CSE 351 - Section 7

Caches

Written Homework #3

- If you are having problems, come to office hours

Caches

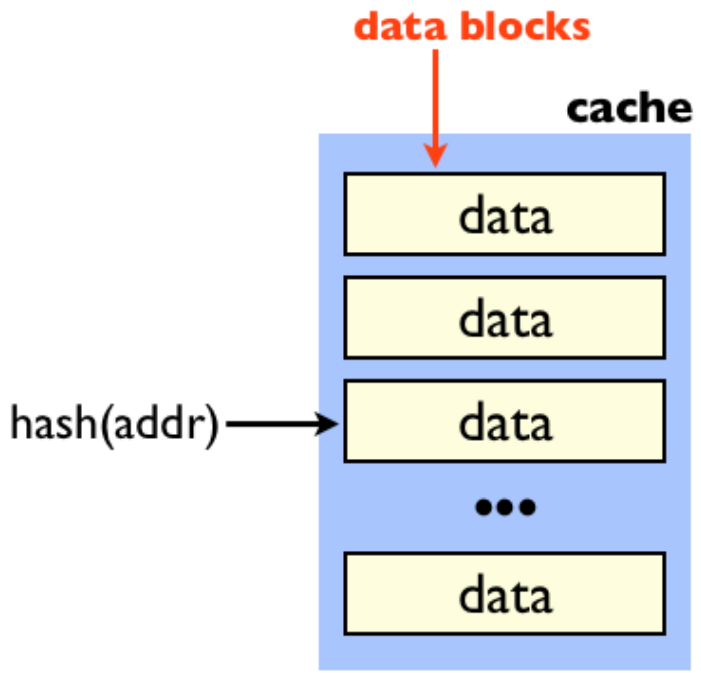
What a cache looks like

A cache is just a *fixed-size* hash table!

key: address

value: data at that address

Size of a data block is configurable



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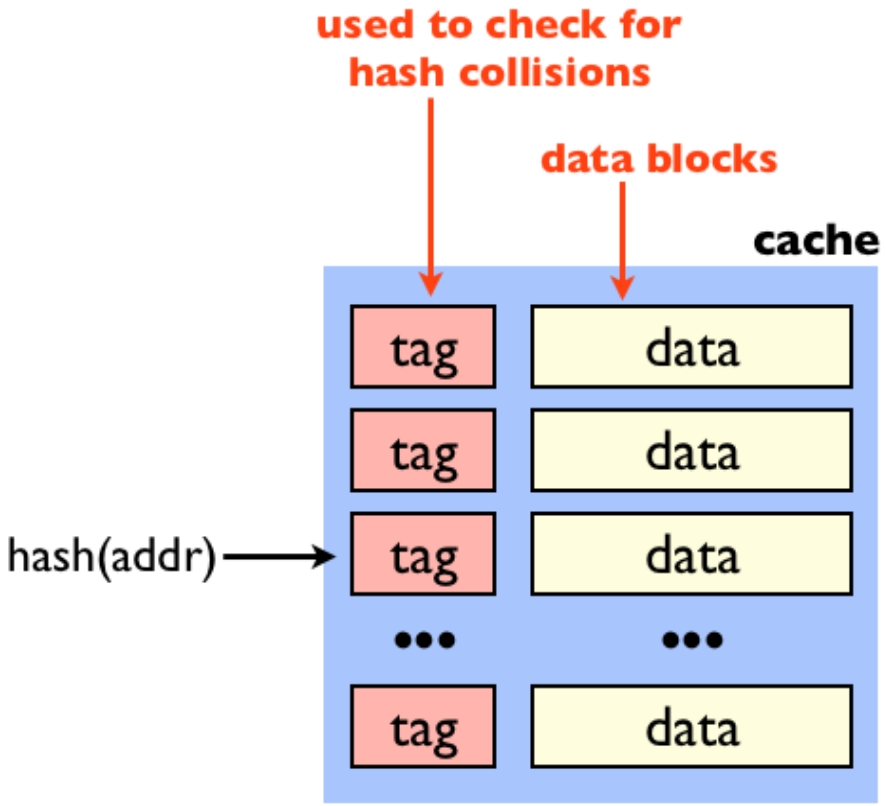

