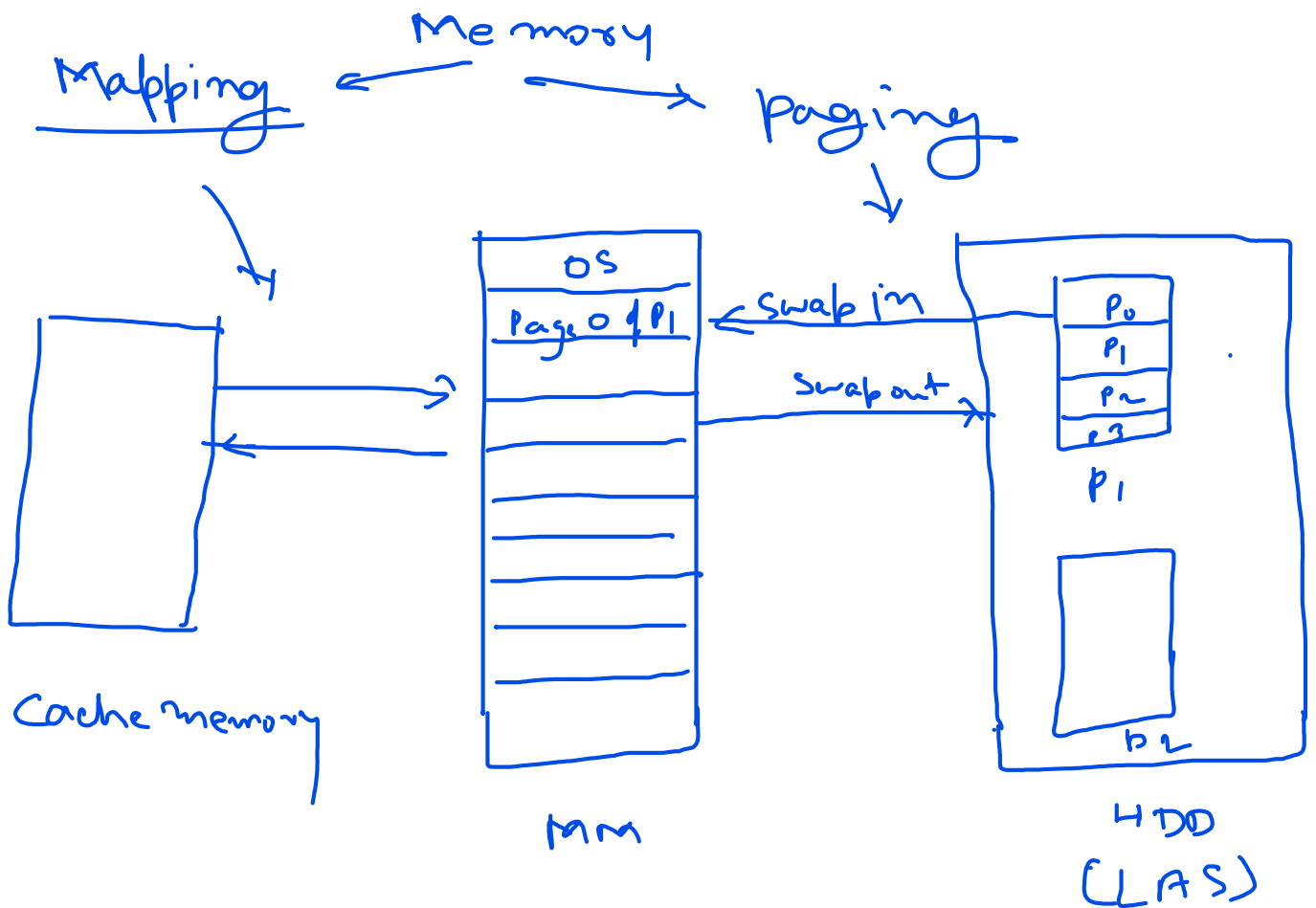
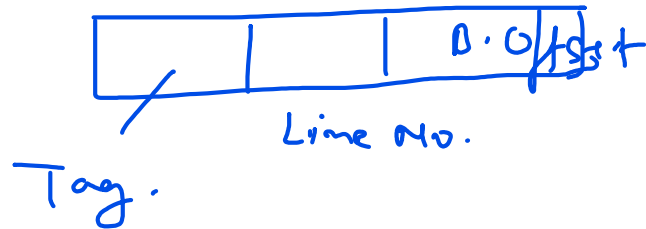


$$\begin{array}{r}
 1047 \\
 - 743 \\
 \hline
 304 \\
 + 753 \\
 \hline
 1057
 \end{array}
 \left. \vphantom{\begin{array}{r} 1047 \\ - 743 \\ \hline 304 \\ + 753 \\ \hline 1057 \end{array}} \right\} \begin{array}{l} P_0 \\ \checkmark \end{array}$$

