25th International Conference on Theory and Applications of Satisfiability Testing

SAT 2022, August 2–5, 2022, Haifa, Israel

Edited by

Kuldeep S. Meel

Ofer Strichman

LIPIcs – Vol. 236 – SAT 2022 www.dagstuhl.de/lipics

Editors

Kuldeep S. Meel
School of Computing, National University of Singapore, Singapore
meel@comp.nus.edu.sg

Ofer Strichman
Technion, Haifa, Israel
ofers@technion.ac.il

ACM Classification 2012
Theory of computation → Automated reasoning; Theory of computation → Logic and verification; Hardware → Hardware validation

ISBN 978-3-95977-242-6

Published online and open access by
Schloss Dagstuhl – Leibniz-Zentrum für Informatik GmbH, Dagstuhl Publishing, Saarbrücken/Wadern, Germany. Online available at https://www.dagstuhl.de/dagpub/978-3-95977-242-6.

Publication date
August, 2022

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 https://portal.dnb.de.

Digital Object Identifier: 10.4230/LIPIcs.SAT.2022.0

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.

ISSN 1868-8969

https://www.dagstuhl.de/lipics

Contents

Papers

25th International Conference on Theory and Applications of Satisfiability Testing (SAT 2022).
Editors: Kuldeep S. Meel and Ofer Strichman
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

Preface

This volume contains the papers presented at SAT 2022, the 25th International Conference on Theory and Applications of Satisfiability Testing, held during August 2–5, 2022 in Haifa, Israel. SAT 2022 was part of the Federated Logic Conference (FLoC) 2022 and was hosted by the Department of Computer Science at the Technion campus.

The International Conference on Theory and Applications of Satisfiability Testing (SAT) is the premier annual meeting for researchers focusing on the theory and applications of the propositional satisfiability problem, broadly construed. Aside from plain propositional satisfiability, the scope of the meeting includes Boolean optimization, including MaxSAT and pseudo-Boolean (PB) constraints, model counting, quantified Boolean formulas (QBF), satisfiability modulo theories (SMT), and constraint programming (CP) for problems with clear connections to Boolean reasoning. Many hard combinatorial problems can be tackled using SAT-based techniques, including problems that arise in formal verification, artificial intelligence, operations research, computational biology, cryptology, data mining, machine learning, mathematics, etc. Indeed, the theoretical and practical advances in SAT research over the past 25 years have contributed to making SAT technology an indispensable tool in a variety of domains.

SAT 2022 welcomed scientific contributions addressing different aspects of SAT interpreted in a broad sense, including (but not restricted to) theoretical advances (such as exact algorithms, proof complexity, and other complexity issues), practical search algorithms, knowledge compilation, implementation-level details of SAT solvers and SAT-based systems, problem encodings and reformulations, applications (including both novel application domains and improvements to existing approaches), as well as case studies and reports on findings based on rigorous experimentation.

This year, we adopted a two-phase reviewing model. After the first phase, papers received one of the three notifications: *Accept*, *Reject*, and *Revise and Resubmit*. The papers that received *Revise and Resubmit* were invited for re-submission, with specific requests from the reviewers. They were then re-reviewed.

A total of 70 papers were submitted to SAT 2022. Unlike previous years, there was no separate category for short papers this year. Each submission was reviewed by three Program Committee members and their selected external reviewers. The review process included an author response period, during which the authors of submitted papers were given the opportunity to respond to the initial reviews of their submissions. To reach a final decision, a Program Committee discussion period followed the author response period. External reviewers supporting the Program Committee were also invited to participate directly in the discussions for the papers they reviewed.

After the first phase, 25 papers were accepted while seven papers received notification of *revise and resubmit*. Following the second phase, six out of seven papers were accepted. Therefore, in total 31 out of 70 submissions were accepted.

The Program Committee singled out the following two submissions for the Best Paper Award:

- Milan Mosse, Harry Sha and Li-Yang Tan "A generalization of the Satisfiability Coding Lemma and its applications"

- Stephan Gocht, Ruben Martins, Jakob Nordström and Andy Oertel "Certified CNF Translations for Pseudo-Boolean Solving"

25th International Conference on Theory and Applications of Satisfiability Testing (SAT 2022).
Editors: Kuldeep S. Meel and Ofer Strichman
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

In addition, the following paper received the Best Student Paper Award:

- Markus Anders “SAT Preprocessors and Symmetry”

This year is a special year for the SAT community: it is the 25th year of the SAT conference. Therefore, in addition to presentations on the accepted papers, the scientific program of SAT included a retrospective session to celebrate some major developments in the field over the past 25 years. Jakob Nordström took on the challenging task conceptualizing and organizing such a session: five speakers were invited to present a summary of selected achievements.

