CARLETON UNIVERSITY

Department of Systems and Computer Engineering

SYSC 5704 **Elements of Computer Systems** **Assignment 6**

Due date: Tuesday, December 2^{nd}, 18:00.

6.2 You are trying to bake 3 blueberry pound cakes. Cake ingredients are as follows:

- 1 cup butter, softened
- i cup sugar
- 4 large eggs
- I teaspoon vanilla extract
- 1/2 teaspoon salt
- 1/4 teaspoon nutmeg
- 1 1/2 cups flour
- 1 cup blueberries

The recipe for a single cake is as follows:

Step 1: Preheat oven to 325F (160C). Grease and flour your cake pan.

Step 2: In large bowl, beat together with a mixer butter and sugar at medium speed until light and fluffy. Add eggs, vanilla, salt and nutmeg. Beat until thoroughly blended. Reduce mixer speed to low and add flour, 1/2 cup at a time, beating just until blended.

Step 3: Gently fold in blueberries. Spread evenly in prepared baking pan. Bake for 60 minutes.

1. [5] <§6.2> Your job is to cook 3 cakes as efficiently as possible. Assuming that you only have one oven large enough to hold one cake, one large bowl, one cake pan, and one mixer, come up with a schedule to make three cakes as quickly as possible. Identify the bottlenecks in completing this task.
2. [5] <§6.2> Assume now that you have three bowls, 3 cake pans and 3 mixers. How much faster is the process now that you have additional resources?

6.4 Consider the following piece of C code:

```
for ( j = 2; j < 1000; j = j + 1 ) {
    D[j] = D[j-1] + D[j-2];
}
```

The MIPS code corresponding to the above fragment is:

```
        addiu   $s2,$zero,7992
        addiu   $s1,$zero,16
loop:   l.d     $f0,-16($s1)
        l.d     $f2,-8($s1)
        add.d   $f4,$f0,$f2
        s.d     $f4,0($s1)
        addiu   $s1,$s1,8
        bne     $s1,$s2,loop
```

Instructions have the followiung associated latencies (in cycles):

add.d	l.d	s.d	addiu
4	6	1	2

1. [10] <§6.2> How many cycles does it take for all instructions in a single iteration of the above loop to execute?
2. [10] <§6.2> When an instruction in a later iteration of a loop depends upon a data value produced in an earlier iteration of the same loop, we say that there is a loop carried dependence between iterations of the loop. Identify the loop-carried dependences in the above code. Identify the dependent program variable and assembly-level registers. You can ignore the loop induction variable `j`.
3. [10] <§6.2> Loop unrolling was described in Chapter 4. Apply loop unrolling to this loop and then consider running this code on a 2-node distributed memory message passing system. Assume that we are going to use message passing as described in Section 6.7, where we introduce a new operation `send (x, y)` that sends to node `x` the value `y`, and an operation `receive()` that waits for the value being sent to it. Assume that send operations take a cycle to issue (i.e., later instructions on the same node can proceed on the next cycle), but take 10 cycles be received on the receiving node. Receive instructions stall execution on the node where they are executed until they receive a message. Produce a schedule for the two nodes assuming an unroll factor of 4 for the loop body (i.e., the loop body will appear 4 times). Compute the number of cycles it will take for the loop to run on the message passing system.
4. [10] <§6.2> The latency of the interconnect network plays a large role in the efficiency of message passing systems. How fast does the interconnect need to be in order to obtain any speedup from using the distributed system described in Exercise 6.4.3?

6.20 Assume a quad-core computer system can process database queries at a steady state rate of requests per second. Also assume that each transaction takes, on average, a fixed amount of time to process. The following table shows pairs of transaction latency and processing rate.

Average Transaction Latency	Maximum transaction processing rate
1 ms	5000/sec
2 ms	5000/sec
1 ms	10,000/sec
2 ms	10,000/sec

For each of the pairs in the table, answer the following questions:

1. [10] <§6.11> On average, how many requests are being processed at any given instant?
2. [10] <§6.11> If move to an 8-core system, ideally, what will happen to the system throughput (i.e., how many queries/second will the computer process)?
3. [10] <§6.11> Discuss why we rarely obtain this kind of speedup by simply increasing the number of cores.