set # = the last bit of block address → m = 2^1

block addr = remove rightmost 4 bits from mem addr. → b = 2^4 → 1 hex digit

replace the block with

Exercise

Assume that a computer system is equipped with two L1 caches i.e. L1 data cache, and L1 instruction cache. Each of the cache is a 2-way set associative cache with 2 sets and block size of 16 bytes. The caches use the Least Recently Used algorithm for the block replacement. They are initially empty.

Instruction cache		Data cache	
0	1	0	1
~~0x100~~ 0x104	~~0x101~~ 0x105	0x2000	~~0x2003~~ 0x2013
~~0x102~~ 0x100	~~0x105~~ ~~0x103~~ 0x101	0x2002	0x2011

Complete the following table for the instruction and data accesses. M = 0x1005 → B = 0x100

Time	Instr Addr	Hit/Miss	Data Addr	Hit/Miss
1	0x1000 → 0x100	M	0x20000 → 0x2000	M
2	0x1004 → 0x100	H	0x20024 → 0x2002	M
3	0x1008	H		
4	0x100C	H		
5	0x1010	M		
6	0x1000	H	0x20004	H
7	0x1004	H	0x20028	H
8	0x1020	M		
9	0x1024	H		
10	0x1010	H		
11	0x1014	H		
12	0x1040	M		
13	0x1044	H	0x20030	M
14	0x1008	M	0x20031	H
15	0x100C	H	0x20032	H
16	0x1050	M		
17	0x1054	H		
18	0x1058	H	0x20110	M
19	0x1018	H		
20	0x1030	M	0x20130	M
21	0x1034	H	0x20134	H
23	0x1050	M		
24	0x1010	M	0x20024	H
25	0x1054	H		

Suppose an L2 unified cache is added to the system. It is a 4-way set associative cache with 4 sets and block size of 16 bytes.

L1 Instruction cache		L1 Data cache	
0	1	0	1
~~0x100~~ 0x104	~~0x101~~ 0x105	0x2000	~~0x2003~~ 0x2013
~~0x102~~ 0x100	~~0x105~~ ~~0x103~~ 0x101	0x2002	0x2011

L2 unified cache			
0	1	2	3
0x100	0x101	0x2002	0x2003
0x2000	0x105	0x102	0x103
0x104	0x2011		0x2013

Complete the following table for the instruction and data accesses.

M ← Main Mem | L1 ← Hit
L2 ← Hit in L2 | in L1

Time	Instr Addr	L1/L2/Miss	Data Addr	L1/L2/Miss
1	0x1000 → 0x100	M	0x20000 → 0x2000	M
2	0x1004	L1	0x20024 → 0x2002	M
3	0x1008 → 0x100	L1		
4	0x100C	L1		
5	0x1010	M		
6	0x1000	L1	0x20004	L1
7	0x1004	L1	0x20028 → 0x2002	L1
8	0x1020	M		
9	0x1024	L1		
10	0x1010	L1		
11	0x1014	L1		
12	0x1040	M		
13	0x1044	L1	0x20030	M
14	0x1008	L2	0x20031	L1
15	0x100C	L1	0x20032	L1
16	0x1050	M		
17	0x1054	L1		
18	0x1058	L1	0x20110	M
19	0x1018	L1		
20	0x1030	M	0x20130	M
21	0x1034	L1	0x20134	L1
23	0x1050	L2		
24	0x1010	L2	0x20024	L1
25	0x1054	L1		