Lecture Notes in Computer Science 8169

Commenced Publication in 1973
Founding and Former Series Editors:
Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison
Lancaster University, UK

Takeo Kanade
Carnegie Mellon University, Pittsburgh, PA, USA

Josef Kittler
University of Surrey, Guildford, UK

Jon M. Kleinberg
Cornell University, Ithaca, NY, USA

Alfred Kobsa
University of California, Irvine, CA, USA

Friedemann Mattern
ETH Zurich, Switzerland

John C. Mitchell
Stanford University, CA, USA

Moni Naor
Weizmann Institute of Science, Rehovot, Israel

Oscar Nierstrasz
University of Bern, Switzerland

C. Pandu Rangan
Indian Institute of Technology, Madras, India

Bernhard Steffen
TU Dortmund University, Germany

Madhu Sudan
Microsoft Research, Cambridge, MA, USA

Demetri Terzopoulos
University of California, Los Angeles, CA, USA

Doug Tygar
University of California, Berkeley, CA, USA

Gerhard Weikum
Max Planck Institute for Informatics, Saarbruecken, Germany

Parosh Aziz Abdulla Igor Potapov (Eds.)

Reachability Problems

7th International Workshop, RP 2013
Uppsala, Sweden, September 24-26, 2013
Proceedings

Springer

Volume Editors

Parosh Aziz Abdulla
Uppsala University
Department of Information Technology
Box 337, 751 05 Uppsala, Sweden
E-mail: parosh@it.uu.se

Igor Potapov
University of Liverpool
Department of Computer Science
Ashton Building, Ashton Street, Liverpool L69 3BX, UK
E-mail: potapov@liverpool.ac.uk

ISSN 0302-9743 e-ISSN 1611-3349
ISBN 978-3-642-41035-2 e-ISBN 978-3-642-41036-9
DOI 10.1007/978-3-642-41036-9
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013948100

CR Subject Classification (1998): F.3, D.2, F.2, D.3, F.4, F.4.1, F.1

LNCS Sublibrary: SL 1 – Theoretical Computer Science and General Issues

© Springer-Verlag Berlin Heidelberg 2013
This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in ist current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

This volume contains the papers presented at the 7th International Workshop on Reachability Problems (RP 2013) held during September 24–26, 2013, at Norrlands nation in the heart of central Uppsala. The workshop was organized by the Department of Information Technology, Uppsala University, Sweden.

RP 2013 was the seventh in the series of workshops following six successful meetings at the University of Bordeaux, France, in 2012, the University of Genoa, Italy, in 2011, Masaryk University of Brno, Czech Republic, in 2010, Ecole Polytechnique, France, in 2009, at the University of Liverpool, UK, in 2008, and at Turku University, Finland, in 2007.

The workshop is specifically aimed at gathering together scholars from diverse disciplines and backgrounds interested in reachability problems that appear in algebraic structures, computational models, hybrid systems, logic, and verification.

Reachability is a fundamental problem that appears in several different contexts: finite- and infinite-state concurrent systems, computational models like cellular automata and Petri nets, decision procedures for classical, modal, and temporal logic, program analysis, discrete and continuous systems, time critical systems, hybrid systems, rewriting systems, algebraic structures (groups, semigroups and rings), deterministic or non-deterministic iterative maps, probabilistic and parametric systems, and open systems modelled as games.

Typically, for a fixed system description given in some form (rewriting rules, transformations by computable functions, systems of equations, logical formulas, etc.) a reachability problem consists in checking whether a given set of target states can be reached starting from a fixed set of initial states. The set of target states can be represented explicitly or via some implicit representation (e.g., a system of equations, a set of minimal elements with respect to some ordering on the states). Sophisticated quantitative and qualitative properties can often be reduced to basic reachability questions. Decidability and complexity boundaries, algorithmic solutions, and efficient heuristics are all important aspects to be considered in this context. Algorithmic solutions are often based on different combinations of exploration strategies, symbolic manipulations of sets of states, decomposition properties, reduction to linear programming problems, and they often benefit from approximations, abstractions, accelerations, and extrapolation heurisitics. Ad hoc solutions as well as solutions based on general-purpose constraint solvers and deduction engines are often combined in order to balance efficiency and flexibility.

