

# 35th IARCS Annual Conference on Foundations of Software Technology and Theoretical Computer Science

FSTTCS 2015, December 16–18, 2015, Bangalore, India

Edited by

Prahladh Harsha

G. Ramalingam



*Editors*

Prahladh Harsha  
Tata Institute of Fundamental Research  
Mumbai 400005  
India  
prahladh@tifr.res.in

G. Ramalingam  
Microsoft Research India  
Bangalore 560001  
India  
grama@microsoft.com

*ACM Classification 1998*

D.2.4 Software/Program Verification, F.1.1 Models of Computation, F.1.2 Modes of Computation, F.1.3 Complexity Measures and Classes, F.2.2 Nonnumerical Algorithms and Problems, F.3.1 Specifying and Verifying and Reasoning about Programs, F.4.1 Mathematical Logic, F.4.3 Formal Languages

**ISBN 978-3-939897-97-2**

*Published online and open access by*

Schloss Dagstuhl – Leibniz-Zentrum für Informatik GmbH, Dagstuhl Publishing, Saarbrücken/Wadern, Germany. Online available at <http://www.dagstuhl.de/dagpub/978-3-939897-97-2>.

*Publication date*

December, 2015

*Bibliographic information published by the Deutsche Nationalbibliothek*

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at <http://dnb.d-nb.de>.

*License*

This work is licensed under a Creative Commons Attribution 3.0 Unported license (CC-BY 3.0): <http://creativecommons.org/licenses/by/3.0/legalcode>.



In brief, this license authorizes each and everybody to share (to copy, distribute and transmit) the work under the following conditions, without impairing or restricting the authors' moral rights:

- Attribution: The work must be attributed to its authors.

The copyright is retained by the corresponding authors.

Digital Object Identifier: 10.4230/LIPIcs.FSTTCS.2015.i

**ISBN 978-3-939897-97-2**

**ISSN 1868-8969**

**<http://www.dagstuhl.de/lipics>**

## LIPICs – Leibniz International Proceedings in Informatics

LIPICs is a series of high-quality conference proceedings across all fields in informatics. LIPICs volumes are published according to the principle of Open Access, i.e., they are available online and free of charge.

### *Editorial Board*

- Susanne Albers (TU München)
- Chris Hankin (Imperial College London)
- Deepak Kapur (University of New Mexico)
- Michael Mitzenmacher (Harvard University)
- Madhavan Mukund (Chennai Mathematical Institute)
- Catuscia Palamidessi (INRIA)
- Wolfgang Thomas (*Chair*, RWTH Aachen)
- Pascal Weil (CNRS and University Bordeaux)
- Reinhard Wilhelm (Saarland University)

**ISSN 1868-8969**

**<http://www.dagstuhl.de/lipics>**



## ■ Contents

Preface	ix
Conference Organization	xi
External Reviewers	xiii

### Invited Talks

Bypassing Worst Case Analysis: Tensor Decomposition and Clustering <i>Moses S. Charikar</i> .....	1
Checking Correctness of Concurrent Objects: Tractable Reductions to Reachability <i>Ahmed Bouajjani, Michael Emmi, Constantin Enea, and Jad Hamza</i> .....	2
Reachability Problems for Continuous Linear Dynamical Systems <i>James Worrell</i> .....	5
Convexity, Bayesianism, and the Quest Towards Optimal Algorithms <i>Boaz Barak</i> .....	7
Beyond Matrix Completion <i>Ankur Moitra</i> .....	8
Relational Refinement Types for Higher-Order Shape Transformers <i>Suresh Jagannathan</i> .....	9

### Contributed Papers

#### Session 1A

Robust Reoptimization of Steiner Trees <i>Keshav Goyal and Tobias Mömke</i> .....	10
Minimizing Weighted $\ell_p$ -Norm of Flow-Time in the Rejection Model <i>Anamitra Roy Choudhury, Syamantak Das, and Amit Kumar</i> .....	25
On Correcting Inputs: Inverse Optimization for Online Structured Prediction <i>Hal Daumé III, Samir Khuller, Manish Purohit, and Gregory Sanders</i> .....	38
Dynamic Sketching for Graph Optimization Problems with Applications to Cut-Preserving Sketches <i>Sepehr Assadi, Sanjeev Khanna, Yang Li, and Val Tannen</i> .....	52

#### Session 1B

Weighted Strategy Logic with Boolean Goals Over One-Counter Games <i>Patricia Bouyer, Patrick Gardy, and Nicolas Markey</i> .....	69
Decidability in the Logic of Subsequences and Supersequences <i>Prateek Karandikar and Philippe Schnoebelen</i> .....	84



