38th International Symposium on Distributed Computing

DISC 2024, October 28–November 1, 2024, Madrid, Spain

Edited by

Dan Alistarh

Editors

Dan Alistarh
Institute of Science and Technology Austria (ISTA), 3400 Klosterneuburg, Austria
dan.alistarh@ist.ac.at

ACM Classification 2012
Software and its engineering → Distributed systems organizing principles; Computing methodologies → Distributed computing methodologies; Computing methodologies → Concurrent computing methodologies; Hardware → Fault tolerance; Information systems → Data structures; Networks; Theory of computation; Theory of computation → Models of computation; Theory of computation → Design and analysis of algorithms

ISBN 978-3-95977-352-2

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/978-3-95977-352-2.

Publication date
October, 2024

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.DISC.2024.0

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

Regular Papers

38th International Symposium on Distributed Computing (DISC 2024).
Editor: Dan Alistarh
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

Brief Announcements

Preface

DISC 2024, the 38th International Symposium on Distributed Computing, was held between October 28th and November 1st, 2024, in Madrid, Spain. DISC is an international forum on the theory, design, analysis, and implementation of distributed systems and networks, focusing on distributed computing. DISC is organized in cooperation with the European Association for Theoretical Computer Science (EATCS).

Statistics

DISC 2024 received 170 submissions in the "regular paper" category, and 9 submissions in the "brief announcement" category. The program was selected by a program committee consisting of 37 full members and 2 half-load members. The program committee was assisted by 111 external reviewers. As usual for DISC, the committee used a relaxed form of double-blind reviewing, where the submissions themselves were anonymous, but authors were permitted to disseminate their work by uploading it to online repositories or by giving talks about it. Each submission was evaluated by at least three reviewers, and final decisions were made during a 2-day virtual PC meeting, during which approximately 30 submissions were discussed.

The final statistics are as follows:

- 39 submissions were accepted as regular papers, for an acceptance rate of $\sim 23\%$;
- 16 brief announcements were accepted, of which two were submitted in this form, and 14 are short versions of full paper submissions.

The keynote talks at DISC 2024 were given by Stephanie Gil (Harvard University), Stefan Schmid (TU Berlin), and by Gauri Joshi (Carnegie Mellon University).

Awards

The following two awards are jointly sponsored by DISC and the ACM Symposium on Principles of Distributed Computing (PODC):

- The **2024 Edsger W. Dijkstra Prize in Distributed Computing** was awarded to Nicola Santoro and Peter Widmayer for their paper: "Time is Not a Healer" which originally appeared in the Proceedings of the 6th Annual Symposium on Theoretical Aspects of Computer Science (STACS), pages 304–313, 1989. The paper introduced the fundamental notion of dynamic transmission faults, with the goal of modeling message losses on a communication channel, in an otherwise synchronous system. As such, it was the first to investigate the impact of a changing communication topology during the execution of the algorithm on the solvability of distributed agreement tasks, enriching our understanding of this area, and leading to significant follow-up work. The prize was awarded to the authors at PODC 2024 in Nantes.
- The **2024 Principles of Distributed Computing Doctoral Dissertation Award** was presented at DISC 2024. The committee decided to share the award between two recipients: Dr. Robin Vacus for his dissertation "Algorithmic Perspectives to Collective Natural Phenomena," and Dr. Yaunhao Wei for his dissertation "General Techniques for Efficient Concurrent Data Structures."

38th International Symposium on Distributed Computing (DISC 2024).
Editor: Dan Alistarh
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

This volume also includes the citations the best paper and best student paper awards at DISC 2024, as well as the citations for the 2024 Edsger W. Dijkstra Prize in Distributed Computing, which was presented at PODC 2024, and for the Best Dissertation Awards, which were presented at DISC 2024.

Acknowledgments

I would like to end by wholeheartedly thanking everyone who contributed to this edition of DISC: the authors who submitted their work to DISC, the PC members and external reviewers who helped formed the DISC 2024 program, the keynote speakers, the organizing committee, and in particular the local chair Alexey Gotsman, the workshop chairs, and the members of the award committees. Further, I would like to thank Joel Rybicki for help with the proceedings, John Lazarsfeld for help running the program committee meeting, and William Moses, Jr. for handling DISC 2024 publicity.

I am also extremely grateful to all the members of the steering committee, who supported me significantly throughout the process, and to former chairs of DISC, in particular Rotem Oshman, who provided extremely useful practical information and advice. Finally, I would like to thank EATCS for their support, and the staff Schloss Dagstuhl – Leibniz-Zentrum für Informatik for their help in preparing these proceedings.

