

Edited by G. Goos and J. Hartmanis

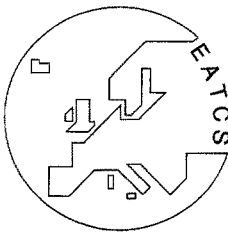
Advisory Board: W. Brauer D. Gries J. Stoer



J. Leach Albert B. Monien
M. Rodríguez Artalejo (Eds.)

Automata, Languages and Programming

18th International Colloquium
Madrid, Spain, July 8-12, 1991
Proceedings



Springer-Verlag

Berlin Heidelberg New York
London Paris Tokyo
Hong Kong Barcelona
Budapest

Series Editors

Gerhard Goos
GMD Forschungsstelle
Universität Karlsruhe
Vincenz-Priessnitz-Straße 1
W-7500 Karlsruhe, FRG

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

Volume Editors

Javier Leach Albert
Mario Rodríguez Artalejo
Departamento de Informática y Automática, Facultad de Matemáticas
Universidad Complutense, Av. Complutense s/n, 28040 Madrid, Spain

Burkhard Monien
Fachbereich Mathematik/Informatik
Universität-Gesamthochschule Paderborn, W-4790 Paderborn, FRG

CR Subject Classification (1991): D.1, E.1, F, I.1, G.2, I.2.3, I.3.5

ISBN 3-540-54233-7 Springer-Verlag Berlin Heidelberg New York
ISBN 0-387-54233-7 Springer-Verlag New York Berlin Heidelberg

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 other ways, and storage in data banks. Duplication of this publication or parts thereof is only permitted under the provisions of the German Copyright Law of September 9, 1965, in its current version, and a copyright fee must always be paid. Violations fall under the prosecution act of the German Copyright Law.

© Springer-Verlag Berlin Heidelberg 1991
Printed in Germany

Printing and binding: Druckhaus Beltz, Hemsbach/Bergstr.
2145/3140-543210 - Printed on acid-free paper

Foreword

ICALP is the Annual Summer Conference sponsored by the European Association for Theoretical Computer Science (EATCS).

ICALP stands for International Colloquium on Automata, Languages, and Programming, but this conference series is intended to cover all important areas of theoretical computer science, such as: computability, automata, formal languages, analysis of algorithms, computational complexity, data types and data structures, theory of data bases and knowledge bases, semantics of programming languages, program specification, transformation and verification, foundations of logic and functional programming, theory of logical design and layout, parallel and distributed computation, theory of concurrency, symbolic and algebraic computation, term rewriting systems, computational geometry, cryptography, and theory of robotics.

ICALP'91 has been organized by the "Universidad Complutense de Madrid", Spain, and is being held on the university campus from July 8 to July 12, 1991.

Previous colloquia were held in Warwick (1990), Stresa (1989), Tampere (1988), Karlsruhe (1987), Rennes (1986), Nafplion (1985), Antwerp (1984), Barcelona (1983), Aarhus (1982), Haifa (1981), Amsterdam (1980), Graz (1979), Udine (1978), Turku (1977), Edinburgh (1976), Saarbrücken (1974) and Paris (1972). ICALP'92 will be held in Vienna, Austria, from July 12 to July 17, 1992.

198 papers were submitted to ICALP'91. Despite our best efforts to timetable the maximum number of submissions possible only 54 could be accepted, and many good papers had to be rejected. Each submitted paper was sent to four Programme Committee members, who were often assisted by other competent referees. The Programme Committee met for the final selection on February 1-2, 1991 in Cercedilla, near Madrid. The members of the Committee are as follows:

K.R.Apt, Amsterdam, The Netherlands, and Austin, TX, USA

A.Arnold, Bordeaux, France

J.Hromkovic, Bratislava, Czechoslovakia, and Paderborn, Germany

N.D.Jones, Copenhagen, Denmark

J.Karhumäki, Turku, Finland

W.Kuich, Vienna, Austria

F.T.Leighton, Cambridge, MA, USA

A.Lingas, Lund, Sweden

B.Monien, Paderborn, Germany (Co-chairman)

U.Montanari, Pisa, Italy

F.Orejas, Barcelona, Spain

M.Paterson, Coventry, UK

A.Pnueli, Rehovot, Israel

M.Rodríguez Artalejo, Madrid, Spain (Co-chairman)

J.-R.Sack, Ottawa, Canada

M.Y.Vardi, San José, CA, USA

U.Vishkin, Tel Aviv, Israel, and College Park, MD, USA

P.Wolper, Liege, Belgium

Those who attended the meeting are underlined. Some members were unable to be present due to the Gulf War. However their evaluations did arrive in time for this selection meeting.

