

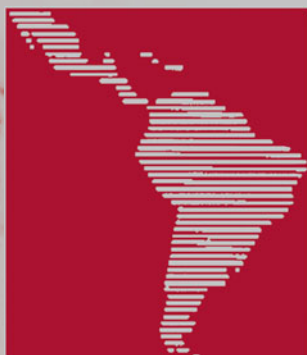
ARCOSS

LNCS 9644

**Evangelos Kranakis  
Gonzalo Navarro  
Edgar Chávez (Eds.)**

# **LATIN 2016: Theoretical Informatics**

**12th Latin American Symposium  
Ensenada, Mexico, April 11–15, 2016  
Proceedings**



 **Springer**

*Commenced Publication in 1973*

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

## Editorial Board

David Hutchison, UK

Josef Kittler, UK

Friedemann Mattern, Switzerland

Moni Naor, Israel

Bernhard Steffen, Germany

Doug Tygar, USA

Takeo Kanade, USA

Jon M. Kleinberg, USA

John C. Mitchell, USA

C. Pandu Rangan, India

Demetri Terzopoulos, USA

Gerhard Weikum, Germany

## Advanced Research in Computing and Software Science

Subline of Lecture Notes in Computer Science

### Subline Series Editors

Giorgio Ausiello, *University of Rome 'La Sapienza', Italy*

Vladimiro Sassone, *University of Southampton, UK*

### Subline Advisory Board

Susanne Albers, *TU Munich, Germany*

Benjamin C. Pierce, *University of Pennsylvania, USA*

Bernhard Steffen, *University of Dortmund, Germany*

Deng Xiaotie, *City University of Hong Kong*

Jeannette M. Wing, *Microsoft Research, Redmond, WA, USA*

More information about this series at <http://www.springer.com/series/7407>

Evangelos Kranakis · Gonzalo Navarro  
Edgar Chávez (Eds.)

# LATIN 2016: Theoretical Informatics

12th Latin American Symposium  
Ensenada, Mexico, April 11–15, 2016  
Proceedings

*Editors*

Evangelos Kranakis  
Carleton University  
Ottawa, ON  
Canada

Gonzalo Navarro  
University Chile  
Santiago  
Chile

Edgar Chávez  
Centro de Investigación Científica  
de Educación Superior de Ensenada  
Ensenada  
Mexico

ISSN 0302-9743                      ISSN 1611-3349 (electronic)  
Lecture Notes in Computer Science  
ISBN 978-3-662-49528-5              ISBN 978-3-662-49529-2 (eBook)  
DOI 10.1007/978-3-662-49529-2

Library of Congress Control Number: 2016932342

LNCS Sublibrary: SL1 – Theoretical Computer Science and General Issues

© Springer-Verlag Berlin Heidelberg 2016

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.

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.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by SpringerNature  
The registered company is Springer-Verlag GmbH Berlin Heidelberg

## Preface

This volume contains the papers presented at the 12th Latin American Theoretical Informatics Symposium (LATIN 2016) held during April 11–15, 2016, in Ensenada, Mexico. Previous editions of LATIN took place in Sao Paulo, Brazil (1992), Valparaiso, Chile (1995), Campinas, Brazil (1998), Punta del Este, Uruguay (2000), Cancun, Mexico (2002), Buenos Aires, Argentina (2004), Valdivia, Chile (2006), Buzios, Brazil (2008), Oaxaca, Mexico (2010), Arequipa, Peru (2012), and Montevideo, Uruguay (2014).

The conference received 131 submissions from around the world. Each submission was reviewed by at least three Program Committee members, and carefully evaluated on quality, originality, and relevance to the conference. Committee members wrote the reviews with the help of additional external referees. Based on an extensive electronic discussion, the committee selected 52 papers. In addition to the accepted contributions, the symposium featured distinguished lectures by Jin Akiyama (Tokyo University of Science), Allan Borodin (University of Toronto), José Correa (University of Chile), Alan Frieze (Carnegie Mellon University), and Héctor García-Molina (Stanford University).

