30th EACSL Annual Conference on Computer Science Logic

CSL 2022, February 14–19, 2022, Göttingen, Germany (Virtual Conference)

Edited by

Florin Manea

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Preface

This volume contains the papers presented at CSL 2022, the 30th meeting in the conference series *Computer Science Logic (CSL)*, the annual conference of the European Association for Computer Science Logic (EACSL). CSL 2022 was held from 14th to 19th February 2022. It was organised at the University of Göttingen, but took place as an on-line meeting due to the ongoing pandemic.

CSL started as a series of international workshops, and became an international conference in 1992. Previous instalments of CSL were held in Ljubljana (2022, on-line), Barcelona (2020), Birmingham (2018), Stockholm (2017), Marseille (2016), Berlin (2015), Vienna (2014), Torino (2013), Fontainebleau (2012), Bergen(2011), Brno (2010), Coimbra (2009), Bologna (2008), Lausanne (2007), Szeged (2006), Oxford (2005), Karpacz (2004), Vienna (2003), Edinburgh (2002), Paris (2001), Munich (2000), Madrid (1999), Brno (1998), Aarhus (1997), Utrecht (1996), Paderborn (1995), Kazimierz (1994), Swansea (1993) and San Miniato (1992).

CSL is an interdisciplinary conference, spanning both basic and application-oriented research in mathematical logic and computer science. It is a forum for the presentation of research on all aspects of logic and its applications, including automated deduction and interactive theorem proving, constructive mathematics and type theory, equational logic and term rewriting, automata and games, game semantics, modal and temporal logic, logical aspects of computational complexity, finite model theory, computational proof theory, logic programming and constraints, lambda calculus and combinatory logic, domain theory, categorical logic and topological semantics, database theory, specification, extraction and transformation of programs, logical aspects of quantum computing, logical foundations of programming paradigms, verification and program analysis, linear logic, higher-order logic, and non-monotonic reasoning.

The conference received 91 abstracts of which 75 were followed up by full-paper submissions. The programme committee selected 35 papers for presentation at the conference. Each paper was reviewed by at least three members of the programme committee, with the help of external reviewers. The submission and reviewing process, programme committee discussion, and author notifications were all handled by the Easychair conference management system. In addition to the contributed papers, there were five invited talks, by: Udi Boker (Interdisciplinary Center, Herzliya, Israel), Martín Escardó (University of Birmingham, UK), Rosalie Iemhoff (Utrecht University, the Netherlands), Karen Lange (Wellesley College, USA), and Annabelle McIver (Macquarie University, Australia). We thank the invited speakers for their stimulating talks and papers, which greatly contributed to the success of the conference.

One of the major regular events at CSL conferences is the presentation of the *Ackermann Award*: the annual EACSL award for an outstanding dissertation in the area of logic in computer science. The recipients of the award are selected by jury from a field of international nominees, and the recipients receive their award at a ceremony at which they give a prize lecture on their dissertation. This year, the jury elected to give the Ackermann Award 2021 to Marie Fortin for her thesis *Expressivity of first-order logic, star-free propositional dynamic logic and communicating automata* defended at ENS Paris-Saclay (France) in 2020, supervised by Paul Gastin and Benedikt Bollig and to Sandra Kiefer for her thesis *Power and Limits of the Weisfeiler-Leman Algorithm* defended at RWTH Aachen (Germany) in 2020, with examiners Martin Grohe, Pascal Schweitzer, and Neil Immerman. The awards were presented during the conference. The citation for the awards is included in the proceedings.

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A significant event at CSL 2022 was the presentation of the inaugural *Helena Rasiowa Award*, named after the eminent Polish mathematician and logician Helena Rasiowa (1917–1994) whose work had an essential impact on the emerging field of logic in computer science. The Helena Rasiowa Award is given to the best paper, as decided by the programme committee, that is written solely by students or to which students were the main contributors. This award, which was presented for the first time at CSL 2022, will be a regular feature of CSL conferences henceforth. There was a strong field of candidates for the inaugural award, with 10 of the accepted papers eligible. From these, the programme committee selected Antonio Casares as the recipient of the 2022 Helena Rasiowa Award, for his paper *On the Minimisation of Transition-Based Rabin Automata and the Chromatic Memory Requirements of Muller Conditions*. Antonio Casares is a PhD student at the University of Bordeaux under the supervision of Thomas Colcombet, Nathanaël Fijalkow and Igor Walukiewicz.

CSL 2022 also had two affiliated workshops: the 22nd International Workshop on Logic and Computational Complexity – LCC 2022 and the Logic Mentoring Workshop.

We are very grateful to all the members of the CSL 2022 programme committee and external reviewers for their careful and efficient evaluation of the papers submitted. We would like to thank also the members of the organisation committee Maria Kosche, Tore Koß, Patricia Nitzke, Viktoriya Pak, and Stefan Siemer, from the University of Göttingen, for taking care to ensure a smooth-running and enjoyable conference, a task that was complicated by organising a virtual meeting. The award-certificates offered at CSL 2022 to the winners of the Ackermann Award and the Helena Rasiowa Award were designed by Elena Lykiardopol, to whom we are very grateful. It was as always a pleasure to work with Thomas Schwentick who, as the EACSL president, provided excellent guidance. The proceedings of CSL 2022 are published as a volume in the LIPIcs series. We thank Michael Wagner, Michael Didas, and all the Dagstuhl/LIPIcs team for their ongoing support and for the high quality preparation of these proceedings. Last, but not least, we are very grateful to the University of Göttingen and to the German Research Foundation (DFG) for supporting the organisation of this conference.