November 2024

Dan Alistarh
DISC 2024 Program Chair

Organization

The International Symposium on Distributed Computing (DISC), is an annual forum for the presentation of research on all aspects of distributed computing. It is organized in cooperation with the European Association for Theoretical Computer Science (EATCS). The symposium was established in 1985 as a biannual International Workshop on Distributed Algorithms on Graphs (WDAG). The scope was soon extended to cover all aspects of distributed algorithms and WDAG came to stand for International Workshop on Distributed AlGorithms, becoming an annual symposium in 1989. To reflect the expansion of its area of interest, the name was changed to DISC (International Symposium on DIStributed Computing) in 1998, opening the symposium to all aspects of distributed computing. The aim of DISC is to reflect the exciting and rapid developments in this field.

Program Chair

Dan Alistarh	Institute of Science and Technology (ISTA), Austria

Program Committee

Ittai Abraham	Intel (Israel)
Vitaly Aksenov	City University of London (United Kingdom)
Dan Alistarh	ISTA (Austria), Chair
Hagit Attiya	Technion (Israel)
Georgia Avarikioti	TU Vienna (Austria)
Naama Ben-David	Technion (Israel)
Janna Burman	Paris-Saclay University, LISN (France)
Armando Castañeda	Universidad Nacional Autónoma de México (UNAM) (Mexico)
Yi-Jun Chang	National University of Singapore (Singapore)
Bogdan Chlebus	Augusta University (USA)
Shir Cohen	Cornell (USA)
Varsha Dani	Rochester Institute of Technology (USA)
Peter Davies-Peck	Durham University (United Kingdom)
Laxman Dhulipala	University of Maryland and Google (USA)
Michal Dory	University of Haifa (Israel)
Faith Ellen	University of Toronto (Canada)
Manuela Fischer	ETH Zurich (Switzerland)
George Giakkoupis	INRIA Rennes (France)
Seth Gilbert	National University of Singapore (Singapore)
Alexey Gotsman	IMDEA (Spain)
Siddhartha Visveswara Jayanti	Google Research (USA)
Mohsen Lesani	University of California, Santa Cruz (USA)
Julian Loss	CISPA Helmholtz Center for Information Security (Germany)
Yannic Maus	TU Graz (Austria)
Darya Melnyk	TU Berlin (Germany)
Alessia Milani	Aix-Marseille University LIS (France)
Giorgi Nadiradze	Aptos (USA)

38th International Symposium on Distributed Computing (DISC 2024).
Editor: Dan Alistarh
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

Dennis Olivetti	Gran Sasso Science Institute (Italy)
Rotem Oshman	Tel-Aviv University and Princeton University (Israel/USA)
Peter Robinson	Augusta University (USA)
Joel Rybicki	HU Berlin (Germany)
Jared Saia	University of New Mexico (USA)
Thomas Sauerwald	Cambridge University (United Kingdom)
Christian Scheideler	Paderborn University (Germany)
Stefan Schmid	TU Berlin (Germany)
Lili Su	Northeastern University (USA)
Jukka Suomela	Aalto University (Finland)
Marko Vukolic	Protocol Labs (Switzerland)
Leqi Zhu	ISTA (Austria)

Organizing Committee

Alexey Gotsman	IMDEA Software Institute (Spain)
Antonio Fernández Anta	IMDEA Networks Institute (Spain)
Yannic Maus	TU Graz (Austria), Workshops Chair
William K. Moses Jr.	Durham University (United Kingdom), Publicity Chair
Joel Rybicki	HU Berlin (Germany), Proceedings Chair

Steering Committee

Jukka Suomela	Aalto University (Finland), Chair
Hagit Attiya	Technion (Israel), Vice-Chair
Christian Scheideler	University of Paderborn (Germany)
Rotem Oshman	Tel Aviv University (Israel)
Seth Gilbert	NUS (Singapore)
Yannic Maus	TU Graz (Austria)

External Reviewers

Sharareh Alipour	James Aspnes	John Augustine
Lukas Aumayer	Alkida Balliu	Joffroy Beauquier
Trevor Brown	Costas Busch	Christian Cachin
Benjamin Chan	Chaodong Cheng	Arka Rai Choudhuri
Daniel Collins	Emilio Cruciani	Poulami Das
Shantanu Das	Quinten De Man	Dipan Dey
Fabien Dufoulon	Antoine El-Hayek	Robert Elsässer
Yuval Emek	Constantin Enea	Ali Farahbakhsh
Alexander Fedorov	Nick Fischer	Orr Fischer
Maxime Flin	Pierre Fraigniaud	Matthias Függer
Hugo Rincon Galeana	Rati Gelashvili	Anna Geisler
Yuval Gil	Jeff Giliberto	Wojciech Golab
Themis Gouleakis	Magnus M. Halldorsson	Thomas P. Hayes
Juho Hirvonen	Gary Hoppenworth	Xing Hu

