29th International Conference on Database Theory

ICDT 2026, March 24–27, 2026, Tampere, Finland

Edited by

Balder ten Cate

Maurice Funk

LIPICS

LIPIcs – Vol. 365 – ICDT 2026 www.dagstuhl.de/lipics

Editors

Balder ten Cate
University of Amsterdam, The Netherlands
b.d.tencate@uva.nl

Maurice Funk
Leipzig University, Germany
mfunk@informatik.uni-leipzig.de

ACM Classification 2012
Theory of computation → Complexity theory and logic; Theory of computation → Database theory; Theory of computation → Logic; Theory of computation → Models of computation; Theory of computation → Data structures design and analysis; Theory of computation → Formal languages and automata theory; Information systems → Decision support systems; Information systems → Database query processing; Information systems → Database views; Information systems → Data streams; Information systems → Data management systems; Information systems → Graph-based database models; Information systems → Join algorithms; Information systems → Parallel and distributed DBMSs; Information systems → Query languages; Information systems → Query optimization; Information systems → Relational database model; Information systems → Stream management; Information systems → Logical and relational learning; Computing methodologies → Modeling and simulation; Computing methodologies → Supervised learning; Applied computing → Decision analysis; Mathematics of computing → Combinatorics; Mathematics of computing → Enumeration; Mathematics of computing → Graph theory; Security and privacy → Management and querying of encrypted data

ISBN 978-3-95977-413-0

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/978-3-95977-413-0.

Publication date
March, 2026

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists all publications of this volume in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at https://portal.dnb.de.

License
This work is licensed under a Creative Commons Attribution 4.0 International license (CC-BY 4.0): https://creativecommons.org/licenses/by/4.0/legalcode.
In brief, this license authorizes each and everybody to share (to copy, distribute and transmit) the work under the following conditions, without impairing or restricting the authors' moral rights:
- Attribution: The work must be attributed to its authors.

The copyright is retained by the corresponding authors.

Digital Object Identifier: 10.4230/LIPIcs.ICDT.2026.0
ISBN 978-3-95977-413-0 **ISSN 1868-8969** **https://www.dagstuhl.de/lipics**

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.

Editorial Board

- Christel Baier (TU Dresden, DE)
- Roberto Di Cosmo (Inria and Université Paris Cité, FR)
- Faith Ellen (University of Toronto, CA)
- Javier Esparza (TU München, DE)
- Holger Hermanns (Universität des Saarlandes, Saarbrücken, DE and Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Wadern, DE)
- Daniel Král' (Leipzig University, DE and Max Planck Institute for Mathematics in the Sciences, Leipzig, DE – Chair)
- Sławomir Lasota (University of Warsaw, PL)
- Meena Mahajan (Institute of Mathematical Sciences, Chennai, IN)
- Chih-Hao Luke Ong (Nanyang Technological University, SG)
- Eva Rotenberg (IT University of Copenhagen, DK)
- Pierre Senellart (ENS, Université PSL, Paris, France)
- Alexandra Silva (Cornell University, Ithaca, US)

ISSN 1868-8969

https://www.dagstuhl.de/lipics

Contents

Preface
Balder ten Cate and Maurice Funk 0:vii

ICDT 2026 Test of Time Award
Ester Livshits, Wim Martens, and Cristian Riveros 0:ix

Organization
..... 0:xi

External Reviewers
..... 0:xiii

List of Authors
..... 0:xv

Invited Talks

Query Decompositions and All That
Kyle Deeds, Timo Camillo Merkl, Reinhard Pichler, and Dan Suciu 1:1–1:20

The Dissection of a Complex Event Recognition Engine
Cristian Riveros 2:1–2:1

Building Relational Circuits
Florent Capelli 3:1–3:20

Regular Papers

Computing Consistent Least Upper Bounds in Aggregate Logic
Aziz Amezian El Khalfioui and Jef Wijsen 4:1–4:21

Rule Rewriting Revisited: A Fresh Look at Static Filtering for Datalog and ASP
Philipp Hanisch and Markus Krötzsch 5:1–5:19

