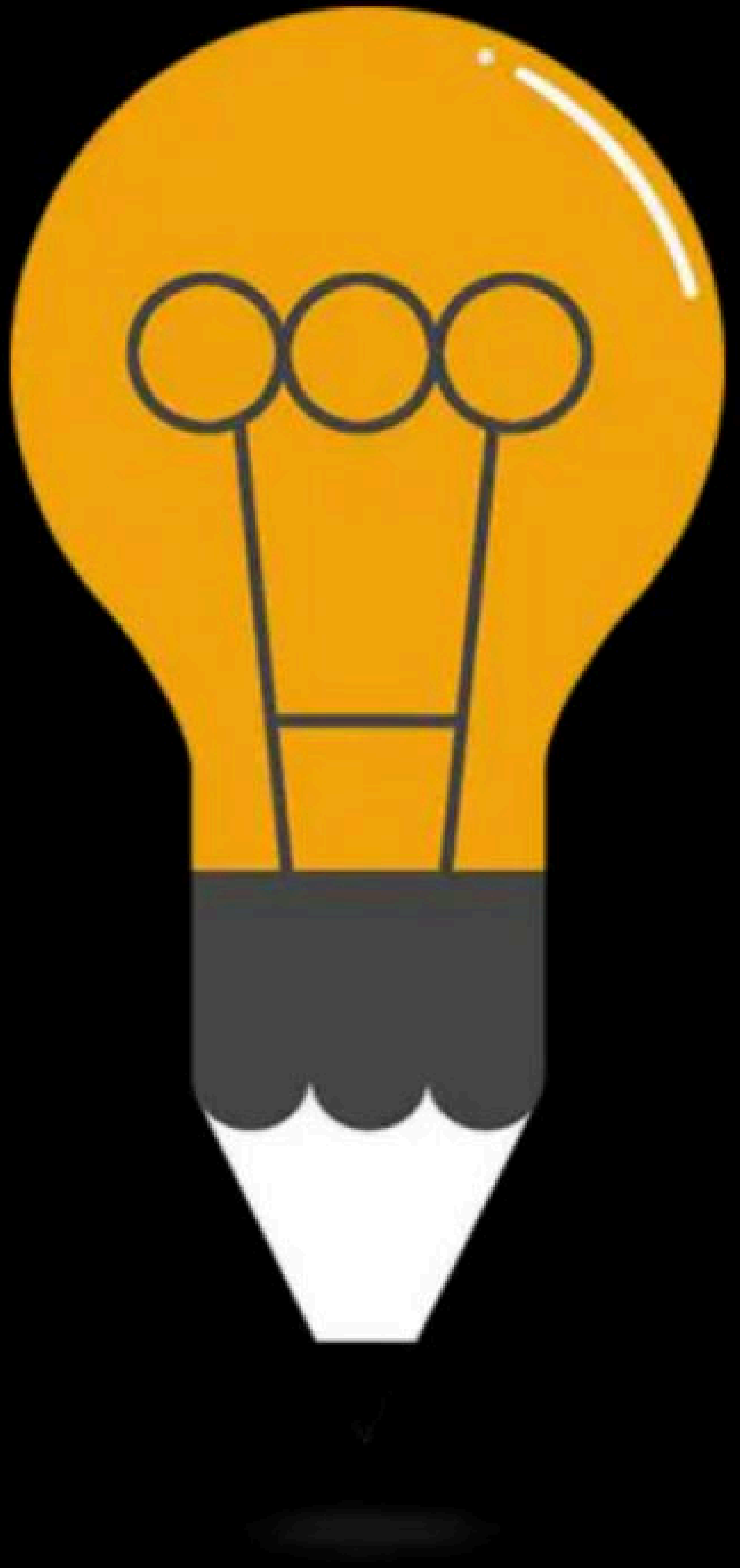
Segmentation & Virtual Memory

Comprehensive Course on Operating System for GATE - 2024/25

Vishvadeep Gothi • Lesson 30 • May 23, 2023



Operating System
Virtual Memory

By: Vishvadeep Gothi

Virtual Memory

- Feature of OS
- Enables to run larger process with smaller available memory

