

Homework-3 Solutions

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2022 年 10 月 12 日

Honor Code: I promise that I finished the homework solutions on my own without copying other people's work.

Problem 1. 4.1-4.3**4.1**

Answer: Address structure is **4(SET)+8(TAG)+7(WORD)**.

Main memory has $4K \times 128 = 2^{12+7} = 2^{19}$, so 19-bit word address needed in total.

Set number = $64 \div 4 = 16 = 2^4$, so set index need 4 bits. Each block has $128 = 2^7$ words, so word index need 7 bits. So tag is $19-4-7=8$ bits length.

4.2

Answer: Address structure is **8(SET)+14(TAG)+4(WORD)**.

Main memory has $64M = 2^{6+20} = 2^{26}$, so 26-bit address needed in total.

Set number = $8K \div 16 \div 2 = 256 = 2^8$, so set index need 8 bits. Each line has $16 = 2^4$ bytes, so byte index need 4 bits. So tag is $26-8-4=14$ bits length.

4.3

Useful information:

111111	000100010001000100010001
666666	011001100110011001100110
BBBBBB	101110111011101110111011

a. direct-mapped cache as figure 4.10

	Tag (8)	Line (14)	Word (2)
111111	$00010001 = 11$	$00010001000100 = 0444$	$01 = 1$
666666	$01100110 = 66$	$01100110011001 = 1999$	$10 = 2$
BBBBBB	$10111011 = BB$	$10111011101110 = 2EEE$	$11 = 3$

b. fully associative cache as figure 4.12

	Tag (22)	Word (2)
111111	0001000100010001000100 = 044444	01 = 1
666666	0110011001100110011001 = 199999	10 = 2
BBBBBB	1011101110111011101110 = 2EEEEEE	11 = 3

c. two-way set associative cache as figure 4.15

	Tag (9)	Line (13)	Word (2)
111111	000100010 = 022	0010001000100 = 0444	01 = 1
666666	011001100 = 0CC	1100110011001 = 1999	10 = 2
BBBBBB	101110111 = 177	0111011101110 = 2EEE	11 = 3

4.4

	Direct mapped (4.10)	fully associative (4.12)	two-way set associative (4.15)
address length	24		
number of addressable units	$2^{24} = 16\text{M}$		
block size	4 words		
number of blocks in main memory	$2^{22} = 4\text{M}$		
number of lines in set	1	$2^{14} = 4\text{K}$	2
number of sets	$2^{14} = 4\text{K}$	1	$2^{13} = 4\text{K}$
number of lines in cache	$2^{14} = 4\text{K}$		
size of tag	8	22	9

Problem 2.

hit ratio of **FIFO** = 0

access	1	2	3	4	1	2	3	4	1	2	3	4
hit?	×	×	×	×	×	×	×	×	×	×	×	×
cache	100	120	123	423	413	412	312	342	341	241	231	234

表 1: FIFO

hit ratio of **LRU** = 0

access	1	2	3	4	1	2	3	4	1	2	3	4
hit?	×	×	×	×	×	×	×	×	×	×	×	×
cache	100	120	123	423	413	412	312	342	341	241	231	234
LRU	100	120	123	423	453	456	756	786	789	a89	ab9	abc

表 2: LRU

direct mapped will improve hit ratio to $\frac{4}{12}$

line number	1	2	3	4	1	2	3	4	1	2	3	4
status	×	×	×	×	×	✓	✓	×	×	✓	✓	×
cache	100	120	123	423	123	123	123	423	123	123	123	423

表 3: direct mapped

Problem 3.

1).

Answer: **The structure is 1(SET)+2(TAG)+2(WORD).**

Because main memory has 8 blocks, set index + tag are 3 bits at least. The cache has $2 = 4 \div 2$ sets, need **1 bit for set index**, so **2 bits for tag**. Each block contains 4 words, so **word index need 2 bits**.

2).

The left most bit of cache line number = The right most bit of main memory block number.

Set index is at the top of cache line number, while block number should modular sets number to decide which set to add in.

3). & 4).

Answer: **hit ratio** = $\frac{2}{16}$, **The first table** is solution to 3) and the second table is analysis process.

block number	cache	set0		set1	
1	0010	invalid	invalid	001	invalid
2	2010	010	invalid	001	invalid
4	2410	010	100	001	invalid
1	2410	010	100	001	invalid
3	2413	010	100	001	011
7	2473	010	100	111	011
0	0473	000	100	111	011
1	0471	000	100	111	001
2	0271	000	010	111	001
5	0251	000	010	101	001
4	4251	100	010	101	001
6	4651	100	110	101	001
4	4651	100	110	101	001
7	4657	100	110	101	111
2	4257	100	010	101	111

block number	address	hit?	cache	LRU
1	001	×	0010	0010
2	010	×	2010	2010
4	100	×	2410	2310
1	001	✓	2410	2340
3	011	×	2413	2345
7	111	×	2473	2365
0	000	×	0473	7365
1	001	×	0471	7368
2	010	×	0271	7968
5	101	×	0251	79a8
4	100	×	4251	b9a8
6	110	×	4651	bca8
4	100	✓	4651	dca8
7	111	×	4657	dcae
2	010	×	4257	dfae

Other things

- \LaTeX code refer to these things and was compiled on texlive2020.
 - [UCB-CS70's given homework template](#).
 - [A free website useful to edit \$\text{\LaTeX}\$ formula code](#).
- The figures in this homework is made with [GoodNotes5](#).

Thanks for your correcting and grading :).