Fragments of Fixpoint Logic on Data Words <i>Thomas Colcombet and Amaldev Manuel</i> .....	98
Efficient Algorithms for Morphisms over Omega-Regular Languages <i>Lukas Fleischer and Manfred Kufleitner</i> .....	112
<b>Session 2A</b>	
Approximating the Regular Graphic TSP in Near Linear Time <i>Ashish Chiplunkar and Sundar Vishwanathan</i> .....	125
On Weighted Bipartite Edge Coloring <i>Arindam Khan and Mohit Singh</i> .....	136
Deciding Orthogonality in Construction-A Lattices <i>Karthekeyan Chandrasekaran, Venkata Gandikota, and Elena Grigorescu</i> .....	151
<b>Session 2B</b>	
Ordered Tree-Pushdown Systems <i>Lorenzo Clemente, Paweł Parys, Sylvain Salvati, and Igor Walukiewicz</i> .....	163
One-way Definability of Sweeping Transducers <i>Félix Baschenis, Olivier Gauwin, Anca Muscholl, and Gabriele Puppis</i> .....	178
What’s Decidable about Availability Languages? <i>Parosh Aziz Abdulla, Mohamed Faouzi Atig, Roland Meyer, and Mehdi Seyed Salehi</i>	192
<b>Session 3A</b>	
Towards Better Separation between Deterministic and Randomized Query Complexity <i>Sagnik Mukhopadhyay and Swagato Sanyal</i> .....	206
Dimension, Pseudorandomness and Extraction of Pseudorandomness <i>Manindra Agrawal, Diptarka Chakraborty, Debarati Das, and Satyadev Nandakumar</i>	221
On the NP-Completeness of the Minimum Circuit Size Problem <i>John M. Hitchcock and A. Pavan</i> .....	236
Counting Euler Tours in Undirected Bounded Treewidth Graphs <i>Nikhil Balaji, Samir Datta, and Venkatesh Ganesan</i> .....	246
<b>Session 3B</b>	
Revisiting Robustness in Priced Timed Games <i>Shibashis Guha, Shankara Narayanan Krishna, Lakshmi Manasa, and Ashutosh Trivedi</i> .....	261
Simple Priced Timed Games are not That Simple <i>Thomas Brihaye, Gilles Geeraerts, Axel Haddad, Engel Lefauchaux, and Benjamin Monmege</i> .....	278

Quantitative Games under Failures <i>Thomas Brihaye, Gilles Geeraerts, Axel Haddad, Benjamin Monmege, Guillermo A. Pérez, and Gabriel Renault</i> .....	293
Games with Delays – A Frankenstein Approach <i>Dietmar Berwanger and Marie van den Bogaard</i> .....	307
<b>Session 4A</b>	
Forbidden Extension Queries <i>Sudip Biswas, Arnab Ganguly, Rahul Shah, and Sharma V. Thankachan</i> .....	320
On Density, Threshold and Emptiness Queries for Intervals in the Streaming Model <i>Arijit Bishnu, Amit Chakrabarti, Subhas C. Nandy, and Sandeep Sen</i> .....	336
Clustering on Sliding Windows in Polylogarithmic Space <i>Vladimir Braverman, Harry Lang, Keith Levin, and Morteza Monemizadeh</i> .....	350
<b>Session 4B</b>	
Congestion Games with Multisets of Resources and Applications in Synthesis <i>Guy Avni, Orna Kupferman, and Tami Tamir</i> .....	365
The Sensing Cost of Monitoring and Synthesis <i>Shaul Almagor, Denis Kuperberg, and Orna Kupferman</i> .....	380
An $\omega$ -Algebra for Real-Time Energy Problems <i>David Cachera, Uli Fahrenberg, and Axel Legay</i> .....	394
<b>Session 5A</b>	
Parameterized Complexity of Secluded Connectivity Problems <i>Fedor V. Fomin, Petr A. Golovach, Nikolay Karpov, and Alexander S. Kulikov</i> ...	408
Parameterized Algorithms for Deletion to $(r, \ell)$ -Graphs <i>Sudeshna Kolay and Fahad Panolan</i> .....	420
Finding Even Subgraphs Even Faster <i>Prachi Goyal, Pranabendu Misra, Fahad Panolan, Geevarghese Philip, and Saket Saurabh</i> 434	
The Parameterized Complexity of the Minimum Shared Edges Problem <i>Till Fluschnik, Stefan Kratsch, Rolf Niedermeier, and Manuel Sorge</i> .....	448
<b>Session 5B</b>	
Control Improvisation <i>Daniel J. Fremont, Alexandre Donzé, Sanjit A. Seshia, and David Wessel</i> .....	463
A Provably Correct Sampler for Probabilistic Programs <i>Chung-Kil Hur, Aditya V. Nori, Sriram K. Rajamani, and Selva Samuel</i> .....	475

On the Problem of Computing the Probability of Regular Sets of Trees  
*Henryk Michalewski and Matteo Mio* ..... 489

