CS & IT ENGINEERING

COMPUTER ORGANIZATION AND ARCHITECTURE

CACHE Organization

Lecture No.- 01

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Recap of Previous Lecture

Topic Multiple Chips in Single Memory System

Topic DRAM Refresh

Topics to be Covered

Topic Associative Memory

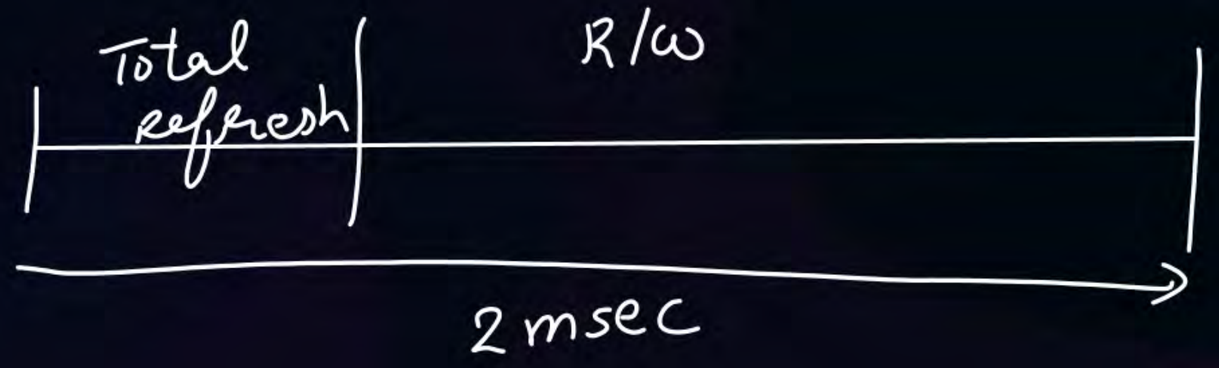
Topic Locality of Reference

Topic Cache Memory

[NAT]

GATE-2018

#Q. A 32-bit wide main memory unit with a capacity of 1 GB is built using 256M X 4-bit DRAM chips. The number of rows of memory cells in the DRAM chip is 2^{14}. The time taken to perform one refresh operation is 50 nanoseconds. The refresh period is 2 milliseconds. The percentage (rounded to the closet integer) of the time available for performing the memory read/write operations in the main memory unit is _____?



Total refresh time $= 2^{14} * 50\ ns$

$= 800 * 2^{10}\ ns$

$2^{10} = 1000$

$= 800\ \mu sec$

$= 0.8\ msec$

$2^{10} = 1024$

$= 819200\ ns$

$= 0.8192\ ms$

% of time Remaining for Read write $= \frac{2 - 0.8}{2} * 100\%$

$= 60\%$

$= \frac{2 - 0.8192}{2} * 100\%$

$= 59\%$

[NAT]

Total cells

$x = 128k$
$y = 2$

#Q. A DRAM chip of 256K×8 bits has x rows of cells with y cells in each row? If DRAM takes 20ns for 1 refresh and 2.56 milliseconds for entire chip refresh then the value of x , y is _____?