Florin Manea and Alex Simpson 10th November 2021

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The Ackermann Award 2021

by Michael Benedikt, Prakash Panangaden and Thomas Schwentick
For the Jury of the EACSL Ackermann Award

The 17th Ackermann Award is presented at CSL'22, which is held online and organised by the Fundamentals of Computer Science Group at University of Göttingen, Germany. The 2021 Ackermann Award was open to any PhD dissertation on any topic represented at the annual CSL and LICS conferences that were formally accepted by a degree-granting institution in fulfilment of the PhD degree between 1 January 2019 and 31 December 2020. The Jury received eight nominations for the 2021 Award. The candidates came from a number of different countries around the world. The institutions at which the nominees obtained their doctorates represent different countries in Europe and Asia.

Again this year, EACSL Ackermann Award is sponsored by the association *Alumni der Informatik Dortmund e.V.*[1]

The topics covered a wide range of areas in Logic and Computer Science as represented by the LICS and CSL conferences. All submissions were of a very high quality and contained significant contributions to their particular fields. The jury wish to extend their congratulations to all the nominated candidates for their outstanding work.

The wide range of excellent candidates presented the jury with an excruciating task. After an extensive discussion, the jury unanimously decided to award the **2021 Ackermann Award** to (in alphabetic order):

- Marie Fortin from France, for her thesis

  Expressivity of first-order logic, star-free propositional dynamic logicand communicating automata

  approved by *Université Paris-Saclay* in 2020,

  and

- Sandra Kiefer from Germany, for her thesis

  Power And Limits Of The Weisfeiler-Leman Algorithm

  approved by *RWTH Aachen* in 2020.

Citation for Marie Fortin

Marie Fortin shares the **2021 Ackerman Award** of the European Association of Computer Science Logic (EACSL) for her thesis

Expressivity of first-order logic, star-free propositional dynamic logic and communicating automata.

[1] `https://www.cs.tu-dortmund.de/nps/en/Alumni/index.html`

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The thesis studies the expressive power of first-order logic over ordered structures. This work has applications to message sequence charts, a fundamental structure that arises in the verification of concurrent systems and more generally to the connection between automata and logic. She proved a concurrent analogue of the classic Büchi-Elgot-Traktenbrot theorem for the relation between concurrent finite-state machines and message sequence charts. A second fundamental result obtained is the fact that first-order logic and FO restricted to three variables are equally expressive over message sequence charts.

Background to the thesis

Fortin's work belongs to the classic theme of relating automata to logics over suitable structures. The Büchi-Elgot-Traktenbrot theorem relates rfinite automata with monadic second-order logic over words. In the realm of concurrency a fundamental result of Mazurkiewicz relates his eponymous traces with asynchronous automata. For message sequence charts and concurrent finite-state automata it is much more complicated because this is a richer model. Earlier work by several authors established such connections in much more restricted cases. In message sequence charts there are three important order relations: $\leq$ the causal partial order which is generated by $\rhd$ and $\rightarrow_p$ which is the immediate precedence relation on a process p. The best existing result was a proof due to Bollig and Leuker that CFSM's are expressively equivalent to $EMSO(\rightarrow_p, \rhd)$, the existential fragment of second-order monadic logic over the two given relations. Capturing the causal relation was out of reach but essential to express many fundamental properties of concurrent computation.

Contributions of the thesis

Dr. Fortin made several fundamental contributions. First she showed that $EMSO^2(\rightarrow_p, \rhd, \leq)$, which is the fragment restricted to two variables is expressively equivalent to CFSM's. This was a proof requiring great technical skill and originality. Later she settled the question completely by showing that $EMSO(\rightarrow_p, \rhd, \leq)$ is expressively equivalent to CFSM's. In this proof she had to formulate a suitable logic of paths (a kind of propositional dynamic logic, PDL). As part of her overall proof she shows an equivalence between this logic and $FO(\rightarrow_p, \rhd, \leq)$ which is again a technically demanding contribution. A corollary of this result is that $FO(\rightarrow_p, \rhd, \leq)$ is expressively equivalent to $FO^3(\rightarrow_p, \rhd, \leq)$ over MSC's. Finally, in a single-authored paper at ICALP she shows that FO is expressively equivalent to FO^3 over a very general class of linear orders. It is very significant that she not only solves hard open problems but invents new tools to attack such problems; these are tools that can be applied to other problems as well so she has invigorated the subject with new techniques as well as new results.

Biographical sketch

Marie Fortin carried out her PhD (under the supervision of Paul Gastin and Benedikt Bollig) at ENS Paris-Saclay, Université Paris-Saclay. She was a winner of the EATCS Distinguished Dissertation Award 2021, a best paper award at CONCUR 2018 and a best student paper award at ICALP 2019 (Track B). She is currently a research associate at the University of Liverpool.

