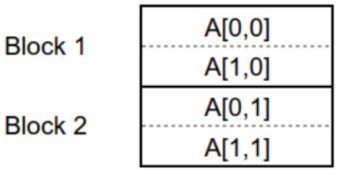
CS230 - Digital Logic Design and Computer Architecture

Problem Set 6 Solution

Autumn 2023

Ans1.
No. of blocks = 2



A[0,0] – Miss, A [0,0] – Hit
A[0,1] – Miss, A [1,0] – Hit
A[1,0] – Hit, A [0,1] – Hit
A[1,1] – Hit, A [1,1] – Hit

Hit Ratio = 6/8 = 0.75

Ans2.
Memory System1:
Access time for the level-1 cache (T1)=5 ns
Access time for the level2 cache (T2)=120 ns

Memory System2:
Access time for the level-3 cache is (T3)=10 ns
Access time for the level-4 cache is (T4)=150 ns

Given -
Hit ratio (h2)=0.8

AMAT1=1/2(AMAT2)

Average access time2 = (T3)+(1-h2)(T4)
= 10+(1-0.8)(150)
= 40

Average access time1 = (T1)+(1-h1)(T2)
20 = 5+(1-h1)(120)

h1 = 0.87

Ans3.

A. Number of sets = Cache memory/(set associativity × cache block size)
   = 256KB/(4 × 16B)
   = 4096
B. Memory address size = 32bit
   Number of bits required to identify a particular set = 12
   Number of bits required to identify a particular location in cache line = 4
   Size of tag field = 32 -12 -4 = 16 bit
C. We use a 4-way set associative cache. So, we need 4 comparators each of size
D. Cache block size is 16-byte. so 4-bits are required to find the byte offset within a cache block.
E. size of tag = 16 bit
   Number of sets = 4096
   Set associativity = 4
   Extra memory required to store the tag bits = 16 × 4096 × 4 bits =2^{18} bits = 2^{15} bytes

Ans4. 5

0	41	0	**45**	0	45	0	45	0	45
1	33	1	33	1	**22**	1	22	1	22
2	25	2	25	2	25	2	25	2	25
3	8	3	8	3	8	3	8	3	8
4	19	4	19	4	19	4	**33**	4	33
5	6	5	6	5	6	5	6	5	**73**
6	16	6	16	6	16	6	16	6	16
7	35	7	35	7	35	7	35	7	35

Ans5.

$\text{Physical Address Space} = 2^P$ Bytes i.e. P bits to represent size of total memory.
$\text{Cache Size} = 2^N$ Byte i.e., N bits to represent Cache memory.
$\text{Tag size} = 2^X$ Bytes i.e., X bits to represent Tag.
Cache is $K-$ way associative.

$$(\text{Size of Tag}) \times \frac{\text{Cache Size}}{K} = \text{Total Memory Size}$$

$$\implies 2^X \times \frac{2^N}{K} = 2^P$$
$$\implies 2^{X+N-\log(K)} = 2^P$$
$$\implies 2^X = 2^{P-N+\log(K)}$$

$$\implies X(\text{Size of Tag in bits}) = P - N + \log(K)$$