

Lecture Notes in Computer Science

857

Edited by G. Goos, J. Hartmanis and J. van Leeuwen

Advisory Board: W. Brauer D. Gries J. Stoer



Gerard Tel Paul Vitányi (Eds.)

# Distributed Algorithms

8th International Workshop, WDAG '1994  
Terschelling, The Netherlands  
September 29 - October 1, 1994  
Proceedings

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

**Series Editors**

**Gerhard Goos**

Universität Karlsruhe

Postfach 69 80, Vincenz-Priessnitz-Straße 1, D-76131 Karlsruhe, Germany

**Juris Hartmanis**

Department of Computer Science, Cornell University

4130 Upson Hall, Ithaka, NY 14853, USA

**Jan van Leeuwen**

Department of Computer Science, Utrecht University

Padualaan 14, 3584 CH Utrecht, The Netherlands

**Volume Editors**

**Gerard Tel**

Department of Computer Science, Utrecht University

Padualaan 14, 3584 CH Utrecht, The Netherlands

**Paul Vitányi**

**CWI**

Kruislaan 413, 1098 SJ Amsterdam, The Netherlands

**CR Subject Classification (1991): F.1, D.1.3, F.2.2, C.2.2, C.2.4, D.4.4-5, G.2.2**

**ISBN 3-540-58449-8 Springer-Verlag Berlin Heidelberg New York**

**CIP data applied for**

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer-Verlag. Violations are liable for prosecution under the German Copyright Law.

**© Springer-Verlag Berlin Heidelberg 1994**

**Printed in Germany**

**Typesetting: Camera-ready by author**

**SPIN: 10478988      45/3140-543210 - Printed on acid-free paper**

## Preface

The EIGHTH INTERNATIONAL WORKSHOP ON DISTRIBUTED ALGORITHMS (WDAG-94), organized from September 29 through October 1 on the island of Terschelling, The Netherlands, continued a tradition of successful workshops with a pleasant atmosphere. Earlier workshops in the series were held in Ottawa (1985), Amsterdam (1987, proceedings published by Springer-Verlag, LNCS 312), Nice (1989, LNCS 392), Bari (1990, LNCS 484), Delphi (1991, LNCS 579), Haifa (1992, LNCS 647), and Lausanne (1993, LNCS 725).

Continuation of the event is supervised by the WDAG Steering Committee, consisting of: D. Dolev (IBM Almaden & Hebrew Univ.); F. Mattern (Univ. Saarlandes); N. Santoro (Carleton Univ.); A. Schiper (EPF, Lausanne); P. Spirakis (CTI & Univ. Patras); R. Tan (Univ. Oklahoma); G. Tel (Univ. Utrecht); S. Toueg (Cornell Univ.); P. Vitányi (CWI & Univ. Amsterdam); S. Zaks (Technion).

The topics discussed in these meetings cover all aspects of distributed algorithms, including network protocols, distributed control and communication, real-time systems, dynamic algorithms, self-stabilizing algorithms, synchronization, graph algorithms, wait-free algorithms, mechanisms for security, techniques for replicating data and distributed databases. In response to our Call for Papers, 52 papers in these areas were submitted, and the Program Committee selected at its meeting on June 3 in Amsterdam 23 out of these for presentation at the workshop. In addition, A.K. Lenstra, M. Yung, and W.J. Paul were invited to give a lecture.

The Program Committee for 1994's WDAG consisted of:

- J. Anderson (Univ. North Carolina, Chapel Hill, USA);
- A. Bar-Noy (IBM T.J. Watson Research, Yorktown Heights, USA);
- Ö. Babaoglu (Univ. Bologna, Bologna, Italy);
- F. Chin (Univ. Hong Kong, Hong Kong);
- B. Charron-Bost (Ecole Polytechnique, Paris, France);
- I. Gopal (IBM T.J. Watson Research, Yorktown Heights, USA);
- M. Herlihy (DEC CRL, Cambridge, USA);
- A. Israeli (Technion, Haifa, Israel);
- S. Kutten (IBM T.J. Watson Research, Yorktown Heights, USA);
- S. Mullender (Twente Univ., Enschede, Netherlands);
- G. Neiger (Georgia Tech, Atlanta, USA);
- G. Tel (Utrecht Univ., Utrecht, Netherlands, co-chair);
- P. Vitányi (CWI / Amsterdam Univ., Amsterdam, Netherlands, co-chair).

The workshop was sponsored by a grant from the *Nationale Faciliteit Informatica (NFI)*, a computer science research programme established by the Netherlands' Ministry of Economic Affairs. The project sponsoring the workshop is "Algorithmic Aspects of Parallel and Distributed Computing (ALADDIN)", contract NF 62-376, a joint project of the CWI (Centre for Mathematics and Computer Science, Amsterdam) and UU (Utrecht University). The workshop was further supported by EATCS, ERCIM, CWI, and UU. The local organization was taken care of by Anna Baanders (CWI), Gerard Tel (UU) and Paul Vitányi (CWI/UvA).

The Ninth International Workshop on Distributed Algorithms will be organized in September 1995 in Mont St.-Michel, France, by Jean-Michel Hélary and Michel Raynal.

We want to thank everybody who helped to make this workshop possible: the authors for submitting papers, the Program Committee and referees for their effort in composing the program, the Steering Committee, the sponsors, the local organizers, and Springer-Verlag.

