

## Homework 5

1.

- a.  $\text{tag} = 32 - 9 - 6 = 17$ ,  $\text{index} = \log_2 512 = 9$ ,  $\text{block offset} = \log_2 64 = 6$   
Data bits = 512 bits/block, tag bits = 17, valid bit = 1 so total bits =  $512(512 + 17 + 1) = 271360$
- b.  $\text{tag} = 32 - 6 - 6 = 20$ ,  $\text{index} = \log_2 64 = 6$ ,  $\text{block offset} = \log_2 64 = 6$   
Data bits = 512 bits/block, tag bits = 20, valid bit = 1 so total bits =  $512(512 + 20 + 1) = 272896$
- c.  $\text{tag} = 32 - 0 - 6 = 26$ ,  $\text{index} = \log_2 1 = 0$ ,  $\text{block offset} = \log_2 64 = 6$   
Data bits = 512 bits/block, tag bits = 26, valid bit = 1 so total bits =  $512(512 + 26 + 1) = 275968$

2. A program exhibits little temporal locality when it does not access the same or similar things at around the same time. A program exhibits little spatial locality when things that it accesses close in time are very far apart in space. An example program pseudocode that wants to sort the data within a file would be:

Fetch last piece of data from the input file

Compare the data collected with the first piece of data that is very far away in memory

Compare the larger of the two with the second to last piece of data

Continue comparing to the second piece of data, third to last piece of data, third piece...

Place largest into new file and remove from input file

Fetch next to last piece of data from the input file

Continue

3. A program exhibits little spatial locality when things it accesses close in time are very far apart in space, but it exhibits high temporal locality when accesses the same or similar code multiple times in a row because it has high likelihood of being used again such as a loop. An example program pseudocode that wants to add data to an array and print them out would be:

Find the memory address of an element and add it to the array

Jump randomly to another memory address that's 2 GB away and add that into the array

Loop through the array

4.  $t_{\text{avg}} = t_{\text{hit}} + \% \text{miss} * \text{miss penalty}$
- a.  $t_{\text{avg}} = 1 + 0.05 * 200 = 11 \text{ ns} * 2 = 22 \text{ ns}$
  - b.  $t_{\text{avg}} = 2 + 0.1 * (10 + 0.05 * 100) = 3.5 \text{ ns}$
- 5.
- a. # blocks = 32

# sets = 32

5 = 101, 1 = 1, 8 = 1000, 20 = 10100, 3 = 11, 16 = 10000, 19 = 10011, 56 = 111000, 12 = 1100, 11 = 1011, 4 = 100, 52 = 110100, 5 = 101, 6 = 110, 9 = 1001, 16 = 10000

Byte-addressed reference	Binary	Tag	Index	Block Offset
5	0000 0000 0000 0000 0000 0000 0000 0101	0000 0000 0000 0000 0000 0000 0	00001	01
1	0000 0000 0000 0000 0000 0000 0000 0001	0000 0000 0000 0000 0000 0000 0	00000	01
8	0000 0000 0000 0000 0000 0000 0000 1000	0000 0000 0000 0000 0000 0000 0	00010	00
20	0000 0000 0000 0000 0000 0000 0001 0100	0000 0000 0000 0000 0000 0000 0	00101	00
3	0000 0000 0000 0000 0000 0000 0000 0011	0000 0000 0000 0000 0000 0000 0	00000	11
16	0000 0000 0000 0000 0000 0000 0001 0000	0000 0000 0000 0000 0000 0000 0	00100	00
19	0000 0000 0000 0000 0000 0000 0001 0011	0000 0000 0000 0000 0000 0000 0	00100	11
56	0000 0000 0000 0000 0000 0000 0011 1000	0000 0000 0000 0000 0000 0000 0	01110	00
12	0000 0000 0000 0000 0000 0000 0000 1100	0000 0000 0000 0000 0000 0000 0	00011	00
11	0000 0000 0000 0000 0000 0000 0000 1011	0000 0000 0000 0000 0000 0000 0	00010	11
4	0000 0000 0000 0000 0000 0000 0000 0100	0000 0000 0000 0000 0000 0000 0	00001	00
52	0000 0000 0000 0000 0000 0000 0011 0100	0000 0000 0000 0000 0000 0000 0	01101	00
5	0000 0000 0000 0000 0000 0000 0000 0101	0000 0000 0000 0000 0000 0000 0	00001	01
6	0000 0000 0000 0000 0000 0000 0000 0110	0000 0000 0000 0000 0000 0000 0	00001	10
9	0000 0000 0000 0000 0000 0000 0000 1001	0000 0000 0000 0000 0000 0000 0	00010	01
16	0000 0000 0000 0000 0000 0000 0001 0000	0000 0000 0000 0000 0000 0000 0	00100	00

