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logic n. **1** the science of reasoning.
– ORIGIN from Greek *logikē tekhnē* ‘art of reason’.

Foreword

In the summer of 2014, Vienna hosted the largest scientific conference in the history of logic. The Vienna Summer of Logic (VSL, http://vsl2014.at) consisted of twelve large conferences and 82 workshops, attracting more than 2000 researchers from all over the world. This unique event was organized by the Kurt Gödel Society and took place at Vienna University of Technology during July 9 to 24, 2014, under the auspices of the Federal President of the Republic of Austria, Dr. Heinz Fischer.

The conferences and workshops dealt with the main theme, logic, from three important angles: logic in computer science, mathematical logic, and logic in artificial intelligence. They naturally gave rise to respective streams gathering the following meetings:

Logic in Computer Science / Federated Logic Conference (FLoC)

- 26th International Conference on Computer Aided Verification (CAV)
- 27th IEEE Computer Security Foundations Symposium (CSF)
- 30th International Conference on Logic Programming (ICLP)
- 7th International Joint Conference on Automated Reasoning (IJCAR)
- 5th Conference on Interactive Theorem Proving (ITP)
- Joint meeting of the 23rd EACSL Annual Conference on Computer Science Logic (CSL) and the 29th ACM/IEEE Symposium on Logic in Computer Science (LICS)
- 25th International Conference on Rewriting Techniques and Applications (RTA) joint with the 12th International Conference on Typed Lambda Calculi and Applications (TLCA)
- 17th International Conference on Theory and Applications of Satisfiability Testing (SAT)
- 76 FLoC Workshops
- FLoC Olympic Games (System Competitions)

Mathematical Logic

- Logic Colloquium 2014 (LC)
- Logic, Algebra and Truth Degrees 2014 (LATD)
- Compositional Meaning in Logic (GeTFun 2.0)
- The Infinity Workshop (INFINITY)
- Workshop on Logic and Games (LG)
- Kurt Gödel Fellowship Competition

Logic in Artificial Intelligence

- 14th International Conference on Principles of Knowledge Representation and Reasoning (KR)
- 27th International Workshop on Description Logics (DL)
- 15th International Workshop on Non-Monotonic Reasoning (NMR)
- 6th International Workshop on Knowledge Representation for Health Care 2014 (KR4HC)

The VSL keynote talks which were directed to all participants were given by Franz Baader (Technische Universität Dresden), Edmund Clarke (Carnegie Mellon University), Christos Papadimitriou (University of California, Berkeley) and Alex Wilkie (University of Manchester); Dana Scott (Carnegie Mellon University) spoke in the opening session. Since the Vienna Summer of Logic contained more than a hundred invited talks, it would not be feasible to list them here.

The program of the Vienna Summer of Logic was very rich, including not only scientific talks, poster sessions and panels, but also two distinctive events. One was the award ceremony of the Kurt Gödel Research Prize Fellowship Competition, in which the Kurt Gödel Society awarded three research fellowship prizes endowed with 100.000 Euro each to the winners. This was the third edition of the competition, themed Logical Mind: Connecting Foundations and Technology this year.

The 1st FLoC Olympic Games formed the other distinctive event and were hosted by the Federated Logic Conference (FLoC) 2014. Intended as a new FLoC element, the Games brought together 12 established logic solver competitions by different research communities. In addition to the competitions, the Olympic Games facilitated the exchange of expertise between communities, and increased the visibility and impact of state-of-the-art solver technology. The winners in the competition categories were honored with Kurt Gödel medals at the FLoC Olympic Games award ceremonies.

Organizing an event like the Vienna Summer of Logic was a challenge. We are indebted to numerous people whose enormous efforts were essential in making this vision become reality. With so many colleagues and friends working with us, we are unable to list them individually here. Nevertheless, as representatives of the three streams of VSL, we would like to particularly express our gratitude to all people who helped to make this event a success: the sponsors and the Honorary Committee; the Organization Committee and

the local organizers; the conference and workshop chairs and Program Committee members; the reviewers and authors; and of course all speakers and participants of the many conferences, workshops and competitions.

