Lab4

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Question 1: Given the main memory that has an address space of 32 bit, a cache with the size of 1 MB, 1 block is 256B, the accessing unit of the system is 1 byte. Determine the bit-width of tag, index, byte-offset with below configurations:

a. Directed map.

Block: 256B = 2^8 B

=> byte-offset: 8 bits

Cache: 1MB => Cache/Block: 2^{12} B

=> index: 12 bits

Tag: 32 - 8 - 12 = 12 bits

b. 4-way set associative.

Byte-offset (4-way) = byte-offset (directed map): 8 bits

Index (4-way) = index (directed map) / 4: 10 bits

Tag: 32 - 8 - 10 = 14 bits

c. Full associative.

Byte-offset (full associative) = byte-offset (directed map): 8 bits

Index (full associative) = 0 bits

Tag: 32 - 8 - 0 = 24 bits

Question 2: Given the main memory that has the capacity of 256MB, a cache with the size of 256KB, 1 block is 64 words, the accessing unit of the system is 2 bytes. Determine the bit-width of tag, index, byte-offset with below configurations:

- The capacity of 256MB = 2^{28} B => an address space of 28 bits

a. Directed map.

“the accessing unit of the system is 2 bytes”

Block: 64 words = 2^8 B => byte-offset: 7 bits

Cache: 256KB => Cache/Block: 2^{10} B => index: 10 bits

Tag: 28 - 7 - 10 = 11 bits

b. 4-way set associative.

Byte-offset (4-way) = byte-offset (directed map) : 7 bits

Index (4-way) = index(directed map) / 4 : 8 bits

Tag: 28 - 7 - 8 = 13 bits

c. Full associative

Byte-offset (full associative) = byte-offset (directed map) :7 bits

Index (full associative) = 0 bits

Tag: 28 - 7 - 0 = 21 bits

Question 3: A program accesses data in main memory with the sequence below (word address): 0, 4, 1, 5, 65, 46, 1, 70, 2, 0 Know that the system is 256B cache, 4-word block, 1-byte accessing unit. Hit time = 6 cycles, RAM (main memory) access time = 10ns, the system works with the frequency of 2GHz. Determine the number of HIT/MISS when executing the program, then calculate the AMAT (Average memory access time) with the below configurations:

- Hit time = 6 / $2x10^9$ = 3ns

a. Directed map.

4-word block ~ 2^4 B => offset: 4 bits

256 B cache => cache/block = 2^4 B => index: 4 bits

	TAG	INDEX	OFFSET	
0	0	0	0	M
4	0	1	0	M
1	0	0	4	H
5	0	1	4	H
65	1	0	4	M
46	0	11	8	M
1	0	0	4	M
70	1	1	8	M
2	0	0	8	H
0	0	0	0	H

Hit ratio = 4/10; Miss ratio = 6/10

AMAT = Hit time + Miss rate x Miss penalty = 3 + 6 / 10 x 10 = 9ns

b. 2-way set associative.

4-word block ~ 2^4 B => offset: 4 bits

256 B cache => cache/block = 2^4 B => index: 3 bits

	TAG	INDEX	OFFSET	
0	0	0	0	M
4	0	1	0	M
1	0	0	4	H
5	0	1	4	H
65	2	0	4	M
46	1	3	8	M
1	0	0	4	H
70	2	1	8	M
2	0	0	8	H
0	0	0	0	H

Hit ratio = 5/10; Miss ratio = 5/10

AMAT = Hit time + Miss rate x Miss penalty = 3 + 5 / 10 x 10 = 8ns

c. Full associative.

4-word block ~ 2^4 B => offset: 4 bits

index: 0 bits

	TAG	INDEX	OFFSET	
0	0	0	0	M
4	1	0	0	M
1	0	0	4	H
5	1	0	4	H
65	16	0	4	M
46	11	0	8	M
1	0	0	4	H
70	17	0	8	M
2	0	0	8	H
0	0	0	0	H

Hit ratio = 5/10; Miss ratio = 5/10

Hit time = 6 / $2x10^9$ = 3ns

AMAT = Hit time + Miss rate x Miss penalty = 3 + 5 / 10 x 10 = 8ns

Question 4: Given L1 cache hit time is 10 cycles, L2 cache hit time is 15 cycles, time to access RAM (main memory) is 100 cycles. L1 miss rate is 25%, L2 miss rate is 5%. Determine AMAT of the system.

AMAT = Hit t.1 + Miss r.1 x (Hit t.2 + Miss r.2 x Miss penalty)

= 10 + 0.25 x (15 + 0.05 x 100) = 15

Question 5: Determine average CPI of a pipeline system that its Instruction memory miss rate is 5% and its Data memory miss rate is 10%. Know that the program has 1000 instructions included 100 load/store instructions and miss penalty is 100 cycles.

CPI = CPI base + I-cache + D-cache = 1004/1000 + 0.05x100 + 0.1x0.1x100

= 7.004