

L09: Cache





Name: _____

ID: _____

Question: Direct Mapping Cache Hit Rate

Consider a 4-block empty Cache, and all blocks initially marked as `not valid`, Given the main memory word addresses “0 1 2 3 4 3 4 15”, calculate Cache hit rate.

Cache

Index	Valid	Tag	Data
00			
01			
10			
11			

0 miss

00	Mem(0)

1 miss

00	Mem(0)
00	Mem(1)

2 miss

00	Mem(0)
00	Mem(1)
00	Mem(2)

3 miss

00	Mem(0)
00	Mem(1)
00	Mem(2)
00	Mem(3)

4 miss

01

00	Mem(0)
00	Mem(1)
00	Mem(2)
00	Mem(3)

4

3 hit

01	Mem(4)
00	Mem(1)
00	Mem(2)
00	Mem(3)

4 hit

01	Mem(4)
00	Mem(1)
00	Mem(2)
00	Mem(3)

15 miss

11

01	Mem(4)
00	Mem(1)
00	Mem(2)
00	Mem(3)

15

● 8 requests, 6 misses

Question: Multiword Direct Mapping Cache Hit Rate

Consider a 2-block empty Cache, and each block is with 2-words. All blocks initially marked as `not valid`. Given the main memory word addresses “0 1 2 3 4 3 4 15”, calculate Cache hit rate.

Cache

Index	Tag	Data
00		
01		

0 miss

00	Mem(1)	Mem(0)

1 hit

00	Mem(1)	Mem(0)

2 miss

00	Mem(1)	Mem(0)
00	Mem(3)	Mem(2)

3 hit

00	Mem(1)	Mem(0)
00	Mem(3)	Mem(2)

4 miss

01

00	Mem(1)	Mem(0)
00	Mem(3)	Mem(2)

5 4

3 hit

01	Mem(5)	Mem(4)
00	Mem(3)	Mem(2)

4 hit

01	Mem(5)	Mem(4)
00	Mem(3)	Mem(2)

15 miss

11

01	Mem(5)	Mem(4)
00	Mem(3)	Mem(2)

15 14

- 8 requests, 4 misses

Question: Bit number in a Cache

How many total bits are required for a direct mapped cache with 16KB of data and 4-word blocks assuming a 32-bit address?

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How many total bits are required for a direct mapped cache with 16KB of data and 4-word blocks assuming a 32-bit address?

Solution

- ▶ 16K bytes == 4K words == 1K blocks
- ▶ Tag field size = $32 - (10 + 2 + 2) = 18$
- ▶ $2^{10} \times [4 \times 32 + 18 + 1] = 2^{10} \times 147 = 147 \text{ Kbits}$

Question: Direct Mapping v.s. 2-Way Set Associate

Consider the following two empty caches, calculate Cache hit rates for the reference word addresses: "0 4 0 4 0 4 0 4"

Cache

Index	Valid	Tag	Data
00			Blue Dotted
01			Orange Dotted
10			Pink Dotted
11			Green Dotted

(a)

Cache

Set	Tag	Data
0		
1		
0		
1		

(b)

(a) Direct Mapping; (b) 2-Way Set Associative.

Question: Direct Mapping v.s. 2-Way Set Associate

Consider the following two empty caches, calculate Cache hit rates for the reference word addresses: "0 4 0 4 0 4 0 4"

Cache

Index	Valid	Tag	Data
00			
01			
10			
11			

(a)

Cache

Set	Tag	Data
0		
1		
0		
1		

(b)

(a) Direct Mapping; (b) 2-Way Set Associative.

- ▶ Direct mapping: 0 hit (Ping pong effect)
- ▶ 2-Way Set Associative: 6 hits