ICAI 2023
12th International Conference on Applied Informatics
Eger, Hungary, 2023

Applications of Answer Set Programming in Nature Inspired Computing

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Abstract

Answer Set Programming emerged in the nineties as a sort of declarative language aiming to find effective solutions for computationally hard problems [3, 4]. An answer set program is closely related to a Prolog program in the sense that it is a collection of facts and relations between them. The evaluation mechanism of an answer set program is, however, radically different: instead of query evaluation, such finite sets of ground statements are sought that satisfy the given program. First, the variables of the program are substituted by specific values of the model in all possible ways. This process is called grounding. Then stable models are generated based on that set of ground atoms: the implementation intends to find all possible sets of ground atomic formulas satisfying the starting program. This phase is based on intensive use of existing SAT-solving techniques. For further information, we refer the interested reader to [1, 5].

Membrane systems, or P systems, are biologically inspired, distributed models of computation [6]. The membrane system model is based on manipulation of multisets in a distributed and synchronized manner. The constituents of membrane systems are the membranes: the membranes can contain a multiset of objects and each computational step consists of the local evolution of those multisets specified by certain rules. In each computational step we assume that the computation is accomplished in a maximally parallel manner, that is, the rules in each membrane are applied simultaneously until there is no more rule that can be applied in the underlying membrane. When each membrane reaches that point the next computational step begins. Concerning the computational modes and the specific forms of the P-systems, several variants of membrane systems have been introduced and

studied, see the monograph [7] for a thorough introduction, or the handbook [8] for a summary of notions and results of the area.

Another interesting nature inspired computational model is that of reaction systems [2]. Reaction systems serve as a tool for the investigation of biochemical processes taking place in living organisms. A reaction system is a finite set of reactions and each reaction is an operation on the underlying set described by the triple (R, I, P), where R is the reactant set, I is the inhibitor set and P is the product set. A reaction is enabled in a set T if $R \subseteq T$ and $T \cap I = \emptyset$. In this case, the result is the product set P. All the unused elements of T are discarded. The result of a set of reactions on T is the union of the results of the reactions enabled on T. Moreover, the operation of a reaction system is described with the notion of an interactive process, where also the behaviour of the reaction system with respect to an environment is taken into consideration.

In the talk, we are going to present the Answer Set Programming approach in more detail, then we define the necessary notions concerning membrane systems and reaction systems in order to try to explore some possible applications of Answer Set Programming in the mentioned fields.

References

[1] C. Baral: *Knowledge Representation, Reasoning and Declarative Problem Solving*, Cambridge, United Kingdom: Cambridge University Press, 2010.

[2] R. Brijder, A. Ehrenfeucht, M. G. Main, G. Rozenberg: *A Tour of reaction Systems*, International Journal of Foundations of Computer Science 22.7 (2011), pp. 1499–1517, doi: https://doi.org/10.1142/S0129054111008842.

[3] M. Gelfond, V. Lifschitz: *Classical Negation in Logic Programs and Disjunctive Databases*, New Generation Computing 9.3 (1991), pp. 365–385, doi: dx.doi.org/10.1007/BF03037169.

[4] M. Gelfond, V. Lifschitz: *The Stable Model Semantics for Logic Programming*, in: Logic Programming, Proceedings of the Fifth International Conference and Symposium, Cambridge, MA, USA: The MIT Press, 1991, pp. 1070–1080.

[5] V. Lifschitz: *Answer Set Programming*, Berlin, Heidelberg: Springer, 2019.

[6] G. Păun: *Computing with Membranes*, Journal of Computer and System Sciences 61.1 (2000), pp. 108–143, doi: https://doi.org/10.1006/jcss.1999.1693.

[7] G. Păun: *Membrane Computing: An Introduction*, Berlin, Heidelberg: Springer-Verlag, 2002.

[8] G. Păun, G. Rozenberg, A. Salomaa: *The Oxford Handbook of Membrane Computing*, New York, NY, USA: Oxford University Press, 2010.