DUBLIN CITY UNIVERSITY

AUGUST/RESIT EXAMINATIONS 2015/2016

MODULE: CA4006 – Concurrent and Distributed Programming

PROGRAMME(S):

CASE	BSc in Computer Applications (Sft.Eng.)
ECSAO	Study Abroad (Engineering & Computing)
SHSAO	Study Abroad (Science & Health)

YEAR OF STUDY: 4,O

EXAMINERS:

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Dr. Ian Pitt

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer 4 questions. All questions carry equal marks.

PLEASE DO NOT TURN OVER THIS PAGE UNTIL YOU ARE INSTRUCTED TO DO SO
The use of programmable or text storing calculators is expressly forbidden.
Please note that where a candidate answers more than the required number of questions, the examiner will mark all questions attempted and then select the highest scoring ones.

Requirements for this paper (Please mark (X) as appropriate)

	Log Tables		*Thermodynamic Tables*
	Graph Paper		*Actuarial Tables*
	Dictionaries		*MCQ Only – Do not publish*
	Statistical Tables		*Attached Answer Sheet*
	Bible		

QUESTION 1 ***[TOTAL MARKS: 25]***

Q 1(a) **[5 Marks]**

Define Amdahl's law in words and as a formula.

Q 1(b) **[14 Marks]**

The efficiency of a parallel code is the serial cost: parallel cost ratio and is given by $E_P = T_1/(p \times T_P)$ (where T_1 is time on one processor and T_P is time on p processors).

[2 marks]

(i) Using Amdahl's law derive an expression for the efficiency E_P in terms of the number of processors *p* and the serial fraction *s*.

[2 marks]

(ii) Using the result in 1 (b) (i) above, what would be the effect on the parallel efficiency (i.e. increase or decrease) of an *increase* in the number of processors *p*? Give a concise reason for your answer.

[3 marks]

(iii) Using the result in 1 (b) (i) above, what would be the effect on the parallel efficiency (i.e. increase or decrease) of an *increase* in the size of the problem? Give a concise reason for your answer.

[3 marks]

(iv) Using the result in 1 (b) (i) above, what would be the effect on the parallel efficiency (i.e. increase or decrease) of an *increase* in the speed of the processors? Give a concise reason for your answer.

[4 marks]

(v) Derive a functional relationship which shows how the serial fraction *s* would have to vary to maintain constant efficiency.

Q 1(c) **[6 Marks]**

Suppose you are given some piece of sequential code that is to be parallelised. You are told that 20% of the code cannot be sped up at all and, of the remainder, 50% can be sped up by a factor of 3 and 50% can be sped up by a factor of 2. Using the fact that the reduced execution time, T_P, is given by the original time T_1 divided by

the speedup, S_P, derive an expression for *overall* speedup that can be achieved on the given code. Comment on your result.

[End of Question 1]

QUESTION 2 ***[TOTAL MARKS: 25]***

Q 2(a) **[9 Marks]**

Describe fully what is the meaning and semantics of a semaphore. Write carefully commented C code which solves the Producer-Consumer Problem using circular buffers and semaphores. You may assume the existence of semaphores (`sem`) and operations on them in C as well as `produce()` and `consume()`, you may also assume buffer management operations `putItemIntoBuffer(item)`, `removeItemFromBuffer()`.

Q 2(b) **[16 Marks]**

Write down the semaphore invariants for the Producer Consumer problem in part (b). Hence, or otherwise, prove the following:

(i) There is no deadlock,
(ii) There is no starvation,
(iii) The consumer does not attempt to remove from an empty buffer.
(iv) The producer does not attempt to append to a full buffer.

[End of Question 2]

QUESTION 3 ***[TOTAL MARKS: 25]***

Q 3(a) **[3 Marks]**

What are the three major components of a Java application that uses Remote Method Invocation (RMI)?

Q 3(b) **[10 Marks]**

Interceptors are not implemented as part of the standard Remote Method Invocation package in Java. From your knowledge of how Interceptors work for a general Remote Object Invocation, outline using diagrams, an implementation of Interceptors in RMI. Your answer should include a description of what would happen at different layers and how invocations would work in the context of replicated objects.

