D. Dolev Z. Galil M. Rodeh (Eds.)

Theory of Computing and Systems

ISTCS '92, Israel Symposium
Haifa, Israel, May 27-28, 1992
Proceedings

Springer-Verlag
Berlin Heidelberg New York
London Paris Tokyo
Hong Kong Barcelona
Budapest

Series Editors

Gerhard Goos
Universität Karlsruhe
Postfach 6980
Vincenz-Priessnitz-Straße 1
W-7500 Karlsruhe, FRG

Juris Hartmanis
Department of Computer Science
Cornell University
5149 Upson Hall
Ithaca, NY 14853, USA

Volume Editors

Danny Dolev
Hebrew University
Givat Ram, Jerusalem, Israel

Zvi Galil
Columbia University, New York, NY 10027, USA
and
Tel Aviv University
Ramat Aviv, Tel Aviv, Israel

Michael Rodeh
IBM Israel Ltd., Science and Technology, Technion City
Haifa 32000, Israel

CR Subject Classification (1991): F.1-4, B.3, C.2, G.1-2, I.1, E.4, D.2-3

ISBN 3-540-55553-6 Springer-Verlag Berlin Heidelberg New York
ISBN 0-387-55553-6 Springer-Verlag New York Berlin Heidelberg

Printed in Germany

Typesetting: Camera ready by author/editor
Printing and binding: Druckhaus Beltz, Hemsbach/Bergstr.
45/3140-543210 - Printed on acid-free paper

Foreword

ISTCS'92 — The Israel Symposium on the Theory of Computing and Systems, came about spontaneously as a result of informal interaction between a group of people who viewed the conference as an appropriate expression of Israeli strength in theoretical aspects of computing and systems. These people then created the following organizational structure:

Symposium Chairs
Zvi Galil, Columbia and Tel-Aviv U.
Michael Rodeh, IBM Israel

Program Committee

Catriel Beeri, Hebrew U.	Shmuel Katz, Technion
Danny Dolev (Chair), Hebrew U.	Nimrod Megiddo, IBM Almaden Research Center
Nissim Francez, Technion	Yoram Moses, Weizmann Institute
Shafi Goldwasser, MIT	Ehud Shapiro, Weizmann Institute
Alon Itai, Technion	Amiram Yehudai, Tel Aviv U.

Local Arrangements
Shmuel Katz, Technion

The enthusiasm that the symposium created took three major forms: submission of high quality papers which led to strict acceptance criteria; acceptance of the symposium invitation to deliver an invited talk by Richard M. Karp and Michael O. Rabin, and positive response to requests for sponsorship/cooperation by non-profit professional organizations, computer-related industrial organizations, and academic institutions:

Sponsorship. The Israel Academy of Sciences and Humanities, Israel Association of Electronic Industries, the Leibniz Center for Research in Computer Science, the Hebrew University of Jerusalem, and U.S. National Science Foundation.

Cooperation. The ACM Special Interest Group for Automata and Computability Theory (SIGACT), IEEE Computer Society, IEEE Israeli Chapter, and ILA - Information Processing Association of Israel.

Industrial Sponsors. Digital (Israel) Ltd., IBM (Israel) Ltd., Intel Ltd., Motorola Communications Ltd., and National Semiconductors.

We thank all the organizations that have helped make this symposium successful. Thanks are also due to the Technion for helping in organizing the symposium, and to Springer Verlag, Heidelberg, for accepting the task of getting this volume into press in a very brief time interval.

April 1992

Danny Dolev
Zvi Galil
Michael Rodeh

This article was processed using the LaTeX macro package with LLNCS style

Table of Contents

Merging and Splitting Priority Queues and Deques in Parallel 1
Jingsen Chen

Lower Bounds for the Complexity of Functions in a Realistic RAM Model . . 12
Nader H. Bshouty

On Boolean Decision Trees with Faulty Nodes 24
Claire Kenyon, Valerie King

Interval Graphs, Interval Orders and the Consistency of Temporal Events . . 32
Martin Charles Golumbic, Ron Shamir

