TIC1001—Introduction to Computing and Programming

National University of Singapore

**Lecture 8: Memory & Cache**

Question 1: DRAM vs SRAM

Select all areas where DRAM is better than SRAM in the following.

~~Speed, i.e. DRAM is faster than SRAM~~

Density, i.e. DRAM takes smaller space compared to SRAM

Simplicity, i.e. DRAM needs lesser components to build compared to SRAM

~~Power consumptions, i.e. DRAM needs less power to maintain compared to SRAM.~~

Question 2: Memory Hierarchy

With your new understanding, identify the different memory technologies that may be involved when your program tries to access a variable, e.g. "i = 123;"?

Register

Cache

Physical Memory (RAM)

~~External Storage (USB drive, network drive etc.)~~

Memory item get loaded into register.

Instruction "i = 123" and the data "i" both get loaded into cache.

Instruction and Data were in the RAM.

Question 3: Locality Principle – 1

If we have the following C code fragment:

int array[SIZE]; // you can assume SIZE is very large

int i, item, index;

for (i = 0; i < 10000; i++){

index = rand() % SIZE; //rand() gives a random number, % SIZE make sure it is in [0...SIZE-1]

array[index] = rand(); //just store a random number at a random location

}

What kind of locality does the instructions in the for-loop exhibits?

Temporal Locality

Spatial Locality

~~None of the above.~~

The same instruction get executed multiple times (due to looping).

When an instruction get executed, the instruction nearby is needed soon (due to sequential execution).

Question 4: Locality Principles – 2

If we have the following C code fragment:

int array[SIZE]; // you can assume SIZE is very large

int i, item, index;

for (i = 0; i < 10000; i++){

index = rand() % SIZE; //rand() gives a random number, % SIZE make sure it is in [0...SIZE-1]

array[index] = rand(); //just store a random number at a random location

}

What kind of locality does the elements of array[] exhibits?

~~Temporal Locality~~

~~Spatial Locality~~

None of the above.

As the element is accessed randomly, no locality is exhibited.

Question 5: Cache Block Size

Cache block size is larger than word size because.....

~~Temporal Locality~~

Spatial Locality

### Question 6: Fully Associative Cache

Given a FA cache with 4 blocks (i.e. cache index = 0, 1, 2, 3), how many cache misses are there for the following **block number access?**

**19, 7, 6, 2, 6, 2, 3, 19**

You can assume that we replace the **oldest**block (block that was in the cache for the longest time) whenever needed.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 19 |  | 19 |  |  |  |  | Miss |
| 7 |  | 19 | 7 |  |  |  | Miss |
| 6 |  | 19 | 7 | 6 |  |  | Miss |
| 2 |  | 19 | 7 | 6 | 2 |  | Miss |
| 6 |  | 19 | 7 | 6 | 2 |  | Hit |
| 2 |  | 19 | 7 | 6 | 2 |  | Hit |
| 3 |  | 3 | 7 | 6 | 2 |  | Miss |
| 19 |  | 3 | 19 | 6 | 2 |  | Miss |

Question 7: Direct Mapped Cache

Given a DM cache with 4 blocks (i.e. cache index = 0, 1, 2, 3), how many cache misses are there for the following **block number access?**

**19, 7, 6, 2, 6, 2, 3, 19**

You can assume that we replace the **oldest**block (block that was in the cache for the longest time) whenever needed.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 0 | 1 | 2 | 3 |  |  |  |
| 19 |  |  |  |  | 19 |  | 19 % 4 = 3 | Miss | |
| 7 |  |  |  |  | 7 |  | 7 % 4 = 3 | Miss | |
| 6 |  |  |  | 6 | 7 |  | 6 % 4 = 2 | Miss | |
| 2 |  |  |  | 2 | 7 |  | 2 % 4 = 2 | Miss | |
| 6 |  |  |  | 6 | 7 |  | 6 % 4 = 2 | Miss | |
| 2 |  | 2 |  | 6 | 7 |  | 2 % 2 = 0 | Miss | |
| 3 |  | 2 | 3 | 6 | 7 |  | 3 % 2 = 1 | Miss | |
| 19 |  | 2 | 3 | 6 | 19 |  | 19 % 4 = 3 | Miss | |