Towards an Efficient Strategy for Searching in P Systems

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Abstract

P systems are, in general, non-deterministic computational devices. Usually, the evolution of a P system generates a computation tree too large to be efficiently handled with present–day computers; and different branches in this tree may differ significantly from a computational complexity point of view, that is, for the amount of time and storage necessary to reach a result.

In this paper we propose a first approach to a strategy for choosing a (suitable) branch of the computation tree associated with a P system. To this end, we introduce the central notion of *dependency graph of a P system*.

1 Introduction

In [2], a new model of computation within the framework of *Natural Computing* was introduced, called *Membrane Computing*[1]. It starts from the assumption that the processes taking place in the compartmental structure of a living cell can be interpreted as computations. The computational devices of this model are called *P systems*.

Roughly speaking, a P system consists of a cell-like membrane structure, in the compartments of which one places multisets of objects which evolve according to given rules in a synchronous non-deterministic maximally parallel manner.

P systems are, in general, non-deterministic devices, so their evolution usually gives rise to a computation tree with several branches, potentially infinite. Moreover, even in the case of finite computation trees, the amount of information is often too big to be efficiently handled with present-day

[1]A layman-oriented introduction can be found in [4] and further bibliography at [6].

computers. This is why it is convenient to look for good strategies for exploring such computation trees. That is, we intend to enrich P systems with a new component, usually called *strategy* or *search plan*, that *controls* the rules to be applied in each step of the evolution, in order to select a branch of the computation tree with a low (if possible, the minimal) cost.

In this framework, it would be very useful to have a tool to help us in the decision of choosing the *shortest* branch in the computation tree, that is, a minimal cost path from the root to a leaf. The ideal situation would be to have a mapping h^* associating to each node n of a computation tree a number $h^*(n)$ which measures the length of the shortest path from node n to a leaf (that is, to a halting configuration). However, the drawback is the high computational cost of such a mapping.

In a more realistic situation, we look for a computable mapping being an *efficient estimation* of h^*. That is, we look for a mapping h such that

(–) h associates to each node n of a computation tree a number $h(n)$ verifying $h(n) \leq h^*(n)$; and

(–) the value $h(n)$ can be calculated with a *low* computational cost.

Then, $h(n)$ is a real-valued function over the nodes that provides a lower bound of the number of transition steps needed to reach a halting configuration from node n. Such a mapping h will be referred to as a *heuristic function* or *evaluation function.*

The paper is organized as follows. In Section 2 we present the P systems model used in this paper. Section 3 introduces the central notion of *dependency graph* of a P system. Based upon this notion, we present in Section 4 a mapping h, which helps us to search for a short branch in the computation tree of a P system. We also prove that this mapping is, indeed, a heuristic function, in the sense of the definition above. Finally, in Section 5 we develop an illustrative example and we finish with some Final Remarks.

References

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[6] `http://psystems.disco.unimib.it/`