The Imre Simon Test-of-Time Award started in 2012 and is given to the authors of the LATIN paper deemed to be most influential among all those published at least ten years prior to the current edition of the conference. Papers published in the LATIN proceedings up to and including 2006 were eligible for the 2016 award. This year the winner was Alistair Sinclair for his paper “Improved Bounds for Mixing Rates of Marked Chains and Multicommodity Flow,” which appeared in LATIN 1992. This year the award was partially supported by Springer.

Many people helped to make LATIN 2016 possible. First, we would like to recognize the outstanding work of the members of the Program Committee. Their commitment contributed to a very detailed discussion on each of the submitted papers. The LATIN Steering Committee offered valuable advice and feedback; the conference benefitted immensely from their knowledge and experience.

The main organizer of the conference was the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), located in northern Mexico. The conference was financially supported by CONACyT, CICESE, and the Mexican Mathematical Society. We are grateful for the facilities provided by EasyChair for paper evaluation and the preparation of the volume.

April 2016

Evangelos Kranakis  
Gonzalo Navarro  
Edgar Chávez

## The Imre Simon Test-of-Time Award

For many fundamental sampling problems, the best and often the only known approach to solving them is to take a long enough random walk on a certain Markov chain and then return to the current state of the chain. Techniques to prove how long “long enough” is, i.e., the number of steps in the chain one needs to take in order to be sufficiently close to its stationary distribution, are crucial in obtaining estimates of running times of such sampling algorithms.

The mixing time of a Markov chain is quite tightly captured by the “spectral gap” of its underlying transition matrix. The spectral gap is closely related to a geometric parameter called “conductance,” which is a measure of the edge-expansion of the Markov chain. Conductance also captures the mixing time up to square factors. Lower bounds on conductance, which give upper bounds on the mixing time, are typically obtained by a technique called “canonical paths” where the idea is to find a set of paths, one between every unequal source-destination pair, such that no edge is very heavily congested.

The method of canonical paths for bounding mixing time was introduced by Sinclair and Jerrum (1989), and then further developed by Diaconis and Stroock (1991). However, the canonical paths approach cannot always show rapid mixing of a rapidly mixing chain. In his LATIN 1992 paper, Sinclair establishes that this “drawback” disappears if one allows flow between a pair of states to be spread along multiple paths. Moreover, solutions to this multi-commodity flow problem are shown to capture the mixing rate closely. Thus, under fairly general conditions, we now know that a Markov chain is rapidly mixing if and only if it supports multicommodity flows of low cost.

In considering Sinclair’s paper for the award, the selection committee was especially impressed by the elegance of the proposed technique, the quality of presentation, its general applicability, and its widespread recognition throughout the literature. This LATIN 1992 paper and its journal version (in the first volume of *Combinatorics, Probability and Computing*) has over 415 citations in Google Scholar. The areas that this paper has influenced include Markov chain Monte Carlo algorithms, random graphs, flows on graphs, approximation algorithms, statistical physics, and communication complexity, among others.

For all these reasons the committee selects “Improved Bounds for Mixing Rates of Markov Chains and Multicommodity Flow” by Alistair Sinclair (LATIN 1992, LNCS 583, 474–487) as the LATIN 2016 winner of the Imre Simon Test-of-Time Paper Award.