Byte-addressed reference	Hit	Miss
5		X
1		X
8		X
20		X
3	X	
16		X
19	X	
56		X
12		X
11	X	
4	X	
52		X
5	X	
6	X	
9	X	
16	X	

Cache Index	Valid	Final Content Tag
00000	1	0000 0000 0000 0000 0000 0000 0
00001	1	0000 0000 0000 0000 0000 0000 0
00010	1	0000 0000 0000 0000 0000 0000 0
00011	1	0000 0000 0000 0000 0000 0000 0
00100	1	0000 0000 0000 0000 0000 0000 0
00101	1	0000 0000 0000 0000 0000 0000 0
00110	0	
00111	0	
01000	0	
01001	0	
01010	0	
01011	0	
01100	0	
01101	1	0000 0000 0000 0000 0000 0000 0
01110	1	0000 0000 0000 0000 0000 0000 0
01111	0	
10000	0	
10001	0	
10010	0	
10011	0	
10100	0	
10101	0	
10110	0	
10111	0	
11000	0	
11001	0	
11010	0	
11011	0	
11100	0	
11101	0	
11110	0	
11111	0	

b.

Reference	Binary	Tag	Index	Block Offset
172	0000 0000 0000 0000 0000 0000 1010 1100	0000 0000 0000 0000 0000 0000 1010	110	0
44	0000 0000 0000 0000 0000 0000 0010 1100	0000 0000 0000 0000 0000 0000 0010	110	0
4	0000 0000 0000 0000 0000 0000 0000 0100	0000 0000 0000 0000 0000 0000 0000	010	0
172	0000 0000 0000 0000 0000 0000 1010 1100	0000 0000 0000 0000 0000 0000 1010	110	0
104	0000 0000 0000 0000 0000 0000 0110 1000	0000 0000 0000 0000 0000 0000 0110	100	0
32	0000 0000 0000 0000 0000 0000 0010 0000	0000 0000 0000 0000 0000 0000 0010	000	0
192	0000 0000 0000 0000 0000 0000 1100 0000	0000 0000 0000 0000 0000 0000 1100	000	0
88	0000 0000 0000 0000 0000 0000 0101 1000	0000 0000 0000 0000 0000 0000 0101	100	0
200	0000 0000 0000 0000 0000 0000 1100 1000	0000 0000 0000 0000 0000 0000 1100	100	0
16	0000 0000 0000 0000 0000 0000 0001 0000	0000 0000 0000 0000 0000 0000 0001	000	0
56	0000 0000 0000 0000 0000 0000 0011 1000	0000 0000 0000 0000 0000 0000 0011	100	0
184	0000 0000 0000 0000 0000 0000 1011 1000	0000 0000 0000 0000 0000 0000 1011	100	0
52	0000 0000 0000 0000 0000 0000 0011 0100	0000 0000 0000 0000 0000 0000 0011	010	0
196	0000 0000 0000 0000 0000 0000 1100 0100	0000 0000 0000 0000 0000 0000 1100	010	0
254	0000 0000 0000 0000 0000 0000 1111 1110	0000 0000 0000 0000 0000 0000 1111	111	0

Byte Addressed Reference	Hit	Miss
172		X
44		X
4		X
172	X	
104		X
32		X
192		X
88		X
200		X
16		X
56		X
184		X
52		X
196		X
254		X

Cache Index	Block 0 Valid	Final Content Block 0 Tag	Block 1 Valid	Final Content Block 1 Tag
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000	1	0000 0000 0000 0000 0000 0000 0001	1	0000 0000 0000 0000 0000 0000 1100
001	0		0	
010	1	0000 0000 0000 0000 0000 0000 1100	1	0000 0000 0000 0000 0000 0000 0011
011	0		0	
100	1	0000 0000 0000 0000 0000 0000 1011	1	0000 0000 0000 0000 0000 0000 0011
101	0		0	
110	1	0000 0000 0000 0000 0000 0000 1010	1	0000 0000 0000 0000 0000 0000 0010
111	1	0000 0000 0000 0000 0000 0000 1111		