Probabilistic Regular Expressions and MSO Logic on Finite Trees  
*Thomas Weidner* ..... 503

**Session 6A**

Rumors Across Radio, Wireless, and Telephone  
*Jennifer Iglesias, Rajmohan Rajaraman, R. Ravi, and Ravi Sundaram* ..... 517

The Price of Local Power Control in Wireless Scheduling  
*Magnús M. Halldórsson and Tigran Tonoyan* ..... 529

Allocation of Divisible Goods Under Lexicographic Preferences  
*Leonard J. Schulman and Vijay V. Vazirani* ..... 543

**Session 6B**

On the Expressiveness of Multiparty Sessions  
*Romain Demangeon and Nobuko Yoshida* ..... 560

Secure Refinements of Communication Channels  
*Vincent Cheval, Véronique Cortier, and Eric le Morvan* ..... 575

Failure-aware Runtime Verification of Distributed Systems  
*David Basin, Felix Klaedtke, and Eugen Zălinescu* ..... 590

## ■ Preface

The 35th IARCS Annual Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2015), organized annually by the Indian Association for Research in Computing Science (IARCS), was held at the Indian Institute of Science, Bangalore, from December 16 to December 18, 2015.

The program consisted of 6 invited talks and 42 contributed papers. This proceedings volume contains the contributed papers and abstracts of invited talks presented at the conference. The proceedings of FSTTCS 2015 is published as a volume in the LIPIcs series under a Creative Commons license, with free online access to all, and with authors retaining rights over their contributions.

The 42 contributed papers were selected from a total of 117 submissions. We thank the program committee for its efforts in carefully evaluating and making these selections. We thank all those who submitted their papers to FSTTCS 2015. We also thank the external reviewers for sending their informative and timely reviews.

We are particularly grateful to the invited speakers: Boaz Barak (Harvard University & Microsoft Research), Ahmed Bouajjani (LIAFA, CNRS & Univ. Paris Diderot), Moses Charikar (Stanford University), Suresh Jagannathan (Purdue University), Ankur Moitra (MIT), and James Worrell (University of Oxford) who readily accepted our invitation to speak at the conference.

There were two pre-conference workshops, *Clustering Theory and Practice* (CTAP) and the *17th International Workshop on Verification of Infinite State Systems* (INFINITY 2015) and two post-conference workshops, *Algorithmic Verification of Real-Time Systems* (AVeRTS) and *Applications of Fourier Analysis to Theoretical Computer Science* (FOURIER). We thank Arnab Bhattacharyya (IISc Bangalore), Aiswarya Cyriac (Uppsala University), Amit Deshpande (Microsoft Research), Frédéric Herbreteau (Univ. Bordeaux, LaBRI), Ravishankar Krishnaswamy (Microsoft Research), M. Praveen (Chennai Mathematical Institute), and Krishna S. (IIT Bombay) for organizing these workshops.

On the administrative side, we thank the organizing committee led by Prof. Aditya Kanade (IISc Bangalore) and Prof. Deepak D'Souza (IISc Bangalore), who put in many months of effort in ensuring excellent conference and workshop arrangements at the Indian Institute of Science.

We would also like to thank Madhavan Mukund, Venkatesh Raman, and S.P. Suresh for promptly responding to our numerous questions and requests relating to the organization of the conference. We also thank the Easychair team whose software has made it very convenient to do many conference related tasks. Finally, we thank the Dagstuhl LIPIcs staff for their coordination in the production of this proceedings, particularly Marc Herbstritt who was very prompt and helpful in answering our questions.

Prahladh Harsha and G. Ramalingam  
December 2015





## ■ Conference Organization

### Programme Chairs

Prahladh Harsha (TIFR)  
G. Ramalingam (Microsoft Research)

### Programme Committee

Andrej Bogdanov (The Chinese University of Hong Kong)  
Amit Deshpande (Microsoft Research)  
Fedor Fomin (Univ. Bergen)  
Naveen Garg (IIT Delhi)  
Sariel Har-Peled (Univ. Illinois, Urbana-Champaign)  
Nutan Limaye (IIT Bombay)  
Meena Mahajan (IMSc)  
Ruta Mehta (Georgia Tech.)  
Alantha Newman (CNRS-Univ. Grenoble Alpes & G-SCOP)  
Debmalya Panigrahi (Duke University)  
Prasad Raghavendra (Univ. California, Berkeley)  
Ramprasad Satharishi (Tel Aviv University)  
Pranab Sen (TIFR)  
Suresh Venkatasubramanian (Univ. Utah)  
Magnus Wahlstrom (Royal Holloway, Univ. London)  
S. Akshay (IIT Bombay)  
Parosh Abdulla (Uppsala University)  
Erika Abraham (RWTH Aachen University)  
Franck Cassez (Macquarie University)  
Avik Chaudhuri (Facebook)  
Thomas Colcombet (LIAFA, CNRS & Univ. Paris Diderot)  
Stephanie Delaune (LSV, CNRS & ENS Cachan)  
Javier Esparza (TU Munich)  
Ashutosh Gupta (TIFR)  
Ranjit Jhala (Univ. California, San Diego)  
Roland Meyer (Univ. Kaiserslautern)  
V. Krishna Nandivada (IIT Madras)  
R. Ramanujam (IMSc)  
Sriram Sankaranarayanan (Univ. Colorado Boulder)  
Nishant Sinha (IBM Research)  
S. P. Suresh (Chennai Mathematical Institute)