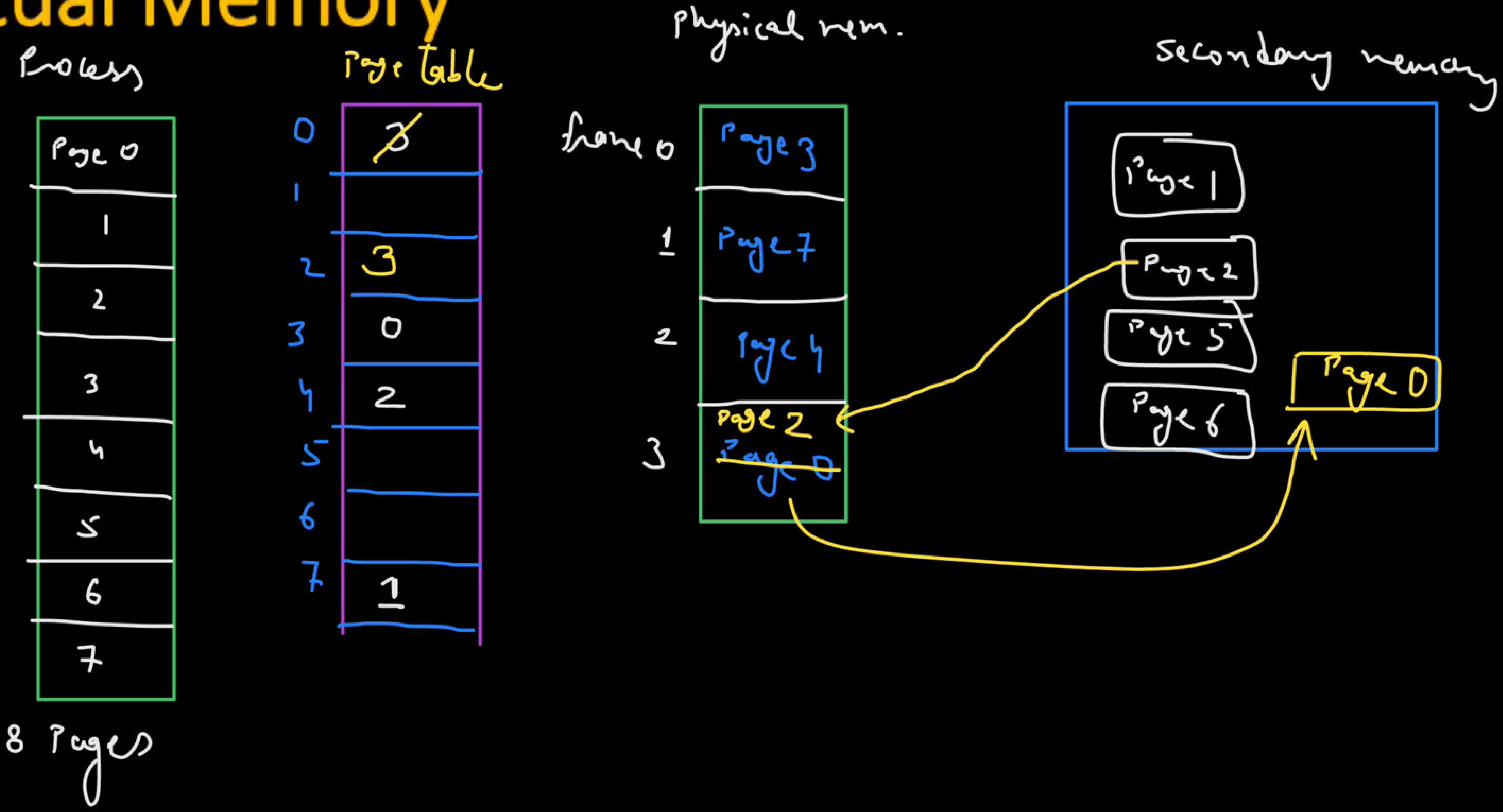
→ A few pages of process kept in mm, and rest in secondary memory.

→ The pages which are in sec. mem., are brought into mm. on demand.

→ Page hit ⇒ If CPU's demanded page is available in m.m.

→ Page fault ⇒ If demanded page is not available in mm.

