RHODES UNIVERSITY
DEPARTMENT OF COMPUTER SCIENCE

EXAMINATION: NOVEMBER 2018

COMPUTER SCIENCE HONOURS
PAPER 1
DISTRIBUTED AND PARALLEL PROCESSING

Internal Examiner: Prof GC Wells
External Examiner: Prof M Kuttel

MARKS: 120 marks
DURATION: 2 hours

GENERAL INSTRUCTIONS TO CANDIDATES

1. This paper consists of **3 pages** and **9 questions**. **Please ensure that you have a complete paper.**
2. Answer ALL questions.
3. The use of calculators is permitted in the examination, however, make sure that you show all workings.
4. The Oxford Concise English Dictionary **may** be used during this examination.

DISTRIBUTED AND PARALLEL PROCESSING [120 MARKS]

QUESTION 1: Theory [8 marks]

During the course the statement was made that "*this might be the most important course you study*". Discuss this claim, and the reasons for it.

QUESTION 2: Hardware/Theory [5+5 = 10 marks]

a) Discuss the relationship between *processor clock frequency* and *power consumption*, and the implications that this has had for modern processor design and the importance of parallel processing.
b) Discuss the relationship between the *computation : communication ratio* and *grain size* (or *granularity*) of a parallel application.

QUESTION 3: Theory [12 marks]

A scientific research centre is considering purchasing a new cluster system. They have narrowed down their options to two systems:

1. A 20-processor system.
2. A 30-processor system, where each processor is 20% slower than those in 1.

If the cluster is to be used for applications where 10% of the application must be executed sequentially, what would be the expected speedup of the two designs compared to a single processor system, using the same processor as cluster 1? (Show your working).

QUESTION 4 [20 marks]

EITHER: Multiprocessing

Describe how you would use the UNIX System V IPC *semaphore* and *shared memory* facilities in order to provide synchronous communication of simple messages between two processes. Your solution should allow a sender to place a message in a shared memory segment and then wait until the receiver has read it before proceeding. You need not give accurate code for your answer, but should mention the important steps in creating and using the IPC facilities that you need to use.

OR: Java Threads

Discuss the *executor* services that are provided by the Java Concurrency Utilities package (`java.util.concurrent`). What is the primary purpose of these services? You should include a discussion of the concept of a "*future*", and its implementation in the Concurrency Utilities package.

QUESTION 5: JCSP [15 marks]

Describe in detail how the Dining Philosophers' Problem might be solved using JCSP. Include details of the processes and channels required, and include a discussion of how deadlock is prevented in your solution.

QUESTION 6: OpenMP **[3+8+2+3 = 16 marks]**

a) What is the effect of executing the following code fragment using OpenMP (i.e. what value is it calculating)?

```
int f = 1;
#pragma omp parallel for reduction(*:f)
for (int k = 1; k <= N; k++)
  { f *= k;
  }
```

b) Explain the bold line in the code above in detail.

c) How many threads will be created to execute the above code fragment? How is this number determined?

d) What are the advantages of using OpenMP compared to other forms of multithreading parallelism?

QUESTION 7: RMI **[15 marks]**

Explain in detail how you would use Java's Remote Method Invocation (RMI) in order to implement a simple location-based service. A client program should send its current location (represented as a string) and a radius of interest (an integer) to the service, which should respond with a list of local services (represented as strings).

QUESTION 8: CSP **[12 marks]**

Explain in detail how a buffer can be introduced between a producer process and a consumer process in CSP. There is a specific communication/coordination problem between the consumer and the buffer that must be solved — what is this, and how is it solved?

QUESTION 9: CSP **[12 marks]**

A machine with alphabet {in50c, out20c, out10c} repeatedly gives change for 50c. The customer may choose any combination of sequences of 20c and 10c coins, provided that the total value equals 50c. Using CSP, construct the process CH to behave as described above.

END OF THE EXAMINATION