

9th Conference on Algebra and Coalgebra in Computer Science

CALCO 2021, August 31–September 3, 2021, Salzburg, Austria

Edited by

Fabio Gadducci

Alexandra Silva



Editors

Fabio Gadducci 

University of Pisa, Italy
fabio.gadducci@unipi.it

Alexandra Silva 

Cornell University, USA
University College London, UK
alexandra.silva@gmail.com

ACM Classification 2012

Theory of computation → Models of computation; Theory of computation → Modal and temporal logics; Theory of computation → Algebraic semantics; Theory of computation → Categorical semantics; Theory of computation → Quantum computation theory; Software and its engineering → Context specific languages

ISBN 978-3-95977-212-9

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/978-3-95977-212-9>.

Publication date

November, 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>.

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.CALCO.2021.0

ISBN 978-3-95977-212-9

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

- Luca Aceto (*Chair*, Reykjavik University, IS and Gran Sasso Science Institute, IT)
- Christel Baier (TU Dresden, DE)
- Mikolaj Bojanczyk (University of Warsaw, PL)
- Roberto Di Cosmo (Inria and Université de Paris, FR)
- Faith Ellen (University of Toronto, CA)
- Javier Esparza (TU München, DE)
- Daniel Král' (Masaryk University - Brno, CZ)
- Meena Mahajan (Institute of Mathematical Sciences, Chennai, IN)
- Anca Muscholl (University of Bordeaux, FR)
- Chih-Hao Luke Ong (University of Oxford, GB)
- Phillip Rogaway (University of California, Davis, US)
- Eva Rotenberg (Technical University of Denmark, Lyngby, DK)
- Raimund Seidel (Universität des Saarlandes, Saarbrücken, DE and Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Wadern, DE)

ISSN 1868-8969

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

■ Contents

Preface	
<i>Fabio Gadducci and Alexandra Silva</i>	0:vii
Conference Organization	
.....	0:ix–0:x

Invited Talks

Distributive Laws for Lawvere Theories	
<i>Eugenía Cheng</i>	1:1–1:1
Towards Engineering Smart Cyber-Physical Systems with Graph Transformation Systems	
<i>Holger Giese</i>	2:1–2:1
Dialectica Comonads	
<i>Valeria de Paiva</i>	3:1–3:13
The Challenges of Weak Persistency	
<i>Viktor Vafeiadis</i>	4:1–4:3

Papers

Initial Algebras Without Iteration ((Co)algebraic pearls)	
<i>Jiří Adámek, Stefan Milius, and Lawrence S. Moss</i>	5:1–5:20
Which Categories Are Varieties? ((Co)algebraic pearls)	
<i>Jiří Adámek and Jiří Rosický</i>	6:1–6:14
Tensor of Quantitative Equational Theories	
<i>Giorgio Bacci, Radu Mardare, Prakash Panangaden, and Gordon Plotkin</i>	7:1–7:17
Pushdown Automata and Context-Free Grammars in Bisimulation Semantics	
<i>Jos C. M. Baeten, Cesare Carissimo, and Bas Luttik</i>	8:1–8:16
From Farkas' Lemma to Linear Programming: an Exercise in Diagrammatic Algebra ((Co)algebraic pearls)	
<i>Filippo Bonchi, Alessandro Di Giorgio, and Fabio Zanasi</i>	9:1–9:19
On Doctrines and Cartesian Bicategories	
<i>Filippo Bonchi, Alessio Santamaria, Jens Seeber, and Paweł Sobociński</i>	10:1–10:17
Presenting Convex Sets of Probability Distributions by Convex Semilattices and Unique Bases ((Co)algebraic pearls)	
<i>Filippo Bonchi, Ana Sokolova, and Valeria Vignudelli</i>	11:1–11:18
Closure Hyperdoctrines	
<i>Davide Castelnovo and Marino Miculan</i>	12:1–12:21
How to Write a Coequation ((Co)algebraic pearls)	
<i>Fredrik Dahlqvist and Todd Schmid</i>	13:1–13:25

9th Conference on Algebra and Coalgebra in Computer Science (CALCO 2021).

Editors: Fabio Gadducci and Alexandra Silva



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

Monads on Categories of Relational Structures <i>Chase Ford, Stefan Milius, and Lutz Schröder</i>	14:1–14:17
Stream Processors and Comodels <i>Richard Garner</i>	15:1–15:17
A Coinductive Version of Milner’s Proof System for Regular Expressions Modulo Bisimilarity <i>Clemens Grabmayer</i>	16:1–16:23
Functorial Semantics as a Unifying Perspective on Logic Programming <i>Tao Gu and Fabio Zanasi</i>	17:1–17:22
The Central Valuations Monad (Early Ideas) <i>Xiaodong Jia, Michael Mislove, and Vladimir Zamdzhiev</i>	18:1–18:5
Coderelictions for Free Exponential Modalities <i>Jean-Simon Pacaud Lemay</i>	19:1–19:21
The Open Algebraic Path Problem <i>Jade Master</i>	20:1–20:20
Preorder-Constrained Simulation for Nondeterministic Automata (Early Ideas) <i>Koko Muroya, Takahiro Sanada, and Natsuki Urabe</i>	21:1–21:5
Quantitative Polynomial Functors (Early Ideas) <i>Georgi Nakov and Fredrik Nordvall Forsberg</i>	22:1–22:5
Nawrotzki’s Algorithm for the Countable Splitting Lemma, Constructively ((Co)algebraic pearls) <i>Ana Sokolova and Harald Woracek</i>	23:1–23:16
Minimality Notions via Factorization Systems ((Co)algebraic pearls) <i>Thorsten Wißmann</i>	24:1–24:21

■ Preface

This volume contains the proceedings of the 9th Conference on Algebra and Coalgebra in Computer Science (CALCO), held both online and at the University of Salzburg, from August 30th to September 3rd, 2021. Previous CALCO editions took place in Swansea (Wales, 2005), Bergen (Norway, 2007), Udine (Italy, 2009), Winchester (UK, 2011), Warsaw (Poland, 2013), Nijmegen (The Netherlands, 2015), Ljubljana (Slovenia, 2017), and London (UK, 2019). This year's edition, following on the tradition started in 2015, was co-located with the conference Mathematical Foundations of Programming Semantics (MFPS).