Designing and Comparing RPQ Semantics
Victor Marsault and Antoine Meyer 6:1–6:20

The Importance of Parameters in Ranking Functions
Christoph Standke, Nikolaos Tziavelis, Wolfgang Gatterbauer, and Benny Kimelfeld 7:1–7:18

Neither Cover nor Pack: Distributed Worst-Case Optimality of Degree-2 Joins
Heba Aamer, Xiao Hu, and Bas Ketsman 8:1–8:20

Acyclic Join Sampling Under Selections: Dichotomy, Union Sampling, and Enumeration
Jinchao Huang, Yufei Tao, and Sibo Wang 9:1–9:20

Bounding the Makespan of Transaction Schedules
Tim Baccaert, Brecht Vandevoort, and Bas Ketsman 10:1–10:20

Factorised Representations of Join Queries: Tight Bounds and a New Dichotomy
Christoph Berkholz and Harry Vinall-Smeeth 11:1–11:20

29th International Conference on Database Theory (ICDT 2026).
Editors: Balder ten Cate and Maurice Funk
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

The Complexity of Finding Missing Answer Repairs
Jesse Comer and Val Tannen 12:1–12:20

Complexity of Evaluating GQL Queries
Diego Figueira, Anthony W. Lin, and Liat Peterfreund 13:1–13:18

Lower Bounds for the Algorithmic Complexity of Learned Indexes
Luis Alberto Croquevielle, Roman Sokolovskii, and Thomas Heinis 14:1–14:21

A Formal Query Language and Automata Model for Aggregation in Complex Event Recognition
Pierre Bourhis, Cristian Riveros, and Amaranta Salas 15:1–15:20

Gamma Acyclicity, Annotated Relations, and Consistency Witness Functions
Albert Atserias and Phokion G. Kolaitis 16:1–16:18

Algorithms for Optimizing Acyclic Queries
Zheng Luo, Wim Van den Broeck, Guy Van den Broeck, and Yisu Remy Wang ... 17:1–17:18

Output-Sensitive Evaluation of Acyclic Conjunctive Regular Path Queries
Mahmoud Abo Khamis, Alexandru-Mihai Hurjui, Ahmet Kara, Dan Olteanu, Dan Suciu, and Zilu Tian 18:1–18:20

Dynamic Necklace Splitting
Rishi Advani, Abolfazl Asudeh, Mohsen Dehghankar, and Stavros Sintos 19:1–19:20

Responsibility Measures for Conjunctive Queries with Negation
Meghyn Bienvenu, Diego Figueira, and Pierre Lafourcade 20:1–20:20

First-Order Rewritability of Rule-Based Ontology Mediated Queries with Negation
Georg Gottlob, Marco Manna, Andreas Pieris, and Aldo Ricioppo 21:1–21:20

View-Based Query Determinacy for Walk-Based Semantics
Nadime Francis 22:1–22:21

Conjunctive Query Containment with Safe Negation and TGD One-Boundedness
Xavier Oriol 23:1–23:20

Database Theory in Actions

Database Theory in Action: Evaluation of Aggregate Queries Without Materialisation
Matthias Lanzinger, Reinhard Pichler, and Alexander Selzer 24:1–24:5

Database Theory in Action: Yannakakis' Algorithm
Paraschos Koutris, Stijn Vansummeren, Qichen Wang, Yisu Remy Wang, and Xiangyao Yu 25:1–25:6

Database Theory in Action: From Inexpressibility to Efficiency in GQL's Order-Constrained Paths
Hadar Rotschield and Liat Peterfreund 26:1–26:5

Database Theory in Action: Direct Access to Query Answers
Jiayin Hu and Nikolaos Tziavelis 27:1–27:5

Database Theory in Action: Learning Logical Modelling with Iltis
Tristan Kneisel, Fabian Vehlken, and Thomas Zeume 28:1–28:5

Preface

The 29th International Conference on Database Theory (ICDT 2026) was held in Tampere, Finland, from March 24th to March 27th, 2026. The Program Committee has selected 20 research papers out of 73 full submissions for publication at the conference.

In addition, for the second time, ICDT 2026 included a track called "Database Theory in Action" to showcase the applications of database theory in practice. The Program Committee has selected 5 papers out of 6.