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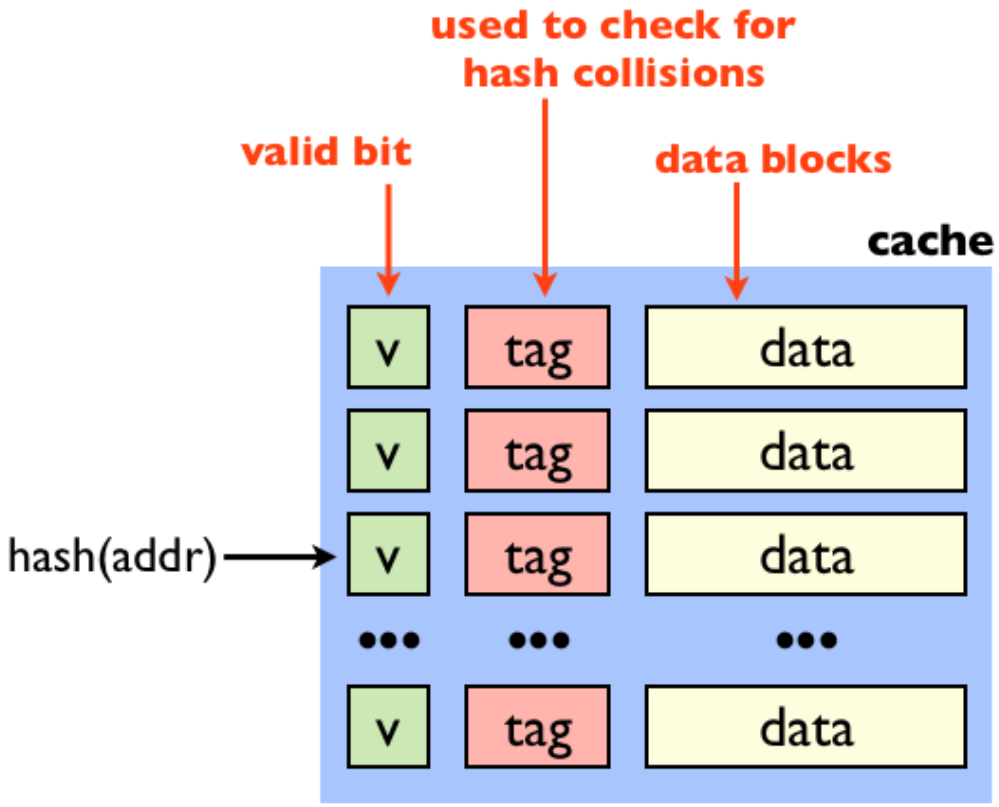
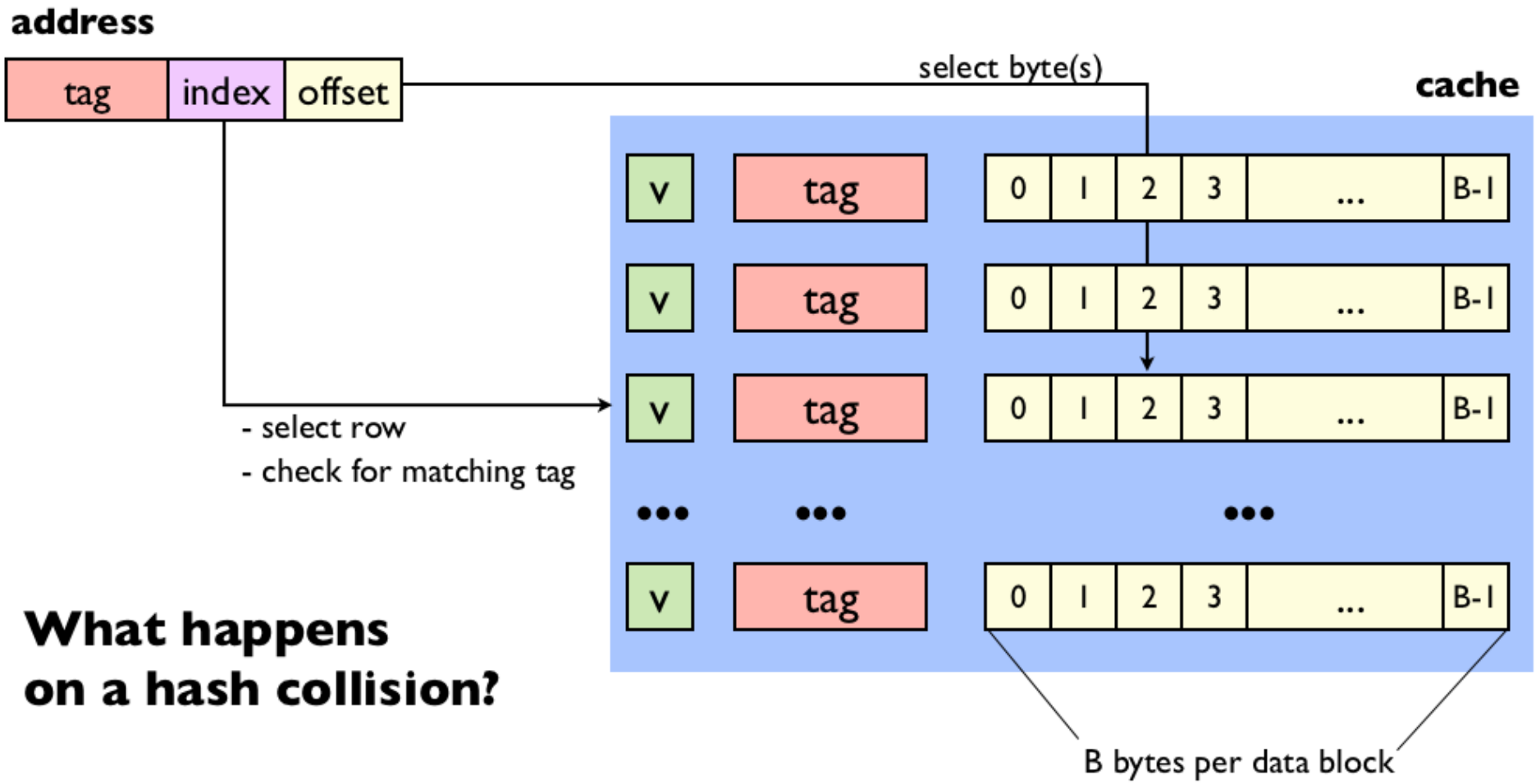
What hash function should we use?