Virtual Memory



Demand Paging

Demand Paging:
Bring pages in memory when CPU demands

Page Fault:
When the demanded page is not available in physical memory

Demand paging

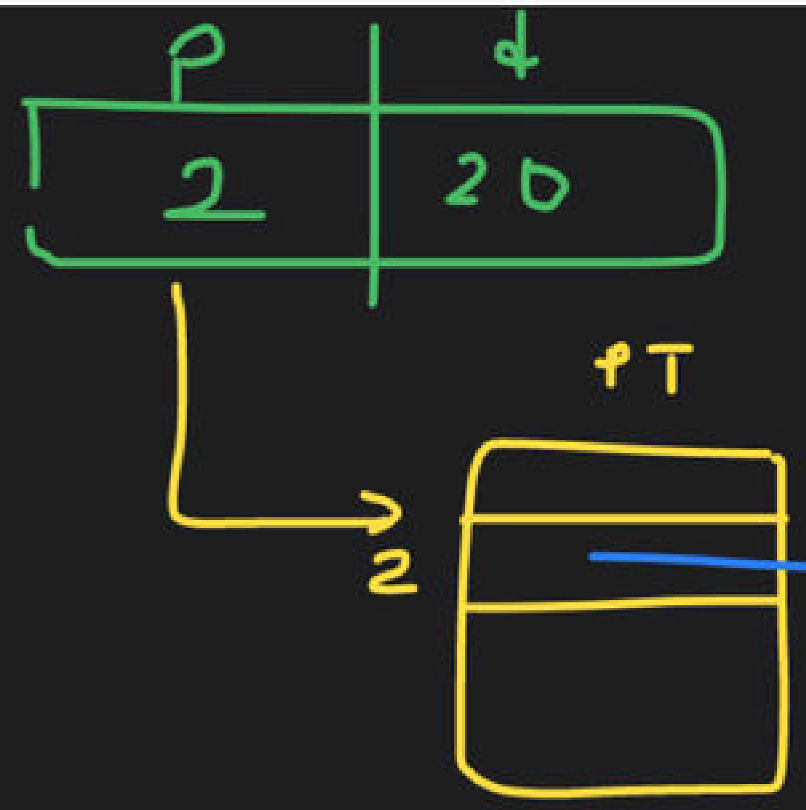
when a process arrives, a few pages are kept into mm. & rest are brought to mm on demand.

pure demand paging

when a process arrives, all its pages will be in sec. mem.

⇒ Initially all frames are empty.

CPU generates L.A.



page fault

OS performs page fault service

OS brings faulted page into mm. & update page table

if a frame is free then keep new page into it.
or else replace a page & bring new page on place of it.

when page fault occurs during an instructⁿ execution :-

→ An internal interrupt generated for OS. (system call)

→ OS performs page fault service.

→ The instⁿ which caused page fault, will restart again.
& this time it will find the content in mm.