The Vienna Summer of Logic continues a great legacy of scientific thought that started in Ancient Greece and flourished in the city of Gödel, Wittgenstein and the Vienna Circle. The heroes of our intellectual past shaped the scientific world-view and changed our understanding of science. Owing to their achievements, logic has permeated a wide range of disciplines, including computer science, mathematics, artificial intelligence, philosophy, linguistics, and many more. Logic is everywhere – or in the language of Aristotle, πάντα πλήρη λογικῆς τέχνης.

July 2014

Matthias Baaz
Thomas Eiter
Helmut Veith

Preface

This volume contains the papers presented at IJCAR'14: 7th International Joint Conference on Automated Reasoning (IJCAR) held on July 19-22, 2014 in Vienna. This year's meeting was a merging of three leading events in automated reasoning – CADE (International Conference on Automated Deduction), FroCoS (International Symposium on Frontiers of Combining Systems) and TABLEAUX (International Conference on Automated Reasoning with Analytic Tableaux and Related Methods). IJCAR is the premier international joint conference on all topics in automated reasoning, including foundations, implementations, and applications. Previous IJCAR conferences were held at Siena (Italy) in 2001, Cork (Ireland) in 2004, Seattle (USA) in 2006, Sydney (Australia) in 2008, Edinburgh (UK) in 2010 and Manchester (UK) in 2012.

IJCAR 2014 is part of Federated Logic Conference (FLoC) that is itself part of Vienna Summer in Logic (VSL) and 24 workshops are affiliated with IJCAR. The Vienna Summer of Logic is a unique event organized by the Kurt Gödel Society at Vienna University of Technology from July 9 to 24, 2014.

The call for papers for IJCAR'14 invited authors to submit full papers (of 15 pages) and system descriptions (of 7 pages). There were 83 submissions (63 regular papers and 20 system descriptions) of which 37 were accepted (26 regular papers and 11 system descriptions). Each submission was assigned to at least three Program Committee members, who carefully reviewed the papers, with the help of 116 external referees. We wish to thank the Program Committee members and all their reviewers for their works and efforts in evaluating the submissions. It was a pleasure to work with all of them. The EasyChair conference management system was a great help in dealing with all aspects of putting our program and the proceedings together.

IJCAR 2014 had invited talks by Rajeev Goré (The Australian National University) and Ken McMillan (Microsoft Research). In addition, IJCAR together with other FLoC conferences, had two invited plenary talks by Véronique Cortier (Centre National de la Recherche Scientifique) and by Orna Kupferman (Hebrew University). These proceedings contain three papers and an abstract of these invited talks. We want to thank the invited speakers for contributing to the success of the IJCAR 2014.

Many people helped to make IJCAR 2014 a success. We want to thank the the conference co-chairs and the organizing committee consisting of Christian Fermüller, Stefan Hetzl and Giselle Reis, the publicity chair Morgan Deters and the workshop chair Matthias Horbach. We are also indebted to the FLoC and VSL organization committees.

Most importantly, we would like to thank all the authors for submitting their work to IJCAR 2014: we believe the outcome is an exciting technical program.

May 2014

Stéphane Demri
Deepak Kapur
Christoph Weidenbach

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Invited Talks
(Abstracts)

From Reachability to Temporal Specifications in Cost-Sharing Games

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Abstract. Multi-agents cost-sharing games are commonly used for modeling settings in which different entities share resources. For example, the setting in which entities need to route messages in a network is modeled by a network-formation game: the network is modeled by a graph, and each agent has to select a path satisfying his reachability objective. In practice, the objectives of the entities are often more involved than reachability. The need to specify and reason about rich specifications has been extensively studied in the context of verification and synthesis of reactive systems. This paper suggests and analyzes a generalization of cost-sharing games that captures such rich specifications. In particular, we study network-formation games with regular objectives. In these games, the edges of the graph are labeled by alphabet letters and the objective of each player is a regular language over the alphabet of labels. Thus, beyond reachability, a player may restrict attention to paths that satisfy certain properties, referring, for example, to the providers of the traversed edges, the actions associated with them, their quality of service, or security. Our results show that the transition to regular objectives makes the game considerably less stable.

