ACS Applied Computer Science

THE UNIVERSITY OF WINNIPEG

APPLIED COMPUTER SCIENCE

ACS-2906-001
Computer Architecture and System Software

Fall 2024

Laboratory 10

Due date: November 27th, 11:59 pm **Total marks: 10**

Motivation

The goal of this laboratory is to reinforce concepts of the memory hierarchy. Note, the code below is written using C++. However, the solution is based on data type sizes and not specifics to the programming language. In other words, just pay attention to the sizes and the cache line capacities.

Questions

1. (5 points) Consider the code below and answer the following questions.

   a. What is the total number of writes?

   b. What is the total number of writes that miss in the cache?

   c. What is the miss rate?

```
struct point_color {
  int c;
  int m;
  int y;
  int k;
}

struct point_color square[16][16];
int i, j;
for (i = 0; i < 16; i++) {
  for (j = 0; j < 16; j++) {
  square[i][j].y = 1;
  }
}
for (i = 0; i < 16; i++) {
  for (j = 0; j < 16; j++) {
    square[i][j].c = 0;
```

```
      square[i][j].m = 0;
      square[i][j].k = 0;
   }
}
```

Assume the following:

- The system has a 2,048-byte direct-mapped data cache with 32-byte blocks
- `sizeof(int)=4`
- `square` begins at memory address 0
- The cache is initially empty
- The only memory accesses are to the entries of the array `square`
- Variables `i` and `j` are stored in registers

2. (5 points) Consider following code and state the percentage of writes in the following code that will miss in the cache.

```
struct pixel {
   char r;
   char g;
   char b;
   char a;
};

struct pixel buffer[480][640];
int i, j;
for (int j = 0; j < 640; j++) {
   for (int i = 0; i < 480; i++){
      buffer[i][j].r = 0;
      buffer[i][j].g = 0;
      buffer[i][j].b = 0;
      buffer[i][j].a = 0;
    }
}
```

Assume the following:

- The machine you are working on has a 64 KB direct-mapped cache with 4-byte lines.
- `sizeof(int)=4` & `sizeof(char)=1`
- `buffer` begins at memory address 0
- The cache is initially empty
- The only memory accesses are to the entries of the array buffer
- Variables `i` and `j` are stored in registers

Hint: Think how many bytes fit per line in the cache. How many bytes does a pixel require?

Evaluation:

- You **must** show your work to receive full marks.

Submission instructions

Submit your laboratory solutions via Nexus.