



THE UNIVERSITY  
*of* LIVERPOOL

## MAY 2003 EXAMINATIONS

Bachelor of Arts : Year 3  
Bachelor of Science : Year 3  
Bachelor of Science : Year 4

### EFFICIENT PARALLEL ALGORITHMS

TIME ALLOWED : Two Hours and a Half

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#### INSTRUCTIONS TO CANDIDATES

Answer **four** questions only

If you attempt to answer more 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) What is the complexity class NC? (3 marks)
- b) What is the balanced binary tree method and why is it convenient to assume the input size is a power of two? (6 marks)
- c) Describe the doubling technique on an example of list ranking. (9 marks)
- d) Describe the scalability of parallel systems. What is the metrics?  
What is Ahmad Law? (7 marks)

**QUESTION 2**

- a) Describe the Parallel Random Access Machine (PRAM) model of parallel computation (6 marks)
- b) What is the difference between a CRCW PRAM and a CREW PRAM? (4 marks)
- c) Describe a constant time parallel computation on a CRCW PRAM of the maximum of  $n$  numbers stored in a table  $X[1..n]$ . (8 marks)
- d) Describe the parallel algorithm for the generalized prefix problem. (7 marks)

**QUESTION 3**

- a) What is a hypercube network? (6 marks)
- b) Give the definitions of broadcasting and gossiping problems. (3 marks)
- c) Consider broadcast on hypercube are using store and forward technique. Explain the principle of the algorithm. How many steps required to perform broadcasting? Justify your answer. (8 marks)
- d) Explain the difference between the "store and forward" routing and "cut-through" routing techniques. Show the sequence of communications for broadcasting on binary tree topology using cut-through routing technique. (8 marks)



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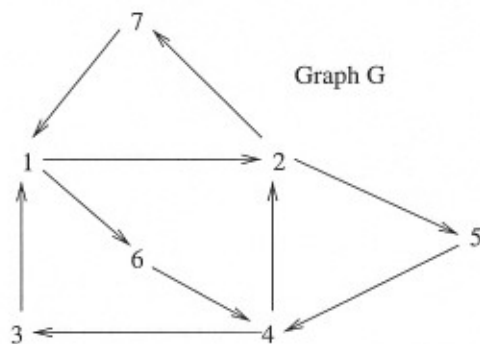


Figure 1: A graph G.

#### QUESTION 4

- a) Please 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. Use the following connectivity matrix to explain the algorithms in detail:

$$A = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

( 13 marks)

- b) Describe the parallel construction of Euler cycle and illustrate all phases of the algorithm on the graph G (see figure 1). ( 12 marks)

#### QUESTION 5

- a) Describe the parallel merge sort. ( 7 marks)
- b) Show how the input stream sorting algorithm on 1-dimensional mesh works in linear time. ( 7 marks)
- c) Describe the parallel evaluation of straight-line programs whose structure is a tree using the simultaneous-substitutions technique. ( 11 marks)

#### QUESTION 6

- a) What does it mean that a parallel algorithm is efficient compared with a sequential algorithm? What does it mean that a parallel algorithm is optimal? ( 4 marks)
- b) Can you compute on a mesh-connected computer the minimum of n numbers in polylogarithmic time? Justify your answer. ( 6 marks)
- c) Describe the Shearsort algorithm on two-dimensional mesh. ( 10 marks)
- d) What is a sorting network. ( 5 marks)