UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009

November 2008

CCS524 – Parallel Computing Architectures and Algorithms

Duration : 2 hours

INSTRUCTION TO CANDIDATE:

- Please ensure that this examination paper contains **FOUR** questions in **FOUR** printed pages before you begin the examination.
- Answer **ALL** questions.

1. (a) Distinguish between the terms "concurrency" and "parallelism".

(4/100)

(b) State **two (2)** differences between the shared memory parallel architecture and the distributed memory parallel architecture.

(4/100)

(c) The goal in parallel programming is to achieve **scalable** programs with **performance** and **portability**.

Define the terms:

(i) scalable

(ii) performance

(iii) portability

(9/100)

(d) Gaussian elimination is a well known method to solve the systems of linear equations of the form $Ax = b$, where A is a n x n non-singular matrix, x is the unknown vector and b is the right hand side vector.

Assume that matrix A is to be partitioned across multiple threads or multiple processes for parallel computation.

Propose **two (2)** ways in which the partitioning can be done in order to ensure a balanced load across the threads or processes.

(8/100)

2. (a) Consider the problem of counting the number of 3's in *array[]* of *length* values to be implemented on a multicore computer using t number of threads. The following solution has been proposed:

```
int length_per_thread = length/t
int start = id * length_per_thread
for (i = start; i < start + length_per_thread; i++)
   { if (array [i] == 3)
        count +=1;
   }
```

However, this solution will result in a **race condition**.

(i) Explain the race condition concept.

(ii) Propose a solultion to the above example in order to overcome race condition.

(10/100)

(b) (i) Briefly describe the term **false sharing**.

(ii) Using the example in 2(a), present a solution that will result in false sharing.

(iii) How can false sharing be avoided?

(15/100)

3. (a) What are the **two (2)** main functions of any message-passing library?

(5/100)

(b) Distinguish between synchronous message-passing (blocking) and asynchronous message-passing (non-blocking).

(8/100)

(c) Given 4 processes P1, P2, P3 and P4 which have been spawned to solve a single problem using the message-passing programming paradigm. Illustrate (using appropriate diagrams) the following concepts:

(i) barrier

(ii) gather

(iii) reduction

(12/100)

4. Given the following sequential code for numerical integration to compute the value of *Pi.*

```
static long num_steps = 100000;
double step, pi;
void main ()
{  int i;
   double x, sum = 0.0;
   step = 1.0/(double) num_steps;
   for (i = 0; i < num_steps; i++) {
       x = (i + 0.5) * step;
       sum = sum + 4.0/(1.0 + x * x);
   }
   pi = step * sum;
   printf ("Pi = %f \n", pi);
}
```

(a) Which design approach would you select to parallelise the above problem, data parallelism or function parallelism? Justify your selection.

(6/100)

(b) If you were asked to parallelise the above code using multithreading, which part of the code would be most suitable to be divided amongst the threads.

(5/100)

(c) Identify the local variables and the shared variables for your solution in 4(b).

(8/100)

(d) If your solution in 4(b) results in a superlinear speedup, what could be a possible reason for the phenomena?

(6/100)

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