From SAT to ASP and back!?

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Answer Set Programming (ASP; [1,2,3,4]) provides an approach to declarative problem solving that combines a rich yet simple modeling language with effective Boolean constraint solving capacities. This makes ASP a model, ground, and solve paradigm, in which a problem is expressed as a set of first-order rules, which are subsequently turned into a propositional format by systematically replacing all variables, before finally the models of the resulting propositional rules are computed. ASP is particularly suited for modeling problems in the area of Knowledge Representation and Reasoning involving incomplete, inconsistent, and changing information due to its nonmonotonic semantic foundations. As such, it offers, in addition to satisfiability testing, various reasoning modes, including different forms of model enumeration, intersection or unioning, as well as multi-objective optimization. From a formal perspective, ASP allows for solving all search problems in NP (and NP^{NP}) in a uniform way, that is, by separating problem encodings and instances. Hence, ASP is well-suited for solving hard combinatorial search (and optimization) problems. Interesting applications of ASP include decision support systems for NASA shuttle controllers [5], industrial team-building [6], music composition [7], natural language processing [8], package configuration [9], phylogeneticics [10], robotics [11,12], systems biology [13,14,15], timetabling [16], and many more. The versatility of ASP is nicely reflected by the ASP solver *clasp* [17], winning first places at various solver competitions, including ASP, MISC, PB, and SAT. In fact, *clasp* is at the heart of the open source platform `potassco.sourceforge.net`. *Potassco* stands for the "Potsdam Answer Set Solving Collection" [18] and has seen more than 145000 downloads world-wide since its inception at the end of 2008.

The talk will start with a gentle introduction to ASP, while focusing on the commonalities and differences to SAT. It will discuss the different semantic foundations and describe the impact of a modelling language along with off-the-shelf grounding systems. Finally, it will highlight some resulting techniques, like meta-programming, preference handling, heuristic constructs, and theory reasoning.

References

1. Gelfond, M., Lifschitz, V.: The stable model semantics for logic programming. In Kowalski, R., Bowen, K., eds.: Proceedings of the Fifth International Conference and Symposium of Logic Programming (ICLP'88), MIT Press (1988) 1070–1080
2. Baral, C.: Knowledge Representation, Reasoning and Declarative Problem Solving. Cambridge University Press (2003)

3. Gebser, M., Kaminski, R., Kaufmann, B., Schaub, T.: Answer Set Solving in Practice. Synthesis Lectures on Artificial Intelligence and Machine Learning. Morgan and Claypool Publishers (2012)
4. Gelfond, M., Kahl, Y.: Knowledge Representation, Reasoning, and the Design of Intelligent Agents: The Answer-Set Programming Approach. Cambridge University Press (2014)
5. Nogueira, M., Balduccini, M., Gelfond, M., Watson, R., Barry, M.: An A-prolog decision support system for the space shuttle. In Ramakrishnan, I., ed.: Proceedings of the Third International Symposium on Practical Aspects of Declarative Languages (PADL'01). Springer-Verlag (2001) 169–183
6. Grasso, G., Iiritano, S., Leone, N., Lio, V., Ricca, F., Scalise, F.: An ASP-based system for team-building in the Gioia-Tauro seaport. In Carro, M., Peña, R., eds.: Proceedings of the Twelfth International Symposium on Practical Aspects of Declarative Languages (PADL'10). Springer-Verlag (2010) 40–42
7. Boenn, G., Brain, M., de Vos, M., Fitch, J.: Automatic composition of melodic and harmonic music by answer set programming. In Garcia de la Banda, M., Pontelli, E., eds.: Proceedings of the Twenty-fourth International Conference on Logic Programming (ICLP'08). Springer-Verlag (2008) 160–174
8. Schwitter, R.: The jobs puzzle: Taking on the challenge via controlled natural language processing. Theory and Practice of Logic Programming **13**(4-5) (2013) 487–501
9. Gebser, M., Kaminski, R., Schaub, T.: aspcud: A Linux package configuration tool based on answer set programming. In Drescher, C., Lynce, I., Treinen, R., eds.: Proceedings of the Second International Workshop on Logics for Component Configuration (LoCoCo'11). Volume 65 of Electronic Proceedings in Theoretical Computer Science (EPTCS). (2011) 12–25
10. Brooks, D., Erdem, E., Erdogan, S., Minett, J., Ringe, D.: Inferring phylogenetic trees using answer set programming. Journal of Automated Reasoning **39**(4) (2007) 471–511
11. Chen, X., Ji, J., Jiang, J., Jin, G., Wang, F., Xie, J.: Developing high-level cognitive functions for service robots. In van der Hoek, W., Kaminka, G., Lespérance, Y., Luck, M., Sen, S., eds.: Proceedings of the Ninth International Conference on Autonomous Agents and Multiagent Systems (AAMAS'10), IFAAMAS (2010) 989–996
12. Erdem, E., Haspalamutgil, K., Palaz, C., Patoglu, V., Uras, T.: Combining high-level causal reasoning with low-level geometric reasoning and motion planning for robotic manipulation. In: Proceedings of the IEEE International Conference on Robotics and Automation (ICRA'11), IEEE (2011) 4575–4581
13. Erdem, E., Türe, F.: Efficient haplotype inference with answer set programming. In Fox, D., Gomes, C., eds.: Proceedings of the Twenty-third National Conference on Artificial Intelligence (AAAI'08), AAAI Press (2008) 436–441
14. Gebser, M., Schaub, T., Thiele, S., Veber, P.: Detecting inconsistencies in large biological networks with answer set programming. Theory and Practice of Logic Programming **11**(2-3) (2011) 323–360
15. Gebser, M., Guziolowski, C., Ivanchev, M., Schaub, T., Siegel, A., Thiele, S., Veber, P.: Repair and prediction (under inconsistency) in large biological networks with answer set programming. In Lin, F., Sattler, U., eds.: Proceedings of the Twelfth International Conference on Principles of Knowledge Representation and Reasoning (KR'10), AAAI Press (2010) 497–507

16. Banbara, M., Soh, T., Tamura, N., Inoue, K., Schaub, T.: Answer set programming as a modeling language for course timetabling. Theory and Practice of Logic Programming **13**(4-5) (2013) 783–798
17. Gebser, M., Kaufmann, B., Schaub, T.: Conflict-driven answer set solving: From theory to practice. Artificial Intelligence **187-188** (2012) 52–89
18. Gebser, M., Kaminski, R., Kaufmann, B., Ostrowski, M., Schaub, T., Schneider, M.: Potassco: The Potsdam answer set solving collection. AI Communications **24**(2) (2011) 107–124