

CSE/EEE 230 Spring 2019 Assignment 9

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1. A cache holds 128 words where each word is 4 bytes. Assume a 32 bit address. There are four different caches
 - a. A direct-mapped cache with block size = 32 words
 - b. 2-way set-associative cache with block size = 16 words
 - c. 4-way set-associative cache with block size = 4 words
 - d. A fully associative cache with block size = 16 words.

Complete the table for each cache.

	Cache a	Cache b	Cache c	Cache d
Number of bits needed for byte displacement	5	2	2	4
Number of bits needed for word displacement (in block)	2	4	2	2
Number of bits in tag	23	24	29	25
Number of sets in cache	2	2	-1	1

Assignment 9

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each word is 4 bytes.

Total 128 words.

$$\Rightarrow 128 \times \frac{32 \text{ (bytes)}}{4 \text{ (bytes)}}$$

- c) A direct mapped cache with block size = 32 words

1 word = 4 bytes. (given)

$$32 \text{ words} \Rightarrow 32 \times 4 = 128 \text{ bytes.}$$

$$\begin{bmatrix} 8 \text{ bits} \\ = 1 \text{ byte} \end{bmatrix}$$

$$\boxed{\text{Block offset} \rightarrow 7 \text{ bits.}} \quad (5+2)$$

128 bytes / block

$$\begin{array}{l} \text{offset} \\ \log_2 128 \Rightarrow 7 \text{ bits} \end{array}$$

$$\text{blocks (total)} \Rightarrow \frac{128 \text{ bytes / block}}{32} \Rightarrow 4.$$

$$\boxed{\text{Index} \Rightarrow \log_2 4 \Rightarrow 2 \text{ bit.}}$$

$$\boxed{\text{Tag} \Rightarrow \text{Total} - (\text{Offset + Index})}$$

$$\Rightarrow 32 - 9 \Rightarrow \boxed{23 \text{ bit.}}$$

- d) A fully associative cache with block size = 16 words.

- b) 2 way set associative cache with block size = 16 words.

1 word = 4 bytes.

$$16 \text{ words} \Rightarrow 16 \times 4 \Rightarrow 64 \text{ bytes.}$$

$$\boxed{\text{Offset} = 6 \text{ bits.}} \quad (4+2)$$

$$\begin{array}{l} \text{offset} \\ \log_2 64 = 6 \text{ bits} \end{array}$$

$$\text{total no. of blocks} \Rightarrow \frac{64}{32} \Rightarrow 2$$

$$\boxed{\text{Index} \Rightarrow \log_2 2 = 1 \text{ bit}}$$

$$\boxed{\text{Tag} \Rightarrow 32 - 10 \Rightarrow \text{result} \Rightarrow 22 \text{ bit}} \quad 2^{22} = 2^{2 \times 2 \times 2 \times 2 \times 2}$$

② 4 way set-associative cache with block size = 4 words.

1 word = 4 bytes.

4 words \Rightarrow 16 bytes.

Offset
 $\log_2 16 = 4 \text{ bits.}$

Offset \Rightarrow 4 bits. $2+2=4 \text{ bits.}$

Total no. of blocks $\Rightarrow \frac{16}{32} = 0.5 \text{ blocks.}$

Index $\Rightarrow \log_2 0.5 = 0 \text{ bits.} - 1$

Tag $\Rightarrow 32 - 4^3 = 24 \Rightarrow 2+6 \text{ bits.}$
27.5 bits.
29 bits.

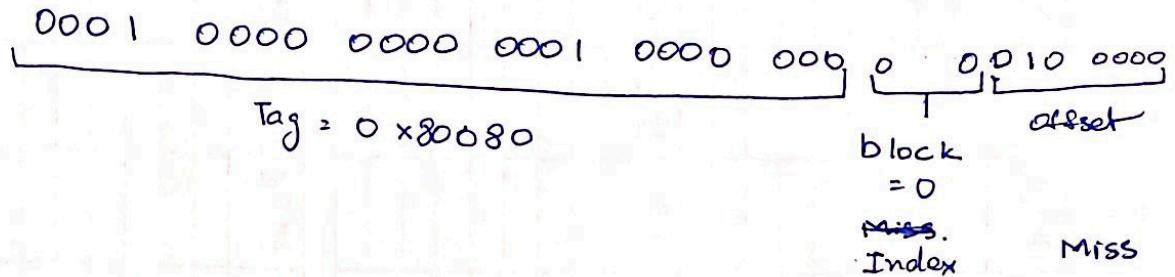
2. Here is a series of **addresses** in hexadecimal:

