GRIFFITH COLLEGE DUBLIN

QUALITY AND QUALIFICATIONS IRELAND EXAMINATION

MASTER OF SCIENCE IN COMPUTING
PARALLEL AND DISTRUBUTED PROGRAMMING
Module code: MSCC-PDP

POSTGRADUATE DIPLOMA IN SCIENCE IN COMPUTING
PARALLEL AND DISTRUBUTED PROGRAMMING
Module code: PGDC-PDP
ONLINE EXAMINATION

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External Examiner(s):   **Dr John Cardiff**

Date: 17th August 2020   **Time: 9.45-12.45**

THIS PAPER CONSISTS OF FOUR QUESTIONS
ALL QUESTIONS TO BE ATTEMPTED
ALL QUESTIONS CARRY EQUAL MARKS

HONOUR CODE

By submitting my exam script via Moodle, I certify that my answers contained in this Examination Script document are entirely composed of my own original work.

During the exam period, which began when I received the exam paper document, I did not work with anyone else on the exam or discuss the examination with anyone else.

I did not copy and hold out as my own any material belonging to or produced by another person.

I understand that failure to adhere to these instructions shall be an Honour Code violation.

Violation of the Honour Code will result in being charged with academic misconduct.

QUESTION 1 (Java)

(a)   Using Java ForkJoin Framework, write code to solve the following problem, given an array of random integers, it is required to reverse the order of elements into a new array.

(15 marks)

We have provided some of the code for you.

```
import java.util.concurrent.ForkJoinPool;
import java.util.concurrent.RecursiveAction;
public class Main {
static final ForkJoinPool fjPool = new ForkJoinPool();
static int[] reverse(int[] array) {
// ADD A LINE HERE
fjPool.invoke(new Reverse(answer,array,0,array.length)); // DO NOT CHANGE
// ADD A LINE HERE
}
}
// DEFINE A CLASS HERE
```

(b)   Discuss a thread safe coding design consideration when two elements in a 2-Dimensional array need to be swapped, this of the 2-Dimensional array as a matrix. Implement a java code method called swap to be thread safe and deadlock free.

(10 marks)
Total (25 marks)

QUESTION 2 (Open MP/MPI)

(a)   An MPI program has the following section

for (i=0; i < numProcs; i++) { // numProcs is the number of processors
MPI_Reduce(b, c, n, MPI_INT, MPI_SUM, i, MPI_COMM_WORLD);
}

Rewrite this to be a more efficient operation (the loop can be replaced by a single MPI collective communication call)

(10 marks)

(b)   What is the output of the following code if OMP_NUM_THREADS=4?

```
main(..)
{
    static int arr[4] = {1,2,3,4} ;

    int x=1, j ;
    #pragma omp parallel for reduction(*:x)
    for(j=0 ; j<4 ; j++)
        x *= arr[j] ;

    printf( "%d", x ) ;
}
```

(5 marks)

(c)   What is the maximum collapse level that can be specified with the #pragma omp for in the following code in order to give the same result as the sequential code?

```
#pragma omp for ..
for(i=0;i<100;i++)
  for(j=0;j<100;j++)
    for(k=10;k<100;k++)
      for(l=10;l<100;l++)
        arr[i][j][k][l] = i+(j*2)+arr[i][j][k-10][l] ;
```

(5 marks)

(d)   Which technique can be used to resolve false sharing issues?

(5 marks)
Total (25 marks)

QUESTION 3 (Java)

(a)   A developer has a problem whose size can increase with an increasing number of processors. He needs to execute the program and determines that in a parallel execution on 100 processors. 5% of the time is spent in the sequential part of the program. What is the scaled speedup of the program on 100 processors?

(5 marks)

(b)   A platform has space for at most 100 people at any one time. People are only admitted when the platform is open and the number of persons does not exceed the prescribed limit. Using condition variables write a class that could be used to control access to the platform.

(15 marks)

(c)   A resource is shared between N threads such that access to the resource is on a *first-come-first-served* basis. Explain how you would implement a policy of *first-come-first-served*.

(5 marks)
Total (25 marks)

QUESTION 4 (MPI/OpenMP)

(a)   Write a complete MPI program to find how negative numbers there are in an integer array A[N] using a scatter/gather pattern. Define N as a constant with a value 10,000. Define the number of slaves as P and set to 10 slaves. Each slave is sent one group of N/P numbers from the array. **Assume A[N] is initialized with integers.**

(15 marks)

(b)   Write the solution of part a using OpenMP.

(10 marks)
Total(25 marks)