We wish to express our gratitude to all the members of the Programme Committee for their cooperation under unusual conditions. We would also like to thank all the referees who assisted them. The list of the referees is as complete as we can achieve, and we apologize for any possible omissions or errors.

This volume contains the 54 selected papers together with the 6 papers from the following invited lecturers:

B.Chazelle (Princeton, NJ, USA)
 J.Díaz, R. Casas, C. Martínez (Barcelona, Spain)
 Y.Gurevich (Ann Arbor, MI, USA)
 G.Levi (Pisa, Italy)
 W.Thomas (Kiel, Germany)
 U.Vishkin (College Park, MD, USA; Tel Aviv, Israel)

We thank them for their willingness in accepting the invitation.

The papers in the volume are printed in the order of presentation and thus grouped into sessions, most of which are thematic. In addition, two sessions have been devoted to papers supported by ESPRIT Basic Research Actions.

We gratefully acknowledge all the institutions and corporations who have supported this conference:

Eritel, Rank Xerox, IBM España, Alcatel SESA, Springer-Verlag, International Computers Limited, Ministerio de Industria, Ministerio de Educación y Ciencia, Comunidad de Madrid, Ayuntamiento de Madrid, Asoc. de Técnicos de Informática ATI, Asoc. Esp. Infor. Automática AEIA, Universidad Complutense de Madrid, ESPRIT Basic Research Actions.

Last but not least, we wish to express our gratitude to the members of the Organizing Committee:

M.Bradley Delso, M.I.Fernández Camacho, D.de Frutos Escrig, A.Gavilanes Franco, A.Gil Luezas, M.T.Hortalá González, J.Leach Albert (Chairman), S.Nieva Soto, Y.Ortega Mallén.

Through their dedication and effort they made the conference possible.