Apart from the 20 regular papers and 5 database theory in action papers, these proceedings include papers accompanying two of the EDBT/ICDT keynotes, namely by the keynote speakers Reinhard Pichler (Vienna University of Technology) and Cristian Riveros (Pontificia Universidad Católica de Chile) and a paper accompanying the invited ICDT lecture by Florent Capelli (Université d'Artois).

The program committee has decided to award the ICDT 2026 Best Paper Award to the paper "Lower Bounds for the Algorithmic Complexity of Learned Indexes" authored by Luis Alberto Croquevielle, Roman Sokolovskii and Thomas Heinis.

A committee formed by Ester Livshits, Wim Martens, and Cristian Riveros has decided to give the Test-of-Time Award for ICDT 2026 to the following ICDT 2016 paper:

Declarative Probabilistic Programming with Datalog.
Vince Bárány, Balder ten Cate, Benny Kimelfeld, Dan Olteanu, Zografoula Vagena.

We would like to thank all people who contributed to the success of ICDT 2026, including the authors of all submitted papers, keynote and invited talk speakers, and, of course, all members of the Program Committee as well as the external reviewers, for the very substantial work that they have invested over the two submission cycles of ICDT 2026. Their effort and wisdom were critical to ensure that the final program of the conference satisfies the highest standards. We would also like to thank the ICDT Council members for their support on a wide variety of matters, and the local organizers of the EDBT/ICDT 2026 conference, led by General Chairs Kostas Stefanidis and Zheying Zhang, for all the hard work they have been doing in organizing the conference and co-located events.

Finally, we wish to acknowledge Dagstuhl Publishing for their support with the publication of the proceedings in the LIPIcs (Leibniz International Proceedings in Informatics) series.

Balder ten Cate and Maurice Funk
January 2026

ICDT 2026 Test of Time Award

The ICDT Test-of-Time Award recognizes one paper, or a small number of papers, presented at earlier ICDT conferences that have best met the "test of time". The 2026 Test-of-Time Award recognizes the following paper selected from the proceedings of the ICDT 2016:

Declarative Probabilistic Programming with Datalog.
Vince Bárány, Balder ten Cate, Benny Kimelfeld, Dan Olteanu, Zografoula Vagena.

The paper proposes Generative Datalog, a probabilistic extension of Datalog that allows sampling from discrete probability distributions. Generative Datalog can be seen as a declarative probabilistic programming language that operates on standard relational databases. The idea is simple but elegant: Given that we can view an existential Datalog program as a generator of families of models, why not turn it into a generator of a probabilistic model? On the side of language design, essentially all it takes is to attach probability distributions to the tuple-generating dependencies. The easy concept of the language is paired with a surprisingly deep mathematical background: Even though all distributions discussed in this initial paper are discrete, laying the semantic groundwork already requires excursions into measure theory. The paper explains the language, defines the semantics, a probabilistic version of the chase, discusses adding constraints in the spirit of probabilistic programming, and touches upon the equivalence problem for programs. It generated a significant amount of follow-up in a variety of top venues spanning database theory, database systems, and programming languages.

Ester Livshits	Wim Martens	Cristian Riveros
Technion Israel	University of Bayreuth Germany	Pontificia Universidad Católica de Chile Chile

The ICDT Test-of-Time Award Committee for 2026

29th International Conference on Database Theory (ICDT 2026).
Editors: Balder ten Cate and Maurice Funk
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

Organization

General Chairs

Kostas Stefanidis, Tampere University, Finland
Zheying Zhang, Tampere University, Finland