Q 3(c) **[12 marks]**

A Remote Method Invocation (RMI) Interface to allow a client to invoke a command to find the factorial of a number on a remote machine is shown in Figure Q 3. You are required to implement the remote interface, develop the server and develop a client that invokes the remote method `fact`. Your code should be fully commented and should document the function of each major component.

```
import java.rmi.*;

public interface RemoteInterface extends Remote
{
  public int fact(int x) throws Exception;
}
```

Figure Q 3. `Factorial.java`

[End of Question 3]

QUESTION 4 ***[TOTAL MARKS: 25]***

Q 4(a) **[9 Marks]**

In the context of Distributed Mutual Exclusion, describe the following using a diagram: A simple, centralized algorithm and a distributed token ring algorithm. Compare these algorithms with respect to the number of messages which must be exchanged and the delay before entry (in terms of message times). What is the main problem with each?

Q 4(b) **[7 Marks]**

Clock Synchronization algorithms are essential for Mutual Exclusive access to shared resources in Distributed Systems. Figure Q4b shows three processes, each with its own clock, each of which runs at different rates. Explain, using a diagram, the operation of Lamport's Algorithm for synchronizing the logical clocks and ensuring partial causal ordering of the messages sent from process to process in Figure Q4b. What is the principal problem with Lamport's algorithm?

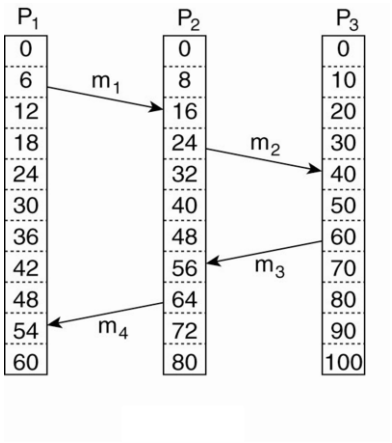

Figure Q4b.

Q 4(c) **[9 Marks]**

In many distributed algorithms, it is necessary for one process to take the role of coordinator or initiator. Dynamically choosing such a process typically happens through an election process. Figure 4c shows a distributed system comprising eight processes. The previous coordinator of the distributed system was process 7 which has now crashed. Using the example shown in Figure 4c, demonstrate the operation of the Bully Algorithm. You may assume that the processes are labelled according to their priority. Would such an algorithm scale up to large scale systems?

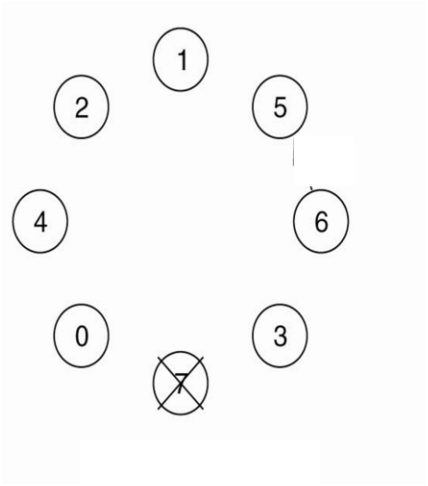

Figure 4c

[End of Question 4]

QUESTION 5 ***[TOTAL MARKS: 25]***

Q 5(a) **[8 Marks]**

In order to facilitate distribution transparency, everything in Distributed Systems is treated as an object and so clients are offered services/resources as objects that they can invoke through interfaces. Describe four such types of objects. Using a fully annotated diagram show the organization of a client-side proxy making invocations on a distributed object.

Q 5(b) **[5 Marks]**

In the context of Web Servers, the role of a Server Cluster is important in terms of improving performance and availability. Describe fully using a diagram the operation of a *TCP handoff* in the face of increased load at the front end.

Q 5(c) **[12 Marks]**

Part of a Java Interface `StockInterface.java` to return the Stock Market symbol and the associated Stock Value of a Company is shown below. Using Java Web Services, give the implementation of the following components of this interface: the Service Endpoint Interface (SEI), the Service Implementation Bean (SIB) and the Endpoint Publisher. You should fully comment your code.

```
public String getSymbol (String Company){
  // implementation omitted
}

public String getStockValue (String Company) {
  // implementation omitted
}
```

[End of Question 5]

[END OF EXAM]