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José Pereira · Laura Ricci (Eds.)

# Distributed Applications and Interoperable Systems

19th IFIP WG 6.1 International Conference, DAIS 2019  
Held as Part of the 14th International Federated Conference  
on Distributed Computing Techniques, DisCoTec 2019  
Kongens Lyngby, Denmark, June 17–21, 2019  
Proceedings

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# Foreword

The 14th International Federated Conference on Distributed Computing Techniques (DisCoTec) took place in Kongens Lyngby, Denmark, during June 17–21, 2019. It was organized by the Department of Applied Mathematics and Computer Science at the Technical University of Denmark.

The DisCoTec series is one of the major events sponsored by the International Federation for Information Processing (IFIP). It comprised three conferences:

- COORDINATION, the IFIP WG 6.1 21st International Conference on Coordination Models and Languages
- DAIS, the IFIP WG 6.1 19th International Conference on Distributed Applications and Interoperable Systems
- FORTE, the IFIP WG 6.1 39th International Conference on Formal Techniques for Distributed Objects, Components and Systems

Together, these conferences cover a broad spectrum of distributed computing subjects, ranging from theoretical foundations and formal description techniques to systems research issues.

In addition to the individual sessions of each conference, the event included several plenary sessions that gathered attendants from the three conferences. This year, the general chair and the DisCoTec Steering Committee joined the three DisCoTec conferences in the selection and nomination of the plenary keynote speakers, whose number was accordingly increased from the traditional three to five. The five keynote speakers and the title of their talks are listed below:

- Prof. David Basin (ETH Zürich, Switzerland) – “Security Protocols: Model Checking Standards”
- Dr. Anne-Marie Kermarrec (Inria Rennes, France) – “Making Sense of Fast Big Data”
- Prof. Marta Kwiatkowska (University of Oxford, UK) – “Versatile Quantitative Modelling: Verification, Synthesis and Data Inference for Cyber-Physical Systems”
- Prof. Silvio Micali (MIT, USA) – “ALGORAND – The Distributed Ledger for the Borderless Economy”
- Prof. Martin Wirsing (LMU, Germany) – “Toward Formally Designing Collective Adaptive Systems”

As is traditional in DisCoTec, an additional joint session with the best papers from each conference was organized. The best papers were:

- “Representing Dependencies in Event Structures” by G. Michele Pinna (Coordination)
- “FOUGERE: User-Centric Location Privacy in Mobile Crowdsourcing Apps” by Lakhdar Meftah, Romain Rouvoy and Isabelle Chrisment (DAIS)

- “Psi-Calculi Revisited: Connectivity and Compositionality” by Johannes Åman Pohjola (FORTE)

Associated with the federated event were also two satellite events that took place:

- ICE, the 12th International Workshop on Interaction and Concurrency Experience
- DisCoRail, the First International Workshop on Distributed Computing in Future Railway Systems

I would like to thank the Program Committee chairs of the different events for their help and cooperation during the preparation of the conference, and the Steering Committee and Advisory Boards of DisCoTec and their conferences for their guidance and support. The organization of DisCoTec 2019 was only possible thanks to the dedicated work of the Organizing Committee, including Francisco “Kiko” Fernández Reyes and Francesco Tiezzi (publicity chairs), Maurice ter Beek, Valerio Schiavoni, and Andrea Vandin (workshop chairs), Ann-Cathrin Dunker (logistics and finances), as well as all the students and colleagues who volunteered their time to help. Finally, I would like to thank IFIP WG 6.1 for sponsoring this event, Springer’s *Lecture Notes in Computer Science* team for their support and sponsorship, EasyChair for providing the reviewing infrastructure, the Nordic IoT Hub for their sponsorship, and the Technical University of Denmark for providing meeting rooms and additional support.

June 2019

Alberto Lluch Lafuente

# Preface

This volume contains the papers presented at DAIS 2019, the 19th IFIP International Conference on Distributed Applications and Interoperable Systems, sponsored by the IFIP (International Federation for Information Processing) and organized by the IFIP Working Group 6.1. The DAIS conference series addresses all practical and conceptual aspects of distributed applications, including their design, modeling, implementation and operation, the supporting middleware, appropriate software engineering methodologies and tools, as well as experimental studies and applications.

