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Preface: The Beyond NP Workshop

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A new computational paradigm has emerged in computer science over the past few decades, which is exemplified by the use of SAT solvers to tackle problems in the complexity class NP. According to this paradigm, a significant research and engineering investment is made towards developing highly efficient solvers for a prototypical problem (e.g., SAT), that is representative of a broader class of problems (e.g., NP). The cost of this investment is then amortized as these solvers are applied to a broader class of problems via reductions (in contrast to developing dedicated algorithms for each encountered problem). SAT solvers, for example, are now routinely used to solve problems in many domains, including diagnosis, planning, software and hardware verification.

The success of this computational paradigm, both in theory and practice, has motivated the consolidation and promotion of research that advances this paradigm more broadly. The AAAI-16 Workshop on Beyond NP is the first workshop dedicated to this goal. Complementing the BeyondNP.org initiative, the aim of the workshop is to help unify and move forward research areas that advance this emerging computational paradigm, while focusing on solvers that reach beyond NP. This class of solvers includes, but is not limited to:

- Model counters, also known as #SAT solvers, which are now established as the prototypical solvers for the complexity class #P.
- Knowledge compilers, which reach to other problems in the polynomial and counting hierarchies.
- QBF solvers, which are prototypical solvers for the complexity class PSPACE.
- Solvers for function problems, including optimization and subset minimal problems, e.g. MaxSAT, MUS and MCS, that reach different levels of the function polynomial hierarchy.

These solvers are increasingly used to effectively tackle a broad class of problems. For example, model counters and knowledge compilers are now the basis of state-of-the-art approaches for probabilistic reasoning, which arise in probabilistic graphical models, probabilistic programming and probabilistic databases. Knowledge compilers have also been influential in online configuration systems (e.g., both Renault and Toyota have deployed online configuration systems based on knowledge compilation). QBF solvers have been used in model checking, verification, debugging, and testing. Finally, function problem solvers have been used in model-based diagnosis, design debugging, CAD and bioinformatics.

This first workshop on Beyond NP encouraged contributions on a variety of topics, including algorithms; descriptions of implementations and/or evaluations of beyond NP solvers; their applications (including encodings); the complexity classes they reach; and their connections to one another. More broadly, submissions were solicited from three types of community members: those who develop solvers, those who use them to solve concrete problems, and those who are interested in the computational complexity of solvers and related problems. Submissions that can help disseminate "best practices" among the relevant research areas have also been encouraged (e.g., competitions, benchmarks, and the development of open-source solvers).

The workshop program consisted of a number of contributions relating to the above topics:

- Valeriy Balabanov, Jie-Hong Roland Jiang, Alan Mishchenko and Christoph Scholl. *Clauses versus gates in CEGAR-based 2QBF solving.*
- Vaishak Belle. *Satisfiability and Model Counting in Open Universes.*
- Olaf Beyersdorff, Leroy Chew and Mikolas Janota. *Extension Variables in QBF Resolution.*
- Bernhard Bliem, Günther Charwat, Markus Hecher and Stefan Woltran. *Subset Minimization in Dynamic Programming on Tree Decompositions.*
- Bart Bogaerts, Tomi Janhunen and Shahab Tasharrofi. *Solving QBF With Nested SAT Solvers.*
- Eric Gribkoff and Dan Suciu. SlimShot: Probabilistic Inference for Web-Scale Knowledge Bases.
- Charles Jordan, William Klieber and Martina Seidl. *Non-CNF QBF Solving with QCIR.*
- Seyed Mehran Kazemi and David Poole. *Lazy Arithmetic Circuits.*
- Batya Kenig and Avigdor Gal. Exploiting the Hidden Structure of Junction Trees for MPE.

Timothy Kopp, Parag Singla and Henry Kautz. Toward Caching Symmetrical Subtheories for Weighted Model Counting.

Junkyu Lee, Radu Marinescu, Rina Dechter and Alexander Ihler. From Exact to Anytime Solutions for Marginal Map.

Kuldeep S. Meel, Moshe Vardi, Supratik Chakraborty, Daniel J. Fremont, Sanjit A. Seshia, Dror Fried, Alexander Ivrii and Sharad Malik. Constrained Sampling and Counting: Universal Hashing meets SAT Solving.

Christian Muise, Sheila McIlraith, Chris Beck and Eric Hsu. DSHARP: Fast d-DNNF Compilation with sharpSAT (Amended Version).

Dan Olteanu. Factorized Databases: A Knowledge Compilation Perspective.

Jonas Vlasselaer, Angelika Kimmig, Anton Dries, Wannes Meert and Luc De Raedt. Knowledge Compilation and Weighted Model Counting for Inference in Probabilistic Logic Programs.

The program also included a number of invited talks, covering a wide spectrum of work on Beyond NP solvers:

Fahiem Bacchus. *On MaxSAT.*

Stefano Ermon. *On Model Counting.*

Malte Helmert. *On Planners as Beyond NP Solvers.*

Mikolas Janota. *On QBFs.*

George Katsirelos. *On MUSes and MCSes.*

Guy Van den Broeck. *On First-Order Knowledge Compilation.*

We would like to thank everyone who helped in making this workshop a success, especially the authors, the program committee members and AAAI for its support.