$2.56\ ms = x * 20ns$

$x = \frac{2.56 * 10^{-3}\ sec}{20 * 10^{-9}\ sec}$

$= 0.128 * 10^{6}$

$= 128 * 10^{3}$

$= 128K$

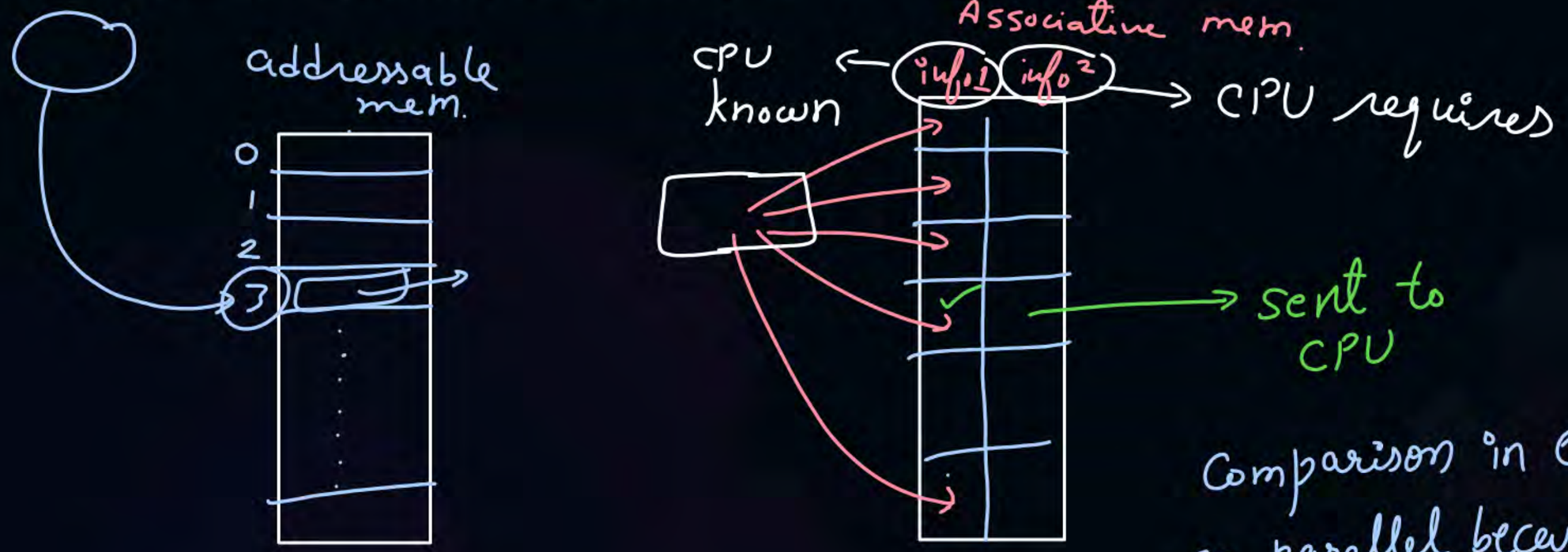
$128k * y = 256k$

$y = 2$

Topic : Associative Memory

↳ in this, cells do not have addresses

Known as content addressable memory also



Comparison in each cell is done in parallel because each cell has it's own comparison H/w.

⇒ mem becomes faster but expensive

⇒ Associative mem. is faster & more expensive as compared to SRAM.

⇒ Associative mem. is used for implementing cache, TLB.