0x10010020, 0x1001003C, 0x10000128, 0x10011016, 0x10011017

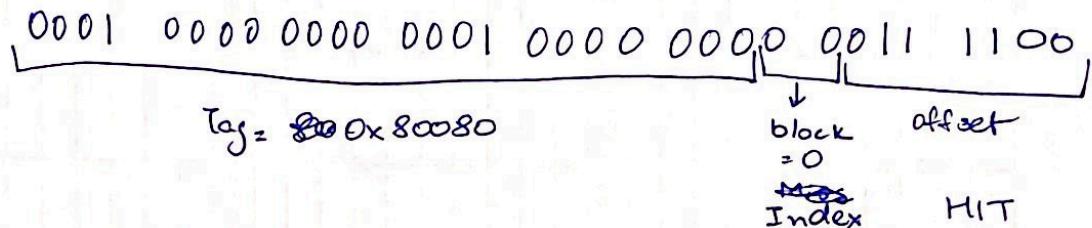
For cache a in problem 1, draw the cache as it would appear at the end of the series of references. Include the valid bit, dirty bit, and tag. Assume all accesses are reads. For each address, show the contents of the block using the byte address range. For example, if the block size is 1 word, $M[0x00000020-0x00000023]$ would hold the address of the work 0x00000021.

Q2

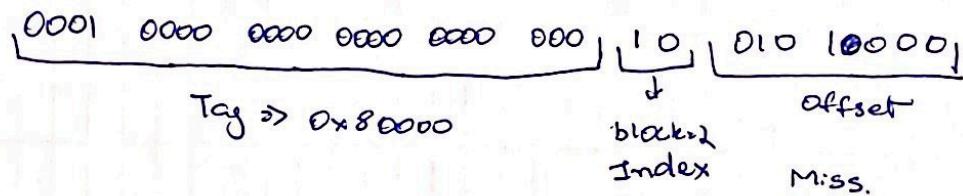
a) $0x10010020$



b) $0x1001003C$

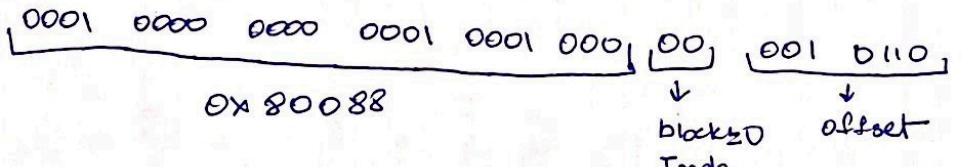


c) $0x10000128$



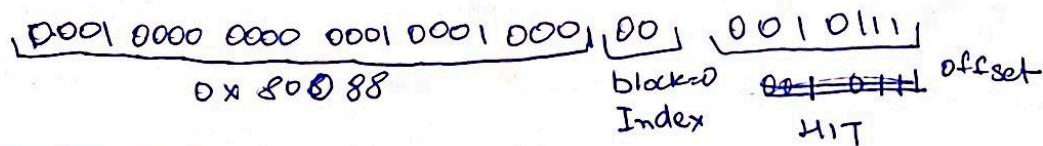
d)

$0x10011016$



e)

$0x10011017$



Valid bit	Tag	Block no.	Content.
Index	Valid	Tag	Data.
00	*1	0x80088	$M[0x10010000 - 0x100107F]$
01	0		
10	*1	0x80000	$M[0x10000100 - 0x1000017F]$
11	0		

3. Repeat the problem above for cache b. In this case, assume that all access are writes to the cache.

(C) ① $0x10010020$

$\Rightarrow \underbrace{0001 \quad 0000 \quad 0000 \quad 0001 \quad 0000 \quad 0000}_{\text{Tag} = 100100}, \underbrace{00, 10 \quad 0000}_{\text{Index set}=0 \quad \text{Offset}}$
Miss.

② $0x1001003C$

$\Rightarrow \underbrace{0001 \quad 0000 \quad 0000 \quad 0001 \quad 0000 \quad 0000}_{\text{Tag} = 100100}, \underbrace{00, 11 \quad 1100}_{\text{Index set}=0 \quad \text{Offset}}$
Hit

③ $0x10000128$

$\underbrace{0001 \quad 0000 \quad 0000 \quad 0000 \quad 0000 \quad 0000}_{\text{Tag} \Rightarrow 100001}, \underbrace{00}_{\text{Index}} \quad \underbrace{10 \quad 1000}_{\text{Offset}}$
 $\text{set}=0$
 $\text{Dirty}=0$
Miss
Hit

4) $0x100\ 11016$

\Rightarrow 0001 0000 0000 0001 0001 0000, 00 01 0110
 Tag $\Rightarrow 100110$ Index $\underline{00}$ Offset $\underline{01\ 0110}$
 Set=0
 Dirty=1

5) $0x100\ 11017$

\Rightarrow 0001 0000 0000 0001 0001 0000 00 01 0111
 Tag = 100110 Index-
 Set=0 offset
 Dirty=1 HIT

Index	Valid	Dirty	Tag	Data
00	0	0	100001	$M[0x10000100 - 0x1001101F]$
01	0	1	100110	$M[0x10011000 - 0x1001101F]$
10	0			
11	0			