Michael Bender  
Marcos Kiwi  
Daniel Panario

# Organization

## Program Committee

Dimitris Achlioptas	UC Santa Cruz, USA
Amihoud Amir	Bar-Ilan University, Israel and Johns Hopkins University, USA
Djamal Belazzougui	University of Helsinki, Finland
Michael Bender	Stony Brook University, USA
Edgar Chavez	CICESE, Mexico
Josep Diaz	UPC Barcelona, Spain
Martin Farach-Colton	Rutgers University, USA
Cristina Fernandes	University of São Paulo, Brazil
Esteban Feuerstein	University of Buenos Aires, Argentina
Fedor Fomin	University of Bergen, Norway
Leszek Gasieniec	University of Liverpool, UK
Joachim von zur Gathen	University of Bonn, Germany
Konstantinos Georgiou	Ryerson University, Canada
Roberto Grossi	University of Pisa, Italy
Giuseppe F. Italiano	University of Rome Tor Vergata, Italy
Christos Kaklamanis	University of Patras, Greece and CTI, The Netherlands
Marcos Kiwi	University of Chile, Chile
Evangelos Kranakis	Carleton University, Canada
Danny Krizanc	Wesleyan University, USA
Gregory Kucherov	CNRS/LIGM, France
Gad M. Landau	University of Haifa, Israel and NYU-Poly, USA
Lucia Moura	University of Ottawa, Canada
J. Munro	University of Waterloo, Canada
Lata Narayanan	Concordia University, Canada
Gonzalo Navarro	University of Chile, Chile
Yakov Nekrich	University of Waterloo, Canada
Jaroslav Opatrny	Concordia University, Canada
Daniel Panario	Carleton University, Canada
Pablo Pérez-Lantero	University of Valparaíso, Chile
Sergio Rajsbaum	National Autonomous University of Mexico, Mexico
Rajeev Raman	University of Leicester, UK
Ivan Rapaport	University of Chile, Chile
Jose Rolim	University of Geneva, Switzerland
Gelasio Salazar	Autonomous University of San Luis Potosí, Mexico
Nicola Santoro	Carleton University, Canada
Subhash Suri	UC Santa Barbara, USA



Dimitrios Thilikos	AIGCo project, CNRS, LIRMM, France and National and Kapodistrian University of Athens, Greece
Jorge Urrutia	National Autonomous University of Mexico, Mexico
Peter Widmayer	ETH Zurich, Switzerland

## Additional Reviewers

Alekseyev, Max	Daigle, Alexandre	Kammer, Frank
Alistarh, Dan	De Beaudrap, Jonathan	Karakostas, George
Alon, Noga	De Marco, Gianluca	Kempa, Dominik
Alonso, Laurent	de Pina, José Coelho	Klein, Rolf
Alvarez, Carme	Diez Donoso, Yago	Koivisto, Mikko
Ambainis, Andris	Dokka, Trivikram	Kolay, Sudeshna
Amit, Mika	Duch, Amalia	Kolliopoulos, Stavros
Aspnes, James	Durocher, Stephane	Komusiewicz, Christian
Bampas, Evangelos	Dürr, Christoph	Korman, Matias
Bampis, Evripidis	El-Zein, Hicham	Kostitsyna, Irina
Bansal, Nikhil	Eppstein, David	Kowalik, Lukasz
Baste, Julien	Escoffier, Bruno	Kuszner, Lukasz
Bodini, Oliver	Feijao, Pedro	Kärkkäinen, Juha
Bohmova, Katerina	Fischer, Johannes	Laber, Eduardo
Bonomo, Flavia	Fotakis, Dimitris	Lamprou, Ioannis
Bravo, Mario	Freedman, Ofer	Lee, Orlando
Brazdil, Tomas	Gagie, Travis	Lewenstein, Noa
Bringmann, Karl	Ganian, Robert	Lin, Min Chih
Broutin, Nicolas	García-Colín, Natalia	Liu, Chih-Hung
Bus, Norbert	Gawrychowski, Pawel	Löffler, Maarten
Buss, Sam	Geissmann, Barbara	Maack, Marten
Butman, Ayelet	Gekman, Efraim	Madry, Aleksander
Bärtschi, Andreas	Gelashvili, Rati	Mamagishvili, Akaki
Cao, Yixin	Giakkoupis, George	Maneth, Sebastian
Carvajal, Rodolfo	Giannopoulou, Archontia	Maniatis, Spyridon
Chan, Timothy M.	Gonzalez-Aguilar, Hernan	Marengo, Javier
Chandran, L. Sunil	Grabowski, Szymon	Marino, Andrea
Chechik, Shiri	Graf, Daniel	Martínez-Viademonte, Javier
Cheng, Siu-Wing	Grant, Oliver	Mastrolilli, Monaldo
Chitnis, Rajesh	Grzesik, Andrzej	Mayer, Tyler
Cicalese, Ferdinando	Hagerup, Torben	Mayr, Richard
Conte, Alessio	Hemaspaandra, Lane	Mccauley, Samuel
Conway, Alexander	Henning, Gabriela	Mcconnell, Ross
Cording, Patrick Hagge	Hernández-Vélez, César	Mignot, Ludovic
Crochemore, Maxime	Hwang, Hsien-Kuei	Misra, Neeldhara
Cygan, Marek	Jansen, Bart M.P.	Mitsou, Valia
Dabrowski, Konrad	Jež, Artur	