**Organizing Committee**

Deepak D'Souza (IISc Bangalore), co-chair

Rahul Gupta (IISc Bangalore)

Inzemamul Haque (IISc Bangalore)

Sabuj Kumar Jena (IISc Bangalore)

Shalini Kaleeswaran (IISc Bangalore)

Aditya Kanade (IISc Bangalore), co-chair

Pallavi Maiya (IISc Bangalore)

Suvam Mukherjee (IISc Bangalore)

Anirudh Santhiar (IISc Bangalore)

## External Reviewers

Adsul, Bharat	Aggarwal, Divesh
Aiswarya, C.	Ambainis, Andris
Batmalle, Hadrien	Bhaskar, Umang
Bhattachar, Sayan	Brazdil, Tomas
Brenguier, Romain	Brihayé, Thomas
Broadbent, Christopher	Brotherston, James
Cadilhac, Michaël	Castro, Pablo
Chakarov, Aleksandar	Chakraborty, Souymodip
Chini, Peter	Chiplunkar, Ashish
Chistikov, Dmitry	Chitnis, Rajesh
Cormode, Graham	Cryan, Mary
Curticaean, Radu	D'Oswaldo, Emanuele
D'Souza, Deepak	Delzanno, Giorgio
Elberfeld, Michael	Escoffier, Bruno
Forbes, Michael A.	Forejt, Vojtech
Fox, Kyle	Francis, Mathew
Freeman, Rupert	Furbach, Florian
Gairing, Martin	Gaspers, Serge
Ge, Rong	Ghica, Dan
Gibson, Matt	Golovach, Petr
Gujar, Sujit	Gupta, Manoj
Gyori, Benjamin	Höfner, Peter
Hague, Matthew	Haney, Samuel
Hoffmann, Philipp	Hofmann, Martin
Holik, Lukas	Horn, Florian
Im, Sungjin	Jain, Rahul
Jones, Mark	Karandikar, Prateek
Karmarkar, Hrishikesh	Kayal, Neeraj
Kell, Nathaniel	Kratsch, Stefan
Kretinsky, Jan	Krishnaswamy, Ravishankar
Kufleitner, Manfred	Kuich, Werner
Kulkarni, Janardhan	Kumar, Mrinal
Kupferman, Orna	Lagerkvist, Victor
Lengal, Ondrej	Lin, Anthony Widjaja
Lodaya, Kamal	Lohrey, Markus
Luttenberger, Michael	Manuel, Amaldev
Mayr, Richard	McGregor, Andrew
Mckenzie, Pierre	Melliès, Paul-André
Misra, Neeldhara	Mnich, Matthias
Mogavero, Fabio	Mohammad, Meesum Syed
Monmege, Benjamin	Mukhopadhyay, Partha
Mukund, Madhavan	Muscholl, Anca
Muskalla, Sebastian	Nasre, Meghana
Natarajan, Raja	Nimbhorkar, Prajakta

Norman, Gethin  
Otop, Jan  
Panolan, Fahad  
Park, Sungwoo  
Paul, Soumya  
Phawade, Ramchandra  
Pilipczuk, Micha  
Raman, Venkatesh  
Roy, Sambuddha  
Sabharwal, Yogish  
Satti, Srinivasa Rao  
Saurabh, Saket  
Schmitz, Sylvain  
Shah, Simoni  
Soltys, Karolina  
Sreejith, A V  
Srivathsan, B  
Sundararajan, Vaishnavi  
Vishnoi, Nisheeth  
Wilde, Mark  
Yazdanbod, Sadra  
Nyman, Ulrik  
Panageas, Ioannis  
Paperman, Charles  
Parrow, Joachim  
Pavan, A  
Pilipczuk, Marcin  
Praveen, M.  
Reidl, Felix  
S., Krishna  
Sanchez, Cesar  
Saurabh, Nitin  
Schewe, Sven  
Seth, Anil  
Simon, Sunil Easaw  
Sproston, Jeremy  
Srinivasan, Srikanth  
Streicher, Thomas  
Swamy, Chaitanya  
Weidner, Thomas  
Wojtczak, Dominik  
Zetsche, Georg