

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