Translation lookaside buffer

Topic : Locality of Reference

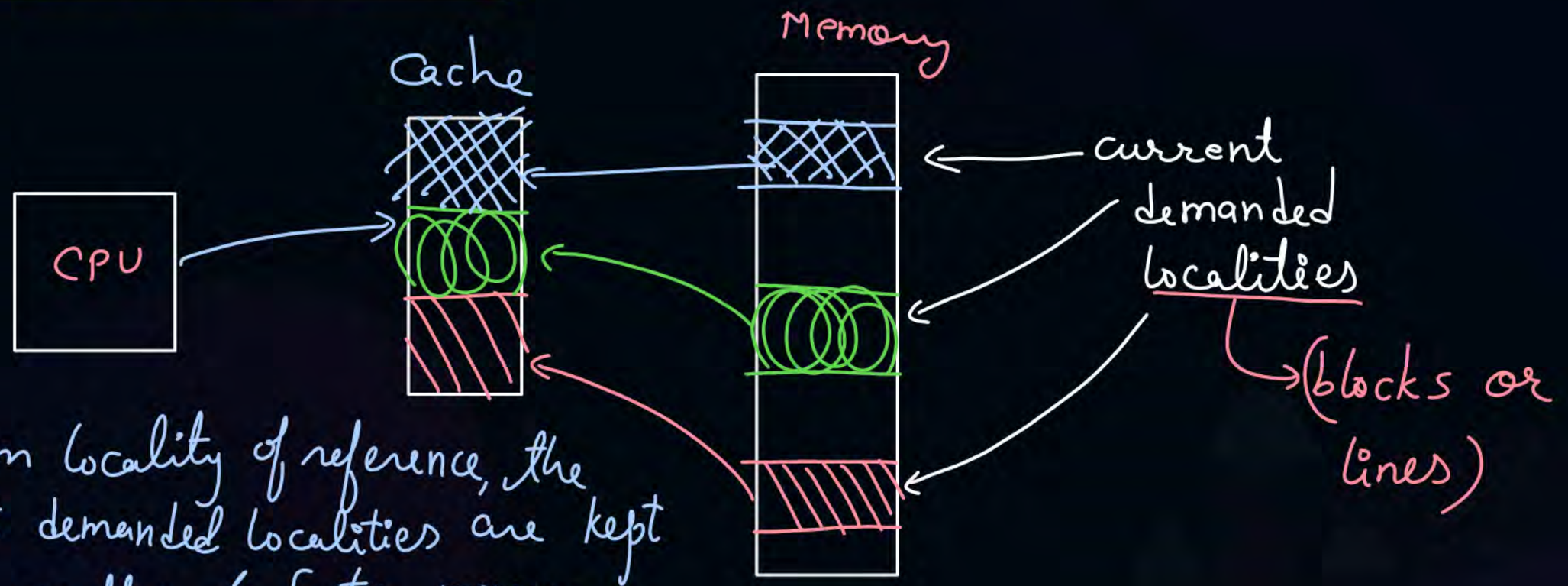
If CPU has requested one address for memory access, then that particular address or near by addresses will be accessed soon.

Topic : Locality of Reference

Types:

1. Spatial (according to space) ⇒ if CPU refers near by addresses soon.
2. Temporal (according to time) ⇒ —11 —— same address soon.

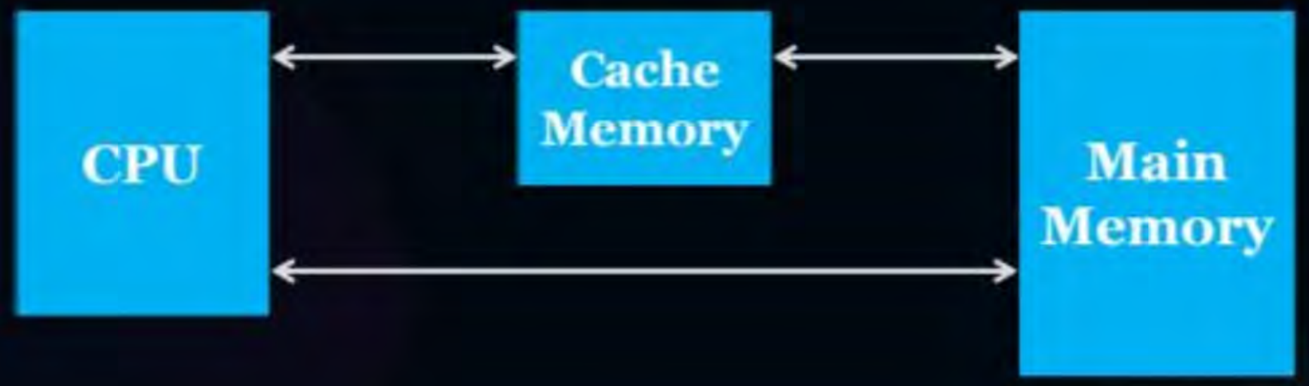
Topic : Cache Memory



Based on locality of reference, the current demanded localities are kept into a smaller & faster memory, called as Cache; to reduce CPU's mem. access time.

Topic : Cache Memory

Use of cache reduces average mem. access time.



Topic : Working of Cache Memory

1. Cache Hit ⇒ when CPU's demanded content is present in cache.
2. Cache Miss ⇒ —— " —— " —— is not —— " ——
3. Hit Ratio

$$\text{Hit ratio } (H \text{ or } h) = \frac{\text{no. of hits in cache}}{\text{Total no. of mem. references}}$$

$$\text{Miss ratio} = \frac{\text{no. of miss in cache}}{\text{Total no. of mem. references}} = (1 - H)$$

when there is a miss in cache (memory read), then demanded content is sent to CPU from main memory and in parallel to that a block (to which missed content belongs) is copied to cache.