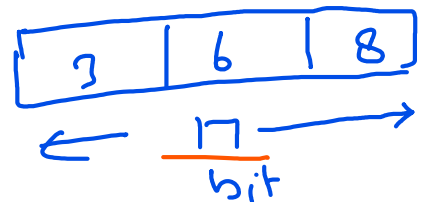


- Direct mapping



M.M	CS	BS	Tag	Tag Directory Size
128 KB	16 KB	256 B	3	3×2^6
32 GB	32 KB	1 KB	—	—

① $MM = 128 \text{ KB}$
 $= 2^7 \times 2^{10} = 2^{17}$



No. of line $\Rightarrow \frac{CS}{BS} = \frac{16 \text{ KB}}{256 \text{ B}}$

$= \frac{16 \times 2^{10}}{2^8 \times 8} = 2^4 \times 2^2 = 2^6$
 $\Rightarrow 6 \text{ bit}$

$$\text{No. of blocks} \Rightarrow \frac{256 \text{ B}}{2 \text{ B}} = 2^8 \Rightarrow 8 \text{ bit}$$

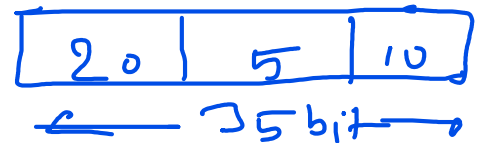
$$\Rightarrow \frac{15}{\text{word}} \because 1 \text{ word} = 10$$

$$\text{Tag} = 17 - (8 + 6) = 3 \text{ bit}$$

$$\text{Tag DS} \Rightarrow \text{Tag bit} \times \text{No. of line} \Rightarrow 3 \times 2^6$$

$$\textcircled{2} \text{ Mm} = 32 \text{ GB} = 2^5 \times 2^{30} = 2^{35} \Rightarrow 35 \text{ bit}$$

$$\text{No. of offset} = \frac{15}{w} = \frac{1 \text{ KB}}{8} = 2^{10} \Rightarrow 10 \text{ bit}$$



$$\text{No. of line} = \frac{CS}{BS} = \frac{32 \text{ KB}}{1 \text{ KB}} = 2^5 \Rightarrow 5 \text{ bit}$$

$$\text{Tag} = 35 - (10 + 5) = 20 \text{ bit}$$

$$\text{Tag DS} \Rightarrow 20 \times 2^5$$

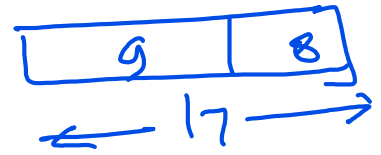
Associative mapping



Ex $mm = 128KB \Rightarrow 2^7 \times 2^{10} = 2^{17} \Rightarrow 17 \text{ bit}$
 $CS = 16KB$
 $BS = 256B$

Tag = ? $\Rightarrow 9$

Tag Dis = ?