Higher Order Functions in First Order Theory 43
Andrei Voronkov

Reduction Relations in Strict Applicative Languages 55
Walter Dosch

Approximation Algorithms for Minimum Time Broadcast 67
Guy Kortsarz, David Peleg

The Complexity of Reconfiguring Network Models 79
Yosi Ben-Asher, David Peleg, Assaf Schuster

Optimal Mapping in Direct Mapped Cache Environments 91
Shmuel Gal, Yona Hollander, Alon Itai

New Algorithms for Generalized Network Flows 103
Edith Cohen, Nimrod Megiddo

Factoring Polynomials via Relation-Finding 115
Victor S. Miller

New Resultant Inequalities and Complex Polynomial Factorization 122
Victor Pan

Can Symmetric Toeplitz Solvers be Strongly Stable? 137
Elliot Linzer

Bounds On Parallel Computation of Multivariate Polynomials 147
Ilan Sadeh, Amir Averbuch

Time-Lapse Snapshots 154
Cynthia Dwork, Maurice Herlihy, Serge A. Plotkin, Orli Waarts

Concurrent Timestamping Made Simple 171
Rainer Gawlick, Nancy Lynch, Nir Shavit

Distributed Evaluation: A Tool for Constructing Distributed Detection Programs 184
Jean-Michel Hélary, Michel Raynal

Foundations of Asymptotical Theory of Determinate Compact Testing 195
Evgeny V. Luk-Zilberman

Optimal K-Colouring and K-Nesting of Intervals 207
Irith Ben-Arroyo Hartman

This article was processed using the LaTeX macro package with LLNCS style

Merging and Splitting Priority Queues and Deques in Parallel

Jingsen Chen

Department of Computer Science, Lund University, Box 118, S-221 00 Lund, Sweden

Abstract. We investigate the parallel complexity of merging priority queues and double-ended priority queues (priority deques, for short). The implicit data structures that implement the queues studied in this paper are the heap, the twin-heap, the min-max heap, and the deap. It is known that heaps can be merged sequentially in sublinear time whereas merging min-max heaps requires linear sequential time. In this paper, we design efficient $O(\log n)$-time parallel algorithms to merge two priority queue or deque structures of the same type on n and k elements ($n \geq k$), respectively, which achieves the optimal speed-up. More precisely, two heaps of sizes n and k can be merged in $O(\log n)$ time with $\log k$ processors. Moreover, a related problem of splitting a heap on n elements into two heaps of sizes k and $n-k$ is solved in $O(\log n)$ parallel time with $\log n$ processors, which also achieves the optimal speed-up. For the merge operation on priority deques, we show that the problem of merging twin-heaps can be solved in the same complexity as that for heaps both sequential and in parallel. Algorithms for merging two min-max heaps or two deaps of sizes n and k are demonstrated, which achieves a parallel time of $O(\log n)$ with $\frac{k}{\log n} + \log k$ processors. The study of parallel solution to the problem of merging deaps also provides us with the first serial deap merging algorithm of time complexity $O(k + \log n \cdot \log k)$. The parallel computation model used in this paper is the EREW PRAM (Exclusive-Read Exclusive-Write Parallel Random Access Machine).

1 Introduction

One of the fundamental data types in computer science is the priority queue. It has been useful in many applications [1, 14]. A *priority queue* is a set of elements on which two basic operations are defined: insert a new element into the set; and retrieve and delete the minimum element of the set. Several data structures have been proposed for implementing priority queues. The probably most elegant one is the heap, which was introduced by Williams [21].

The problems of constructing, merging, and splitting heaps have received considerable attention in the literature [7, 10, 11, 12, 14, 15, 19, 20] and sequential constructing algorithms of linear time and sublinear time heap merging and splitting algorithms have been developed. However, designing optimal heap construction and heap merging and splitting algorithms in parallel models of computation has not been so deeply studied. Recently, Rao and Zhang [18] presented a $\Theta(\log n)$ worst case time EREW parallel algorithm for building a heap on n elements and Carlsson and Chen [6] reduced the time for the construction to $\Theta((\log \log n)^2)$ on the parallel comparison tree model.