Citation for Sandra Kiefer

Sandra Kiefer shares the *2021 Ackerman Award* of the European Association of Computer Science Login (EACSL) for her thesis

Power And Limits Of The Weisfeiler-Leman Algorithm.

The Weisfeiler-Leman (WL) color refinement algorithm has long played a central role in computational graph theory and descriptive complexity theory and has come into new prominence recently via its role in machine learning over graphs. The thesis provides a plethora of new and deep insights on the power of WL. WL can be parameterized by the number of rounds required for termination and the number of pebbles required ("WL dimension"). Both parameters can be interpreted in terms of logic – the former corresponding to quantifier rank in an appropriate logic and the latter corresponding to number of variables. The thesis provides new bounds on both of these quantities, including a bound of 3 on the WL dimension for planar graphs.

The thesis is beautifully written, and makes use of a wide range of techniques; unusually for a thesis with close connections to graph theory and logic, it even makes use of empirical methods.

Background of the Thesis

The original version of the WL algorithm – now referred to as 1-dimensional WL – was introduced by Russian mathematicians Boris Weisfeiler and Andrei Leman in 1968. The algorithm evolved into its current, more general form, parameterized by a dimension k in the 1980s. It iteratively computes a colouring of the k-tuples of vertices of a graph. It can be seen in a number of lights: originally it was an approximate isomorphism test. Later it was found to be intimately connected to logic, with the distinguishing power of the WL test corresponding to the expressiveness of a canonical logic with counting. More recently it has been seen to play a fundamental rule in analysis of so-called Graph Neural Networks.

Contributions of the Thesis

Kiefer's dissertation provides a systematic analysis of the WL algorithm. It focuses on two natural parameters: the number of iterations the algorithm needs to converge, and the dimension it needs to recognize certain graph properties and identify certain graphs. For both quantities, the thesis provides new upper and lower bounds; previously, non-trivial results were only qualitative (bounded vs unbounded) or gave very rough estimates.

Notable results include bounds on the iteration number, making use of a combination of analytical and experimental methods. For the WL dimension it gives a complete classification of all graphs with WL dimension 1, along with an upper bound on dimension based on the tree width. Perhaps most importantly, the thesis provides a bound of 3 on the dimension for planar graphs.

The innovations in this thesis will be of interest to an unusually wide range of researchers, from computational graph theory to descriptive complexity theory to machine learning.

Biographical Sketch

Sandra Kiefer carried out her PhD (under the supervision of Martin Grohe and Pascal Schweitzer) at RWTH in Aachen Germany. For her project for female doctoral candidates, RWTH Aachen University awarded her the Brigitte Gilles Prize in 2019. After completing

her PhD, she took up a 1-year position as a postdoctoral research associate at the University of Warsaw, Poland. She is currently a postdoctoral research associate at RWTH Aachen University, Germany.

Jury

The jury for the **Ackermann Award 2021** consisted of eight members, two of them *ex officio*, namely, the president and the vice-president of EACSL. In addition, the jury also included a representative of SIGLOG (the ACM Special Interest Group on Logic and Computation).

The members of the jury were:

- Christel Baier (TU Dresden),
- Michael Benedikt (University of Oxford),
- Mikołaj Bojańczyk (University of Warsaw),
- Jean Goubault-Larrecq (ENS Paris-Saclay),
- Prakash Panangaden (McGill University),
- Simona Ronchi Della Rocca (University of Torino), the vice-president of EACSL,
- Thomas Schwentick (TU Dortmund University), the president of EACSL,
- Alexandra Silva, (University College London), ACM SigLog representative.

Previous winners

Previous winners of the Ackermann Award were

2005, Oxford:
Mikołaj Bojańczyk from Poland,
Konstantin Korovin from Russia, and
Nathan Segerlind from the USA.

2006, Szeged:
Balder ten Cate from the Netherlands, and
Stefan Milius from Germany.

2007, Lausanne:
Dietmar Berwanger from Germany and Romania,
Stéphane Lengrand from France, and
Ting Zhang from the People's Republic of China.

2008, Bertinoro:
Krishnendu Chatterjee from India.

2009, Coimbra:
Jakob Nordström from Sweden.

2010, Brno:
no award given.

2011, Bergen:
Benjamin Rossman from USA.

2012, Fontainebleau:
Andrew Polonsky from Ukraine, and
Szymon Toruńczyk from Poland.

2013, Turin:
Matteo Mio from Italy.

2014, Vienna:
Michael Elberfeld from Germany.

2015, Berlin:
Hugo Férée from France, and
Mickael Randour from Belgium.
2016, Marseille:
Nicolai Kraus from Germany
2017, Stockholm:
Amaury Pouly from France.
2018, Birmingham:
Amina Doumane from France.
2019, Barcelona (conference in 2020):
Antoine Mottet from France.
2020, Ljubljana (conference online in 2021)
Benjamin Kaminski from Germany.

Detailed reports on their work appeared in the CSL proceedings and are also available on the EACSL homepage.