No. of offsets $\frac{256B}{1B} = 2^8$

line = $\frac{16KB}{256B} = 2^6$

TDS = $2^6 \times 9$

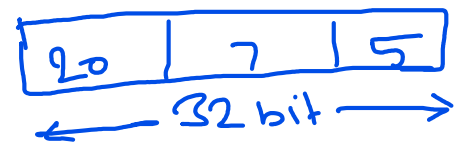
Set associative mapping



Ex - 4-way set associative mapping

$mm = 4GB = 2^2 \times 2^{30} = 2^{32} \Rightarrow 32 \text{ bit}$
 $CS = 16KB$

$BS = 32B = 8 \times 32 = 32B$
 $1B = 32 \text{ bit}$



$\Rightarrow \text{offset} = BS = 32B$

$= 2^5 \Rightarrow (5 \text{ bit})$

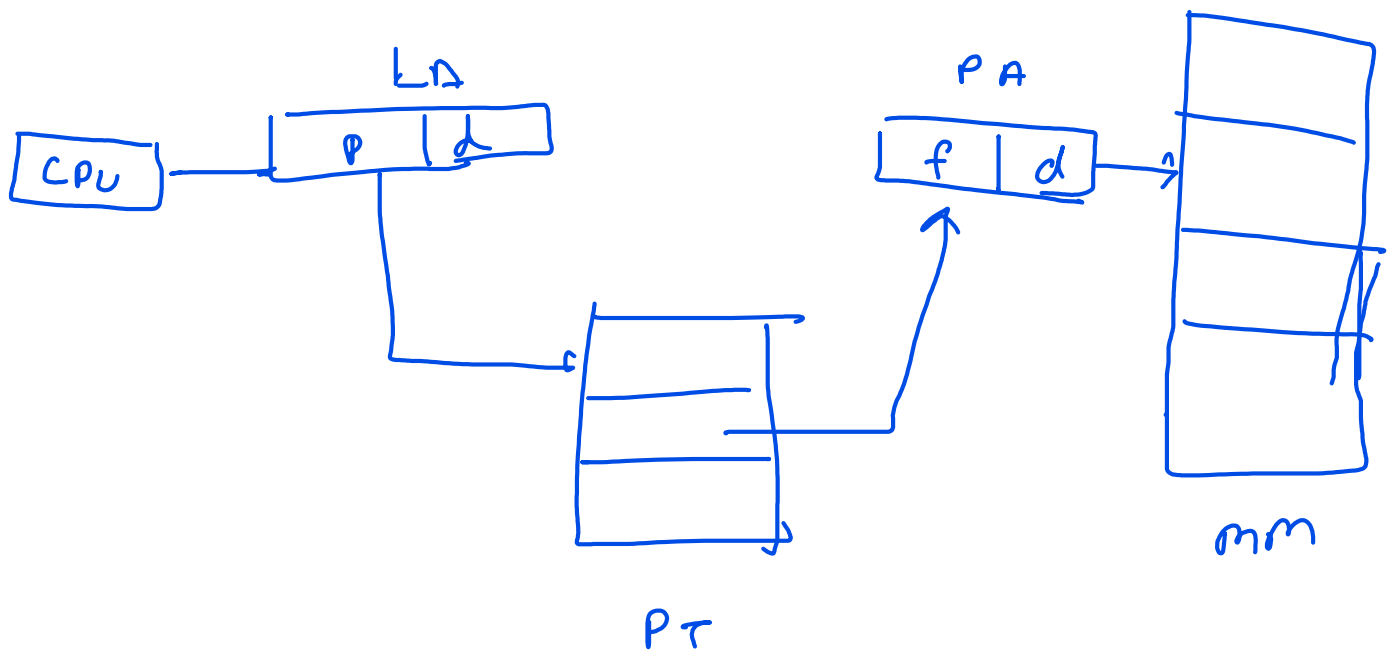
No. of Line = $\frac{CS}{BS} = \frac{16KB}{32B} = \frac{2^4 \times 2^{10}}{2^5} = 2^9$

$$\text{Set bit} = \frac{\text{No. of line}}{N\text{-way}}$$

$$= \frac{2^9}{4} = 2^7 \Rightarrow 7 \text{ bit}$$

$$\text{Tag} = 32 - (5 + 7) = 20 \text{ bit}$$

Paging



Ex

LA = 32 bit

PS = 4 KB

Page table entries = 4 byte each

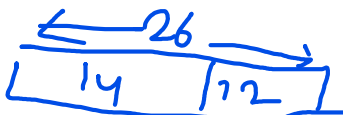
Size of Page table = ?

Offset $\Rightarrow ?$

$$\frac{PS}{\text{size of each entry}} = \frac{41 \text{ MB}}{1 \text{ B}} = 2^2 \times 2^{10} = 2^{12}$$