Shang-En Huang	David Ilcinkas	Sucharita Jayanty
Valerie King	Lucianna Kiffer	Peter Kling
Ajay Kshemkalyani	Ralf Kuestera	Petr Kuznetsov
Arnaud Labourel	Rustam Latypov	John Lazarsfeld
John Lazarsfeld sysadmin	François Le Gall	Christoph Lenzen
Peter Li	Dimitrios Los	Giuliano Losa
Akaki Mamageiashvili	Elad Michael Schiller	Gopinath Mishrai
Slobodan Mitrović	Masayuki Miyamoto	Kaushik Mondal
William K. Moses Jr.	Yoram Moses	Raïssa Nataf
Yasamin Nazari	Ray Neiheiser	Calvin Newport
Thomas Nowak	Tsutomu Okano	Charlotte Out
Shreyas Pai	Sergei Pankratov	Ami Paz
Sriram V. Pemmaraju	Matthieu Perrin	Seth Pettie
Rafael Pinot	Nuno Preguica	Mikaël Rabie
Sergio Rajsbaum	Michel Raynal	Wen Richard
Nicolas Rivera	Atri Rudra	Mher Safaryan
Giulia Scafino	Noa Schiller	Gal Sela
Gokarna Sharma	Kecheng Shi	Gilad Stern
Hsin-Hao Su	Yuichi Sudo	Pierre Sutra
John Sylvester	Gadi Taubenfeld	Amitabh Trehan
Jara Uitto	Manuel Vidigueira	Hoa Vu
Koichi Wada	Haochen Wang	Yuanhao Wei
Jennifer Welch	Julian Werthmann	Luca Zanetti

Acknowledgements

DISC 2024 was organized by the IMDEA Software Institute. The travel of the invited speakers to DISC was supported by grant CNS2023-144164, funded by MCIN/AEI/10.13039/501100011033 and by the European Union NextGenerationEU/PRTR.

DISC 2024 acknowledges the use of HotCRP for handling submissions and managing the review process and LIPIcs for producing and publishing the proceedings.

DISC is organized in cooperation with the European Association for Theoretical Computer Science (EATCS).

Distinguished Paper Awards

Best Papers

The DISC Program Committee has selected the following two papers to share the DISC 2024 best paper award:

Hyperproperty-Preserving Register Specifications
by Yoav Ben Shimon, Ori Lahav, and Sharon Shoham.

Reasoning about hyperproperties of concurrent implementations, such as the guarantees these implementations provide to "client" programs, has been a central area in distributed computing. This paper makes significant contributions to this area by introducing novel concepts such as "complete" implementations and "decisive linearizability." The authors provide a comprehensive framework for understanding and analyzing the preservation of hyperproperties in shared object implementations, extending beyond traditional linearizability. This research opens up new avenues for simplifying reasoning about concurrent systems and their complex behaviors. The paper's clear presentation, technical depth, and potential for far-reaching impact in both theory and practice make it a standout contribution to this year's program. This work also receives this year's Best Student Paper award.

Lock-Free Augmented Trees
by Panagiota Fatourou and Eric Ruppert.

The paper introduces an elegant and efficient method for maintaining aggregate information in concurrent tree data structures, addressing a critical challenge in parallel computing. The authors' ingenious propagation technique enables the augmentation of both static and dynamic tree structures with powerful query capabilities while preserving lock-free concurrency and linearizability. The work demonstrates the technique's applicability to tries and binary search trees, rigorously proving its correctness and efficiency. The work could have significant impact on both theoretical and practical aspects of concurrent programming.

38th International Symposium on Distributed Computing (DISC 2024).
Editor: Dan Alistarh
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

2024 Principles of Distributed Computing Doctoral Dissertation Awards

The committee for the 2024 Principles of Distributed Computing Doctoral Dissertation Award decided to share the award between two recipients:

- Dr. Robin Vacus for his dissertation "Algorithmic Perspectives to Collective Natural Phenomena."
- Dr. Yaunhao Wei for his dissertation "General Techniques for Efficient Concurrent Data Structures."