- Alexander Nadel: “Conflict-Driven SAT Solving”
- Marijn Heule: “Modern SAT Techniques ”
- Jeremias Berg: “Maximum Satisfiability for Real-World Optimization”
- Armin Biere: “Trusting SAT Solvers”
- Olaf Beyersdorff: “Proof complexity and SAT solving”

Each of the invited speakers presented a broad overview of a particular direction of research, in a celebratory style that sought to highlight achievements of the community at large.

Three additional keynote and plenary speakers presented in talks held jointly with with other conferences of FLoC: Donald Kunth, Orna Kupferman, and Catuscia Palamidessi

SAT, together with the other constituent conferences of FLoC, hosted various associated events. In particular, the following four workshops were held, affiliated with SAT:

- Logic-based Methods in Machine Learning, organized by Alexey Ignatiev and Stefan Szeider
- Proof Complexity, organized by Olaf Beyersdorff, Jan Johannsen, and Marc Vinyals
- Pragmatics of SAT, organized by Matti Järvisalo and Daniel Le Berre
- Quantified Boolean Formulas and Beyond, organized by Hubie (Hubert) Chen, Florian Lonsing, Martina Seidl, and Friedrich Slivovsky,
- Counting and Sampling, organized by Johannes Fichte, Markus Hecher, Kuldeep S. Meel

As in previous years, the results of several competitive events were announced at SAT:

- MaxSAT Evaluation 2022, organized by Fahiem Bacchus, Matti Järvisalo, Jeremias Berg, Ruben Martins, and Andreas Niskanen,
- Model Counting Competition 2022, organized by Markus Hecher and Johannes K. Fichte,
- SAT Competition 2022, organized by Marijn Heule, Markus Iser, Matti Jarvisalo, Martin Suda, and Tomáš Balyo, and
- QBFEVAL 2022, organized by Luca Pulina, Martina Seidl, and Ankit Shukla

We thank everyone who contributed to making SAT 2022 a success. We are indebted to the Program Committee members and the external reviewers, who dedicated their time to review and evaluate the submissions to the conference. We thank the authors of all submitted papers for their contributions, the SAT association for their guidance and support in organizing the conference, the EasyChair conference and program management system for facilitating the submission and selection of papers, as well as scheduling of the final program. We wish to thank the workshop chair, Alexander Nadel, the webmaster, Jiong Yang, and all the organizers of the SAT affiliated workshops and competitions. Special thanks goes to the organizers of FLoC, in particular to Orna Grumberg and Eran Yahav, for coordinating the various conferences and taking care of the local arrangements.

We gratefully thank the sponsors of SAT 2022: RenYing Technology, the Artificial Intelligence journal, CAS Merlin, and the SAT association for the financial and organizational support for SAT 2022. Thank you.

July 2022

Kuldeep S. Meel
Ofer Strichman

Program Committee Members

Supratik Chakraborty	IIT Bombay
Martina Seidl	Johannes Kepler University Linz
Daniel Le Berre	CNRS – Université d'Artois
Armin Biere	Albert-Ludwigs-University Freiburg
Olaf Beyersdorff	Friedrich Schiller University Jena
Alexander Nadel	Intel
Friedrich Slivovsky	Vienna University of Technology
Elizabeth Polgreen	University of Edinburgh
Florian Lonsing	Stanford University
Jordi Levy	IIIA – CSIC
Marijn Heule	Carnegie Mellon University
Jeremias Berg	University of Helsinki
Tomáš Peitl	TU Wien
Meena Mahajan	The Institute of Mathematical Sciences, HBNI, Chennai
Subodh Sharma	Indian Institute of Technology Delhi
Stefan Szeider	TU Wien
Fei He	Tsinghua University
Jie-Hong Roland Jiang	National Taiwan University
Inês Lynce	INESC-ID / IST, Universidade de Lisboa
Christoph Scholl	University of Freiburg
Vasco Manquinho	INESC-ID / IST, Universidade de Lisboa
Mikolas Janota	Czech Technical University in Prague
Gilles Audemard	CRIL
Mate Soos	National University of Singapore
Carlos Ansótegui	Universitat de Lleida
Matti Järvisalo	University of Helsinki
Miquel Bofill	Universitat de Girona
Antonina Kolokolova	Memorial University of Newfoundland
Felip Manyà	IIIA-CSIC
Shaowei Cai	Institute of Software, Chinese Academy of Sciences
Chu-Min Li	Université de Picardie Jules Verne
Takehide Soh	Information Science and Technology Center, Kobe University
Gilles Dequen	MIS/UPJV
Oliver Kullmann	University of Swansea
Carsten Sinz	Karlsruhe Institute of Technology
Vijay Ganesh	University of Waterloo