Madrid, April 1991

Javier Leach Albert
 Burkhard Monien
 Mario Rodríguez Artalejo

List of Referees

Aiken, A.	Dietzfelbinger, M.	Jennings, E.
Ajtai, M.	Duris, P.	Jensen, T. P.
Andersen, L. O.	Dybkjaer, H.	Jeurig, J. T.
Andersen, N.	Dybkjaer, L.	Jones, N. D.
Anderson, J. H.	Dwork, C.	Jouannaud, J. P.
Arnold, A.	Edenbrandt, A.	Kaivola, R.
Apt, K. R.	van Emde Boas, P.	Karhumäki, J.
Atkinson, M. D.	Emerson, A.	Kari, J.
Awerbuch, B.	Engberg, U.	Karlsson, R.
Baaz, M.	Fagin, R.	Karvi, T.
Babai, L.	Fantechi, A.	Katz, S.
Baiardi, F.	Feigenbaum, J.	Kelemenová, A.
Balcázar, J. L.	Feldmann, R.	Kemp, R.
Banachowski, L.	Fernández Camacho, M. I.	Kenyon, C. M.
Barbuti, R.	Ferrari, G.	Khuller, S.
Baudinet, M.	Francez, N.	Klasing, R.
Bauer, B.	Françon, J.	Kleijn, J.
Bellare, M.	Frandsen, G. S.	Klincewicz, J. G.
Bellia, M.	Frederickson, G.	Klusener, A. S.
Berkman, O.	Frougny, Ch.	Korec, I.
Berry, G.	de Frutos Escrig, D.	Kortelainen, J. M.
Betrema, J.	Fugini, M.	Koubek, V.
Blum, A.	Gabarro, J.	Kranakis, E.
Bol, R. N.	Gallo, G.	Krishnamoorthy, S.
Bolognesi, M.	Gammelgaard, A.	Kruskal, C.
Bondorf, A.	Ganzinger, H.	Kuich, W.
Bonuccelli, M.	Garrido, O.	Lambert, J. L.
Boudol, G.	Gasarch, W.	Larsen, K. G.
Bousdira, W.	Gavalda, R.	Lazard, D.
Brandenburg, F. J.	Gavilanes Franco, A.	Leach Albert, J.
Carlsson, S.	Geffert, V.	Leduc, G.
Casamayor, J. C.	Gerth, R.	Leighton, F. T.
Castellani, I.	Gibbons, A. M.	Lehmann, D.
Casteron, P.	Gil Luezas, A.	Lescanne, P.
Celma Gimenez, M.	Girard, J.	Levcopoulos, Ch.
Cerlioli, M.	Girault, M.	Levi, G.
Cerny, A.	van Glabbeek, R. J.	Lindgreen, P.
Cerny, V.	Gnesi, S.	Lingas, A.
Cerná, I.	Godefroid, P.	Linna, M.
Chen, J.	Goerdt, A.	Litovsky, I.
Cocco, N.	Gomard, C. K.	Longo, G.
Courcelle, B.	Gorrieri, R.	Loogen, R.
Cucker, F.	Graf, D.	Lozano, A.
Culik II, K.	Green, F.	Lucas, P.
Cunningham, W.	Gregoire, E.	Lüling, R.
Czyzowicz, J.	Groote, J. F.	Madhavapeddy, S.
Darondeau, Ph.	de Groote, Ph.	Mandrioli, D.
Dassow, J.	Grue, K.	Martin, U.
Degano, P.	Grumberg, O.	Masini, A.
Dehne, F.	Haberstrau, M.	Matias, Y.
Delahaye, J. P.	Hannan, J.	Mazoyer, J.
Devolder, J.	Harju, T.	Menzel, K.
Devroye, L.	Holst, N. C. K.	Merenciano, J. M.
Díaz, J.	Honkala, J.	Metivier, Y.
Diekert, V.	Hortalá González, M. T.	Meyer auf der Heide, F.

- Mirkowska, G.
 Mogensen, T.
 Monien, B.
 Moran, S.
 Mosses, P. D.
 Mumbeck, W.
 Munro, I.
 Mysliwicz, P.
 Naor, J.
 de Nicola, R.
 Nielson, F.
 Nielson, H. R.
 Niemi, V.
 Nieuwenhuis, R.
 Nilsson, J. F.
 Nipkow, T.
 Ojala, L.
 Olderog, E. R.
 Oommen, J.
 Orejas, F.
 Orponen, P.
 Ortega Mallén, Y.
 Ortega Ortiz de Apodaca, M.
 Orsini, R.
 Palamidessi, C.
 Paterson, M. S.
 Pecuchet, J. P.
 Pedreschi, D.
 Peine, R.
 Peled, D.
 Peleg, D.
 Penttonen, M.
 Peña, R.
 Plümer, L.
 Pnueli, A.
 Prellowski, W.
 Pudlák, P.
 Pugh, W.
 Rabinovich, A.
 Ramme, F.
 Ramos Salavert, I.
 Rangaravan, S.
 Raspand, A.
 Reggio, G.
 Richter, R. B.
 Rodríguez Artalejo, M.
 Rosendahl, M.
 Ruohonen, K.
 Ruzicka, P.
 Rutten, J. J. M. M.
 Sack, J. R.
 Salibra, A.
 Salomaa, A.
 Salomaa, K.
 Salwicki, A.
 Santean, L.
 Santoro, N.
 Sassone, V.
 Schieber, B.
 Schmid, U.
 Schmidt, E. R.
 Schwartzbach, M. I.
 Schwichtenberg, H.
 Seidl, H.
 Seidel, R.
 Sellis, T.
 Sénizergues, G.
 Serna, M.
 Sestoft, P.
 Shamir, A.
 Shmoys, D.
 Sidney, J.
 Sifakis, J.
 Sipser, M.
 Smith, C. H.
 Sondergaard, H.
 Stein, C.
 Steinby, M.
 Stockmeyer, L.
 Strandh, R.
 Stomp, F. A.
 Stoughton, A.
 Suri, S.
 Sykora, O.
 Tardos, E.
 Tarhio, J. A.
 Thomas, W.
 Thurimella, R.
 Torán, J.
 Torras, C.
 Tulipani, S.
 Turakainen, P.
 Unger, W.
 Upfal, E.
 Urbanek, F. J.
 Vaandrager, F. W.
 Viennot, X. G.
 Vishkin, U.
 Vitanyi, P.
 de Vries, F. J.
 Vrto, I.
 Vyskoc, J.
 Wagner, K. W.
 Wanke, E.
 Warmerdam, J. H. A.
 Wechler, W.
 Wegener, I.
 Wein, J.
 Welzl, E.
 Wertz, U.
 Wimmers, E.
 Winskel, G.
 van der Wonde, J. C. S. P.
 Yesha, Y.
 Yung, M.
 Yoccoz, S.
 Zaks, S.
 Zucca, E.