$\Rightarrow 12 \text{ bit} \Rightarrow d$

$PA \Rightarrow ?$



mm = 64 MB

$$= 2^6 \times 2^{20} = 2^{26} \Rightarrow 26 \text{ bit}$$

frame bit = $26 - 12 = 14 \text{ bit}$

Page bit = $32 - 12 = 20 \text{ bit}$

LA $\Rightarrow$

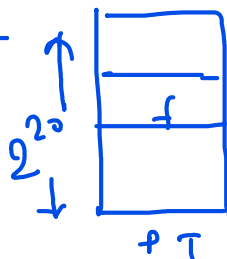


$\leftarrow 32 \text{ bit} \rightarrow$

in the page table

frame = 14 bit

$\Rightarrow 2^B$



entries = $2^{\text{Page No.}} \Rightarrow 2^P$

$= 2^{20}$

page table size = $2^{20} \times 2^B$

$= 1 \text{ MB} \times 2^B$

$= 2 \text{ MB}$

Ex $mm = 256mm = 2^8 \times 2^{20} = 2^{28} \Rightarrow$

16	12
----	----

 $\leftarrow 28 \rightarrow$

$PS = 4KB = 2^2 \times 2^{10} = 2^{12} \Rightarrow$

$LA = 40bit$

28	12
----	----

 $\leftarrow 40 \rightarrow$

$P = 28bit$

Process Size = 4MB

Size of Page table = ?

= No. of Page $\times$ Size of each Entry

= 1KB $\times$ 2B

= 2KB

Size of each entries

= 16 bit

= 2B

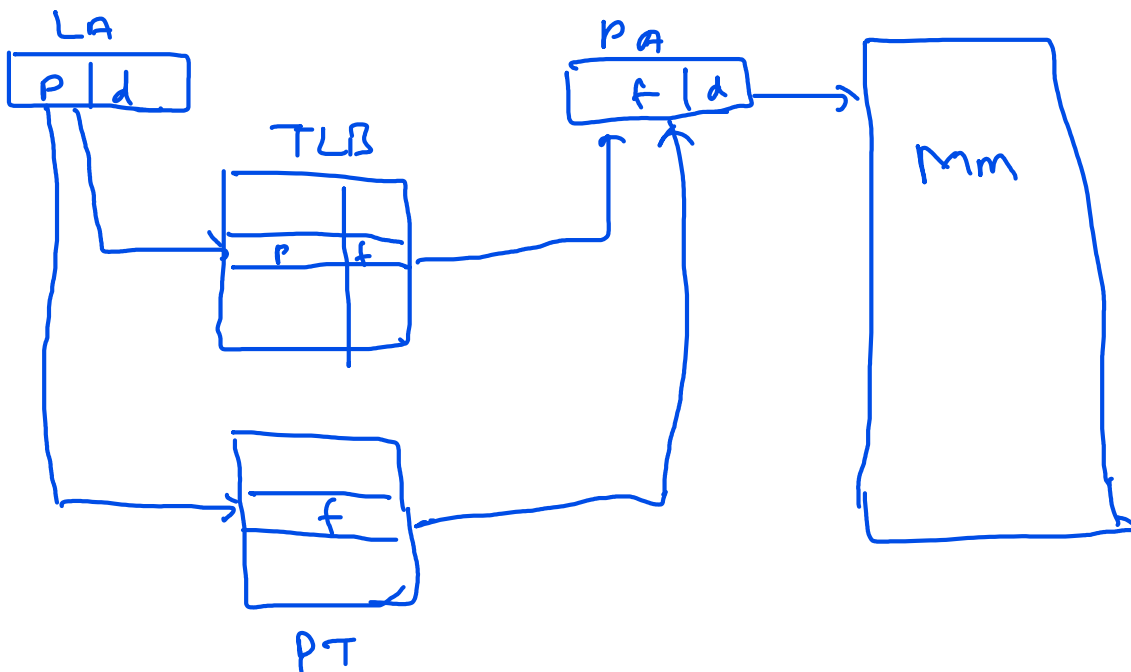
No. of Page = $\frac{\text{Process Size}}{PS}$

= $\frac{4MB}{4KB}$

= $\frac{4 \times 2^{20}}{4 \times 2^{10}} = 2^{10}$

= 1KB

Memory Access Time -



$$MAT = h(TLB + mm) + (1-h)(TLB + mm + mm)$$

Ex $mm = 400 \mu s$

$$TLB = 50 \mu s$$

$$h = 90\%$$

without using TLB $\Rightarrow$

$$MAT = 2 \times mm$$

$$= 2 \times 400 = 800 \mu s$$

with using TLB $\Rightarrow$

$$0.9(50 + 400) + (1 - 0.9)(50 + 400 + 400)$$

$$= 490 \mu s$$