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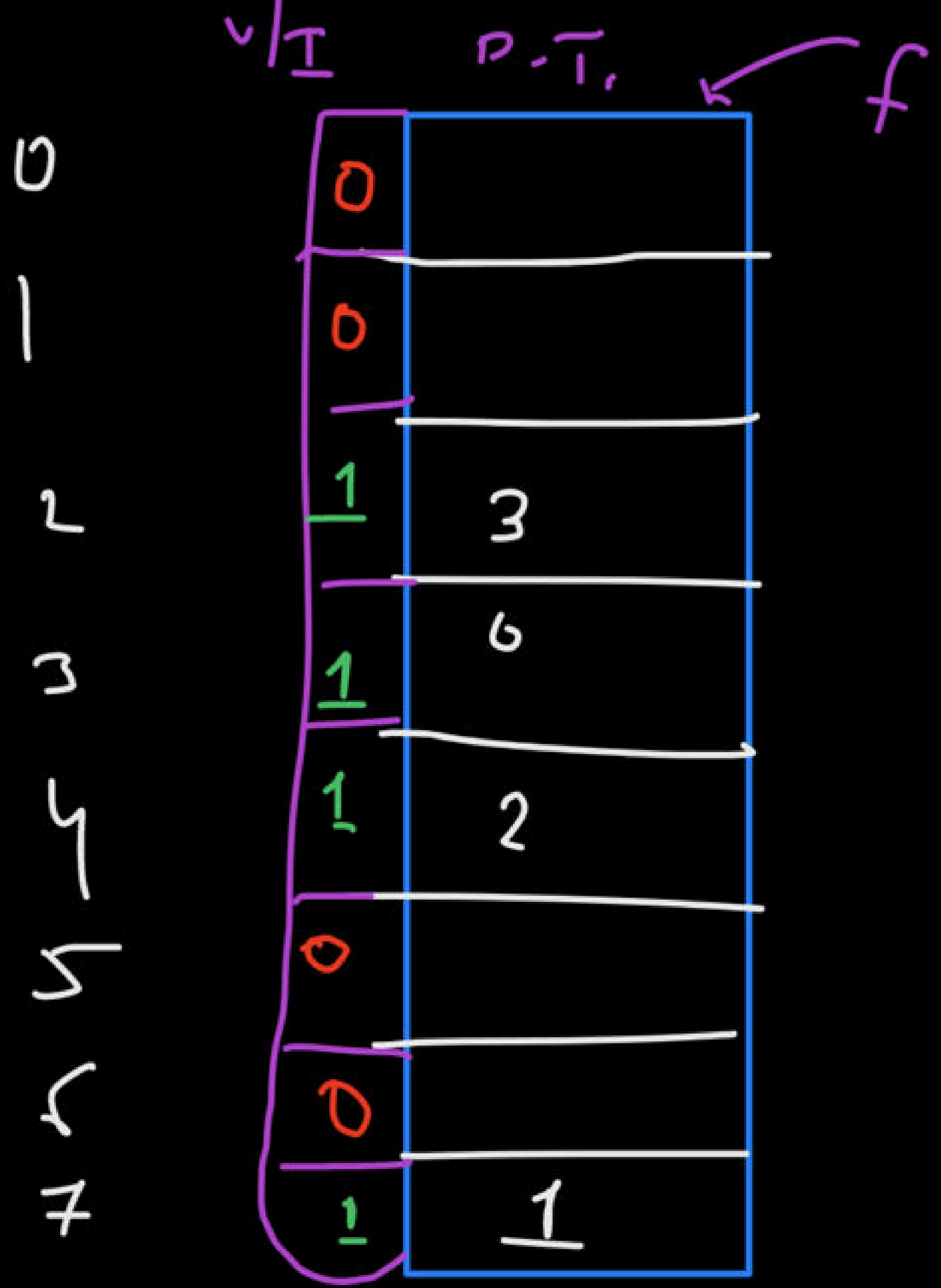
page fault service ⇒ copy page from sec. mem (I/O device)
to mm.
⇓
service of DMA needed

Time needed to service page fault ⇒ page fault service time

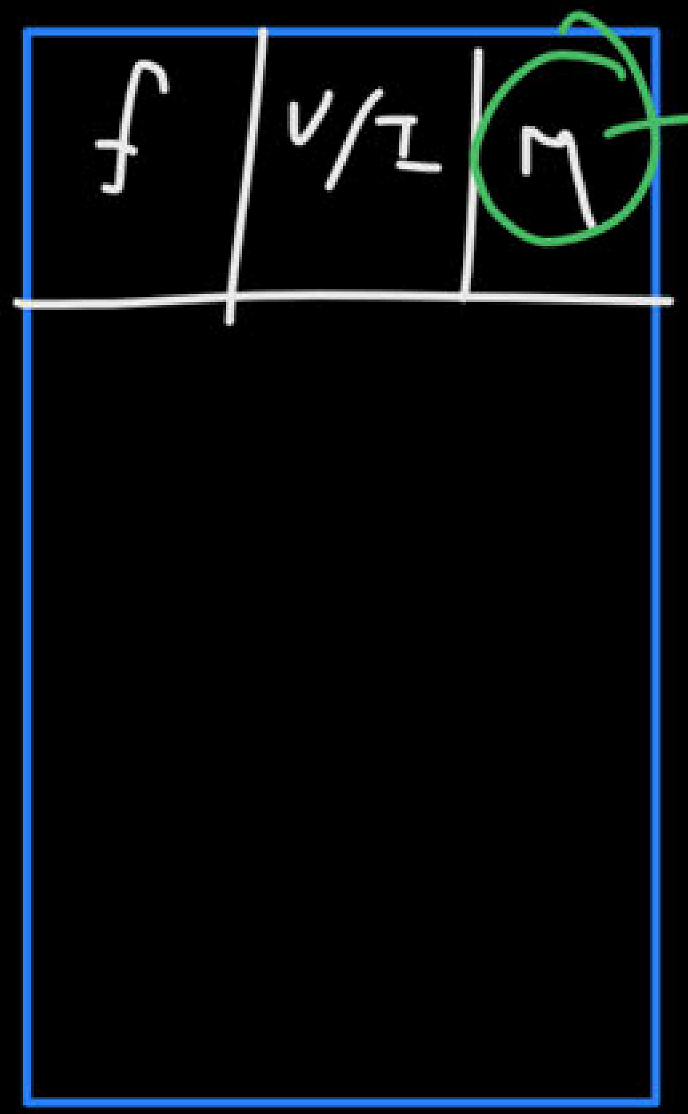
How to Ensure the Page hit or fault?



