第四章作业

1. pp.169. problem 4.1-4.4

4.1 A set-associative cache consists of 64 lines, or slots, divided into four-line sets. Main memory contains 4K blocks of 128 words each. Show the format of main memory addresses.

解：

块内偏移：每个块包含 128 个字，因此需要 $\log_2 128 = 7$ 位来表示块内偏移。

组号：缓存有 64 个行，每组包含 4 个行，所以总共有 $\frac{64}{4} = 16$ 组。为组号分配 $\log_2 16 = 4$ 位。

主存地址总位数：主存包含 4K 个块，每个块有 128 个字，因此主存中总共有 $4K \times 128 = 4096 \times 128 = 524288$ 个字。

要寻址 524288 个字，需要 $\log_2 524288 = 19$ 位来表示主存地址。

标记：剩下的 $19 - 7 - 4 = 8$ 位。

综上：

Tag	Set	Word
8	4	7

4.2 A two-way set-associative cache has lines of 16 bytes and a total size of 8 KB. The 64-MB main memory is byte addressable. Show the format of the main memory addresses.

解：

块内偏移：每行的大小为 16 字节，因此块内偏移需要 $\log_2 16 = 4$ 位。

组号：缓存的总大小是 8KB=8192bytes ，每行有 16 字节，总共有 $\frac{8KB}{16bytes} = 512$ 行，每组有 2 行，因此总共有 $\frac{512}{2} = 256$ 组，需要 $\log_2 256 = 8$ 位。

标记：主存是 64MB（$64 \times 1024 \times 1024$ bytes），主存地址需要 $\log_2 64 \times 1024 \times 1024 = 26$ 位，标记位数为 $26 - 8 - 4 = 14$ 位。

综上：

Tag	Set	Word
14	8	4

4.3 For the hexadecimal main memory addresses 111111,666666,BBBBB, show the following information, in hexadecimal format:

a. Tag, Line, and Word values for a direct-mapped cache, using the format of Figure 4.10

b. Tag and Word values for an associative cache, using the format of Figure 4.12

c. Tag, Set, and Word values for a two-way set-associative cache, using the format of Figure 4.15

解：

	111111	666666	BBBBB
a.Tag/Line/Word	11/444/1	66/1999/2	BB/2EEE/3
b.Tag/Word	44444/1	199999/2	2EEEEE/3
c.Tag/Set/Word	22/444/1	CC/1999/2	177/EEE/3

4.4 List the following values:

a. For the direct cache example of Figure 4.10: address length, number of addressable units, block size, number of blocks in main memory, number of lines in cache, size of tag

b. For the associative cache example of Figure 4.12: address length, number of addressable units, block size, number of blocks in main memory, number of lines in cache, size of tag

c. For the two-way set-associative cache example of Figure 4.15: address length, number of addressable units, block size, number of blocks in main memory, number of lines in set, number of sets, number of lines in cache, size of tag

解：

	a. Direct	b. Associative	c. Set-associative
Address length	24	24	24
Number of addressable units	2^{24}	2^{24}	2^{24}
Block size	4	4	4
Number of blocks in main memory	2^{22}	2^{22}	2^{22}
Number of lines in cache	2^{14}	2^{14}	2^{14}
Size of tag	8	22	9
Number of lines in set	/	/	2
Number of sets	/	/	2^{13}

2. For the address sequence: 1 2 3 4 1 2 3 4 1 2 3 4, draw and compute the hit ratio of 3-line cache using FIFO & LRU; which methods can be used to improve the hit ratio?

解：

FIFO:

地址	缓存状态	是否命中
1	[1]	否

2	[1,2]	否
3	[1,2,3]	否
4	[2,3,4]	否
1	[3,4,1]	否
2	[4,1,2]	否
3	[1,2,3]	否
4	[2,3,4]	否
1	[3,4,1]	否
2	[4,1,2]	否
3	[1,2,3]	否
4	[2,3,4]	否

命中次数：0 次 ，命中率： 0%

LRU:

地址	缓存状态	是否命中
1	[1]	否
2	[1,2]	否
3	[1,2,3]	否
4	[2,3,4]	否
1	[3,4,1]	否
2	[4,1,2]	否
3	[1,2,3]	否
4	[2,3,4]	否
1	[3,4,1]	否
2	[4,1,2]	否
3	[1,2,3]	否
4	[2,3,4]	否

命中次数：0 次 ，命中率： 0%

提高命中率的方法：增加缓存行的数量；采用更合适的替换策略（如 MRU、LFU）。

3.Consider a machine with Cache-main memory system structure. Its main memory has 8 blocks(0-7) which block size is 4 words, and its Cache has 4 lines(0-3) and adapts a organization of 2-way set associative with LRU replacement algorithm, require:

1) show the structure of main memory address

2) show the corresponding relationship of main memory block number and Cache line number

3) Supposed initial Cache status is empty, for the address sequence: 1，2，4，1，3，7，0，1，2，5，4，6，4，7，2，list the assigned addresses of cache lines after each visit.

4) Given the hit ratio of Cache after above steps.

解：

1)

块地址：主存有 8 个块，因此块地址长度为$\log_2 8 = 3$ 位；

组地址：缓存采用 2 路组相联，且有 4 条缓存行（即 2 组）。因此组地址长度为$\log_2 \frac{4}{2} = 1$ 位；

标记：标记地址长度为块地址长度减去组地址长度，即 $3 - 1 = 2$ 位；

字地址：每个块有 4 个字，因此字地址长度为$\log_2 4 = 2$ 位。

综上：

Tag	Set	Word
2	1	2

2)

Block Number	Set Number
0 (000)	0
1 (001)	1

2 (010)	0
3 (011)	1
4 (100)	0
5 (101)	1
6 (110)	0
7 (111)	1

Set 0：块号的最低位是 0，映射到 Set 0 的块有 Block 0、Block 2、Block 4 和 Block 6；

Set 1：块号的最低位是 1，映射到 Set 1 的块有 Block 1、Block 3、Block 5 和 Block 7；

3)

地址	Set 0	Set 1	是否命中
1	[]	[1]	否
2	[2]	[1]	否
4	[2,4]	[1]	否
1	[2,4]	[1]	是
3	[2,4]	[1,3]	否
7	[2,4]	[7,3]	否
0	[0,4]	[7,3]	否
1	[0,4]	[7,1]	否
2	[0,2]	[7,1]	否
5	[0,2]	[5,1]	否
4	[4,2]	[5,1]	否
6	[4,6]	[5,1]	否
4	[4,6]	[5,1]	是
7	[4,6]	[5,7]	否
2	[4,2]	[5,7]	否

4)命中次数：2 次；命中率：$\frac{2}{15} \times 100\% = 13.33\%$