Mnich, Matthias	Prencipe, Giuseppe	Subramanya, Vijay
Moisset de Espanes, Pablo	Pruhs, Kirk	Suchan, Karol
Montanari, Sandro	Pröger, Tobias	Sulzbach, Henning
Montealegre, Pedro	Puleo, Gregory	Suomela, Jukka
Moreno, Eduardo	Radoszewski, Jakub	Svensson, Ola
Moura, Arnaldo	Rampersad, Narad	Ta-Shma, Amnon
Moysoglou, Yannis	Raymond, Jean-Florent	Talbot, Jean-Marc
Mozes, Shay	Rigo, Michel	Tani, Seiichiro
Nebel, Markus	Rojas, Javiel	Thraves Caro, Christopher
Nekrich, Yakov	Rozenberg, Liat	Todincea, Ioan
Nicaud, Cyril	Rubinstein, Aviad	Tschager, Thomas
Nikoletseas, Sotiris	Sach, Benjamin	Turowski, Krzysztof
Nimbhorkar, Shriram	Salikhov, Kamil	Unger, Luise
Nishimura, Naomi	Saptharishi, Ramprasad	Valicov, Petru
Nisse, Nicolas	Sau, Ignasi	Versari, Luca
Ota, Takahiro	Sauerwald, Thomas	Verschae, José
Panholzer, Alois	Saurabh, Saket	Vialette, Stéphane
Panolan, Fahad	Schabanel, Nicolas	Viglietta, Giovanni
Papadopoulos, Charis	Schmitz, Sylvain	Wahlström, Magnus
Pardini, Giovanni	Schouery, Rafael	Wakabayashi, Yoshiko
Parotsidis, Nikos	Schutt, Andreas	Weimann, Oren
Pedrosa, Lehlton L.C.	Serna, Maria	Weinberg, S. Matthew
Peleg, David	Sitters, Rene	Xavier, Eduardo
Pelsmajer, Michael	Soltys, Michael	Xiao, Mingyu
Pietrzak, Krzysztof	Sorenson, Jonathan	Yang, Siwei
Pilz, Alexander	Stojakovic, Milos	Zabala, Paula
Pizaña, Miguel	Strejilevich de Loma,	Zhang, Shaojie
Ponty, Yann	Alejandro	Zito, Michele
Popa, Alexandru	Strømme, Torstein	Ziv-Ukelson, Michal

# Contents

A Faster FPT Algorithm and a Smaller Kernel for BLOCK GRAPH VERTEX DELETION . . . . .	1
<i>Akanksha Agrawal, Sudeshna Kolay, Daniel Lokshantov, and Saket Saurabh</i>	
A Middle Curve Based on Discrete Fréchet Distance. . . . .	14
<i>Hee-Kap Ahn, Helmut Alt, Maike Buchin, Eunjin Oh, Ludmila Scharf, and Carola Wenk</i>	
Comparison-Based FIFO Buffer Management in QoS Switches. . . . .	27
<i>Kamal Al-Bawani, Matthias Englert, and Matthias Westermann</i>	
Scheduling on Power-Heterogeneous Processors . . . . .	41
<i>Susanne Albers, Evripidis Bampis, Dimitrios Letsios, Giorgio Lucarelli, and Richard Stotz</i>	
Period Recovery over the Hamming and Edit Distances. . . . .	55
<i>Amihoud Amir, Mika Amit, Gad M. Landau, and Dina Sokol</i>	
Chasing Convex Bodies and Functions . . . . .	68
<i>Antonios Antoniadis, Neal Barcelo, Michael Nugent, Kirk Pruhs, Kevin Schewior, and Michele Scquizzato</i>	
Parameterized Lower Bounds and Dichotomy Results for the NP-completeness of $H$ -free Edge Modification Problems . . . . .	82
<i>N.R. Aravind, R.B. Sandeep, and Naveen Sivadasan</i>	
Parameterized Complexity of RED BLUE SET COVER for Lines . . . . .	96
<i>Pradeesha Ashok, Sudeshna Kolay, and Saket Saurabh</i>	
Tight Bounds for Beacon-Based Coverage in Simple Rectilinear Polygons. . .	110
<i>Sang Won Bae, Chan-Su Shin, and Antoine Vigneron</i>	
On Mobile Agent Verifiable Problems . . . . .	123
<i>Evangelos Bampas and David Ilcinkas</i>	
Computing Maximal Layers of Points in $E^{f(n)}$ . . . . .	138
<i>Indranil Banerjee and Dana Richards</i>	
On the Total Number of Bends for Planar Octilinear Drawings. . . . .	152
<i>Michael A. Bekos, Michael Kaufmann, and Robert Krug</i>	