Table of Contents

Logic Programming (Session 1)

M. Gabbrielli and G. Levi <i>On the Semantics of Logic Programs (Invited Lecture)</i>	1
Hong Chen and Jieh Hsiang <i>Logic Programming with Recurrence Domains</i>	20

Functional Programming (Session 2)

A. Bucciarelli and T. Ehrhard <i>Extensional Embedding of a Strongly Stable Model of PCF</i>	35
C. Ernoult and A. Mycroft <i>Uniform Ideals and Strictness Analysis</i>	47
V. Breazu-Tannen and R. Subrahmanyam <i>Logical and Computational Aspects of Programming with Sets/Bags/Lists</i>	60

Specification and Verification (Session 3)

A. Bouajjani, J.C. Fernández, S. Graf, C. Rodríguez and J. Sifakis <i>Safety for Branching Time Semantics</i>	76
L. Fix, N. Francez and O. Grumberg <i>Program Composition and Modular Verification</i>	93
R. Alur, C. Courcoubetis and D. Dill <i>Model-checking for Probabilistic Real-time Systems</i>	115
R. Cleaveland and B. Steffen <i>Computing Behavioural Relations, Logically</i>	127

Complexity (Session 4)

Y. Ben-Asher, D. Peleg, R. Ramaswami and A. Schuster <i>The Power of Reconfiguration</i>	139
J.-D. Fouks <i>General Resolution of Tseitin Formulas is Hard</i>	151
S. Kannan and A. Yao <i>Program Checkers for Probability Generation</i>	163
J. Kaneps and R. Freivalds <i>Running Time to Recognize Nonregular Languages by 2-Way Probabilistic Automata</i>	174

Complexity and Concurrency (Session 5)

R. Casas, J. Díaz and C. Martínez <i>Statistics on Random Trees (Invited Lecture)</i>	186
K.G. Larsen <i>The Expressive Power of Implicit Specifications</i>	204
Wang Yi <i>CCS+Time = an Interleaving Model for Real Time Systems</i>	217

Formal Languages (Session 6)

V. Diekert, E. Ochmanski and K. Reinhardt <i>On Confluent Semi-Commutations-Decidability and Complexity Results</i>	229
G. Duchamp and D. Krob <i>Lazard's Factorizations of Free Partially Commutative Monoids</i>	242
P. Gastin, A. Petit and W. Zielonka <i>A Kleene Theorem for Infinite Trace Languages</i>	254

Rewriting and Logic (Session 7)

N. Dershowitz <i>Canonical Sets of Horn Clauses</i>	267
K. Madlener, P. Narendran and F. Otto <i>A Specialized Completion Procedure for Monadic String-Rewriting Systems Presenting Groups</i>	279
P.-L. Curien and R. Di Cosmo <i>A Confluent Reduction for the λ-Calculus with Surjective Pairing and Terminal Object</i>	291
T. Fernando <i>Provably Recursive Programs and Program Extraction</i>	303

Graph Algorithms (Session 8)

T. Lengauer and D. Theune <i>Efficient Algorithms for Path Problems with General Cost Criteria</i>	314
H.N. Djidjev, G.E. Pantziou and C.D. Zaroliagis <i>Computing Shortest Paths and Distances in Planar Graphs</i>	327
Z. Galil and G.F. Italiano <i>Maintaining Biconnected Components of Dynamic Planar Graphs</i>	339
M. Loebl <i>Efficient Maximal Cubic Graph Cuts</i>	351

Complexity (Session 9)

