GRIFFITH COLLEGE DUBLIN

QUALITY AND QUALIFICATIONS IRELAND

EXAMINATION

POSTGRADUATE DIPLOMA IN SCIENCE IN BIG DATA MANAGEMENT AND ANALYTICS

PARALLEL AND DISTRIBUTED PROGRAMMING
Module Code: PGDBD-PDP

MASTER OF SCIENCE IN BIG DATA MANAGEMENT AND ANALYTICS

PARALLEL AND DISTRIBUTED PROGRAMMING
Module code: MSCBD-PDP

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External Examiner(s): **Dr Joseph Rafferty**

Date: January 2022 P2 **Time: 2.15-5.15**

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

QUESTION 1

(a) Explain the semantics of counting semaphores.

(5 marks)

(b) A platform has space for at most n people at any one time. People are only admitted when the number of persons on the platform does not exceed the prescribed limit. Using a semaphore write a class that could be used to control automated access to the platform. Your class must keep a record of the number of people on the platform at any given point in time and must make this value visible through a public method count().

(15 marks)

(c) What are Cyclic barriers? Give an example of when you might use this type of barrier.

(5 marks)

Total (25 marks)

QUESTION 2

(a) Write a Java Program to calculate the sum of the even values in an integer array. The workload equally between the 4 threads, waits for them to complete their calculations and then calculates the final result by invoking the result method of each thread.

(10 marks)

(b) The following class will deadlock by invoking method t(). Why?

```
class A{
private Semaphore sem;
public A(){
        sem = new Semaphore(0);
}
synchronized void t(){
        ...
        try{
            sem.acquire();
        }catch(InterruptedException e){}
}
synchronized void t1(){
        ...
        sem.release();
}
}
```

(5 marks)

(c) Draw a picture of the three states of a thread and label the transitions between the states.

(5 marks)

(d) Explain the terms Synchronization, critical section, mutual exclusion.

(5 marks)

Total (25 marks)

QUESTION 3

(a) Write an OpenMP C program to compute the count of negative numbers in a square matrix A of size n.Your code needs to be optimal.

(10 marks)

(b) Re-write the same task in part 1 using MPI.

(15 marks)

Total (25 marks)

QUESTION 4

(a) Explain the main limitation of OpenMP, and how Hybrid OpenMP/MPI overcome that limitation.

(6 marks)

(b) Explain why there is less locking in MPI compared to OpenMP.

(5 marks)

(c) The following OpenMP code computes the norm of the difference between two vectors

double a[], b[], using a temporary vector double t[], leaving the result in the variable double s.

```
#pragma omp parallel for nowait
for (i=0; i<N; i++)
t[i] = (a[i]-b[i])*(a[i]-b[i]);
s = 0;
#pragma omp parallel for
for (i=0; i<N; i++)
#pragma omp atomic
s += t[i];
s = sqrt(s);
```

(i) What is the purpose of the nowait clause? In the above example, what assumptions are being made for its use to be safe?

(2 marks)

(ii) Why is the #pragma omp atomic directive needed? Illustrate your answer with a scenario describing at the instruction level what could happen if the directive was missing.

(3 marks)

(iii) Rewrite the above code so that the second loop would be more efficient.

(5 marks)

(iv) Explain the differences between critical and atomic in OpenMP

(4 marks)

Total (25 marks)

QUESTION 5

(a) Explain the meaning and purpose of resource ordering

(5 marks)

(b) Explain how Fork-Join pool mechanism works?

(4 marks)

(c) Compare callable threads versus runnable threads, implementation, usage, and performance

(6 marks)

(d) List the conditions needed for a deadlock to happen.

(8 marks)

(e) Why is concurrent programming hard to debug?

(2 marks)

Total (25 marks)