25th International Conference on Theory and Applications of Satisfiability Testing (SAT 2022).
Editors: Kuldeep S. Meel and Ofer Strichman

Leibniz International Proceedings in Informatics
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

External Reviewers

Agnes Schleitzer	Andre Schidler
Benjamin Böhm	Brian Li
Che Cheng	Chia-Hsuan Su
Chunxiao Li	Dhananjay Ashok
Eduard Torres Montiel	Franz Reichl
Gaurav Sood	Guo-Wei Ho
Hao-Ren Wang	Hidetomo Nabeshima
Iyad Kanj	Jakob Nordstrom
Katalin Fazekas	Kumar Madhukar
Laure Devendeville	Marc Vinyals
Markus Iser	Martin Suda
Mathias Fleury	Maximilian Heisinger
Miyuki Koshimura	N. V. Vinodchandran
Nicolas Szczepanski	Nils Froleyks
Noah Fleming	Romain Wallon
Sebastian Ordyniak	Tim Hoffmann
Xiao-Nan Lu	Yogesh Dahiya
Yu-Wei Fan	Yun-Rong Luo

25th International Conference on Theory and Applications of Satisfiability Testing (SAT 2022).
Editors: Kuldeep S. Meel and Ofer Strichman
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

List of Authors

Josep Alòs (25)
Logic & Optimization Group (LOG), University of Lleida, Spain

Markus Anders (1)
TU Darmstadt, Germany

Carlos Ansótegui (25)
Logic & Optimization Group (LOG), University of Lleida, Spain

Gilles Audemard (28)
CRIL, Univ. Artois & CNRS, Lens, France

Jakob Bach (2)
Karlsruhe Institute of Technology (KIT), Germany

Max Bannach (19)
Institute for Theoretical Computer Science, Universität zu Lübeck, Germany

Lucas Berent (18)
Technical University of Munich, Germany

Jeremias Berg (12, 13, 14)
HIIT, Department of Computer Science, University of Helsinki, Finland

Olaf Beyersdorff (5, 11)
Institut für Informatik, Friedrich-Schiller-Universität Jena, Germany

Armin Biere (27)
University of Freiburg, Germany

Nikolaj Bjørner (26)
Microsoft Research, Redmond, WA, USA

Lukas Burgholzer (18)
Johannes Kepler University Linz, Austria

Benjamin Böhm (11)
Friedrich Schiller Universität Jena, Germany

Klemens Böhm (2)
Karlsruhe Institute of Technology (KIT), Germany

Miguel Cabral (29)
INESC-ID, IST, University of Lisbon, Portugal

Leroy Chew (10)
TU Wien, Austria

Md Solimul Chowdhury (27)
Carnegie Mellon University, Pittsburgh, PA, USA

Johannes K. Fichte (30)
TU Wien, Austria

Robert Ganian (15)
Algorithms and Complexity Group, TU Wien, Austria

Iván Garzón (3)
LSI, DaSCI, University of Granada, Spain

Jesús Giráldez-Cru (3)
DECSAI, DaSCI, University of Granada, Spain

Stephan Gocht (16)
Lund University, Sweden; University of Copenhagen, Denmark

Markus Hecher (30)
TU Wien, Austria

Marijn J. H. Heule (10, 27)
Carnegie Mellon University, Pittsburgh, PA, USA; Amazon Web Services, Inc., Pittsburgh, PA, USA

Marijn J.H. Heule (21)
Carnegie Mellon University, Pittsburgh, PA, USA

Markus Iser (2)
Karlsruhe Institute of Technology (KIT), Germany

Dmitry Itsykson (6)
St. Petersburg Department of V.A. Steklov Mathematical Institute of RAS, Russia

Christoph Jabs (12)
HIIT, Department of Computer Science, University of Helsinki, Finland

Mikoláš Janota (7, 29)
Czech Technical University in Prague, Czech Republic

Jie-Hong Roland Jiang (23)
Graduate Institute of Electronics Engineering / Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan

Jean Christoph Jung (31)
Universität Hildesheim, Germany

Matti Järvisalo (12, 13, 14)
HIIT, Department of Computer Science, University of Helsinki, Finland

25th International Conference on Theory and Applications of Satisfiability Testing (SAT 2022).
Editors: Kuldeep S. Meel and Ofer Strichman
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

