



Ve370 Introduction to Computer Organization

Homework 8

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Due: 2:00pm on December 7, 2021

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1. (20 points) Assume that main memory accesses take 70 ns and that memory accesses are 36% of all instructions. The following table shows parameters for a two-level cache memory.

	Size	Miss Rate	Hit Time
L1	16 KB	7.3%	1.18 ns
L2	1 MB	1.5%	5.34 ns

- (1) What is the AMAT for the computer? (10 points)

$$1 + 7.3\% * (5.34 / 1.18 + 1.5\% * 70 / 1.18) = 1.4307 \text{ cycles} = 1.688 \text{ ns}$$

- (2) Assuming the L1 hit time determines the cycle times and a base CPI is 1.0 without any memory stalls, what is the total CPI? (10 points)

$$1 + 7.3\% * (1 - 1.5\%) * 5.34 / 1.18 * (1 + 36\%) + 7.3\% * 1.5\% * 70 / 1.18 * (1 + 36\%) = 1.578$$

2. (30 points) In this exercise, we will examine how replacement policies impact miss rate. Assume a 2-way set associative cache with 4 blocks. Following table gives addresses for memory access.

- (1) Assuming an LRU replacement policy, how many hits does this address sequence exhibit?

(10 points)

Block Address of memory	Hit/Miss	Evicted Block	Contents of Cache			
			Set 0		Set 1	
1	Miss	-	-	-	1	-
3	Miss	-	-	-	1	3
5	Miss	1	-	-	5	3
1	Miss	3	-	-	5	1
3	Miss	5	-	-	3	1
1	Hit	-	-	-	3	1
3	Hit	-	-	-	3	1
5	Miss	1	-	-	3	5
3	Hit	-	-	-	3	5

3 Hits.

- (2) Assuming an MRU (most recently used) replacement policy, how many hits does this address sequence exhibit? (10 points)

Block Address of memory	Hit/Miss	Evicted Block	Contents of Cache			
			Set 0		Set 1	
1	Miss	-	-	-	1	-
3	Miss	-	-	-	1	3
5	Miss	3	-	-	1	5
1	Hit	-	-	-	1	5
3	Miss	1	-	-	3	5
1	Miss	3	-	-	1	5
3	Miss	1	-	-	1	5
5	Hit	-	-	-	1	5
3	Miss	5	-	-	1	3

2 Hits.

- (3) Simulate a random replacement policy by flipping a coin. For example, “heads” means to evict the first block in a set and “tails” means to evict the second block in a set. How many hits does this address sequence exhibit? Note: you should flip the coin yourself, not by computer. (10 points)

Block Address of memory	Hit/Miss	Evicted Block	Contents of Cache			
			Set 0		Set 1	
1	Miss	-	-	-	1	-
3	Miss	-	-	-	1	3
5	Miss	1	-	-	5	3
1	Miss	3	-	-	5	1
3	Miss	1	-	-	5	3
1	Miss	3	-	-	5	1
3	Miss	5	-	-	3	1
5	Miss	3	-	-	5	1
3	Miss	5	-	-	3	1

0 Hits.

3. (50 points) Virtual memory uses a page table to track the mapping of virtual addresses to physical addresses. The following is a stream of virtual byte addresses used to access memory. Virtual addresses (in decimal): 12648, 45419, 46824, 16975, 40004, 12707, 52236. Assume 4 KB pages, a 4-entry fully associative TLB, and LRU replacement. If pages must be brought in from disk, increment to the next largest page number.

TLB:

Valid	Tag	Physical Page Number
1	11	12
1	7	4
1	3	6
0	4	9

Page Table:

Index	Valid	Physical Page Number
0	1	5
1	0	Disk
2	0	Disk
3	1	6
4	1	9
5	1	11
6	0	Disk
7	1	4
8	0	Disk
9	0	Disk
10	1	3
11	1	12

- (1) Given the virtual address stream, and the initial TLB and page table states shown above, show the final state of the system. Also list for each reference if it is a hit in the TLB, a hit in the page table, or a page fault. (15 points)

Page entries: 1024, 10-bit

Virtual Page Number: 4-bit

Final state:

Valid	Tag	Physical Page Number
1	11	12
1	9	13
1	12	14
1	4	9

12648: Hit in TLB & Page Table
 45419: Hit in TLB & Page Table
 46824: Hit in TLB & Page Table
 16975: Miss in TLB, Hit in Page Table
 40004: Miss in TLB & Page Table, Page fault
 12707: Hit in TLB & Page Table
 52236: Miss in TLB & Page Table, Page fault

- (2) Repeat question (1), but this time use 16 KB pages instead of 4 KB pages. (15 points)
Page entries: 4096, 12-bit

Virtual Page Number: 2-bit

Final state:

Valid	Tag	Physical Page Number
1	2	13
1	1	14
1	3	6
1	0	5

12648: Miss in TLB, Hit in Page Table

45419: Miss in TLB & Page Table, Page fault

46824: Hit in TLB & Page Table

16975: Miss in TLB & Page Table, Page fault

40004: Hit in TLB & Page Table

12707: Hit in TLB & Page Table

52236: Hit in TLB & Page Table

- (3) What would be some of the advantages and disadvantages of having a larger page size? (5 points)

Miss rate will be lower, while it will be harder to allocate such a large memory for pages, also most of the memory will be wasted if only small programs are running.

- (4) Show the final contents of the TLB if it is 2-way set associative. (15 points)

Index	Valid	Tag	Physical Page Number
0	1	2	14
0	1	6	15
1	1	1	13
1	1	4	9