

**CS3021/3421 Tutorial 6**

Q1. Compute the number of hits and misses if the subsequent list of hexadecimal addresses is applied to caches with the following organisations.

- (i) 128 byte 1-way cache with 16 bytes per line (direct mapped)
- (ii) 128 byte 2-way set associative cache with 16 bytes per line
- (iii) 128 byte 4-way set associative cache with 16 bytes per line
- (iv) 128 byte 8-way associative cache with 16 bytes per line (fully associative)

0000  $\Rightarrow$  0004  $\Rightarrow$  000c  $\Rightarrow$  2200  $\Rightarrow$  00d0  $\Rightarrow$  00e0  $\Rightarrow$  1130  $\Rightarrow$  0028  $\Rightarrow$   
 113c  $\Rightarrow$  2204  $\Rightarrow$  0010  $\Rightarrow$  0020  $\Rightarrow$  0004  $\Rightarrow$  0040  $\Rightarrow$  2208  $\Rightarrow$  0008  $\Rightarrow$   
 00a0  $\Rightarrow$  0004  $\Rightarrow$  1104  $\Rightarrow$  0028  $\Rightarrow$  000c  $\Rightarrow$  0084  $\Rightarrow$  000c  $\Rightarrow$  3390  $\Rightarrow$   
 00b0  $\Rightarrow$  1100  $\Rightarrow$  0028  $\Rightarrow$  0064  $\Rightarrow$  0070  $\Rightarrow$  00d0  $\Rightarrow$  0008  $\Rightarrow$  3394  $\Rightarrow$

Assume that the first 4 bits of the address is used as the offset within the cache line, the next  $\log_2(N)$  bits select the set and the remaining bits form the tag. Furthermore, assume that the all cache lines are initially invalid and that a LRU replacement policy is used.

- Q2. Determine the number of compulsory, capacity and conflict misses for each cache organisation in Q1.
- Q3. Write a program (in C, C++, Java, ...) to solve Q1. Make sure you can create a generalised cache object with parameters L, K and N. Hand in a copy of your source code and evidence that your program works.
- Q4. FOR AN EXTRA 5 MARKS modify your program to simulate a pseudo LRU replacement policy. What are the hit rates for the cache organisations specified in Q1?

THIS TUTORIAL IS WORTH DOUBLE MARKS (MARKED OUT OF 20 OR 25/20)

**128 byte 1-way cache with 16 bytes per line (L = 16, N = 8, K=1)**

| <u>tag</u> | <u>4 word (16bytes)</u> |  |  |  |
|------------|-------------------------|--|--|--|
|            |                         |  |  |  |
|            |                         |  |  |  |
|            |                         |  |  |  |
|            |                         |  |  |  |
|            |                         |  |  |  |
|            |                         |  |  |  |
|            |                         |  |  |  |

**Address Format**

|    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
|----|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|
| 15 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0 |
|----|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|

| <u>address</u> | <u>set</u> | <u>hit/miss</u> |
|----------------|------------|-----------------|
| 0000           |            |                 |
| 0004           |            |                 |
| 000c           |            |                 |
| 2200           |            |                 |
| 00d0           |            |                 |
| 00e0           |            |                 |
| 1130           |            |                 |
| 0028           |            |                 |
| 113c           |            |                 |
| 2204           |            |                 |
| 0010           |            |                 |
| 0020           |            |                 |
| 0004           |            |                 |
| 0040           |            |                 |
| 2208           |            |                 |
| 0008           |            |                 |
| 00a0           |            |                 |
| 0004           |            |                 |
| 1104           |            |                 |
| 0028           |            |                 |
| 000c           |            |                 |
| 0084           |            |                 |
| 000c           |            |                 |
| 3390           |            |                 |
| 00b0           |            |                 |
| 1100           |            |                 |
| 0028           |            |                 |
| 0064           |            |                 |
| 0070           |            |                 |
| 00d0           |            |                 |
| 0008           |            |                 |
| 3394           |            |                 |

**128 byte 2-way cache with 16 bytes per line (L = 16, N = 4, K=2)**

| <u>tag (K=0)</u> | <u>tag(K=1)</u> | <u>4 word (16bytes)</u> |  |  |  | <u>4 word (16bytes)</u> |  |  |  |
|------------------|-----------------|-------------------------|--|--|--|-------------------------|--|--|--|
|                  |                 |                         |  |  |  |                         |  |  |  |
|                  |                 |                         |  |  |  |                         |  |  |  |
|                  |                 |                         |  |  |  |                         |  |  |  |
|                  |                 |                         |  |  |  |                         |  |  |  |

**Address Format**

|    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
|----|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|
| 15 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0 |
|----|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|

| <u>address</u> | <u>set</u> | <u>hit/miss</u> |
|----------------|------------|-----------------|
| 0000           |            |                 |
| 0004           |            |                 |
| 000c           |            |                 |
| 2200           |            |                 |
| 00d0           |            |                 |
| 00e0           |            |                 |
| 1130           |            |                 |
| 0028           |            |                 |
| 113c           |            |                 |
| 2204           |            |                 |
| 0010           |            |                 |
| 0020           |            |                 |
| 0004           |            |                 |
| 0040           |            |                 |
| 2208           |            |                 |
| 0008           |            |                 |
| 00a0           |            |                 |
| 0004           |            |                 |
| 1104           |            |                 |
| 0028           |            |                 |
| 000c           |            |                 |
| 0084           |            |                 |
| 000c           |            |                 |
| 3390           |            |                 |
| 00b0           |            |                 |
| 1100           |            |                 |
| 0028           |            |                 |
| 0064           |            |                 |
| 0070           |            |                 |
| 00d0           |            |                 |
| 0008           |            |                 |
| 3394           |            |                 |