What a cache looks like

(direct mapped cache)



What happens on a hash collision?

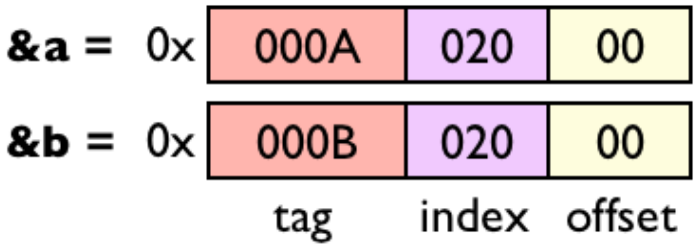
Pathological Case

(direct mapped cache)

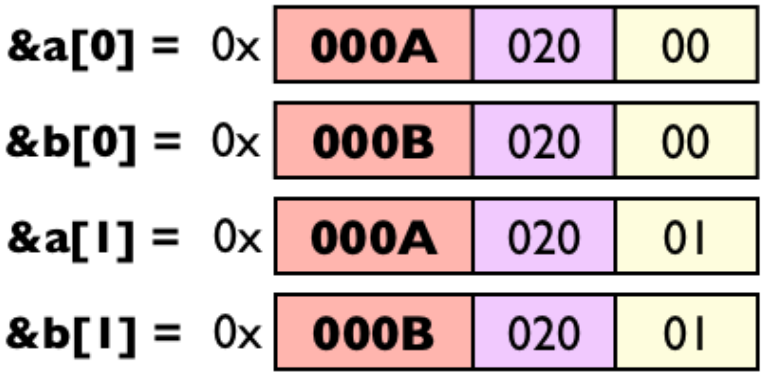
A simple program:

```
int a[64];
int b[64];
for (i=0; i<64; ++i)
   b[i] = a[i];
```

What if:



There will be a cache miss on every access!