Program Committee Chair

Balder ten Cate, University of Amsterdam, The Netherlands

Program Committee

Antonella Poggi, University of Rome Sapienza, Italy
Batya Kenig, Technion, Israel
Carsten Lutz, University of Leipzig, Germany (Senior PC member)
Cristina Sirangelo, CNRS, Université Paris Cité, France
Diego Figueira, CNRS, Université de Bordeaux, France
Dominik Freydenberger, Loughborough University, United Kingdom
Emanuel Sallinger, TU Wien, Austria
Floris Geerts, University of Antwerp, Belgium (Senior PC member)
Francesco Scarcello, Università della Calabria, Italy
Hubie Chen, King's College London, United Kingdom
Jeff M. Phillips, University of Utah, United States
Liat Peterfreund, Hebrew University of Jerusalem, Israel
Luc Segoufin, INRIA, ENS Ulm, France (Senior PC member)
Mahmoud Abo Khamis, RelationalAI
Marco Calautti, Università degli Studi di Milano, Italy
Markus Schmid, Humboldt-Universität zu Berlin, Germany
Martin Grohe, RWTH Aachen University, Germany
Matthias Niewerth, Bayreuth University, Germany
Miika Hannula, University of Tartu, Estonia
Sanjay Krishnan, University of Chicago, United States
Sebastian Rudolph, TU Dresden, Germany
Stavros Sintos, University of Illinois Chicago, United States
Stefan Mengel, CNRS, Université d'Artois, France

Proceedings Chair

Maurice Funk, Leipzig University, Germany

29th International Conference on Database Theory (ICDT 2026).
Editors: Balder ten Cate and Maurice Funk
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

External Reviewers

We gratefully acknowledge the contributions of the following external reviewers:

Aryan Esmailpour
Daniel Paul-Pena
Davide Mario Longo
Florent Capelli
Gianluca Cima
Hangdong Zhao
Hannah Van Santvliet
Joseph Near
Lukas Schulze
Markus Schneider
Martín Muñoz
Maurice Funk
Minna Hirvonen
Nofar Carmeli
Pierre Lafourcade
Quentin Manière
Rémi Morvan
Sam M. Thompson
Stefan Siemer
Yijia Chen

29th International Conference on Database Theory (ICDT 2026).
Editors: Balder ten Cate and Maurice Funk
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

List of Authors

Heba Aamer (8)
Vrije Universiteit Brussel, Belgium

Mahmoud Abo Khamis (18)
RelationalAI, Berkeley, CA, USA

Rishi Advani (19)
University of Illinois Chicago, IL, USA

Aziz Amezian El Khalfioui (4)
Research fellow FNRS, University of Mons, Mons, Belgium

Abolfazl Asudeh (19)
University of Illinois Chicago, IL, USA

Albert Atserias (16)
Universitat Politècnica de Catalunya, Barcelona, Spain; Centre de Recerca Matemàtica, Bellaterra, Spain

Tim Baccaert (10)
Software Languages Lab, Vrije Universiteit Brussel, Belgium

Christoph Berkholz (11)
Technische Universität Ilmenau, Germany

Meghyn Bienvenu (20)
Univ. Bordeaux, CNRS, Bordeaux INP, LaBRI, UMR5800, F-33400 Talence, France

Pierre Bourhis (15)
Univ. Lille, CNRS, Centrale Lille, UMR 9189 CRIStAL, INRIA Lille, F-59000 Lille, France

Florent Capelli (3)
Univ. Artois, CNRS, UMR 8188, Centre de Recherche en Informatique de Lens (CRIL), F-62300 Lens, France

Jesse Comer (12)
University of Pennsylvania, Philadelphia, PA, USA

Luis Alberto Croquevielle (14)
Imperial College London, UK

Kyle Deeds (1)
University of Washington, Seattle, WA, USA

Mohsen Dehghankar (19)
University of Illinois Chicago, IL, USA

Diego Figueira (13, 20)
University of Bordeaux, CNRS, Bordeaux INP, LaBRI, UMR 5800, F-33400, Talence, France

Nadime Francis (22)
LIGM, Université Gustave Eiffel, CNRS, Marne-la-Vallée, France

Wolfgang Gatterbauer (7)
Northeastern University, Boston, MA, USA

Georg Gottlob (21)
University of Calabria, Rende, Italy

Philipp Hanisch (5)
Knowledge-Based Systems Group, TU Dresden, Germany

Thomas Heinis (14)
Imperial College London, UK

Jiayin Hu (27)
University of California Santa Cruz, CA, USA

Xiao Hu (8)
University of Waterloo, Canada

Jinchao Huang (9)
The Chinese University of Hong Kong, Hong Kong

Alexandru-Mihai Hurjui (18)
University of Zurich, Switzerland

Ahmet Kara (18)
OTH Regensburg, Germany

Bas Ketsman (8, 10)
Vrije Universiteit Brussel, Belgium

Benny Kimelfeld (7)
Technion, Haifa, Israel; RelationalAI Inc., Berkeley, CA, USA

