

Suppose a computer using fully associative cache has  $2^{24}$  words of main memory and a cache of 128 blocks, where each cache block contains 64 words. ...

- a. How many blocks of main memory are there?
- b. What is the format of a memory address as seen by the cache, i.e., what are the sizes of the tag and word fields?
- c. To which cache block will the memory reference  $01D872_{16}$  map?

a. Number of blocks in main memory:

$$2^{24} / 64 = 2^{18} \text{ blocks}$$

b. Format of a memory address in the cache:

- Word size: 64 words
- Cache block size: 64 words
- Number of blocks in main memory:  $2^{18}$  blocks

Memory Address Format:

- Tag: 18 bits (for uniquely identifying each block in main memory)
- Word: 6 bits (to specify one of the 64 words within a block)

c. Cache block for memory reference  $01D872_{16}$ :

- Convert memory address to binary: 0000 0001 1101 1000 0111 0010 (24 bits)
- Tag: 0000 0001 1101 1000 01 (18 bits)
- Word: 1001 1000 0111 0010 (6 bits)
- The memory reference maps to the cache block identified by the tag 0000 0001 1101 1000 01.

Consider a byte-addressable computer with 24-bit addresses, a cache capable of storing a total of 64K bytes of data and blocks of 32 bytes. Show the format of a 24-bit memory address for:

- a. direct mapped
- b. associative
- c. 4-way set associative

a. Direct Mapped:

- Cache Size: 64K bytes
- Block Size: 32 bytes
- Number of Blocks in Cache:  $64K / 32 = 2K$  blocks

Memory Address Format:

- Block Offset:  $\log_2(32) = 5$  bits
- Cache Index:  $\log_2(2K) = 11$  bits
- Tag:  $24 - 5 - 11 = 8$  bits

Memory Address Format (Direct Mapped): Tag (8 bits) | Cache Index (11 bits) | Block Offset (5 bits)

b. Fully Associative (Associative):

- Cache Size: 64K bytes
- Block Size: 32 bytes

Memory Address Format:

- Block Offset:  $\log_2(32) = 5$  bits
- Tag:  $24 - 5 = 19$  bits

Memory Address Format (Fully Associative): Tag (19 bits) | Block Offset (5 bits)

c. 4-Way Set Associative:

- Cache Size: 64K bytes
- Block Size: 32 bytes
- Number of Sets:  $2K / 4 = 512$  sets

Memory Address Format:

- Block Offset:  $\log_2(32) = 5$  bits
- Cache Index (Set Index):  $\log_2(512) = 9$  bits
- Tag:  $24 - 5 - 9 = 10$  bits

Memory Address Format (4-Way Set Associative): Tag (10 bits) | Cache Index (9 bits) | Block Offset (5 bits)