



DUBLIN CITY UNIVERSITY

SEMESTER 2 EXAMINATIONS 2016/2017

MODULE: CA4006 – Concurrent and Distributed Programming

PROGRAMME(S):

CASE	BSc in Computer Applications (Sft.Eng.)
CPSSD	BSc in Computational Problem Solv & SW Dev.
ECSAO	Study Abroad (Engineering & Computing)
ECSA	Study Abroad (Engineering & Computing)

YEAR OF STUDY: 4,O,X

EXAMINER(S):

Dr. Martin Crane	(Ext:8974)
Prof. David Bustard	
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.

There are no additional requirements for this paper.

QUESTION 1**[TOTAL MARKS: 25]****Q 1(a)****[4 Marks]**

Describe Amdahl's Law for the theoretical speedup of a program executed across multiple processors. The answer should give the formula involved and explain it.

Q 1(b)**[8 Marks]**

The efficiency of a program executed across multiple processors can be expressed as $E_p = T_1 / (p \times T_p)$ (where T_1 is the time taken to execute the program on one processor and T_p , the time taken to execute the program 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 .

[3 marks]

- (ii) Using the result in 1 (b) (i) above, what would be the effect on E_p (i.e. increase or decrease) of an *increase* in the size of the computational task? Explain your answer.

[3 marks]

- (iii) Using the result in 1 (b) (i) above, what would be the effect on the efficiency E_p (i.e. increase or decrease) of an *increase* in the speed of the processors? Explain your answer.

Q 1(c)**[9 Marks]**

Define what is meant by Strong versus Weak Scalability. State and explain thoroughly Gustafson-Barsis' Law for *scaled speedup*. Your answer should explain using a comparative performance graph, or in words, the difference between Gustafson-Barsis' Law and Amdahl's law for speedup.

Q 1(d)**[4 Marks]**

Vicki plans to justify her purchase of a \$30 million iGadzooks supercomputer by demonstrating its 16,384 processors can achieve a scaled speedup of 15,000 on a problem of great importance to her employer. Use Gustafson-Barsis' law to find the maximum fraction of the execution time that can be devoted to inherently sequential operations if her application is to achieve this goal.

[End of Question 1]

QUESTION 2

[TOTAL MARKS: 25]

Q 2(a)

[5 Marks]

Explain the operation of a monitor and how it can be used to control access to a shared resource.

Q 2(b)

[10 Marks]

Give a solution to the Dining Philosophers problem using monitors in C, and prove that deadlock cannot occur. Give in your answer a high level description of the algorithm.

Q 2(c)

[10 Marks]

The Dining Schoolboys: A class of Schoolboys eats communal dinners from a large pot that can hold M servings of porridge. When a Schoolboy wants to eat, he helps himself from the pot unless it is empty in which case he waits for the pot to be filled. If the pot is empty, the cook refills the pot with M servings. The operations carried out by the cook and the Schoolboys are `fill_pot()` and `get_serving()` respectively. Model the behaviour of the pot using a monitor and implement this monitor in C. Your solution should state explicitly what the condition variables are.

[End of Question 2]

QUESTION 3**[TOTAL MARKS: 25]****Q 3(a)****[9 Marks]**

Implement fully a Bounded Buffer in Java which uses ReentrantLocks. Your code should be fully commented. Explain, giving an example, what is meant by the term Reentrant Synchronization.

Q 3(b)**[16 Marks]**

The interface `PowerService.java` is shown in Figure Q3 presenting two methods, `square(int num1)` and `power(num1,num2)`, that return as `BigIntegers`, the square (of a number `num1`) and the power (of two numbers, `num1` and `num2`, such that $\text{power} = \text{num1}^{\text{num2}}$), respectively. Develop fully commented RMI code to implement the interface as follows, documenting the function of each of the following major components:

- i. A class `PowerServiceServer.java` that implements the server and the methods `square(int num1)` and `power(num1,num2)`,
- ii. A class `PowerServiceClient.java` that interacts with the server and calls the `square ()` and `power()` methods.

You may need to use the following methods from `BigInteger` Class:

- i. `BigInteger(String val)`, a constructor that translates the decimal String (of value `val`) representation of a `BigInteger` into a `BigInteger`.
- ii. `BigInteger pow(num)` a method that returns a `BigInteger` whose value is (this^{num})

```
import java.math.BigInteger;
import java.rmi.*;

public interface PowerService extends java.rmi.Remote
{
    // Calculate the square of a number
    public BigInteger square ( int number )
        throws RemoteException;

    // Calculate the power of a number
    public BigInteger power  ( int num1, int num2)
        throws RemoteException;
}
```

Figure Q3: PowerService Interface

[End of Question 3]

QUESTION 4**[TOTAL MARKS: 25]****Q 4(a)****[10 Marks]**

Outline two advantages and two disadvantages of both MPI and OpenMP. How might a combination of the two be advantageous in certain circumstances?

Q 4(b)**[10 Marks]**

Using the MPI_Bcast routine, implement a fully commented Matrix-Vector product on an 8 node cluster in MPI. You may assume that the Matrix is 8X8 and the vector is 8X1 and that both have been previously set up and are of type MPI_INT.

Q 4(c)**[5 Marks]**

Using OpenMP, with number of threads set to 8 and the OpenMP reduction operation, optimise the nodal calculations in the code that you have developed in Q4(b).

[End of Question 4]

QUESTION 5**[TOTAL MARKS: 25]****Q 5(a)****[13 Marks]**

Describe with the aid of a fully labelled diagram the functionality of an Apache Web Server. What is the role of (i) the Apache Portable Runtime and (ii) the hook?

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

Part of a Java Interface `PhoneBook.java` to return the Number (as a string e.g. '35317008974') and an associated Office (e.g. 'L2.51') of a member of a department is shown Figure Q5. Using Java SOAP 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 getNumber (String Name){  
    // implementation omitted  
}  
  
public String getOffice (String Name) {  
    // implementation omitted  
}
```

Figure Q5 Interface `PhoneBook.java`

[End of Question 5]**[END OF EXAM]**