U. Vishkin <i>Structural Parallel Algorithmics (Invited Lecture)</i>	363
D. Ranjan, S. Chari and P. Rohatgi <i>Improving Known Solutions is Hard</i>	381
L.A. Hemachandra and A. Hoene <i>Collapsing Degrees via Strong Computation</i>	393

Parallel Algorithms (Session 10)

T. Hagerup <i>Fast Parallel Generation of Random Permutations</i>	405
H. Jung, M. Serna and P. Spirakis <i>A Parallel Algorithm for two Processors Precedence Constraint Scheduling</i>	417
M. Fürer and B. Raghavachari <i>An Efficient NC Algorithm for Finding Hamiltonian Cycles in Dense Directed Graphs</i>	429

Logic in Computer Science (BRA session) (Session 11)

W. Thomas <i>On Logics, Tilings, and Automata (Invited Lecture)</i>	441
J.-P. Jouannaud and M. Okada <i>Satisfiability of Systems of Ordinal Notations with the Subterm Property is Decidable</i>	455
H. Comon <i>Complete Axiomatizations of some Quotient Term Algebras</i>	469

Concurrency (BRA session) (Session 12)

R. Bol and J. F. Groote <i>The Meaning of Negative Premises in Transition System Specifications</i>	481
W. Vogler <i>Deciding History Preserving Bisimilarity</i>	495
L. Aceto and M. Hennessy <i>Adding Action Refinement to a Finite Process Algebra</i>	506

Algorithms (Session 13)

D. Bini, L. Gemignani and V. Pan <i>Improved Parallel Computations with Matrices and Polynomials</i>	520
J. Lagergren and S. Arnborg <i>Finding Minimal Forbidden Minors Using a Finite Congruence</i>	532
H. L. Bodlaender and T. Kloks <i>Better Algorithms for the Pathwidth and Treewidth of Graphs</i>	544
F. Cucker and A. Torrecillas <i>Two P-complete Problems in the Theory of the Reals</i>	556

Formal Languages (Session 14)

J. Honkala and A. Salomaa <i>L Morphisms: Bounded Delay and Regularity of Ambiguity</i>	566
V. Bruyere and C. de Felice <i>Degree et Decomposability of Variable-Length Codes</i>	575
T. Wilke <i>An EILENBERG Theorem for ∞-Languages</i>	588
K. Culik II and S. Dube <i>Balancing Order and Chaos in Image Generation</i>	600

Formal Languages and Complexity (Session 15)

Y. Gurevich <i>Average Case Complexity (Invited Lecture)</i>	615
Tao Jiang and B. Ravikumar <i>Minimal NFA Problems are Hard</i>	629
K. Hashiguchi <i>Algorithms for Determining the Smallest Number of Nonterminals (States) Sufficient for Generating (Accepting) a Regular Language</i>	641

Computational Geometry (Session 16)

B. Bhattacharya and G. Toussaint <i>Computing Shortest Transversals</i>	649
B. Chazelle, H. Edelsbrunner, M. Grigni, L. Guibas, J. Hershberger, M. Sharir and J. Snoeyink <i>Ray Shooting in Polygons Using Geodesic Triangulations</i>	661
M. Bern, D. Eppstein and F. Yao <i>The Expected Extremes in a Delaunay Triangulation</i>	674

Complexity and Computational Geometry (Session 17)

B. Chazelle <i>Computational Geometry for the Gourmet: Old Fare and New Dishes (Invited Lecture)</i>	686
P. Duris and Z. Galil <i>On the Power of Multiple Reads in a Chip</i>	697
H.D. Gröger and G. Turán <i>On Linear Decision Trees Computing Boolean Functions</i>	707

Algorithms (Session 18)

Z. Galil and O. Margalit <i>An Almost Linear-Time Algorithm for the Dense Subset-Sum Problem</i>	719
S. Khuller, S.G. Mitchell and V.V. Vazirani <i>On-line Algorithms for Weighted Bipartite Matching and Stable Marriages</i>	728
M. Naor <i>String Matching with Preprocessing of Text and Pattern</i>	739
R. Ravi, A. Agrawal and P. Klein <i>Ordering Problems Approximated: Single-Processor Scheduling and Interval Graph Completion</i>	751
Author Index	763