

# 35th International Symposium on Distributed Computing

DISC 2021, October 4–8, 2021, Freiburg, Germany (Virtual  
Conference)

Edited by

Seth Gilbert



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*ACM Classification 2012*

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

**ISBN 978-3-95977-210-5**

*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/978-3-95977-210-5>.

*Publication date*

October, 2021

*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>.

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Digital Object Identifier: 10.4230/LIPIcs.DISC.2021.0

ISBN 978-3-95977-210-5

ISSN 1868-8969

<https://www.dagstuhl.de/lipics>

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## ■ Preface

Welcome to the DISC 2021, the 35th International Symposium on Distributed Computing, held on October 4–18, 2021. DISC is an international forum on the theory, design, analysis, and implementation of distributed systems and networks, focusing on distributed computing in all its forms. DISC is organized in cooperation with the European Association for Theoretical Computer Science (EATCS).

This volume contains the papers presented at DISC 2021, including 40 regular papers and 21 brief announcements. Overall, there were 135 papers submitted to DISC on a wide variety of topics in distributed computing. Submissions were double-blind, and they were each reviewed by at least three experts. Final decisions were made during two virtual PC meetings.

This volume also includes the abstracts for two keynote talks, given by Dahlia Malkhi and Bernhard Haeupler. It includes the citations for the best paper and best student paper awards at DISC 2021, as well as citations for two awards jointly sponsored by DISC and the ACM Symposium on Principles of Distributed Computing (PODC):

- The 2021 Edsger W. Dijkstra Prize in Distributed Computing will be presented at DISC 2021 to Paris C. Kanellakis (posthumously) and Scott A. Smolka for their paper “CCS Expressions, Finite State Processes, and Three Problems of Equivalence”.
- The 2021 Principles of Distributed Computing Doctoral Dissertation Award will be presented at PODC 2021 to Dr. Leqi Zhu, for his dissertation titled “On the Space Complexity of Colourless Tasks,” and to Dr. Goran Zuzic, for his dissertation titled “Towards Universal Optimality in Distributed Optimization.”

I would like to thank everyone who contributed to DISC 2021: the authors of the submitted papers, PC members and external reviewers, keynote speakers, members of the organizing committee, workshop organizers, members of the award committees, and participants at the conference. I would also like to thank the members of the steering committee, former chairs and many other members of the community for their valuable assistance and suggestions, EATCS for their support, and the staff at Schloss Dagstuhl – Leibniz-Zentrum für Informatik for their help in preparing these proceedings.

October 2021

Seth Gilbert  
DISC 2021 Program Chair





## ■ Organization

DISC, the International Symposium on Distributed Computing, is an annual forum for 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.

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DISC 2021 acknowledges the use of HotCRP for handling submissions and managing the review process, LIPICs for producing and publishing the proceedings, and Zulip for providing virtual interaction space for conference participants.



DISC thanks VMware for their support.



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



## ■ Awards

### Best Paper

The DISC Program Committee has selected the following paper to receive the DISC 2021 best paper award:

**Lower Bounds for Shared-Memory Leader Election  
under Bounded Write Contention**

by Dan Alistarh, Giorgi Nadiradze, and Rati Gelashvili.

This paper examines a classical and long-studied problem: electing a leader in a shared memory system. It focuses on the question of how fast a leader election protocol can terminate in a good execution, e.g., when a single process runs all alone. It provides an elegant proof that  $\Omega(\log n)$  steps are needed, developing new techniques for proving this type of lower bound. Moreover, the new bound matches the best existing algorithms, showing that the result is tight. As leader election is a foundational problem in distributed computing the new insights in this paper have significant value that merit the best paper award at DISC 2021.

### Best Student Paper

The DISC Program Committee has selected the following two papers to receive the DISC 2021 best student paper award:

**Broadcast CONGEST Algorithms against Adversarial Edges**

by Yael Hitron and Merav Parter.

and

**General CONGEST Compilers against Adversarial Edges**

by Yael Hitron and Merav Parter.