V/I { 0 Page not available in mm
V/I { 1 Page in mm

Page Swap Time Saving

for each page entry in P.T., a dirty bit is maintained



modified or dirty bit
- 0 page not dirty
- 1 page dirty

while replacing a page from mm, only dirty pages are written back to sec. mem.

Page Swap Time Saving

Dirty page means ⇒ CPU performed write operation into that page.

Page fault service time = If no empty frame then run replacement algo + check dirty bit of selected victim page, if dirty then write back to sec. mem. + copy faulted page from sec. mem. to m.m.

+ update page-table

Effective Memory Access Time

$p \Rightarrow$ page fault rate

$(1-p) \Rightarrow$ page hit rate

E.M.A.T. $= (1-p) *$ time required when page hit $+ p *$ time required when page fault

$$E.M.A.T. = \underbrace{(1-p) * (2 * t_{mm})}_{\text{one for P.T. \& one for content}} + p * (t_{mm} + \text{page fault service time})$$

t_{mm}: to check in P.T. for fault

Ques) Consider a demand paging system in which page fault rate is 5 %. When there is a page fault then a memory access takes 5000 nsec, but when there is a page hit a mem. access takes 50 nsec.

E.M.A.T. = ?

Sol^n

$$= (1 - 0.05) * 50 \text{ nsec} + 0.05 * 5000 \text{ nsec}$$

$$= 297.5 \text{ nsec}$$

Ques) $t_{mm} = 100\,nsec$

$p = 2\%$

p.f. service time = 10000 nsec

E.M.A.T. = ?

Soln:-

$$EMAT = 0.98 * 2 * 100\,nsec + 0.02 * (100 + 10000)$$

$$= 398\,nsec$$

TLB & virtual memory :-

CPU generates L.A.