Bidirectional Variable-Order de Bruijn Graphs . . . . .	164
<i>Djamal Belazzougui, Travis Gagie, Veli Mäkinen, Marco Previtali, and Simon J. Puglisi</i>	
The Read/Write Protocol Complex Is Collapsible . . . . .	179
<i>Fernando Benavides and Sergio Rajsbaum</i>	
The I/O Complexity of Computing Prime Tables . . . . .	192
<i>Michael A. Bender, Rezaul Chowdhury, Alexander Conway, Martín Farach-Colton, Pramod Ganapathi, Rob Johnson, Samuel McCauley, Bertrand Simon, and Shikha Singh</i>	
Increasing Diamonds . . . . .	207
<i>Olivier Bodini, Matthieu Dien, Xavier Fontaine, Antoine Genitrini, and Hsien-Kuei Hwang</i>	
Scheduling Transfers of Resources over Time: Towards Car-Sharing with Flexible Drop-Offs . . . . .	220
<i>Kateřina Böhmová, Yann Disser, Matúš Mihalák, and Rastislav Šrámek</i>	
A 0.821-Ratio Purely Combinatorial Algorithm for Maximum $k$ -vertex Cover in Bipartite Graphs . . . . .	235
<i>Édouard Bonnet, Bruno Escoffier, Vangelis Th. Paschos, and Georgios Stamoulis</i>	
Improved Spanning Ratio for Low Degree Plane Spanners . . . . .	249
<i>Prosenjit Bose, Darryl Hill, and Michiel Smid</i>	
Constructing Consistent Digital Line Segments . . . . .	263
<i>Iffat Chowdhury and Matt Gibson</i>	
Faster Information Gathering in Ad-Hoc Radio Tree Networks . . . . .	275
<i>Marek Chrobak and Kevin P. Costello</i>	
Stabbing Circles for Sets of Segments in the Plane . . . . .	290
<i>Mercè Claverol, Elena Khramtcova, Evanthia Papadopoulou, Maria Saumell, and Carlos Seara</i>	
Faster Algorithms to Enumerate Hypergraph Transversals . . . . .	306
<i>Manfred Cochefert, Jean-François Couturier, Serge Gaspers, and Dieter Kratsch</i>	
Listing Acyclic Orientations of Graphs with Single and Multiple Sources . . .	319
<i>Alessio Conte, Roberto Grossi, Andrea Marino, and Romeo Rizzi</i>	
Linear-Time Sequence Comparison Using Minimal Absent Words & Applications . . . . .	334
<i>Maxime Crochemore, Gabriele Fici, Robert Mercas, and Solon P. Pissis</i>	

The Grandmama de Bruijn Sequence for Binary Strings. . . . . 347  
*Patrick Baxter Dragon, Oscar I. Hernandez, and Aaron Williams*

Compressing Bounded Degree Graphs . . . . . 362  
*Pål Grønås Drange, Markus Dregi, and R.B. Sandeep*

Random Partial Match in Quad- $K$ - $d$  Trees . . . . . 376  
*A. Duch, G. Lau, and C. Martínez*