Both of these papers focus on a new class of problems in distributed graph theory: algorithms for the adversarial CONGEST model. In the traditional CONGEST model, the network is modeled as a graph where each node can communicate reliably with its neighbors; the key restriction is that nodes can only send a limited amount of information to each neighbor in each round. In the adversarial CONGEST model, by contrast, a subset of the edges are controlled by a malicious adversary that can send arbitrary malicious messages on those edges. The first paper focuses specifically on the task of broadcast, while the second paper develops a general “compiler” that can be used to transform any algorithm into one that is robust to adversarial edge control. For their development of new techniques to design algorithms for malicious distributed networks, the program committee chose these papers for the best student paper award.





## ■ 2021 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 2021 Edsger W. Dijkstra Prize in Distributed Computing to

*Paris C. Kanellakis and Scott A. Smolka*

for their paper:

**CCS Expressions, Finite State Processes, and Three Problems of Equivalence**  
Information and Computation, Volume 86, Issue 1, pages 43–68, 1990.

A preliminary version of this paper appeared in the proceedings of the Second Annual ACM Symposium on Principles of Distributed Computing (PODC) 1983, pages 228–240.

This paper was a foundational contribution to the fundamental challenge of assigning semantics to concurrent processes, for specification and verification. It addressed the computational complexity of the previously introduced celebrated notion of behavioral equivalence, a cornerstone of Milner’s Calculus of Communicating Systems (CCS), aimed at tackling semantics by considering equivalence classes.

With the publication of their PODC 1983 paper, Kanellakis and Smolka pioneered the development of efficient algorithms for deciding behavioral equivalence of concurrent and distributed processes, especially bisimulation equivalence, which is the cornerstone of the process-algebraic approach to modeling and verifying concurrent and distributed systems. Specifically, the main result of their paper is what has come to be known as the K-S Relational Coarsest Partitioning algorithm, which at the time was a new combinatorial problem of independent interest.

The paper also presented complexity results that showed certain behavioral equivalences are computationally intractable. Collectively, Kanellakis and Smolka’s results founded the subdiscipline of algorithmic process theory, and helped jump-start the field of Formal Verification.

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# ■ 2021 Principles of Distributed Computing Doctoral Dissertation Award

A pleasingly large number of doctoral dissertations were submitted for the 2021 Principles of Distributed Computing Doctoral Dissertation Award, all of outstanding quality. After careful deliberation, the Committee made the choice to share the award between two theses:

## **On the Space Complexity of Colourless Tasks**

by Leqi Zhu,

and

## **Towards Universal Optimality in Distributed Optimization**

by Goran Zuzic.

Zhu's thesis establishes general memory lower bounds for both deterministic and randomized algorithms for a variety of basic synchronization tasks including consensus, k-set agreement, and epsilon-approximate agreement. These bounds hold under a weak liveness assumption – obstruction-freedom – making them very general. Among the results in the thesis one stands out. It provides a definitive solution to a classic and long-standing open problem in distributed computing: to determine the space complexity of consensus in asynchronous, shared-memory systems. Besides the significance of the result, the Committee also appreciated its beautiful execution – a clean, textbook-quality proof. On the basis of this achievement the Committee made its decision to assign the award to this excellent piece of work.

Zuzic's thesis tackles another fundamental problem, in the area of distributed graph algorithms. Loosely speaking, the thesis concerns graph theoretic problems that are non-local, in the sense that they require a number of steps at least proportional to the diameter of the network. This is a large class containing fundamental algorithmic problems such as MST, shortest paths, and min cut. The stated goal is to come up with distributed algorithms that are optimal for every graph topology. In doing so, one must first divine the relevant graph-topology parameters embodying the computational obstruction, and then design algorithms whose performance matches those topological bounds. This is an arduous and ambitious research program, and Zuzic's thesis insightfully covers a lot of ground. For this impressive overall achievement the Committee judged this excellent thesis also worthy of the award.

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