UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2000

BEng Honours Degree in Computing Part III
MSc in Computing Science
MSc in Advanced Computing
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute

PAPER C325=I4.22

PARALLEL PROBLEM SOLVING

Thursday 11 May 2000, 10:00
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions

1a Discuss the techniques used to efficiently implement parallel versions of iterative solvers for finite difference equations of the following form.

$$x_{ij} = \frac{x_{i-1\,j} + x_{i+1\,j} + x_{ij+1} + x_{ij-1}}{4}$$

b The following Fortran program fragment implements a sequential version of an iterative Jacobi solver for the above finite difference equation.

```
program jacobi

!   Initialise variables
    real x(100,100),x_old(100,100)
    real error,tolerance
    integer i,j

!   Set the exit tolerance
    tolerance=0.001

!   Set the initial conditions
    do i=1,100
      do j=1,100
        x(i,j)=0.0
      end do
    end do
    x(50,50)=1.0

!   Set the error to ensure at least one sweep
    error=tolerance+1

!   Sweep over the problem until error reaches tolerance
    do while (error>tolerance)

!     Copy the current solution from x to x_old
      do i=1,100
        do j=1,100
          x_old(i,j)=x(i,j)
        end do
      end do

      error=0.0
!     Sweep over the domain evaluating relaxation
      do i=2,99
        do j=2,99
          x(i,j)=0.25*(x_old(i-1,j)+x_old(i+1,j)+x_old(i,j-1)+x_old(i,j+1))
          error=MAX(error,ABS(x_old(i,j)-x(i,j)))
        end do
      end do
    end do

    stop
    end
```

i) Describe two possible ways of distributing the arrays in order to support parallel evaluation and discuss the costs of the communication patterns these distributions would require.

ii) For one parallel data distribution strategy describe how this could be specified using the primitives of the Structured Co-ordination language (SCL).

The two parts carry, respectively, 40% and 60% (30% for each sub-part) of the marks.

2a Explain what is meant by the term Computational Grid and discuss the differences and similarities between Computational Grids and stand-alone parallel machines.

b What are the main issues that have to be addressed when running programs over a Computational Grid? Illustrate your answer by outlining the main components and services provided by the Globus toolkit.

c Compare and contrast the Globus approach to that of a distributed computing system based on an Object Orientated language such as Java. What are the advantages and disadvantages of each approach?

The three parts carry, respectively, 20%, 30% and 50% of the marks.

3a Outline the factors that effect the performance of a program running on a parallel machine.

b What is a *performance model*? Describe how performance models can be used in conjunction with a component-based method of software construction to aid the efficient mapping of an application onto a parallel machine or a networked system of heterogeneous machines.

c The meaning of the SCL SPMD co-ordination form can be defined functionally as follows

SPMD [] = id
SPMD (globalf, localf) : l = (SPMD l) ° globalf ° (map localf)

i) Explain the intended behaviour of this model of parallel computation.

ii) Derive a performance model for the SPMD co-ordination form that would allow the execution time of a program constructed using this form to be derived from information about the performance characteristics of its components.

The three parts carry, respectively, 20%, 30% and 50% (25% for each subpart) of the marks.

4a Define what is meant by

i) a Call Option

ii) a Put Option

on some underlying share or asset.

b Explain how one would value a one year Call Option on a share using the stock price model and Monte Carlo simulation. What factors effect the accuracy of your result?

c Discuss the differences between the Finite Difference Method and Monte Carlo simulation for evaluating Call Options with regard to ease of parallelisation and the accuracy of the computed value.

The three parts carry, respectively, 20% (10% for each sub-part), 40% and 40% of the marks.