ICS Homework 8

April 25, 2020

1 Organization

1.1 Cache I

The following table gives the parameters for a number of different caches. Fill in the missing fields in the table for each cache. Recall that m is the number of memory address bits, C is the cache size (number of data bytes), B is the block size in bytes, E is the associativity, S is the number of cache sets, t is the number of tag bits, s is the number of set index bits, and b is the number of block offset bits.

Cache	C	S	E	B	m	t	s	b
A	1024	16		4	64		4	2
B	32768	128	8			20		
C	2048	32			32		5	6
D			2	8	64	53	8	3

ANS:

Cache	C	S	E	B	m	t	s	b
A	1024	16	16	4	64	58	4	2
B	32768	128	8	32	32	20	7	5
C	2048	32	1	64	32	21	5	6
D	4096	256	2	8	64	53	8	3

1.2 Cache II

Bob has a machine with 4-way cache. The cache line size is 64 bytes. There are 4 sets in the cache. Alice executes the code below on this machine. Suppose **sum, i, j, k** are stored in registers and **sizeof(int)** will return 4.

```
#define M 16
#define N 16

int a[M][N];

int sum()
{
        int i, j;
        int sum = 0;

        for (i = 0; i < M; i++)
12                for (j = 0; j < N; j++)
13                        sum += a[i][j];
14
15        return sum
16 }
```

1. How many memory accesses in total are there in the loop between line 11 and 13?
   ANS:
   $16 \times 16 = 256$

2. How many cache misses in the loop in total?
   ANS:
   16, one cache miss on each iteration of the outer loop.

3. Suppose the latency of cache hit is 4 cycles. An access to main memory requires 200 cycles for 64 bytes. What is the average latency of accessing array elements in cycles when executing the loop between line 11 and 13?
   ANS:
   $4 \times \frac{15}{16} + (200 + 4) \times \frac{1}{16} = 16.5$

4. Bob wants to execute this program on a new machine, whose cache doubles in size to get better performance. The larger cache comes in different styles. Which one(s) of the followings will help?

   (a) Double the associativity of a set

   (b) Double the number of sets

   (c) Double the size of cache line

   ANS:
   Only the c will reduce the miss rate into half.

2 System Software

```
int main()
{
    int fd1, fd2, fd3;
    char *buf1 = (char *)malloc(10);
    char *buf2 = (char *)malloc(10);
    fd1 = open(”a.txt”, O_RDWR, 0);
    fd2 = open(”b.txt”, O_RDWR | O_APPEND, 0);
    fd3 = open(”a.txt”, O_RDWR, 0);
    if (fork() == 0) {
        read(fd2, buf1, 2);
        dup2(fd1, fd2);
        read(fd2, buf1, 1);
        exit(0);
    }
    waitpid(-1, NULL, 0);
    read(fd2, buf1, 3);
    write(fd1, buf1, 3);
    read(fd1, buf1, 10);
    printf("%s\n", buf1);
    read(fd3, buf2, 10);
    dup2(fd2, 1);
    printf("%s\n", buf2);
    free(buf1);
    free(buf2);
    exit(0);
}
```

The content of `a.txt` is

```
abcdefg
```

and the content of `b.txt` is

```
0123456789
```

1. What will the contents of a.txt and b.txt be after the program completes?
   ANS:
   a.txt: `a234efg` b.txt: `0123456789a234efg`

2. What will be printed on stdout?
   ANS:
   `efg`