The purpose of the conference is to promote exploration of new approaches for the predictability of computational processes by merging mathematical, algorithmic, and computational techniques. Topics of interest include (but are not limited to): reachability for infinite state systems; rewriting systems;

reachability analysis in counter/timed/cellular/communicating automata; Petri-nets; computational aspects of semigroups, groups, and rings; reachability in dynamical and hybrid systems; frontiers between decidable and undecidable reachability problems; complexity and decidability aspects; predictability in iterative maps and new computational paradigms.

All these aspects were discussed in the presentations of the seventh edition of the RP workshop. The proceedings of the previous editions of the workshop appeared in the following volumes:

Mika Hirvensalo, Vesa Halava, Igor Potapov, Jarkko Kari (Eds.): Proceedings of the Satellite Workshops of DLT 2007. TUCS General Publication No 45, June 2007. ISBN: 978-952-12-1921-4.

Vesa Halava and Igor Potapov (Eds.): Proceedings of the Second Workshop on Reachability Problems in Computational Models (RP 2008). Electronic Notes in Theoretical Computer Science. Volume 223, Pages 1-264 (26 December 2008).

Olivier Bournez and Igor Potapov (Eds.): Reachability Problems, Third International Workshop, RP 2009, Palaiseau, France, September 2325, 2009, Lecture Notes in Computer Science, 5797, Springer 2009.

Antonin Kucera and Igor Potapov (Eds.): Reachability Problems, 4th International Workshop, RP 2010, Brno, Czech Republic, August 2829, 2010, Lecture Notes in Computer Science, 6227, Springer 2010.

Giorgio Delzanno, Igor Potapov (Eds.): Reachability Problems, 5th International Workshop, RP 2011, Genoa, Italy, September 2830, 2011, Lecture Notes in Computer Science, 6945, Springer 2011.

Alain Finkel, Jerome Leroux, Igor Potapov (Eds.): Reachability Problems, 6th International Workshop, RP 2012, Bordeaux, France, September 17-19, 2012. Lecture Notes in Computer Science 7550, Springer 2012.

The five keynote speakers at the 2013 conference were:

- **Patricia Bouyer**, CNRS Cachan, "Robustness in Timed Automata"
- **Daniel Kroening**, Oxford University, "Automated Verification of Concurrent Software"
- **Rupak Majumdar**, MPI-SWS, "Provenance Verification"
- **Shaz Qadeer**, Microsoft Research Redmond, "Reachability Modulo Theories"
- **Thomas Schwentick**, TU Dortmund University, "The Dynamic Complexity of the Reachability Problem on Graphs"

There were 24 submissions. Each submission was reviewed by at least three Program Committee members. The full list of the members of the Program Committee and the list of external reviewers can be found on the next two

pages. The Program Committee is grateful for the highly appreciated and high-quality work produced by these external reviewers. Based on these reviews, the Program Committee decided to accept 14 papers, in addition to the five invited talks. The workshop also provided the opportunity to researchers to give informal presentations that are prepared very shortly before the event and inform the participants about current research and work in progress.

We gratefully acknowledge the organization team for their help and especially Mohamed Faouzi Atig for effective team management.

It is also a great pleasure to acknowledge the team of the EasyChair system, and the fine cooperation with the Lecture Notes in Computer Science team of Springer, which made the production of this volume possible in time for the conference. Finally, we thank all the authors for their high-quality contributions, and the participants for making this edition of RP 2013 a success.