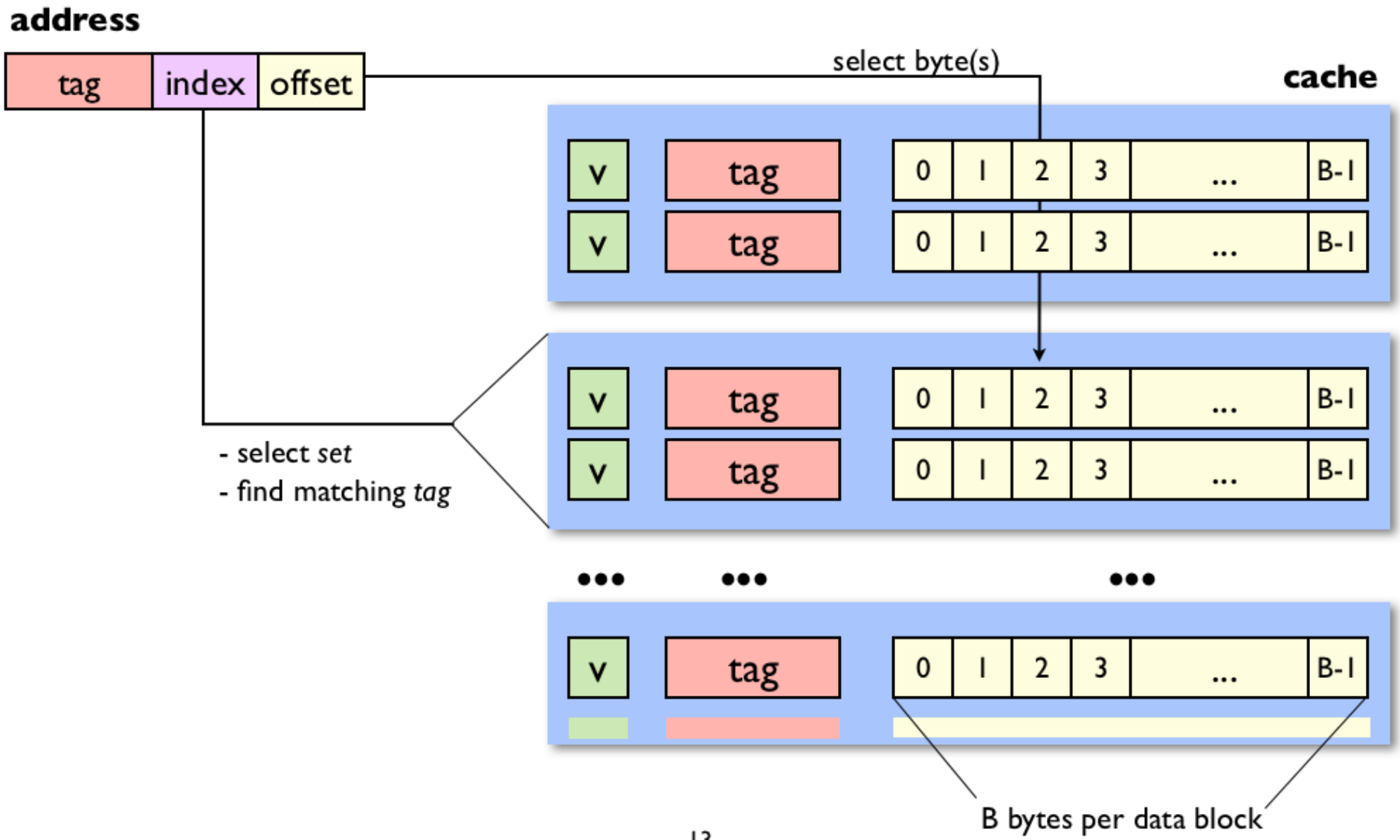


← **Note the alternating tags**

Solution: *associative sets*

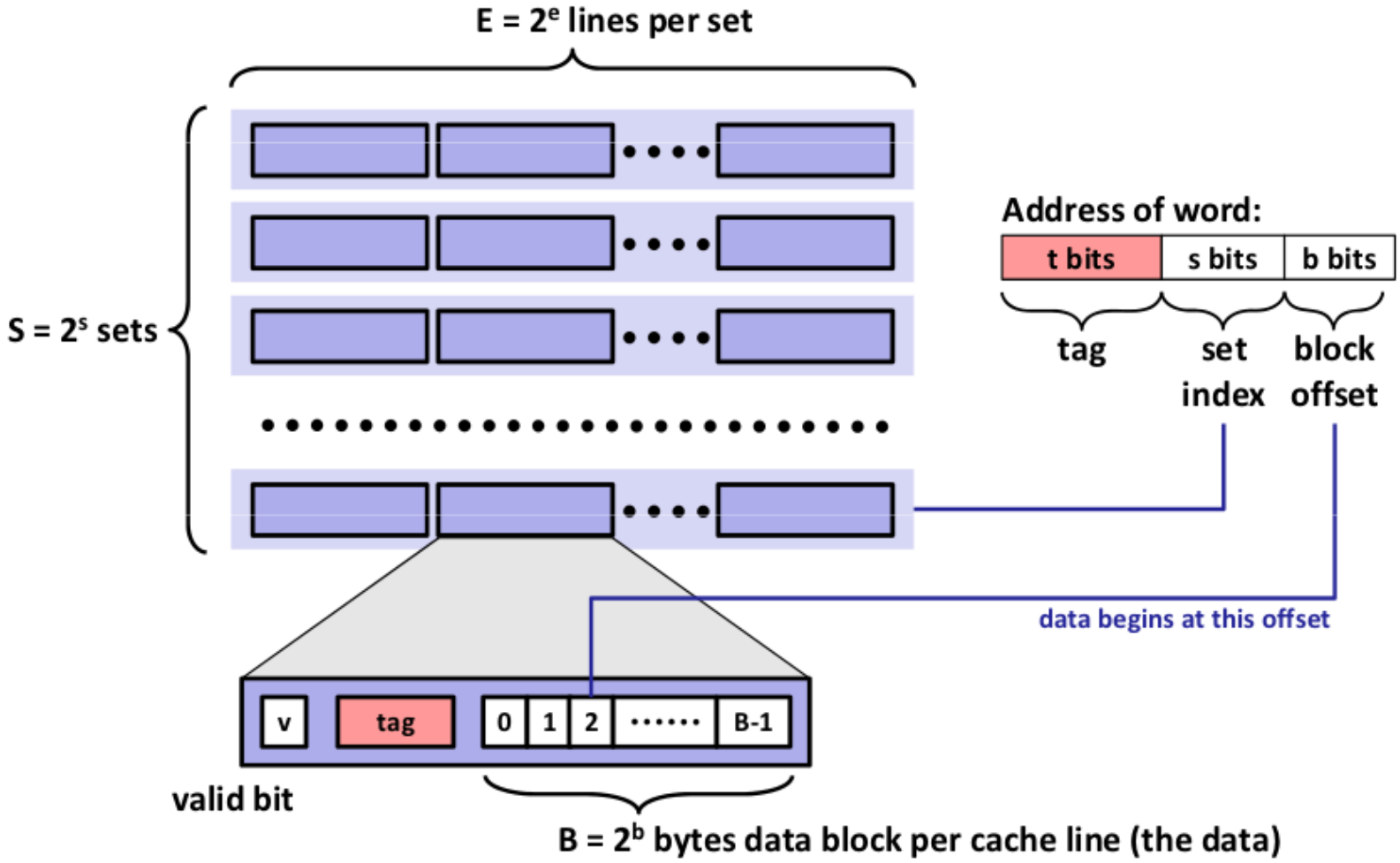
What a cache looks like

(set associative cache)



What a cache looks like

(set associative cache)



(figure from lecture slides)

Cache Example

2-way set associative cache

	Line 0						Line 1					
Set index	Tag	Valid	Byte 0	Byte 1	Byte 2	Byte 3	Tag	Valid	Byte 0	Byte 1	Byte 2	Byte 3
0	09	1	86	30	3F	10	00	0	—	—	—	—
1	45	1	60	4F	E0	23	38	1	00	BC	0B	37
2	EB	0	—	—	—	—	0B	0	—	—	—	—
3	06	0	—	—	—	—	32	1	12	08	7B	AD
4	C7	1	06	78	07	C5	05	1	40	67	C2	3B
5	71	1	0B	DE	18	4B	6E	0	—	—	—	—
6	91	1	A0	B7	26	2D	F0	0	—	—	—	—
7	46	0	—	—	—	—	DE	1	12	C0	88	37

Suppose a program running on the machine with the above cache references the 1-byte word at address 0x0E34. Assume addresses are 13 bits.

Address in binary:

0b0111000110100

CT CI CO

2-way set associative cache

	Line 0						Line 1					
Set index	Tag	Valid	Byte 0	Byte 1	Byte 2	Byte 3	Tag	Valid	Byte 0	Byte 1	Byte 2	Byte 3
0	09	1	86	30	3F	10	00	0	—	—	—	—
1	45	1	60	4F	E0	23	38	1	00	BC	0B	37
2	EB	0	—	—	—	—	0B	0	—	—	—	—
3	06	0	—	—	—	—	32	1	12	08	7B	AD
4	C7	1	06	78	07	C5	05	1	40	67	C2	3B
5	71	1	0B	DE	18	4B	6E	0	—	—	—	—
6	91	1	A0	B7	26	2D	F0	0	—	—	—	—
7	46	0	—	—	—	—	DE	1	12	C0	88	37

CT = Tag = **0x71**
CI = Set = **0x5**
CO = Offset = **0x0**

Set 0x5 has one line entry, with tag 0x71. **HIT**
Return byte 0 from set 0x5. **0xB**