CALCO is a high-level, bi-annual conference formed by joining CMCS (the International Workshop on Coalgebraic Methods in Computer Science) and WADT (the Workshop on Recent Trends in Algebraic Development Techniques). It provides a forum to present and discuss results of theoretical nature on the mathematics of algebras and coalgebras, the way these results can support methods and techniques for software development, as well as experience reports concerning the transfer of the resulting technologies into industrial practice. Typical topics of interest include

- Models and logics
- Algebraic and coalgebraic semantics
- Methodologies in software and systems engineering
- Specialised models and calculi
- System specification and verification
- Tools supporting algebraic and coalgebraic methods
- String diagrams and network theory
- Quantum computing

At the conference were three invited talks by Holger Giese, Valeria de Paiva, and Viktor Vafeiadis. Additionally, Eugenia Cheng was a joint invited speaker for CALCO and MFPS, and there was a joint special session on Termination Analysis and Synthesis organised by Azadeh Farzan, who delivered an invited tutorial, and with talks by Zac Kincaid and Florian Zuleger. In addition, there were 20 contributed talks, of which 10 were regular papers, 7 (co)algebraic pearls, and 3 early ideas. This volume collects the abstracts of the four invited talks, as well as the peer-reviewed papers.

We are grateful to the Program Committee members for their hard work in reviewing and selecting the papers. They also selected the *Best Paper*, awarded to *Tensor of Quantitative Equational Theories*, authored by Giorgio Bacci, Radu Mardare, Prakash Panangaden, and Gordon Plotkin. The audience instead selected the *Best Talk*, awarded to Ana Sokolova for her presentation of the paper *Nawrotzki's Algorithm for the Countable Splitting Lemma, Constructively*, coauthored with Harald Woracek. Warmest congratulations to the authors!

We would also like to thank the local organisers – Henning Basold, Adriana Pratter, Jurriaan Rot, Sarah Sallinger, Ana Sokolova, and Michael Starzinger – who took on the difficult task of organising a hybrid conference, Thorsten Wißmann, who was publicity chair, and Stefan Milius and Markus Roggenbach, the CALCO steering committee chairs. Our last acknowledgement goes to Michael Wagner and the LIPIcs team, who provided impeccable support in the production of these proceedings.

Fabio Gadducci and Alexandra Silva



■ Conference Organization

Programme Committee

- Zena M. Ariola (University of Oregon)
- Paolo Baldan (University of Padova)
- Rui Soares Barbosa (International Iberian Nanotechnology Laboratory)
- Francisco Durán (University of Málaga)
- Brendan Fong (Massachusetts Institute of Technology)
- Fabrizio Romano Genovese (University of Pisa)
- Jules Hedges (University of Strathclyde, Glasgow)
- Thomas Hildebrandt (IT University of Copenhagen)
- Peter Jipsen (Chapman University)
- Wolfram Kahl (McMaster University)
- Marie Kerjean (CNRS — Laboratoire d'Informatique de Paris Nord)
- Michele Loreti (University of Camerino)
- Sonia Marin (University College London)
- Manuel A. Martins (University of Aveiro)
- Annabelle McIver (Macquarie University)
- Hernan Melgratti (University of Buenos Aires)
- Koko Muroya (RIMS, Kyoto University)
- Elaine Pimentel (Federal University of Rio Grande do Norte)
- Elvinia Riccobene (University of Milan)
- Alex Simpson (University of Ljubljana)
- David I. Spivak (Massachusetts Institute of Technology)
- Christine Tasson (Sorbonne University)
- Tarmo Uustalu (Reykjavik University/Tallinn U. of Technology)
- Maaïke Zwart (University of Oxford)
- Rob van Glabbeek (Data61 – CSIRO)

Program Committee Chairs

- Fabio Gadducci (University of Pisa)
- Alexandra Silva (University College London)

Additional reviewers

- Elena Aladova
- Pablo Barenbaum
- Flavien Breuvert
- Thomas Cottrell
- Joerg Endrullis
- Alfredo Roque Freire
- Tobias Fritz
- Richard Garner
- Leandro Gomes
- Clemens Grabmayer

9th Conference on Algebra and Coalgebra in Computer Science (CALCO 2021).

Editors: Fabio Gadducci and Alexandra Silva



Leibniz International Proceedings in Informatics

LIPIC Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

0:x

Conference Organization

- Adrien Guatto
- Gerco van Heerdt
- Alexander Kurz
- Dylan McDermott
- Alexandre Madeira
- Konstantinos Mamouras
- Paul-André Melliès
- David Jaz Myers
- Andrew Polonsky
- John Power
- Francesco Santini
- Claude Stolze
- Davide Trotta
- Simon Willerton
- Hans Zantema
- Noam Zeilberger