Worksheet 8

Turn this in during class on April 25, 2016

Consider the following memory system snapshot,

Figure A. TLB: Four sets, 16 entries, four-way set associative

Set	Tag	PPN	Valid	Tag	PPN	Valid	Tag	PPN	Valid	Tag	PPN	Valid
0	03	–	0	09	0D	1	00	–	0	07	02	1
1	03	2D	1	02	–	0	04	–	0	0A	–	0
2	02	–	0	08	–	0	06	–	0	03	–	0
3	07	–	0	03	0D	1	0A	34	1	02	–	0

Figure B. Page table: Only the first 16 PTEs are shown

VPN	PPN	Valid	VPN	PPN	Valid
00	28	1	08	13	1
01	—	0	09	17	1
02	33	1	0A	09	1
03	02	1	0B	—	0
04	—	0	0C	—	0
05	16	1	0D	2D	1
06	—	0	0E	11	1
07	—	0	0F	0D	1

Figure C. Cache: Sixteen Sets, 4 byte blocks, direct mapped

Idx	Tag	Valid	Blk 0	Blk 1	Blk 2	Blk 3
0	19	1	99	11	23	11
1	15	0	—	—	—	—
2	1B	1	00	02	04	08
3	36	0	—	—	—	—
4	32	1	43	6D	8F	09
5	0D	1	36	72	F0	1D
6	31	0	—	—	—	—
7	16	1	11	C2	DF	03
8	24	1	3A	00	51	89
9	2D	0	—	—	—	—
A	2D	1	93	15	DA	3B
B	0B	0	—	—	—	—
C	12	0	—	—	—	—
D	16	1	04	96	34	15
E	13	1	83	77	1B	D3
F	14	0	—	—	—	—

- The memory is byte addressable.
- Memory accesses are to 1-byte words (not 4-byte words).
- Virtual addresses are 14 bits wide (n = 14).
- Physical addresses are 12 bits wide (m = 12).
- The page size is 64 bytes (P = 64).
- The TLB is four-way set associative with 16 total entries.
- The L1 d-cache is physically addressed and direct mapped, with a 4-byte line size and 16 total sets.

Note

We have not specified how the VA is split into VPN, VPO, TLB-I or TLB-T and how the PA is split into PPN, PPO, CO, CI or CT. It is your task to figure that out.

For Example

➔ If Page Size is 128 bytes => Number of bits for VPO and PPO = 7 bits. (The remaining bits are for VPN or PPN).

➔ If TLB has 8 sets => Number of TLB set index bits is 3 (The remaining bits are for TLB tag).

Show how the memory system described above translates a virtual address into a physical address and accesses the cache.
For the given virtual address, indicate the TLB entry accessed, the physical address, and the cache byte value returned. Indicate whether the TLB misses, whether a page fault occurs, and whether a cache miss occurs. If there is a cache miss, enter "−" for "Cache Byte returned." If there is a page fault, enter "−" for "PPN" and leave parts C and D blank.

Q1. Virtual Address: **0x03a9**

A. Virtual Address Format

13	12	11	10	9	8	7	6	5	4	3	2	1	0

B. Address translation

Parameter	Value
VPN	
TLB Index	
TLB tag	
TLB Hit? (Y/N)	
Page Fault? (Y/N)	
PPN	

C. Physical Address Format

11	10	9	8	7	6	5	4	3	2	1	0

D. Physical Memory Reference

Parameter	Value
Byte Offset	
Cache Index	
Cache tag	
Cache Hit? (Y/N)	
Cache byte returned	

Q2. Virtual Address: **0x0040**

A. Virtual Address Format

13	12	11	10	9	8	7	6	5	4	3	2	1	0

B. Address translation

Parameter	Value
VPN	
TLB Index	
TLB tag	
TLB Hit? (Y/N)	
Page Fault? (Y/N)	
PPN	

C. Physical Address Format

11	10	9	8	7	6	5	4	3	2	1	0

D. Physical Memory Reference

Parameter	Value
Byte Offset	
Cache Index	
Cache tag	
Cache Hit? (Y/N)	
Cache byte returned	