Tristan Kneisel (28)
Ruhr University Bochum, Germany

Phokion G. Kolaitis (16)
University of California Santa Cruz, CA, USA; IBM Research, San Jose, CA, USA

Paraschos Koutris (25)
University of Wisconsin-Madison, WI, USA

Markus Krötzsch (5)
Knowledge-Based Systems Group, TU Dresden, Germany

Pierre Lafourcade (20)
Univ. Bordeaux, CNRS, Bordeaux INP, LaBRI, UMR5800, F-33400 Talence, France

29th International Conference on Database Theory (ICDT 2026).
Editors: Balder ten Cate and Maurice Funk
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

Matthias Lanzinger (24)
TU Wien, Austria

Anthony W. Lin (13)
University of Kaiserslautern-Landau, Germany; MPI-SWS, Kaiserslautern, Germany

Zheng Luo (17)
University of California, Los Angeles, CA, USA

Marco Manna (21)
University of Calabria, Rende, Italy

Victor Marsault (6)
Univ Gustave Eiffel, CNRS, LIGM, F-77454 Marne-la-Vallée, France

Timo Camillo Merkl (1)
TU Wien, Austria

Antoine Meyer (6)
Univ Gustave Eiffel, CNRS, LIGM, F-77454 Marne-la-Vallée, France

Dan Olteanu (18)
University of Zurich, Switzerland

Xavier Oriol (23)
Universitat Politècnica de Catalunya, Barcelona, Spain

Liat Peterfreund (13, 26)
Hebrew University of Jerusalem, Israel

Reinhard Pichler (1, 24)
TU Wien, Austria

Andreas Pieris (21)
University of Cyprus, Nicosia, Cyprus; University of Edinburgh, UK

Aldo Ricioppo (21)
University of Calabria, Rende, Italy

Cristian Riveros (2, 15)
Pontificia Universidad Católica de Chile, Chile; Millennium Institute for Foundational Research on Data, Santiago, Chile

Hadar Rotschield (26)
School of Computer Science and Engineering, The Hebrew University of Jerusalem, Israel

Amaranta Salas (15)
Pontificia Universidad Católica de Chile, Santiago, Chile; Millennium Institute for Foundational Research on Data, Santiago, Chile

Alexander Selzer (24)
TU Wien, Austria

Stavros Sintos (19)
University of Illinois Chicago, IL, USA

Roman Sokolovskii (14)
Imperial College London, UK

Christoph Standke (7)
RWTH Aachen University, Germany

Dan Suciu (1, 18)
University of Washington, Seattle, WA, USA

Val Tannen (12)
University of Pennsylvania, Philadelphia, PA, USA

Yufei Tao (9)
The Chinese University of Hong Kong, Hong Kong

Zilu Tian (18)
University of Zurich, Switzerland

Nikolaos Tziavelis (7, 27)
University of California Santa Cruz, CA, USA

Guy Van den Broeck (17)
University of California, Los Angeles, CA, USA

Wim Van den Broeck (17)
University of Bergen, Norway

Brecht Vandevoort (10)
UHasselt, Data Science Institute, ACSL, Diepenbeek, Belgium

Stijn Vansummeren (25)
UHasselt, Data Science Institute, Diepenbeek, Belgium

Fabian Vehlken (28)
Ruhr University Bochum, Germany

Harry Vinall-Smeeth (11)
RWTH Aachen University, Germany

Qichen Wang (25)
Nanyang Technological University, Singapore

Sibo Wang (9)
The Chinese University of Hong Kong, Hong Kong

Yisu Remy Wang (17, 25)
University of California, Los Angeles, CA, USA

Jef Wijsen (4)
University of Mons, Mons, Belgium

Xiangyao Yu (25)
University of Wisconsin-Madison, WI, USA

Thomas Zeume (28)
Ruhr University Bochum, Germany