Electronic Voting: How Logic Can Help*

Véronique Cortier

LORIA - CNRS, France

Abstract. Electronic voting should offer at least the same guarantees than traditional paper-based voting systems. In order to achieve this, electronic voting protocols make use of cryptographic primitives, as in the more traditional case of authentication or key exchange protocols. All these protocols are notoriously difficult to design and flaws may be found years after their first release. Formal models, such as process algebra, Horn clauses, or constraint systems, have been successfully applied to automatically analyze traditional protocols and discover flaws. Electronic voting protocols however significantly increase the difficulty of the analysis task. Indeed, they involve for example new and sophisticated cryptographic primitives, new dedicated security properties, and new execution structures.

After an introduction to electronic voting, we describe the current techniques for e-voting protocols analysis and review the key challenges towards a fully automated verification.

* The research leading to these results has received funding from the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013)/ERC grant agreement no 258865, project ProSecure.

And-Or Tableaux for Fixpoint Logics with Converse: LTL, CTL, PDL and CPDL

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Abstract. Over the last forty years, computer scientists have invented or borrowed numerous logics for reasoning about digital systems. Here, I would like to concentrate on three of them: Linear Time Temporal Logic (LTL), branching time Computation Tree temporal Logic (CTL), and Propositional Dynamic Logic (PDL), with and without converse. More specifically, I would like to present results and techniques on how to solve the satisfiability problem in these logics, with global assumptions, using the tableau method. The issues that arise are the typical tensions between computational complexity, practicality and scalability. This is joint work with Linh Anh Nguyen, Pietro Abate, Linda Postniece, Florian Widmann and Jimmy Thomson.

Structured Search and Learning

Kenneth L. McMillan

Microsoft Research

Abstract. Most modern Boolean satisfiability (SAT) solvers use conflict-driven clause learning (CDCL). In this approach, search for a model and search for a refutation by resolution are tightly coupled in a way that helps to focus search on relevant decisions and resolution on relevant deductions. Decision making narrows the search by applying arbitrary constraints. When a contradiction is reached, a "learned" fact is deduced in response. This fact generalizes the conflict and constrains future decisions. The learned fact can also be viewed as a Craig interpolant. As we will see this view allows us to generalize the notion of conflict learning in useful ways.

Satisfiability Module Theories (SMT solvers) of the lazy type apply the same paradigm to first-order decision problems with certain background theories, such as linear arithmetic or the theory of arrays. In this case, the interpolants may be validities of the theory generated by "theory solvers", but the basic conflict-driven mechanism remains the same.

A common shortcoming of these procedures, successful though they are, is that model search and conflict learning are essentially unstructured. That is, they do not take into account any modular structure that may be present in the decision problem. Decisions are made on variables regardless of their structural relationship, and consequently learned facts do not reflect the problem structure. This is in contrast to a saturation approach, in which we might order resolution so as to exploit, say, narrow tree width of the problem.

In this talk we will consider structured approaches to conflict learning. These techniques have been developed in the context of model checking, an area in which the need to exploit structure is acute. Structured learning can produce facts about reachable states of a system or summaries of procedures, which in turn can be combined to form inductive invariants. Examples of such techniques include IC3 [1] and Lazy Annotation [2].

These techniques have similar search strategies, differing primarily in their approach to computing interpolants. The approaches make different trade-offs between cost and generality, which in turn determine the usefulness of the resulting generalizations. We observe, for example, that more specialized decisions can make the learning problem easier, but possibly at the cost of reduced generality or relevance of the learned facts. Moreover, a substantial effort in generalizing the interpolants can be justified by the corresponding reduction in search.

The net effect of structured learning can be a dramatic improvement in performance, as we observe by comparing with unstructured SMT solvers on bounded software model checking problems.

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