

Assignment 5

Due Date : May 24, 2021 (day)

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Score : _____

Problem 1 (3.5) Score: _____

Solution: (1) The cache size is $2^{5-2} = 8$ (In words).

(2) Since $\text{len}(\text{index})=5$, The number of entry of this cache is $2^5 = 32$.

(3) Total number of bits is $2^n \times (\text{block size} + \text{tag size} + \text{valid size}) = 2^5 \times (8 \times 32 + 22 + 1) = 32 \times 279$. And the bits for data storage is $2^5 \times 8 \times 32 = 2^5 \times 256$. So the final answer (ratio) is $\frac{2^5 \times 256}{2^5 \times 279} \approx 0.918$.

(4) First rewrite the address in binary form (only show the low 12 bits since other bits are all 0):

	address					
decimal	0	4	16	132	232	160
binary	0000_0000_0000	0000_0000_0100	0000_0001_0000	0000_1000_0100	0000_1110_1000	0000_1010_0000
decimal	1024	30	140	3100	180	2180
binary	0100_0000_0000	0000_0001_1110	0000_1000_1110	1100_0001_1100	0000_1011_0100	1000_1000_0100

We only need to check the 9-5 bits as index, 11-10 as tag (other part of tag are same):

	address	index	tag	result
0	0000_0000_0000	00000	00	Miss
4	0000_0000_0100	00000	00	Hit
16	0000_0001_0000	00000	00	Hit
132	0000_1000_0100	00100	00	Miss
232	0000_1110_1000	00111	00	Miss
160	0000_1010_0000	00101	00	Miss
1024	0100_0000_0000	00000	01	Miss and replace
30	0000_0001_1110	00000	00	Miss and replace
140	0000_1000_1110	00100	00	Hit
3100	1100_0001_1100	00000	11	Miss and replace
180	0000_1011_0100	00101	00	Hit
2180	1000_1000_0100	00100	10	Miss and replace

From the table we can obtain that the answer is 4.

(5) Hit ratio = $\frac{4}{12} \times 100\% \approx 33.3\%$

(6) The answer is shown as the following table

index	tag	data
00000	11	mem[11_00000]~mem[11_11111]
00100	10	mem[10_00100]~mem[11_00011]
00101	00	mem[00_00101]~mem[01_00100]
00111	00	mem[00_00111]~mem[01_00110]

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Problem 2 (5.6) Score: _____

Solution: (1) P1 cycle time: $\frac{1}{0.66ns} = \frac{1}{0.66 \times 10^{-9}s} = 1.52GHz$
P2 cycle time: $\frac{1}{0.90ns} = 1.11GHz$.

(2) AMAT = hit time + miss rate \times miss price (dajia). Notice that the cycle is unable to divided. From the problem set description we can obtain that main memory accesses take 70 ns. The AMAT for P1 is $1 + 8.0\% \times \lceil \frac{70ns}{0.66ns} \rceil = 9.56\text{cycle} = 6.3096ns$.

The AMAT for P2 is $1 + 6.0\% \times \lceil \frac{70ns}{0.90ns} \rceil = 5.68\text{cycle} = 5.112ns$.

	L1 size	L1 Miss Rate	L1 Hit Time
P1	2 KiB	8.0%	0.66ns
P2	4 KiB	6.0%	0.90ns

- (3) According to the instruction counter I , The number of clock cycles lost due to instruction missing is $0.08I \times 107$, The number of clock cycles due to missing data at any time is $0.08 \times 0.36 \times 107$. In a word, the CPI for P1 is $1 + 0.08 \times 107 + 0.08 \times 0.36 \times 107 \approx 12.64$. Similarly, we can calculate that the CPI for P2 is 7.36. $12.64 \times 0.66 \approx 8.34$, $7.36 \times 0.90 \approx 6.62$. Since $6.62 < 8.34$, then P2 is faster.
- (4) By the same way in sub-problem 2, $AMAT = 1 + 8.0\% \times (\lceil \frac{5.62ns}{0.66ns} \rceil + 95\% \times 107) \approx 9.9$ cycle. Compare to 2, since $9.9 > 9.56$, then the AMAT is worse with the L2 cache.
- (5) By the same way in sub-problem 3, $CPI = 1 + 8.0\% \times (\lceil \frac{5.62ns}{0.66ns} \rceil + 95\% \times 107) + 36\% \times 8.0\% \times (\lceil \frac{5.62ns}{0.66ns} \rceil + 95\% \times 107) = 13.03872 \approx 13.04$.
- (6) $13.04 \times 0.66 \approx 8.61 > 6.62$, P2 is faster. Consider the miss rate t would P1 need in its L1 cache. For new CPI in P1 to match the performance of P2, we can obtain that $\frac{6.64}{0.66} = 1 + t \times (\lceil \frac{5.62ns}{0.66ns} \rceil + 95\% \times 107) + t \times 36\% \times (\lceil \frac{5.62ns}{0.66ns} \rceil + 95\% \times 107)$. After solving the equation, we can find the answer is $0.06021 \times 100\% \approx 6\%$. □