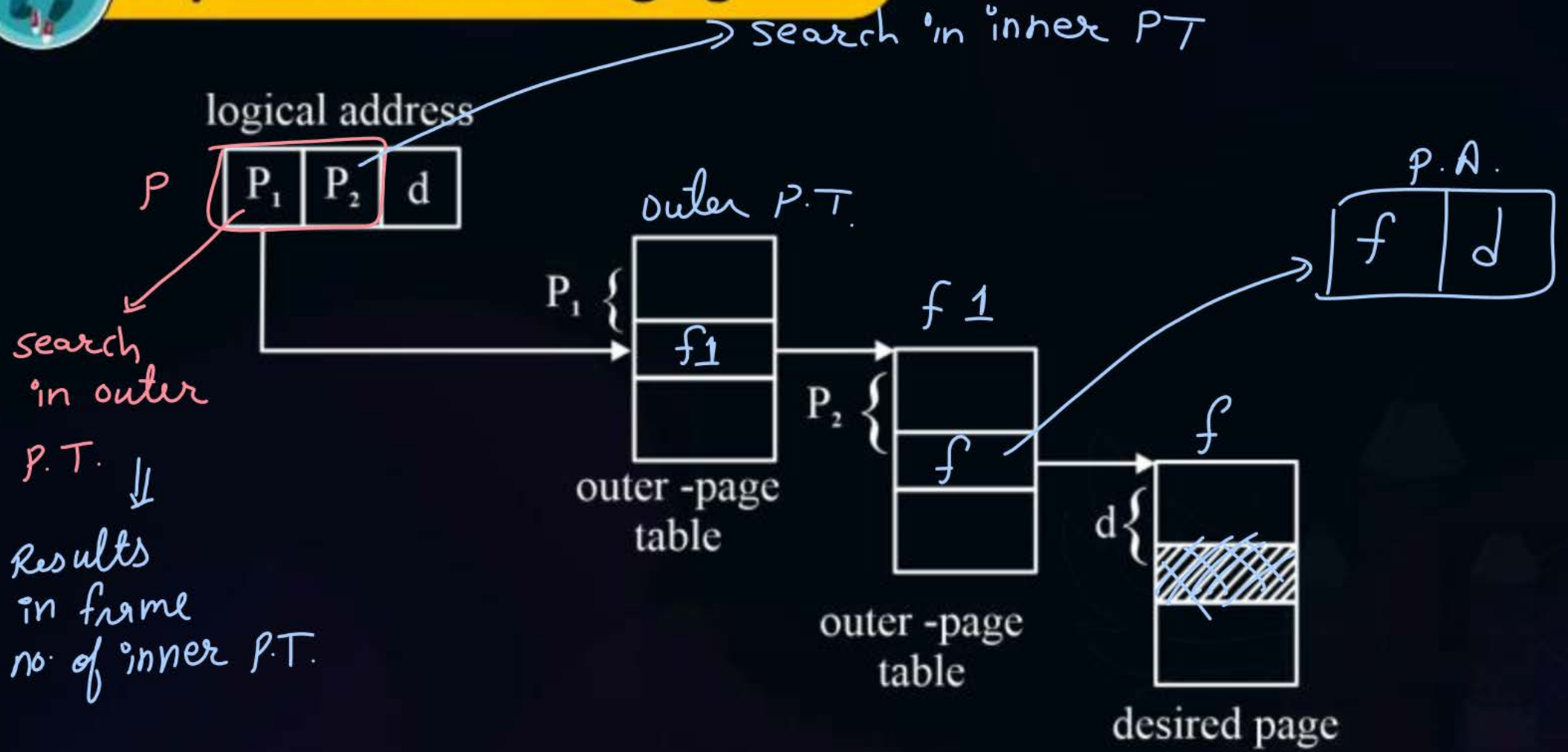
mm 16 frames

0000	
0001	Page 101
0010	Page 111
0011	P.T. Page 0
0100	Page 010
0101	Page 000
0110	
0111	
1000	Page 001
1001	P.T. Page 1
1010	Page 100
1011	
1100	Page 011
1101	
1110	
1111	Page 110

Topic : Multilevel Paging



Topic : Multilevel Paging



2 mins Summary

Topic Frame Allocation

Topic Thrashing

Topic Multilevel Paging

Happy Learning

THANK - YOU