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Computer organization HW04

① a. Calculate the range of bits used for tag, index and offset

$$\text{offset} = \log_2 32 = 5 \text{ bits}$$

$$\text{index} = \frac{256}{32} = \frac{2^8}{2^5} = 2^3 = 3 \text{ bits}$$

$$\text{Tag} = 32 - 5 - 3 = 24 \text{ bits}$$

∴ 4-0 for offset

7-5 for index

31-8 for tag

b).

Hex	Binary	index	Tag	offset	Hit/miss	replaced
0X00	0000 0000	000	0	00000	miss	
0X04	0000 0100	000	0	00100	hit	
0X10	0001 0000	000	0	10000	hit	
0X84	1000 0100	100	0	01000	miss	
0X E8	1110 1000	111	0	01000	miss	
0x A0	1010 0000	101	0	00000	miss	
0X 400	0100 0000 0000	000	0100	00000	miss	0x00
0X1E	0001 1110	000	0	11110	miss	0100 = 0x04
0x8C	1000 1100	100	0	01100	hit	
0xC1C	1100 0001 1100	000	1100	11100	miss	0x00
0x B4	1011 0100	101	0	10100	hit	
0x884	1000 1000 0100	100	1000	00100	miss	0x 00

c. hit ratio $= \frac{4}{12} = 33\%$

d.

	index	tag	data
0	000	1100	MEM[0XC\C]
1	001		
2	010		
3	011		
4	100	1000	MEM[0x884]
5	101	0	MEM[0xA0]
6	110		
7	111	0	MEM [0xE8]

2). a). Index $= 8 = 2^3 = 3$ bits (8 sets)

offset $= 2 \times 4 = 2^3 \Rightarrow$ 3 bits

2-0 for offset, 5-3 for index, 31-6 for tag

b). $\frac{24}{2} = 12$ blocks, 4 sets, $2^2 \Rightarrow$ index = 2 bits

offset = 3 bits, 3 blocks / set

set 0			set 1			set 2			set 3		
Hex	Tag	H/M	Hex	Tag	H/M	Hex	Tag	H/M	Hex	Tag	H/M
0x03	0	M	0x2B	1	M	0xB4	101	M	0x8E	101	M
0x02	0	H	0x0E	0	M	0xB5	101	M	0x58	010	M
			0x2E	1	H				0xBF	101	H
			0xCE	110	M				0x1F	0	M
									0x8E	101	H
									0xBA	101	H

∴ Final Cache Contents in Set 0 :

<0, 0, mem[0x03]>

. in set 1

<1, 1, Mem[0x2B]>, <1, 0, Mem[0x0E]>, <1, 110, Mem[0xCE]>

. in set 2

<2, 101, Mem[0xB4]>

. in Set 3

<3, 101, Mem[0xBE]>, <3, 010, Mem[0x58]>, <3, 0, Mem[0x1F]>

c). offset = 2 bits

Hex	Tag	H/M	0	1	2	3	4	5	6	7	
0x03	0	M	0x03								
0xB4	101 (01)	M	0x03	0xB4							
0x2B	1010	M	0x03	0xB4	0x2B						
0x02	0	H	0x03	0xB4	0x2B						
0xBE	101 111	M	0x03	0xB4	0x2B	0xBE					
0x50	10 110	M	0x03	0xB4	0x2B	0xBE					
0xBF	101 111	H	0x03	0xB4	0x2B	0xBE	0x58				
0x0E	11	M	0x03	0xB4	0x2B	0xBE	0x58				
0x1F	111	M	0x03	0xB4	0x2B	0xBE	0x58	0x0E			
0xB5	101 101	H	0x03	0xB4	0x2B	0xBE	0x58	0x0E			
0xBF	101 111	H	0x03	0xB4	0x2B	0xBE	0x58	0x0E	0x1F		
0xBA	101 110	M	0x03	0xB4	0x2B	0xBE	0x58	0x0E	0x1F		
0x2E	10 11	M	0x03	0x2E	0x2E	0xBE	0x58	0x0E	0x1F	0xBA	
0xCE	1100 11	M	0x03	0x2E	0x2E	0xBE	0x58	0x0E	0x1F		

3a). CPU time $= \frac{1}{2 \times 10^9} = 0.5\ ns$

memory cycles $= \frac{100\ ns}{0.5\ ns} = 200$

CPI $= 1.5 + 7\% \times 200 = 29.5$

b). CPI $= 1.5 + 7\% \times 12 + 3.5\% \times 200$

$= 9.34$

c). CPI $= 1.5 + 7\% \times 28 + 1.5\% \times 200 = 6.46$

d). CPI $= 1.5 + 7\% (12 + 3.5\% \times 200) = 2.83$

4). a) 1, 2, 4, 8, 16, 32, 64, 128, 256

b). 0x375 = 0011 0111 0101

	p_1	p_2	d_1	p_4	d_2	d_3	d_4	p_8	d_5	d_6	d_7	d_8
p_1	✓		✓		✓		✓		✓		✓	
p_2		✓	✓			✓	✓			✓	✓	
p_3				✓	✓	✓	✓					✓
p_4								✓	✓	✓	✓	✓

0 0 1 1

0 0 1 0

0 0 0 1 $= 1000_2 = 8$ in hex

⇒ 0011 0110 0101 ⇒ 0x365

5a). Page offset : $\log_2 4096 = 12$ bits

addr	virtual page no.	TLB Ld/M	T/B			
			valid	Tag	Physical Page no.	last accession
4669 0x1238	1	TLB Miss PT Hit page fault	1 1 1	6 7 3 1	12 4 6 15	5 2 4 0
2227 0x08B3	0	TLB Miss PT Hit	1 1 1	0 1 3 1	5 4 6 13	6 3 5 1
13916 0x365C	3	TLB hit PT hit	1 1 1	6 7 3 1	5 4 6 13	1 4 0 2
34587 0x871B	8	TLB Miss PT Hit PF	1 1 1 1	6 8 3 1	5 14 6 13	2 0 1 3
48870 0xBEE6	b	TLB miss PT Hit	1 1 1	6 8 3 b	5 14 6 12	3 1 2 0

12608 0x3140	3	TLB Hit PT Hit	1 1	0 8 3 b	5 14 6 12	4 2 0 1
49225 0xC049	C	TLB Miss PF PT Miss	1 1 1	C 8 3 b	15 14 6 12	0 3 1 2

b). offset 12 bits

index = 1 bit (12 - 11)

Addr	Virtual PN	Tag	Index	TLB H/M	TLB			
					index	Tag	Physical PN	Last Access
4669 0x123P	1	0	1	TLB Miss PT Hit PF	0 1 6 1	6 7 3 0	12 4 6 13	5 2 4 6
2227 0x08B3	0	0	0	TLB Miss PT Hit	0 1 0 1	0 7 3 0	5 4 6 13	0 3 5 1
139C6 0x365C	3	1	1	TLB Miss PT Hit	0 1 6 1	0 1 3 1	5 6 6 13	1 0 6 2
34587 0x871B	8	4	7	TLB Miss PT Hit PF	0 1 0 1	0 1 4 1	5 6 14 13	2 1 0 3
48820 0xBEE6	b	5	1	TLB Miss PT Hit	0 1 6 1	0 1 4 5	5 6 14 12	3 2 1 0
12608 0x3140	3	1	1	TLB Hit PT Hit	0 1 0 1	0 1 4 5	5 6 14 12	4 0 2 1
49225 0xC049	C	6	0	TLB Miss PT Miss	0 1 0 1	6 1 4 5	15 6 14 12	0 1 3 2