DAIS 2019 was held during June 17–21, 2019, in Kongens Lyngby, Denmark, as part of DisCoTec, the 12th International Federated Conference on Distributed Computing Techniques. There were 28 submissions for DAIS. Each submission was reviewed by four Program Committee (PC) members. The review process included an in-depth discussion phase, during which the merits of all papers were discussed by the PC. The committee decided to accept nine full papers and two short papers.

Accepted papers address challenges in multiple application areas, such as the Internet of Things, cloud and edge computing, and mobile systems. A number of papers focus on middleware for managing concurrency and consistency in distributed systems, including data replication and transactions. There is also an emphasis on distributed systems security, including the evaluation and application of trusted execution environments and applications of blockchain technology.

The conference was made possible by the work and cooperation of many people working in several committees and organizations that are listed in these proceedings. In particular, we thank the Program Committee members for their commitment and thorough reviews and for their active participation in the discussion phase, and all the external reviewers for their help in evaluating submissions. Finally, we also thank the DisCoTec general chair, Alberto Lluch Lafuente, and the DAIS Steering Committee chair, Rui Oliveira, for their constant availability, support, and guidance.

June 2019

José Pereira  
Laura Ricci

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# **DisCoTec Keynotes**

# Versatile Quantitative Modelling: Verification, Synthesis and Data Inference for Cyber-Physical Systems

Marta Kwiatkowska

University of Oxford, UK

**Abstract.** Computing systems are becoming ever more complex, encompassing autonomous control of physical processes, stochasticity and inference from sensor data. This lecture will demonstrate the versatility of quantitative modelling and verification to aid the design of cyber-physical systems with machine learning components. Topics discussed will include recent advances in probabilistic/quantitative verification, template-based model synthesis, resource-performance trade off analysis, attacks on biometric security, and robustness guarantees for machine learning components. The lecture will conclude by giving an overview of future challenges in this field.

# **ALGORAND – The Distributed Ledger for the Borderless Economy**

Silvio Micali

MIT, USA

**Abstract.** A distributed ledger is a tamperproof sequence of data that can be read and augmented by everyone. Distributed ledgers stand to revolutionize the way democratic societies and traditional economies operate. They secure all kinds of traditional transactions –such as payments, asset transfers, titling– in the exact order in which they occur; and enable totally new transactions –such as cryptocurrencies and smart contracts. They can remove intermediaries and usher in a new paradigm for trust. As currently implemented, however, distributed ledgers cannot achieve their enormous potential. The global participation and trust necessary to realize an inclusive and borderless economy require substantially better technology. Algorand is an alternative, democratic, and efficient distributed ledger. Unlike prior ledgers based on ‘proof of work’, it dispenses with ‘miners’. Indeed, Algorand requires only a negligible amount of computation. Moreover, its transaction history does not ‘fork’ with overwhelming probability: i.e., Algorand guarantees the finality of all transactions. In addition, Algorand guarantees flexible self-governance. A successful society and economy must be able to evolve. A cryptocurrency cannot be an ocean liner on autopilot. By using its hallmark propose-and-agree process, Algorand can consensually correct its course, as necessary or desirable, without any ‘hard forks’, to meet the current and future needs of the community.

# Making Sense of Fast Big Data (DAIS Keynote)

Anne-Marie Kermarrec

Inria Rennes, France

**Abstract.** Computing systems that make human sense of big data, usually called personalization systems or recommenders, and popularized by Amazon and Netflix, essentially help Internet users extracting information of interest to them. Leveraging machine learning techniques, research on personalization has mainly focused on improving the quality of the information extracted, according to some measure of quality. Yet, building an operational recommender goes far beyond, especially in a world where data is not only big but also changes very fast. This talk will discuss system challenges to scale to a large number of users and a growing volume of fastly changing data to eventually provide real-time personalization.

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