Student Number .....

The University of Melbourne

Semester 2 Assessment 2013

Computing and Information Systems

COMP90025 Parallel and Multicore Computing

Reading Time 15 minutes

Writing Time 3 hours

Open Book Status Closed Book

This paper has 2 **pages (not including this page).**

Authorised Materials:
The following items are authorised: (list here) ☐
OR
Students may have unrestricted access to all materials ☐
OR
No materials are authorised ☑

Paper to be held by Baillieu Library: Indicate whether the paper is to be held with the Baillieu Library.
☑ Yes ☐ No

Instructions to Invigilators:
No papers may be taken from the exam room.

Instructions to Students:
All answers are to be written in the script book(s) provided.
Answer questions in order.
Attempt all questions - partial credit is available.
The examination is worth 60% of the subject assessment.

Extra Materials required (please tick & supply)

☐ Graph Paper ☐ Multiple Choice form ☐ Other (please specify)

1. **(6 marks)** Illustrate the concepts of parallel computing using Flynn's taxonomy and Schwartz's parallel machine architecture.

2. **(10 marks)** Explain in equations and/or words: speedup, Amdahl's law and Gustafon's law. Then analyse the below code in terms of speedup, Amdahl's law and Gustafon's law.

```
#include <omp.h>
#include <stdio.h>
#include <math.h>

#define SIZE 1024

main(int argc, char *argv[]) {
   double Sum = 0.0, a[SIZE], b[SIZE];
   int i;
   a[0] = b[0] = 0;
   for (i = 1; i < SIZE; i++) {
         a[i] = a[i-1] + 0.5*cos(b[i-1]);
         b[i] = b[i-1] + 2.0*sin(a[i-1]);;
   }
   #pragma omp parallel for reduction(+:Sum)
   for (i = 0; i < SIZE; i++) {
         Sum = Sum + a[i]*tan(b[i]);
   }
   printf("Sum = %f\n", Sum);
}
```

3. **(6 marks)** Describe the Map-reduce programming model, list its advantages and challenges. Give an example with pseudocode to strengthen your arguments.

4. **(6 marks)** Describe how you would parallelise merge sort with an example illustration and a pseudocode. Also discuss the complexity of the parallel version of the merge sort.

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5. **(10 marks)** A common network metric is the cost, defined as cost = degree x diameter. Give precise definitions of both degree and diameter, and compute the cost of the following networks:

   a) A ring network of degree = 2 and diameter = 5
   b) A tree network of degree = 3 and diameter = 6
   c) A completely connected network with degree = 9

6. **(8 marks)** Explain the following terms as applied to workflow management:
   (a) Spatial clustering
   (b) Task clustering
   (c) Data parallelism
   (d) Data throttling

7. **(6 marks)** Define Cloud computing, explain it in-terms-of X-as-a-Service.

8. **(8 marks)** Explain the following MPI program line by line and its output. Assume the number of processing units = 5 when executing at command line.

```
#include "mpi.h"
#include <stdio.h>
int main( int argc, char *argv[] )
{
    int rank, size;
    MPI_Init( &argc, &argv );
    MPI_Comm_rank( MPI_COMM_WORLD, &rank );
    MPI_Comm_size( MPI_COMM_WORLD, &size );
    printf( "I am %d of %d\n", rank, size );
    MPI_Finalize();
    return 0;
}
```

END OF EXAMINATION