CS & IT ENGINEERING

COMPUTER ORGANIZATION AND ARCHITECTURE

Cache Organization

Lecture No.- 02

By- Vishvadeep Gothi sir

Recap of Previous Lecture

Topic Associative Memory

Topic Locality of Reference

Topic Cache Memory

Topics to be Covered

Topic Cache Memory

Topic Average Memory Access Time

Topic Cache Write

General

$$t_{avg} = H * \text{hit time} + (1-H) * \text{miss time}$$

Sim.

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

Hie.

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

or

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

Topic : When to Use Which Formula

t_{cm}, t_{mm} given

- NO
  - use general formula
  - eq ①
- yes
  - words 'Hierarchy' or 'level' given
    - NO
      - Use simultaneous access formula
      - eqn ②
      - [search time or look-up time in cache is ignored]
    - yes
      - Use hierarchical access formula
      - eqn ③

[NAT]

Ans = 95

#Q. Assume that for a certain processor, a read request takes 200 nanoseconds on a cache miss and 25 nanoseconds on a cache hit. Suppose while running a program, it was observed that 60% of the processor's read requests result in a cache hit. The average read access time in nanoseconds is_______?

Use general formula:-

$$t_{avg} = 0.6 * 25 + 0.4 * 200$$
$$= 95 \text{ ns}$$

[NAT]

mem. which is closer to CPU ⇒ Cache

#Q. In a two-level hierarchy, if the top level has an access time of 8 ns and the bottom level has an access time of 60 ns, what is the hit rate on the top level required to give an average access time of 10ns?

Hierarchical access

$t_{cm} = 8ns$

$t_{mm} = 60ns$

$t_{avg} = 10ns$

$10 = 8 + (1-H)\,60$

$H = 0.967 = 0.97$

if hit rate asked

if asked in % then 96.67%

if not asked in % then = 0.9667

[NAT]

#Q. In previous question if hit rate of the top-level memory is 100%, then the access time of bottom level memory will be 60 ns?

main mem.

miss rate = 0 %

Given

$t_{cm} = 8 ns$

$t_{mm} = 60 ns$

$H = 100\%$

$t_{avg} = 1 * 8 + 0 * (8 + 60)$

$= 8$

$= t_{cm}$

Ques)

$t_{cm} = 15$ ns

$t_{mm} = 200$ ns

hierarchical access

$T_{avg} = 12$ ns

$H =$ ______ ?

$\boxed{t_{avg} < t_{cm}} \implies$ not possible

wrong question

$$\boxed{t_{avg} \geq t_{cm}}$$

[NAT]

#Q. A computer system contains a cache. Uncached memory access takes 7 times longer than access to cache. If cache has a hit ratio 0.9. The ratio of cached memory access time to uncached memory access time is?

Uncached mem. ⇒ mem. system without cache ⇒ main memory

cached mem. ⇒ —— " —— with —— " —— ⇒ cache, main memory both

if $t_{cm} = x$

$t_{mm} = 7x$

$H = 0.9$

$$= \frac{\text{Cached mem. access time (avg)}}{\text{uncached mem. access time}} = \frac{0.9 * x + 0.1 * 7x}{7x}$$

$$= \frac{1.6}{7} = 0.228 = 0.23$$

#Q. Consider a system which has a main memory with access time of 200 ns. The system later on had a cache with hit rate of 90% and access time of 30 ns. What is the speed up of the system with using cache over without cache?

Ans :-

Sol^n

$$\text{Speed up} = \frac{\text{mem. access time without cache}}{\text{mem. access time with cache}} = \frac{200}{0.9 * 30 + 0.1 * 200} = \frac{200}{47}$$

$$= 4.255$$

Topic : T_{avg} When Locality of Reference is Used

Simultaneous access:-

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

Hierarchical access:-

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

or

$$= t_{cm} + (1-H) t_{bt}$$

t_{bt} = block transfer time from m.m. to cache

[NAT]

#Q. In a two-level hierarchy, the top level has an access time of 10 ns and hit rate of 90%. If the block transfer from main memory to cache takes 500ns in case of miss then average memory access time is <u>60</u>?

$t_{cm} = 10ns$

$H = 90\%$

$t_{bt} = 500ns$

$$t_{avg} = 10 + (0.1) * 500ns$$
$$= 60 ns$$

[NAT]

#Q. 1 byte transfer from mm to cm takes 50ns.

Block size = 16 bytes.

Block transfer time = 800 nanoseconds?

$$t_{bt} = 16 * 50ns$$
$$= 800\ ns$$

[NAT]

#Q. 1 byte transfer from mm to cm takes 50ns.

Block size = 8 words. $= 8 * 4 = 32$ bytes

1 word size = 4 bytes

Block transfer time = <u>1600</u> nanoseconds?

$t_{bt} = 32 * 50$

$= 1600$ ns

[NAT]

#Q. Block size = 128 bytes

First byte transfer from mm to cm = 10ns

Remaining each byte from mm to cm transfer takes = 2ns

Block transfer time = 264 nanoseconds?

$$t_{bt} = 10ns + (127) * 2ns$$

$$= 264 ns$$

[NAT] GATE-PYQ

#Q. A ~~direct mapped~~ cache memory of 1 MB has a block size of 256 bytes. The cache has an access time of 3 ns and a hit rate of 94%. During a cache miss, it takes 20ns to bring the first word of a block from the main memory, while each subsequent word takes 5 ns. The word size is 64 bits. The average memory access time in ns (round off to 1 decimal place) is 13.3 or 13.5 ?

Cache size = 1 MB

Block = 256 bytes

t_{cm} = 3 ns

H = 94%

first word transfer time = 20 ns

each remaining word -"- = 5 ns

word = 64 bits = 8 bytes

Block = 256 B = $\frac{256\ B}{8\ B}$ = 32 words

$T_{bt} = 20 + 31 * 5 \text{ ns} = 175 \text{ ns}$

Simultaneous:-

$T_{avg} = 0.94 * 3 + 0.06 * 175 = 13.3 \text{ ns}$

Hierarchical

$T_{avg} = 0.94 * 3 + 0.06 * (3 + 175) = 13.5 \text{ ns}$

2 mins Summary

Topic Cache Memory

Topic Average Memory Access Time

Topic Cache Write

Happy Learning

THANK - YOU