Dr. Vacus's Dissertation

Dr. Vacus completed bis PhD under the supervision of Amos Korman and Pierre Fraigniaud, at the Université Paris Cité. His thesis applies a distributed systems approach to problems and models inspired by biology and sociology. The first part of the thesis considers solutions to two agreement-related problems in a setting in which agents have very limited resources, as one would expect in an algorithm that may be executed by animals or even biological cells. It starts by studying a "bit dissemination" problem in which the agents need to decide among two alternatives. Each starts with an opinion but only one of the agents knows the correct choice and will insist on it. Agents exchange opinions with a small sample of peers. The analysis shows an exponential gap beween convergence times in the case in which agents move simultaneously vs. moving sequentially, and a similar gap between memoryless solutions and ones that employ strong separation between the simultaneous and the sequential activation models, and between memory-less solutions and ones in which agents use a small amount of memory. The next problem tacked in this part involves a continuous setting, in which agents try to come as close to their center of mass as possible, while they suffer from Gaussian drift over time and from noisy distance measurements. Somewhat unexpectedly, it is shown that an algorithm using all-to-all communication is not significantly better than one that employs no communication whatsoever. The second part of the thesis considers the role and impact of altruism vs free riding on cooperation in a game-theoretic setting. In one game, it is shown that players' motivation to work to increase their payoffs can sometimes be positively be affected by the amount of easily accessible resources ("low hanging fruit"), while in other cases it may be negatively correlated to that amount. The final question studied in the thesis is a variant of the "tragedy-of-the-commons" in which besides cooperating or defecting players may opt to behave hypocritically, meaning that they perform the least amount of work needed in order to appear to be cooperating. An original mechanism that uses moderate social pressure on non-cooperators is shown to cause defectors to be more cooperative. Dr. Vacus' thesis provides an inspiring overview of the questions studied, and employs a wide range of tools and techniques, involving probabilistic analysis, control theory, statistics and game theory, and computer simulations.

Dr. Wei's Dissertation

Dr. Wei completed his PhD under the supervision of Prof. Guy E. Blelloch, at CMU. In his thesis, Dr. Wei proposes general techniques for improving existing concurrent data structures by simplifying their design and enhancing their performance. The goal of the thesis is to offer techniques that are easy to use to non-experts, even though their implementation

38th International Symposium on Distributed Computing (DISC 2024).
Editor: Dan Alistarh

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

behind-the-scenes is complicated and subtle. The techniques presented in the thesis are: (a) Lock-free locks, an automated and general method for converting lock-based concurrent code into lock-free code, requiring no involvement from the programmer; (b) Consistent snapshots: a method for enriching any data structure with a linearizable snapshot operation, which provides a global copy of the state of the object as it existed at some point during the snapshot operation; and (c) Safe memory reclamation: a combination of manual safe-memory reclamation and automated reference counting, which is simpler than existing techniques, and is shown to be competitive in its performance. The thesis also includes implementations and a rigorous empirical evaluation of the techniques it contributes, including applications to a variety of concurrent data structures. The implementations are offered as libraries which are freely available to the public. Given the growing importance of concurrency, and the well-known difficulty of writing correct and efficient concurrent code, the thesis is well-poised to find practical impact in the programming world.

2024 Edsger W. Dijkstra Prize in Distributed Computing

The Edsger W. Dijkstra Prize in Distributed Computing is awarded for outstanding papers on the principles of distributed computing, whose significance and impact on the theory or practice of distributed computing have been evident for at least a decade. It is sponsored jointly by the ACM Symposium on Principles of Distributed Computing (PODC) and the EATCS Symposium on Distributed Computing (DISC). The prize is presented annually, with the presentation taking place alternately at PODC and DISC.

The committee decided to award the 2024 Edsger W. Dijkstra Prize in Distributed Computing to **Nicola Santoro** and **Peter Widmayer** for their paper:

"Time is Not a Healer"
appearing in
Proceedings of the 6th Annual Symposium on Theoretical Aspects of Computer Science,
pages 304–313, 1989.

The paper introduced the fundamental notion of dynamic transmission faults, with the goal of modeling message losses on a communication channel, in an otherwise synchronous system. As such, it was the first to investigate the impact of a changing communication topology during the execution of the algorithm on the solvability of distributed agreement tasks, complementing the classic processor crash fault model.

Beyond this modeling contribution, the paper also showed, via an elegant proof, the surprising technical fact that, in a system with sufficiently many dynamic transmission faults, a weak version of the Consensus problem is "either trivial or impossible." More precisely, Consensus is unsolvable in a synchronous system if an adversary is able to cause up to $n-1$ messages to be lost in every communication round. This illustrated, for the first time, that the impossibility of Consensus can be also caused by insufficient communication, rather than just the lack of synchrony.

These insights have been very impactful over time, highlighting the connection between the communication topology and the computational power of a distributed system. In turn, the paper has had broad influence across diverse areas such as fault-tolerance, agreement problems, dynamic communication networks, and even topological understanding of distributed computing. The paper has also become a classic text thanks to its excellent exposition.

In summary, the seminal paper by Santoro and Widmayer combines original conceptual contributions with deep theoretical insights, and stands out as a significant stepping stone in our theoretical understanding of distributed computing.

The 2024 Award Committee:

Dan Alistarh (chair), ISTA
Shlomi Dolev, Ben-Gurion University of the Negev
Faith Ellen, University of Toronto
Fabian Kuhn, University of Freiburg
Petr Kuznetsov, Telecom Paris & Institut Polytechnique Paris
Jukka Suomela, Aalto University

38th International Symposium on Distributed Computing (DISC 2024).
Editor: Dan Alistarh

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