The University of Melbourne
COMP90025 Parallel and Multicore Computing
Semester 2, 2018 Final Examination

School of Computing and Information Systems
COMP90025 Parallel and Multicore Computing
Reading Time: 15 minutes
Writing Time: 3 hours

Open Book Status: Closed Book

This paper has 3 pages including this page

Identical Examination Papers: none
Common Content: none

Authorized Materials:
No materials are authorized.

Instructions to invigilators:
No papers may be taken from the exam room.

Instructions to students:
The total marks for this paper is 60. All answers are to be written in the script book(s) provided. Attempt all questions - partial credit is available. Ensure your student number is written on all script books during writing time. The examination is worth 60% of the subject assessment.

Paper to be held by Baillieu Library: yes

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Q.1. (a) [**1 marks**] Define *Gustafson's Law.*

(b) [**1 marks**] Define the *Efficiency* of a parallel algorithm.

(c) [**4 marks**] Define the following classifications of algorithms:

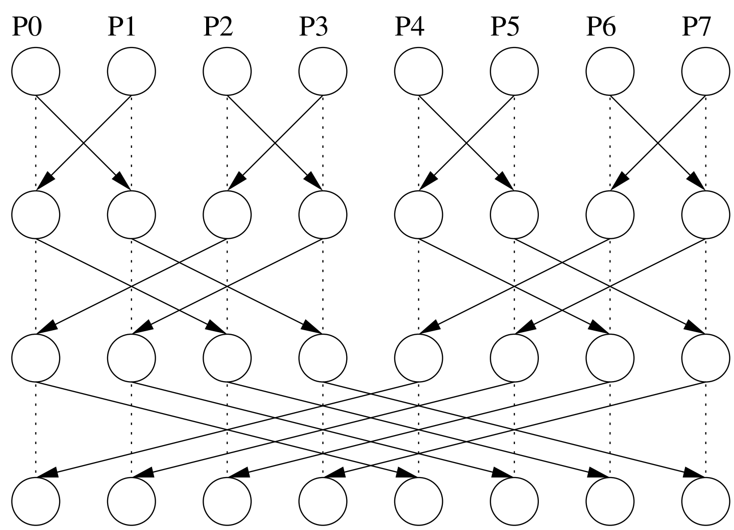
i. parametric
ii. data parallel
iii. task parallel
iv. loosely synchronous

(d) [**4 marks**] Define the *diameter* and *degree* of a static interconnection network. Explain why these two properties are important from a parallel computer architecture perspective and explain the tradeoff between them.

Q.2. (a) [**5 marks**] The Shear sort algorithm takes $\mathcal{O}(\log n \sqrt{n})$ time to complete on a mesh of size $\sqrt{n} \times \sqrt{n}$. Provide a proof of this time complexity. In your proof you may make use of the knowledge that the Odd-Even Transposition sort on a linear array of n elements takes $\mathcal{O}(n)$ steps.

(b) [**5 marks**] Explain the *dual pass ring termination algorithm.* Draw a diagram to aid your explanation.

Q.3. (a) [**5 marks**] The following diagram shows a butterfly construction (on eight processors) that can be used for barrier synchronization. Each arrow represents a synchronization message. Write a parallel algorithm that implements the butterfly barrier on a hypercube of $n = 2^t$ processors.



(b) [**5 marks**] Define the BSP model and explain the parameters of the model. What advantage does the BSP model have over the PRAM model?

Q.4. [**5 marks**] Consider the problem of finding the *second* largest number in an array of n numbers. Write an optimal EREW PRAM algorithm that does so. Show that your algorithm is optimal.

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Q.5. [**5 marks**] Consider the problem of finding the index of the first occurrence of a number x in an array of n numbers. Using an appropriate PRAM model, write an algorithm that does this in constant time.

Q.6. [**10 marks**] Consider a 3-dimensional array of processors of size $n \times n \times n$, i.e. with n^3 processors in total. Assume each processor contains one element of an array of size n^3 elements. Show an approach to sort the n^3 numbers in $\mathcal{O}(n \log n)$ steps. Draw a diagram of a $3 \times 3 \times 3$ array and show where the numbers $1, 2, \ldots, 27$ would end up using your approach.

Q.7. [**10 marks**] Consider the problem of counting the number of times a string of length m occurs in a string of length $n > m$. For example, for the string ABC of length $m = 3$ it occurs 3 times in the string $AJ\boldsymbol{ABC}DF\boldsymbol{ABC}ASD\boldsymbol{ABC}KALD$ of length $n = 20$. A naive sequential solution can be done in $\mathcal{O}(m\,n)$ time steps.

(**a**) Show how to solve the problem in constant time using a Combining CRCW PRAM with $\mathcal{O}(m\,n)$ processors.

(**b**) Show how to solve the problem on an EREW PRAM with $\mathcal{O}(n)$ processors in a lower time complexity than the naive sequential solution, i.e. $o(m\,n)$, and show what that complexity is.

END OF EXAMINATION