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while bringing missed block from mm to cache, if cache does not have empty space then an existing block from cache is replaced.

Topic : Average Memory Access Time

T_{avg} = H * time needed to access content in case of hit + (1 − H) * time needed to access content in case of miss ..... (1)

ex:-

CPU refers mem 200 times

no. of hits = 160

no. of miss = 40

Cache hit time = 20ns

Cache miss time = 100 ns

Total hit time = 160 * 20ns = 3200 ns

Total miss time = 40 * 100 = 4000 ns

Total time = 7200 ns

Avg mem. access = $\frac{7200\ ns}{200\ ns} = 36\ ns$

Hit ratio = $\frac{160}{200} = 0.8$

$T_{avg} = 0.8 * 20 + (1-0.8) * 100$

$= 16 + 20$

$= 36$ nsec

$$\frac{160 * 20 + 40 * 100}{200}$$

$$= \frac{160 * 20}{200} + \frac{40 * 100}{200}$$

$$= 0.8 * 20 + 0.2 * 100$$

Topic : Types of Cache Accesses

Simultaneous Access: (Parallel access)

Request for cache and main-memory are generated simultaneously

$$T_{avg} = H * t_{cm} + (1-H)\, t_{mm} \quad \text{.....---(2)}$$

H = Hit ratio of cache

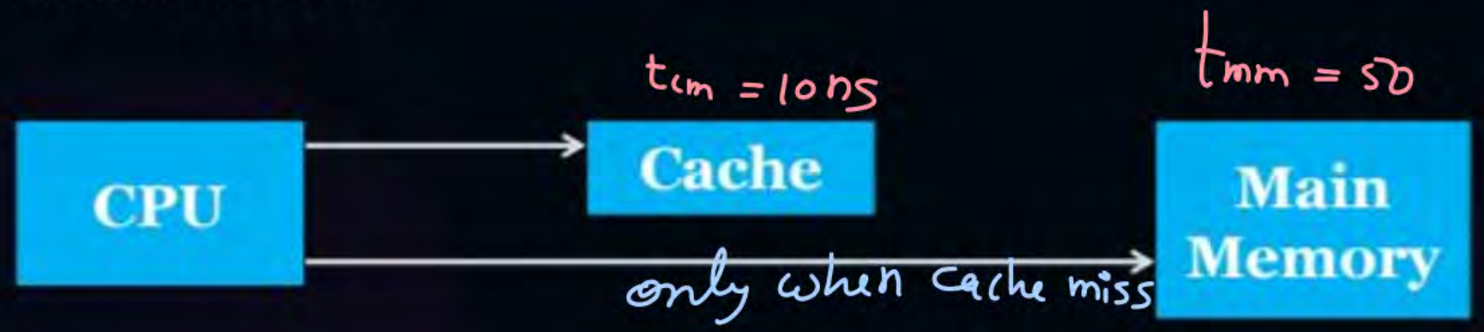
t_{cm} = cache access time

t_{mm} = main mem. access time

Topic : Types of Cache Accesses

Hierarchical Access: (serial access)

Only cache is accessed first



$$T_{avg} = H * t_{cm} + (1-H)(t_{cm} + t_{mm}) \quad \ldots\ldots\ldots\ldots \quad (3)$$

or

$$= t_{cm} + (1-H)\, t_{mm}$$

$$t_{avg} = H * t_{cm} + (1-H)(t_{cm} + t_{mm})$$

$$= \cancel{H * t_{cm}} + t_{cm} + t_{mm} - \cancel{H * t_{cm}} - H * t_{mm}$$

$$= t_{cm} + (1-H)\, t_{mm}$$

2 mins Summary

Topic Associative Memory

Topic Locality of Reference

Topic Cache Memory

Happy Learning

THANK - YOU