# NWEN242 Assignment 4

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## Q1

### a

It can store 4 Integers.
32-bit =4- byte
$\frac{16}{4}$=4
Hence it can store four integers.

### b

The variables i and j are accessed through each iteration. I and J exhibits temporal locality in the inner loop function. We also use B[I][0] through each iteration. Hence B[I][0] also exhibits temporal locality.

### c

A[I][J] exhibits spatial locality. Because in the inner loop J changes through each iteration and the value placed next to each other, once J reaches 7999 it will start again from 0.

## Q2

### a

| Word Address | Binary Address | Tag | Index | Hit/Miss |
|---|---|---|---|---|
| 3 | 0000 0011 | 0 | 3 | M |
| 180 | 1011 0100 | 11 | 4 | M |
| 43 | 0010 1011 | 2 | 11 | M |
| 2 | 0000 0010 | 0 | 2 | M |
| 191 | 1011 1111 | 11 | 15 | M |
| 88 | 0101 1000 | 5 | 8 | M |
| 190 | 1011 1110 | 11 | 14 | M |
| 14 | 0000 1110 | 0 | 14 | M |
| 181 | 1011 0101 | 11 | 5 | M |
| 44 | 0010 1100 | 2 | 12 | M |
| 186 | 1011 1010 | 11 | 10 | M |
| 253 | 1111 1101 | 15 | 13 | M |

**b**

| Word Address | Binary Address | Tag | Index | Hit/Miss |
|---|---|---|---|---|
| 3 | 0000 0011 | 0 | 1 | M |
| 180 | 1011 0100 | 11 | 2 | M |
| 43 | 0010 1011 | 2 | 5 | M |
| 2 | 0000 0010 | 0 | 1 | H |
| 191 | 1011 1111 | 11 | 7 | M |
| 88 | 0101 1000 | 5 | 4 | M |
| 190 | 1011 1110 | 11 | 7 | H |
| 14 | 0000 1110 | 0 | 7 | M |
| 181 | 1011 0101 | 11 | 2 | H |
| 44 | 0010 1100 | 2 | 6 | M |
| 186 | 1011 1010 | 11 | 5 | M |
| 253 | 1111 1101 | 15 | 6 | M |

**c**

| | | | Cache1 | | Cache2 | | Cache3 | |
|---|---|---|---|---|---|---|---|---|
| Word Address | Binary Address | Tag | Index | Hit/Miss | Index | Hit/Miss | Index | Hit/Miss |
| 3 | 0000 0011 | 0 | 3 | M | 1 | M | 0 | M |
| 180 | 1011 0100 | 22 | 4 | M | 2 | M | 1 | M |
| 43 | 0010 1011 | 5 | 3 | M | 1 | M | 0 | M |
| 2 | 0000 0010 | 0 | 2 | M | 1 | M | 0 | M |
| 191 | 1011 1111 | 23 | 7 | M | 3 | M | 1 | M |
| 88 | 0101 1000 | 11 | 0 | M | 0 | M | 0 | M |
| 190 | 1011 1110 | 23 | 6 | M | 3 | H | 1 | H |
| 14 | 0000 1110 | 1 | 6 | M | 3 | M | 1 | M |
| 181 | 1011 0101 | 22 | 5 | M | 2 | H | 1 | M |
| 44 | 0010 1100 | 5 | 4 | M | 2 | M | 1 | M |
| 186 | 1011 1010 | 23 | 2 | M | 1 | M | 0 | M |
| 253 | 1111 1101 | 31 | 5 | M | 2 | M | 1 | M |

Cache 1 :
Miss Rate: 100%
Total Cycle : $12 \times 25 + 12 \times 2 = 324$
Cache 2 :
Miss Rate : $\frac{10}{12} \approx 83\%$
Total Cycle: $10 \times 25 + 12 \times 3 = 286$
Cache 3 : Miss Rate: $\frac{10}{12} \approx 92\%$
Total Cycle : $11 \times 25 + 12 \times 5 = 335$
From the information shown above, cache2 provides the best performance.

**d**

Cache Data Size : 32 KiB
Cache Block Size : 2 words
block numbers= $\frac{2^{15}}{2^3} = 2^{12}$
(Note: here I divide three because each word have 2 byte and the cache is 2-word cache, it can hold 2 words per block so I divide it by 2 again. In order to find how many blocks we have. )
So the index is 12 bits to identify each block.
Because of 2 words block, the offset is 1 bit.
Tag = 32 - index - offset = 32 - 12 - 1 = 19 bits
Total block size : 1 + 19 + 64 = 84 bits
Total cache size : $\frac{84 \times 2^{12}}{8 \times 1024} \approx 42$ KiB

# Q3

## a

The cache block size = $2^5$=32 bytes
In words : $\frac{32}{4}$=8

## b

From the 5-bits index, it shows the cache has 32 blocks($2^5$=32).

## c

For each block it has 8 words (8 × 4=32 bytes), 32 × 8 =256-bits
Data storage : 32 × 256 = 8192 bits
Total storage: (256 + 22 + 1) × 32 = 8928 bits
The ratio is $\frac{8298}{8192}$= 1.089

# Q5

From three way associative cache, it determines we have a 8 sets cache. So the index is 3 bits. Because the cache we have is a two-word cache so the less significant bit is the offset.

| Word Address | Binary Address | Tag | Index | Hit/Miss | Block0/Way0 | Block1/Way1 | Block2/Way2 |
|---|---|---|---|---|---|---|---|
| 3 | 0000 0011 | 0 | 1 | Miss | T(1)=0 | | |
| 180 | 1011 0100 | 11 | 2 | Miss | T(1)=0/T(2)=11 | | |
| 2 | 0000 0010 | 0 | 1 | Hit | T(1)=0/T(2)=11 | | |
| 191 | 1011 1111 | 11 | 7 | Miss | T(1)=0/T(2)=11/T(7)=11 | | |
| 14 | 0000 1110 | 0 | 7 | Miss | T(1)=0/T(2)=11/T(7)=11 | T(7)=0 | |
| 31 | 0001 1111 | 1 | 7 | Miss | T(1)=0/T(2)=11/T(7)=11 | T(7)=0 | T(7)=1 |
| 190 | 1011 1110 | 11 | 7 | Hit | T(1)=0/T(2)=11/T(7)=11 | T(7)=0 | T(7)=1 |
| 158 | 1001 1110 | 9 | 7 | Miss | T(1)=0/T(2)=11/T(7)=9 | T(7)=0 | T(7)=1 |