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CS 219-1002: Computer Organization
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CS 219 – Assignment #8

Purpose: Become familiar with basic cache implementation and operation
Points: 60

Reading/References:

Chapter 5

Assignment:

Answer the following questions:

1-4) A series of address references generated in order (0-7) by the microprocessor are provided. The table shows the address references (in binary) and the data stored at that address (in decimal).

The cache uses 4 bytes per block. All data items shown are word sized values. Assume a 2-way set associative cache design that uses the LRU algorithm (with a cache that can hold a total of 4 blocks). Assume that the cache is initially empty.

a) Determine the *tag*, *line/set*, and *offset* fields and fill in the appropriate table (first table). (2 pts)

b) In the provided table (second table), insert for each access the *tag* (in binary), *valid bit* (0/1), *least recently used* (0/1), and *data* (in decimal) for each access. Use the provided tables (next page). Assume any unprovided data items are all set to 0. (10 pts)

c) What is the hit ratio for this access sequence (hits/accesses) as a percentage? (3 pts)

Question #1

Hit! Hit!

	0	1	2	3	4	5	6	7
address	10001100	10110010	10111110	10001100	10011100	11101000	11111110	11101000
data	3	32	98	3	51	48	42	48
tag	10001	10110	10111	10001	10011	11101	11111	11101
line/set	1	0	1	1	1	0	1	0
offset	00	10	10	00	00	00	10	00

access 0	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	0	-	-	-	0	-	-	-
line/set 1	1	1	10001	3	0	-	-	-

access 1	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	10110	32	0	-	-	-
line/set 1	1	1	10001	3	0	-	-	-

access 2	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	10110	32	0	-	-	-
line/set 1	1	0	10001	3	1	1	10111	98

access 3	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	10110	32	0	-	-	-
line/set 1	1	1	10001	3	1	0	10111	98

access 4	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	10110	32	0	-	-	-
line/set 1	1	0	10001	3	1	1	10011	51

access 5	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	10110	32	1	1	11101	48
line/set 1	1	0	10001	3	1	1	10011	51

access 6	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	10110	32	1	1	11101	48
line/set 1	1	1	11111	42	1	0	10011	51

access 7	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	10110	32	1	1	11101	48
line/set 1	1	1	11111	42	1	0	10011	51

Hit Ratio: 2 / 8 = 25%

Question #2

	0	1	2	3	4	5	6	7
address	11000000	11111110	11000100	11001000	10011100	11001100	11010000	11010100
data	25	24	35	45	28	55	65	75
tag	11000	11111	11000	11001	10011	11001	11010	11010
line/set	0	1	1	0	1	1	0	1
offset	00	10	00	00	00	00	00	00

access 0	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11000	25	0	-	-	-
line/set 1	0	-	-	-	0	-	-	-
access 1	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11000	25	0	-	-	-
line/set 1	1	1	11111	24	0	-	-	-
access 2	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11000	25	0	-	-	-
line/set 1	1	0	11111	24	1	1	11000	35
access 3	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	11000	25	1	1	11001	45
line/set 1	1	0	11111	24	1	1	11000	35
access 4	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	11000	25	1	1	11001	45
line/set 1	1	1	10011	28	1	0	11000	35
access 5	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	11000	25	1	1	11001	45
line/set 1	1	0	10011	28	1	1	11001	55
access 6	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11010	65	1	0	11001	45
line/set 1	1	0	10011	28	1	1	11001	55
access 7	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	11010	65	1	1	11010	75
line/set 1	1	0	10011	28	1	1	11001	55

Hit Ratio: 0 / 8 = 0%

Question #3

			Hit!		Hit!	Hit!	Hit!	Hit!
	0	1	2	3	4	5	6	7
address	10001100	11101010	10001100	11101110	11101010	10001100	11101010	11101110
data	51	21	51	91	21	51	21	91
tag	10001	11101	10001	11101	11101	10001	11101	11101
line/set	1	0	1	1	0	1	0	1
offset	00	10	00	10	10	00	10	10

access 0	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	0	-	-	-	0	-	-	-
line/set 1	1	1	10001	51	0	-	-	-
access 1	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11101	21	0	-	-	-
line/set 1	1	1	10001	51	0	-	-	-
access 2	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11101	21	0	-	-	-
line/set 1	1	1	10001	51	0	-	-	-
access 3	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11101	21	0	-	-	-
line/set 1	1	0	10001	51	1	1	11101	91
access 4	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11101	21	0	-	-	-
line/set 1	1	0	10001	51	1	1	11101	91
access 5	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11101	21	0	-	-	-
line/set 1	1	1	10001	51	1	0	11101	91
access 6	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11101	21	0	-	-	-
line/set 1	1	1	10001	51	1	0	11101	91
access 7	**Block 0**				**Block 1**			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	11101	21	0	-	-	-
line/set 1	1	0	10001	51	1	1	11101	91

Hit Ratio: 5 / 8 = 62.5%

Question #4

Hit!

	0	1	2	3	4	5	6	7
address	10101000	10111110	11101000	10011100	10001100	10111100	10110010	10001100
data	71	21	91	92	31	10	43	31
tag	10101	10111	11101	10011	10001	10111	10110	10001
line/set	0	1	0	1	1	1	0	1
offset	00	10	00	00	00	00	10	00

access 0	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	10101	71	0	-	-	-
line/set 1	0	-	-	-	0	-	-	-
access 1	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	10101	71	0	-	-	-
line/set 1	1	1	10111	21	0	-	-	-
access 2	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	10101	71	1	1	11101	91
line/set 1	1	1	10111	21	0	-	-	-
access 3	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	10101	71	1	1	11101	91
line/set 1	1	0	10111	21	1	1	10011	92
access 4	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	10101	71	1	1	11101	91
line/set 1	1	1	10001	31	1	0	10011	92
access 5	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	0	10101	71	1	1	11101	91
line/set 1	1	0	10001	31	1	1	10111	10
access 6	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	10110	43	1	0	11101	91
line/set 1	1	0	10001	31	1	1	10111	10
access 7	Block 0				Block 1			
	v	lru	tag	data	v	lru	tag	data
line/set 0	1	1	10110	43	1	0	11101	91
line/set 1	1	1	10001	31	1	0	10111	10

Hit Ratio: 1 / 8 = 12.5%