THE UNIVERSITY
of LIVERPOOL

MAY 2006 EXAMINATIONS

Bachelor of Arts : Year 3
Bachelor of Science : Year 3
Bachelor of Science : Year 4
No qualification aimed for: Year 1

Efficient Parallel Algorithms

TIME ALLOWED : Two Hours and a Half

INSTRUCTIONS TO CANDIDATES

Credits will be given for the best **four** questions only.

If you attempt to answer more questions than the required number of questions (in any section), the marks awarded for the excess questions will be discarded (starting with your lowest mark).

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QUESTION 1

a) Explain the notions of *parallel running time*, *cost*, *speed up* and *efficiency* of a parallel algorithm.
(5 marks)

b) Describe the Parallel Random Access Machine (PRAM) model of parallel computation. Why is the PRAM model useful in the conceptual design of parallel algorithms?
(5 marks)

c) Is it possible to compute the minimum of n numbers in polylogarithmic time on a mesh-connected computer? Justify your answer.
(5 marks)

d) Describe the Broadcast and Scatter operations in the message passing interface and show the structure of the corresponding operations on a time diagram.
(5 marks)

e) Describe the CRCW PRAM algorithm for the problem of finding the minimum of n numbers in an array.
(5 marks)

QUESTION 2

a) Assume that 25% of some task is entirely sequential. What is the maximal speed up you can achieve with parallel computations? Justify your answer.
(5 marks)

b) Explain how to perform the activation of p processors in a constant number of steps on the concurrent read PRAM model or in $log_2(p)$ steps on the executive read PRAM model.
(5 marks)

c) Define the complexity classes NC and the class of P-complete problems?
(5 marks)

d) What is a Parallel Virtual Machine?
(5 marks)

e) Explain the importance of the "zero-one principle" in the context of comparison networks.
(5 marks)

QUESTION 3

a) What is the "Zero-one-principle"? Use it to show that the Shearsort algorithm is correct.
(**10 marks**)

b) Construct an O(log n) time parallel algorithm computing the depth of each node in a binary tree.
(**10 marks**)

c) Explain the difference between the "store and forward" and the "cut-through" routing techniques.
(**5 marks**)

QUESTION 4

a) Describe the fine-grained and coarse-grained versions of Warshall's algorithm for the Transitive Closure Problem.
(**10 marks**)

b) What is a sorting network? Draw a sorting network for sorting sequences of 16 elements in 10 parallel steps.
(**10 marks**)

c) Describe the hypercube network of processors and draw the hypercube of dimension 4.
(**5 marks**)

QUESTION 5

a) Explain the simulation of $CRCW$ algorithm on the $CREW$ model with a logarithmic slow-down.
(**10 marks**)

b) Describe the pebbling game technique for the evaluation of arithmetic expressions.
(**10 marks**)

c) Describe the Merge Sorting PRAM algorithm.
(**5 marks**)