From Discrepancy to Majority . . . . . 390  
*David Eppstein and Daniel S. Hirschberg*

On the Planar Split Thickness of Graphs . . . . . 403  
*David Eppstein, Philipp Kindermann, Stephen Kobourov,  
Giuseppe Liotta, Anna Lubiw, Aude Maignan, Debajyoti Mondal,  
Hamideh Vosoughpour, Sue Whitesides, and Stephen Wismath*

A Bounded-Risk Mechanism for the Kidney Exchange Game. . . . . 416  
*Hossein Esfandiari and Guy Kortsarz*

Tight Approximations of Degeneracy in Large Graphs. . . . . 429  
*Martín Farach-Colton and Meng-Tsung Tsai*

Improved Approximation Algorithms for Capacitated Fault-Tolerant  
 $k$ -Center. . . . . 441  
*Cristina G. Fernandes, Samuel P. de Paula, and Lehilton L.C. Pedrosa*

Bundled Crossings in Embedded Graphs . . . . . 454  
*Martin Fink, John Hershberger, Subhash Suri, and Kevin Verbeek*

Probabilistic Analysis of the Dual Next-Fit Algorithm for Bin Covering . . . . 469  
*Carsten Fischer and Heiko Röglin*

Deterministic Sparse Suffix Sorting on Rewritable Texts . . . . . 483  
*Johannes Fischer, Tomohiro I., and Dominik Köppl*

Minimizing the Number of Opinions for Fault-Tolerant Distributed  
Decision Using Well-Quasi Orderings . . . . . 497  
*Pierre Fraigniaud, Sergio Rajsbaum, and Corentin Travers*

Unshuffling Permutations . . . . . 509  
*Samuele Giraudo and Stéphane Vialette*

Generating Random Spanning Trees via Fast Matrix Multiplication. . . . . 522  
*Nicholas J.A. Harvey and Keyulu Xu*

Routing in Unit Disk Graphs . . . . . 536  
*Haim Kaplan, Wolfgang Mulzer, Liam Roditty, and Paul Seiferth*

Graph Drawings with One Bend and Few Slopes . . . . .	549
<i>Kolja Knauer and Bartosz Walczak</i>	
Edge-Editing to a Dense and a Sparse Graph Class . . . . .	562
<i>Michal Kotrbčík, Rastislav Královič, and Sebastian Ordyniak</i>	
Containment and Evasion in Stochastic Point Data . . . . .	576
<i>Nirman Kumar and Subhash Suri</i>	
Tree Compression Using String Grammars . . . . .	590
<i>Moses Ganardi, Danny Hucke, Markus Lohrey, and Eric Noeth</i>	
Trees and Languages with Periodic Signature . . . . .	605
<i>Victor Marsault and Jacques Sakarovitch</i>	
Rank Reduction of Directed Graphs by Vertex and Edge Deletions . . . . .	619
<i>Syed Mohammad Meesum and Saket Saurabh</i>	
New Deterministic Algorithms for Solving Parity Games . . . . .	634
<i>Matthias Mnich, Heiko Röglin, and Clemens Rösner</i>	
Computing a Geodesic Two-Center of Points in a Simple Polygon . . . . .	646
<i>Eunjin Oh, Sang Won Bae, and Hee-Kap Ahn</i>	
Simple Approximation Algorithms for Balanced MAX 2SAT . . . . .	659
<i>Alice Paul, Matthias Poloczek, and David P. Williamson</i>	
A Parameterized Algorithm for MIXED-CUT . . . . .	672
<i>Ashutosh Rai, M.S. Ramanujan, and Saket Saurabh</i>	
$(k, n - k)$ -MAX-CUT: An $\mathcal{O}^*(2^p)$ -Time Algorithm and a Polynomial Kernel . . .	686
<i>Saket Saurabh and Meirav Zehavi</i>	
Independent Set of Convex Polygons: From $n^\epsilon$ to $1 + \epsilon$ via Shrinking . . . . .	700
<i>Andreas Wiese</i>	
<b>Author Index</b> . . . . .	713