September 2013

Parosh Aziz Abdulla
Igor Potapov

Organization

Program Committee

Parosh Aziz Abdulla	Uppsala University, Sweden
Rajeev Alur	University of Pennsylvania, USA
Mohamed Faouzi Atig	Uppsala University, Sweden
Bernard Boigelot	University of Liege, Belgium
Ahmed Bouajjani	LIAFA, University Paris Diderot, France
Krishnendu Chatterjee	Institute of Science and Technology (IST), Austria
Giorgio Delzanno	DIBRIS, Università di Genova, Italy
Javier Esparza	Technische Universität München, Germany
Alain Finkel	ENS Cachan, France
Pierre Ganty	IMDEA Software Institute, Spain
Kim Guldstrand Larsen	Aalborg University, Denmark
Jerome Leroux	CNRS, France
Richard Mayr	University of Edinburgh, UK
Markus Müller-Olm	Westfälische Wilhelms-Universität Münster, Germany
K. Narayan Kumar	Chennai Mathematical Institute, India
Andreas Podelski	University of Freiburg, Germany
Igor Potapov	University of Liverpool, UK
Jean-Francois Raskin	Université Libre de Bruxelles, Belgium
Ahmed Rezine	Linköping University, Sweden
James Worrell	Oxford University, UK
Hsu-Chun Yen	National Taiwan University, China
Gianluigi Zavattaro	Dep. Computer Science Bologna, Italy

Additional Reviewers

Bogomolov, Sergiy
Bournez, Olivier
Fijalkow, Nathanael
Geeraerts, Gilles
Haase, Christoph
Hoenicke, Jochen
Prabhakar, Pavithra
Saivasan, Prakash
Sassolas, Mathieu

Table of Contents

Robustness in Timed Automata 1
Patricia Bouyer, Nicolas Markey, and Ocan Sankur

Automated Verification of Concurrent Software 19
Daniel Kroening

Provenance Verification 21
Rupak Majumdar, Roland Meyer, and Zilong Wang

Reachability Modulo Theories 23
Akash Lal and Shaz Qadeer

The Dynamic Complexity of the Reachability Problem on Graphs 45
Thomas Schwentick

Reachability Problems for Hierarchical Piecewise Constant Derivative Systems 46
Paul C. Bell and Shang Chen

Parametric Interrupt Timed Automata 59
Beatrice Bérard, Serge Haddad, Aleksandra Jovanović, and Didier Lime

Deciding Continuous-Time Metric Temporal Logic with Counting Modalities 70
Marcello M. Bersani, Matteo Rossi, and Pierluigi San Pietro

MaRDiGraS: Simplified Building of Reachability Graphs on Large Clusters 83
Carlo Bellettini, Matteo Camilli, Lorenzo Capra, and Mattia Monga

Modular Synthesis with Open Components 96
Ilaria De Crescenzo and Salvatore La Torre

Parameterized Verification of Broadcast Networks of Register Automata 109
Giorgio Delzanno, Arnaud Sangnier, and Riccardo Traverso

Monomial Strategies for Concurrent Reachability Games and Other Stochastic Games 122
Søren Kristoffer Stiil Frederiksen and Peter Bro Miltersen

Stability Controllers for Sampled Switched Systems 135
Laurent Fribourg and Romain Soulat

Formal Languages, Word Problems of Groups and Decidability 146
Sam A.M. Jones and Richard M. Thomas

Verification of Reachability Properties for Time Petri Nets 159
Kais Klai, Naïm Aber, and Laure Petrucci

Branching-Time Model Checking Gap-Order Constraint Systems 171
Richard Mayr and Patrick Totzke

Constructing Minimal Coverability Sets 183
Artturi Piipponen and Antti Valmari

On the Complexity of Counter Reachability Games 196
Julien Reichert

Completeness Results for Generalized Communication-Free Petri Nets with Arbitrary Edge Multiplicities 209
Ernst W. Mayr and Jeremias Weihmann

Author Index 223