↓

search in TLB

Hit

P. A.

↓

goto mm & access content

miss

search P.T. in mm

page fault

page fault service

page hit

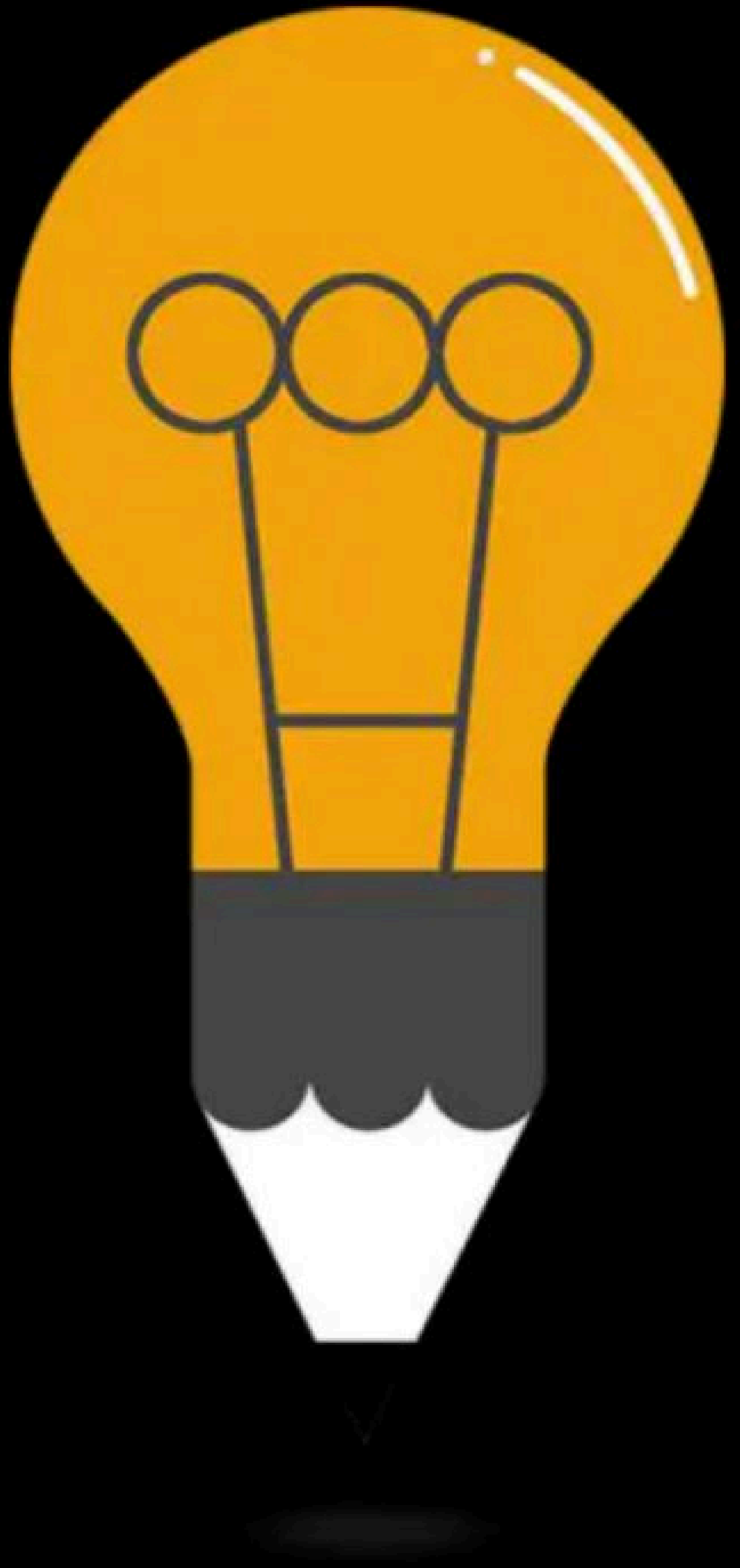
P.A.

goto page in mm & access content

$$E.M.A.T. = H * (t_{TLB} + t_{mm}) +$$

$$(1-H)\Big[(1-p) * (\underbrace{t_{TLB}}_{\text{To search in TLB}} + \underbrace{t_{mm}}_{\text{for P.T.}} + \underbrace{t_{mm}}_{\text{for content}}) +$$

$$p * (t_{TLB} + t_{mm} + \text{page fault service time})\Big]$$



DPP

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Question 1

When a program tries to access a page that is mapped in address space but not loaded in physical memory, then _____________?

a) segmentation fault occurs
b) fatal error occurs
c) page fault occurs
d) no error occurs

Question 2

Effective access time is directly proportional to ____________

a) page-fault rate
b) hit ratio
c) memory access time
d) none of the mentioned

Question 3

It is advantageous for the page size to be large because:

(A) Less unreferenced data will be loaded into memory

(B) Virtual address will be smaller

(C) Page table will be smaller

(D) Large program can be run

Question 4

It is advantageous for the page size to be small because:

(A) Less unreferenced data will be loaded into memory
(B) Virtual address will be smaller
(C) Page table will be smaller
(D) Large program can be run

Question 5

A demand paged memory environment has physical memory access time of 50 microseconds and page fault service time of 10 milliseconds. If the page fault rate is 5% then the effective memory access time is ______ microseconds?

Question 6

A demand paged memory environment has physical memory access time of 50 microseconds and page fault service time of 5000 microseconds if the replaced page is not dirty. The page fault service time of 100 milliseconds if a dirty page is replaced. Assume that among all pages which are getting replaced, only 2% are dirty, and 95% page hit ratio then the effective memory access time is ______ microseconds?

Happy Learning.!