Abstract of PhD Thesis

Author:	Katalin Anna Lázár
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Supervisors:	Erzsébet Csuhaj–Varjú and András Lőrincz
Institute:	Eötvös Loránd University, Budapest, Hungary
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Abstract

The concept and the reality of self–organizing networks have come to pervade modern society. Scientists from a range of disciplines have been pursuing questions on the particularities of self–organizing networks. The dissertation addresses self–organizing systems that compile to the scale–free small world model. We model self–organizing networks at syntactical level and reveal some semantical and experimental aspects related to them.

At syntactical level, we use devices from grammar systems theory. In these systems the agents are represented by grammars and the generated strings describe the behaviour of the system. At experimental level, we utilize the methods of selective learning and value estimation are under evolutionary pressure. The selection is influenced by the ever changing external world and by the competing individuals.

First, we model peer–to–peer networks by networks of parallel multiset string processors. The members of the peer–to–peer networks are represented by multiset string processors, form teams, send and receive information through collective and individual filters. Our work deals with the dynamics of string collections. We establish the connection between the growth of the number of strings being present during the computation at the components of these networks and the growth function of a developmental system. We demonstrate how the formal language theoretic model can be employed to incorporate network security requirements. More specifically, we show how to model and detect SYN flooding attacks and enforce Discretionary Access Control. We formalize security rules that conform to self–organizing dynamic systems and allow intra– and intercommunity collaborations. Our approach guarantees quick and efficient local analysis of the security requirements, thus reducing the need for global verification.

Secondly, we describe the search strategy of Internet crawlers in quest of novel information on different topics on the World Wide Web. We employ programmed grammars in eco–grammar systems. An eco–grammar system is comprised of a finite number of agents and their commonly shared environment, represented by sets of context–free rules and by a set of Lindenmayer rules, respectively. The generated language is the result of the interplay between the environment and the agents. We verify that if we ignore the aging of the World Wide Web, then these systems determine the class of recursively enumerable languages. Whereas if the web pages may become obsolete, then the language family generated by unordered scattered context grammars of finite index can be obtained. We argue the applicability of other regulated rewriting devices to the description of the search strategies of the crawlers. Through simulations we investigate the extent to which communication makes a goal–oriented community efficient in different graph topologies. We compare the selective learning algorithm to the linear function approximation based reinforcement learning algorithm.

Finally, we extend the conditions of dynamic team constitution in eco–grammar systems to represent network cluster formation. We establish the relationships of eco–grammar systems formed according to different team constitution modes to each other, on the basis of which we can conclude that the number of agents plays a crucial part in cluster formation. We investigate how eco–grammar systems given various team constitution modes are related to the language classes of the Chomsky hierarchy and developmental systems. From the language classes that these systems are capable of generating, we can deduce the difficulty of the problem the agents are capable of solving. We prove that the cooperation of teams leads to quite a large computational power, since in certain team constitution modes eco–grammar systems are able to produce any recursively enumerable language.

For all self–organizing networks presented in the dissertation, we propose some further research directions.

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Author's correspondence address Katalin Anna Lázár
Faculty of Informatics
Eötvös Loránd University
Pázmány Péter sétány 1/C.
1117 – Budapest
Hungary