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THE UNIVERSITY
of LIVERPOOL

MAY 2004 EXAMINATIONS

Bachelor of Science : Year 3

Efficient Parallel Algorithms

TIME ALLOWED : Two hours and half

INSTRUCTIONS TO CANDIDATES

Answer **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) Describe the notion of scalability in the context of parallel systems. What is the metrics? What is Amdahl's Law?
(4 marks)

b) Describe a CRCW PRAM constant time parallel computation of the maximum of an array X[1..n].
(6 marks)

c) State and prove the theorem about the simulation of CRCW algorithms by EREW PRAM.
(10 marks)

QUESTION 2

a) Describe the Parallel Random Access Machine (PRAM) model of parallel computation.
(3 marks)

b) Explain the difference between MIDM and SIMD in Flynn's Taxonomy.
(5 marks)

c) Describe the pebbling game technique and apply it to the evaluation of the following arithmetic expression $423 - (((7 + ((2 * 3) + 5)/6) + (4 * 2)) * 7)$.
(12 marks)

QUESTION 3

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

b) Consider broadcasting on a hypercube using store and forward technique. Explain the principle of the algorithm. How many steps are required to perform broadcasting? Justify your answer.
(6 marks)

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

QUESTION 4

a) Describe the hypercube network of processors and construct the hypercube of dimension 4.
(4 marks)

b) Describe the Shearsort algorithm on a two-dimensional mesh. Apply it to the following array of elements [3,11,6,16,8,1,5,10,14,7,12,2,4,13,9,15].
(6 marks)

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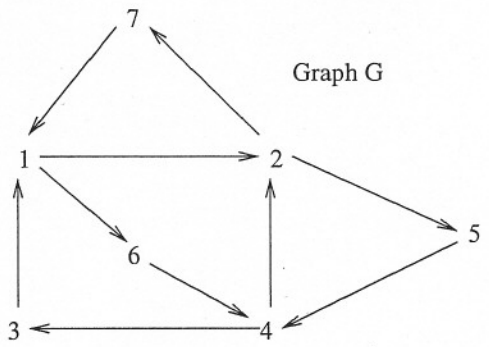

Figure 1: A graph G.

c) Explain the difference between fine-grained computation and course-grained computation. Describe the fine-grained and course-grained versions of Warshall's algorithm for the Transitive Closure Problem.
(10 marks)

QUESTION 5

a) What is the "Zero-one-principle"? Explain how to use it for a comparison network.
(3 marks)

b) Describe the parallel evaluation of straight-line programs whose structure is a tree using the simultaneous-substitutions technique.
(6 marks)

c) Describe the parallel algorithm for the construction of an Euler cycle in a graph. Illustrate all phases of the algorithm on the graph G (see figure 1).
(11 marks)

QUESTION 6

a) Formally define the notions of efficiency and optimality for a parallel algorithm.
(3 marks)

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

c) Explain the difference between the "store and forward" and the "cut-through" routing techniques. Show the sequence of communications for broadcasting on binary tree topology using cut-through routing technique.
(6 marks)

d) Draw a sorting network for sorting sequences of 16 elements in 10 parallel steps.
(8 marks)