Benjamin Kiesl (27)
Amazon Web Services, Inc., Munich, Germany

Markus Kirchweger (4)
Algorithms and Complexity Group,
TU Wien, Autria

Jean-Marie Lagniez (28)
CRIL, Univ Artois & CNRS, Lens, France

Meena Mahajan (22)
The Institute of Mathematical Sciences,
Chennai, India; Homi Bhabha National Institute,
Training School Complex, Anushaktinagar,
Mumbai, India

Vasco Manquinho (29)
INESC-ID, IST, University of Lisbon, Portugal

Ruben Martins (16)
Carnegie Mellon University,
Pittsburgh, PA, USA

Valentin Mayer-Eichberger (31)
Universität Potsdam, Germany

Stefan Mengel (17)
Univ. Artois, CNRS, Centre de Recherche en
Informatique de Lens (CRIL), Lens, France

Pablo Mesejo (3)
DECSAI, DaSCI, University of Granada, Spain

Marie Miceli (28)
CRIL, Univ Artois & CNRS, Lens, France

Milan Mossé (9)
Department of Philsophy,
University of California Berkeley, CA, USA

Alexander Nadel (8)
Intel Corporation, Haifa, Israel

Nina Narodytska (26)
VMware Research, Palo Alto, CA, USA

Andreas Niskanen (12, 14)
HIIT, Department of Computer Science,
University of Helsinki, Finland

Jakob Nordström (16)
University of Copenhagen, Denmark;
Lund University, Sweden

Andy Oertel (16)
Lund University, Sweden;
University of Copenhagen, Denmark

Tomáš Peitl (11)
TU Wien, Vienna, Austria

Jelle Piepenbrock (7)
Czech Technical University in Prague,
Czech Republic;
Radboud University Nijmegen, Netherlands

Bartosz Piotrowski (7)
Czech Technical University in Prague,
Czech Republic;
University of Warsaw, Poland

Filip Pokrývka (15)
Masaryk University, Brno, Czech Republic

Franz-Xaver Reichl (20)
TU Wien, Austria

Artur Riazanov (6)
St. Petersburg Department of V.A. Steklov
Mathematical Institute of RAS, Russia;
The Henry and Marylin Taub Faculty of
Computer Science, Technion, Israel

Valentin Roland (30)
secunet Security Networks AG, Essen, Germany

Abdallah Saffidine (31)
University of New South Wales,
Sydney, Australia

Josep M. Salvia (25)
Logic & Optimization Group (LOG),
University of Lleida, Spain

Manfred Scheucher (4)
Institut für Mathematik,
Technische Universität Berlin, Germany

André Schidler (15)
Algorithms and Complexity Group,
TU Wien, Austria

Agnes Schleitzer (5)
Institut für Informatik,
Friedrich-Schiller-Universität Jena, Germany

Christoph Scholl (23)
Department of Computer Science,
Universität Freiburg, Germany

Harry Sha (9)
Department of Computer Science,
University of Toronto, CA

Kirill Simonov (15)
Algorithms and Complexity Group,
TU Wien, Austria

Malte Skambath (19)
Department of Computer Science,
Universität Kiel, Germany

Friedrich Slivovsky (20, 24)
TU Wien, Austria

Pavel Smirnov (13)
HIIT, Department of Computer Science,
University of Helsinki, Finland

Petr Smirnov (6)
HSE University at Saint Petersburg, Russia;
St. Petersburg Department of V.A. Steklov
Mathematical Institute of RAS, Russia

Gaurav Sood (22)
The Institute of Mathematical Sciences,
Chennai, India;
Homi Bhabha National Institute,
Training School Complex, Anushaktinagar,
Mumbai, India

Bernardo Subercaseaux (21)
Carnegie Mellon University,
Pittsburgh, PA, USA

Stefan Szeider (4, 15)
Algorithms and Complexity Group,
TU Wien, Autria

Li-Yang Tan (9)
Department of Computer Science,
Stanford University, CA, USA

Till Tantau (19)
Institute for Theoretical Computer Science,
Universität zu Lübeck, Germany

Eduard Torres (25)
Logic & Optimization Group (LOG),
University of Lleida, Spain

Kuan-Hua Tu (23)
Graduate Institute of Electronics Engineering,
National Taiwan University, Taipei, Taiwan

Hao-Ren Wang (23)
Graduate Institute of Electronics Engineering,
National Taiwan University, Taipei, Taiwan

Michael W. Whalen (27)
Amazon Web Services, Inc.,
Minneapolis, MN, USA;
The University of Minnesota,
Minneapolis, MN, USA

Robert Wille (18)
Technical University of Munich, Germany;
Software Competence Center Hagenberg GmbH
(SCCH), Austria