July 1994

Gerard Tel, Paul Vitányi

## List of Referees

The Program Committee wishes to thank the following persons, who acted as referees for WDAG-94:

Afek, Y.	Gerstel, O.	Peterson, G.L.
Ahamat, M.	Grumberg, O.	Petit, A.
Attiya, H.	Herman, T.	Plotkin, S.
Bakker, E.M.	Heuberger, P.	Put, P. van der
Bar-Yehuda, R.	Heydemann, M.-C.	Rachman, O.
Bazzi, R.A.	Hoepman, J.-H.	Ramamurthy, S.
Beauquier, J.	Italiano, P.	Raynal, M.
Berard, B.	Ivan, D.	Riely, J.
Berstel, J.	Jalfon, M.	Schieber, B.
Burns, J.E.	Jard, C.	Schoone, A.A.
Cheung, D.W.L.	Jehuda, J.	Schwarz, R.
Cheung, H.W.H.	Karloff, H.	Shachnai, H.
Chretienne, P.	Katz, S.	Shirazi, A.
Clayton, R.	König, J.-C.	Singh, A.
Cori, R.	Lau, F.C.M.	Sterbenz, J.
Delaet, S.	Lavault, C.	Taubenfeld, G.
Delporte, C.	Malki, D.	Ting, H.F.
Dolev, S.	Mattern, F.	Trehel, M.
Doligez, D.	Mavronicolas, M.	Trystam, D.
Etzion, T.	Mayer, A.	Tsigas, Ph.
Fauconnier, H.	Moir, M.	Upfal, E.
Fidge, C.	Moran, S.	Zaks, S.
Flocchini, P.	Papatriantafilou, M.	Zamsky, A.
Francez, N.	Pazel, D.	Zegura, E.W.
Freignaud, P.	Peleg, D.	Zernik, D.

# Table of Contents

## Applications and Distributed Systems

Replicated File Management in Large-scale Distributed Systems <i>Ö. Babaoglu, A. Bartoli, G. Dini</i>	1
Realization of PRAMs: Processor Design (Invited Lecture) <i>J. Keller, W.J. Paul, D. Scheerer</i>	17
Factoring (Invited Lecture) <i>A.K. Lenstra</i>	28
Primary Partition “Virtually-synchronous Communication” Harder than Consensus <i>A. Schiper, A. Sandoz</i>	39
Secure Distributed Computing: Theory and Practice (Invited Lecture) <i>M. Yung</i>	53

## Wait-free Algorithms and Synchronization

Fast Increment Registers <i>S. Chaudhuri, M.R. Tuttle</i>	74
Coping with Contention <i>M. Choy, A.K. Singh</i>	89
Exotic Behaviour of Consensus Numbers <i>R. Cori, S. Moran</i>	101
Space-optimum Conflict-free Construction of 1-Writer 1-Reader Multivalued Atomic Variable <i>S. Haladar, P.S. Subramanian</i>	116
Linear-time Snapshot Using Multi-writer Multi-reader Registers <i>M. Inoue, W. Chen, T. Masuzawa, N. Tokura</i>	130
Fast, Long-lived Renaming <i>M. Moir, J.H. Anderson</i>	141
Anomalies in the Wait-free Hierarchy <i>O. Rachman</i>	156

## Network Algorithms

Finding the Extrema of a Distributed Multiset .....	164
<i>P. Alimonti, P. Flocchini, N. Santoro</i>	
The Level of Handshake Required for Establishing a Connection .....	179
<i>H. Attiya, R. Rappoport</i>	
Local Labeling and Resource Allocation Using Preprocessing .....	194
<i>H. Attiya, H. Shachnai, T. Tamir</i>	
A Scalable Approach to Routing in ATM Networks.....	209
<i>I. Cidon, O. Gerstel, S. Zaks</i>	
Low Complexity Network Synchronization.....	223
<i>L. Shabtay, A. Segall</i>	
An Incremental Distributed Algorithm for Computing Biconnected Components .....	238
<i>B. Swaminathan, K.J. Goldman</i>	

## Fault-tolerant Algorithms

Reaching (and Maintaining) Agreement in the Presence of Mobile Faults... . . . .	253
<i>J.A. Garay</i>	
Uniform Deterministic Self-stabilizing Ring-orientation on Odd-length Rings.....	265
<i>J.-H. Hoepman</i>	
Using Failure Detectors to Solve Consensus in Asynchronous Shared-memory Systems .....	280
<i>W.-K. Lo, V. Hadzilacos</i>	
An Algorithm with Optimal Failure Locality for the Dining Philosophers Problem .....	296
<i>Y.-K. Tsay, R.L. Bagrodia</i>	

## Miscellaneous

Average and Randomized Complexity of Distributed Problems .....	311
<i>N. Allenberg-Navony, A. Itai, S. Moran</i>	
Self-stabilization by Local Checking and Global Reset .....	326
<i>B. Awerbuch, B. Patt-Shamir, G. Varghese, S. Dolev</i>	
Breakpoints and Time in Distributed Computations .....	340
<i>T. Basten</i>	
Cheaper Matrix Clocks .....	355
<i>F. Ruget</i>	

<b>Author Index .....</b>	370
---------------------------	-----