

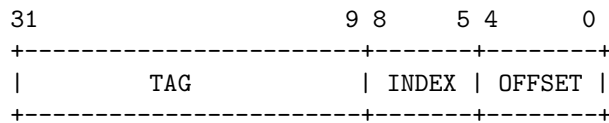
Homework 5 Solutions

CS/ECE 552 Spring 2008

April 29, 2008

Problem 3 - Direct Mapped Cache

- Number of Lines = Cache Capacity/(Block or Line Size)
 32 byte blocks =, $\log_2 32 = 5$ bit offset
 Number of Index Bits = $\log(\text{Number of lines})$
 512 byte capacity =, $\log_2(512/32) = 4$ bit index
 32 bit address - 4 bit index - 5 bit offset = 23 bit index



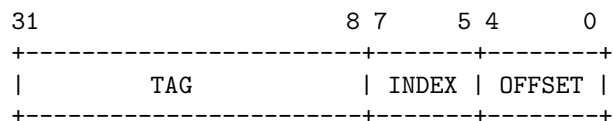
2.	ADDRESS	TAG	INDEX	OFFSET	HIT/MISS	C Type
	0x0000a796	0x000053	c	22	Miss	Compulsory
	0x000092e8	0x000049	7	8	Miss	Compulsory
	0x000092f4	0x000049	7	20	Hit	
	0x00004182	0x000020	c	2	Miss	Conflict
	0x0000780a	0x00003c	0	a	Miss	Compulsory
	0x0000a690	0x000053	4	16	Miss	Compulsory
	0x0000408e	0x000020	4	e	Miss	Conflict
	0x0000a798	0x000053	c	24	Miss	Conflict
	0x00007800	0x00003c	0	0	Hit	
	0x000092fc	0x000049	7	28	Hit	
	0x00027c02	0x00013e		2	Miss	Compulsory
	0x0000408a	0x000020	4	a	Hit	
	0x00004198	0x000020	c	24	Miss	Compulsory
	0x00006710	0x000033	8	16	Miss	Compulsory
	0x0000670c	0x000033	8	c	Hit	
	0x00027c04	0x00013e	0	4	Hit	
	0x0000a790	0x000053	c	16	Miss	Conflict

3. INDEX	TAG
0	00013e
1	
2	
3	
4	000020
5	
6	
7	000049
8	000033
9	
a	
b	
c	000053
d	
e	
f	

4. (a) Compulsory Misses - Can be reduced by increasing the block size.
 (b) Conflict Misses - Can be reduced by increasing the associativity.
 (c) Capacity Misses - Can be reduced by increasing the cache size.

Problem 4 - Set-Associative Cache

1. Number of Lines = Cache Capacity / (Block or Line Size)
 32 byte blocks $\Rightarrow \log_2 32 = 5$ bit offset
 Number of Index Bits = $\log(\text{Number of lines})$
 512 byte capacity, 2 ways $\Rightarrow \log_2 \left(\frac{512}{32 \times 2} \right) = 3$ bit index
 32 bit address - 3 bit index - 5 bit offset = 24 bit index



2.	ADDRESS	TAG	INDEX	OFFSET	HIT/MISS	C Type
	0x0000a796	0x0000a7	4	22	Miss	Compulsory
	0x000092e8	0x000092	7	8	Miss	Compulsory
	0x000092f4	0x000092	7	20	Hit	
	0x00004182	0x000041	4	2	Miss	Compulsory
	0x0000780a	0x000078	0	a	Miss	Compulsory
	0x0000a690	0x0000a6	4	16	Miss	Conflict
	0x0000408e	0x000040	4	e	Miss	Conflict
	0x0000a798	0x0000a7	4	24	Miss	Conflict
	0x00007800	0x000078	0	0	Hit	
	0x000092fc	0x000092	7	28	Hit	
	0x00027c02	0x00027c	0	2	Miss	Compulsory
	0x0000408a	0x000040	4	a	Hit	
	0x00004198	0x000041	4	24	Miss	Conflict
	0x00006710	0x000041	0	16	Miss	Conflict
	0x0000670c	0x000067	0	c	Hit	
	0x00027c04	0x00027c	0	4	Hit	
	0x0000a790	0x0000a7	4	16	Miss	Conflict

3.	INDEX	TAG1	TAG2
	0	00027c	000067
	1		
	2		
	3		
	4	0000a7	000041
	5		
	6		
	7	000092	

4. The speedup is 1 as the number of hits are same.

Problem 5 - Cache Storage

- 32 byte block * 1024 sets * 5-ways = 163840 bytes (160KB)
- Each line of each way holds a valid bit, a dirty bit, two LRU bits, a tag, and 32 bytes of data:

$$\begin{aligned}
 \text{Tag size} &= 47 \text{ bits} - \# \text{ index bits} - \# \text{ offset bits} \\
 &= 47 - \log_2 1024 - \log_2 32 \\
 &= 47 - 10 - 5 \\
 &= 32 \text{ bits}
 \end{aligned}$$

$$\begin{aligned}
 \text{Line Size} &= \text{valid} + \text{dirty} + \text{LRU} + \text{tag} + \text{data} \\
 &= 1 \text{ bit} + 1 \text{ bit} + 2 \text{ bits} + 32 \text{ bits} + 32 \text{ bytes} * (8 \text{ bits/byte}) \\
 &= 292 \text{ bits}
 \end{aligned}$$

$$\begin{aligned}
 \text{Cache size} &= 5 \text{ ways} * (1024 \text{ sets} * (\text{set size})) \\
 &= 5 * 1024 * 292 \\
 &= 1495040 \text{ bits}
 \end{aligned}$$