Characterizing Tractability with Membrane Creation

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***Abstract*— This paper analyzes the role that membrane dissolution rules play in order to characterize (in the framework of recognizer P systems with membrane creation) the tractability of decision problems –that is, the efficient solvability of problems by deterministic Turing machines. In this context, the use or not of these rules provides an interesting borderline between the tractability and the (presumable) intractability.**

I. Introduction

Membrane Computing is a cross-disciplinary field of Natural Computing with contributions by computer scientists, biologists and formal linguists that was introduced by Gh. Păun in [6]. Since then it has received important attention from the scientific community. In fact, Membrane Computing has been chosen by the Institute for Scientific Information as a fast *Emerging Research Front* in Computer Science in October 2003 [14].

This new non-deterministic model of computation starts from the assumption that the processes taking place in the compartmental structure of a living cell can be interpreted as computations. The 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[1].

In living cells, new membranes are produced basically through two processes, *mitosis* (membrane division) and *autopoiesis* (membrane creation)[2]. These two processes have inspired two variants of P systems, namely *P systems with active membranes* and *P systems with membrane creation*.

P systems with active membranes have been successfully used to design solutions to well-known **NP**-complete problems (e.g. [11], [12], [13]). Recently, the first (*uniform*) results related to the computational efficiency using membrane creation have arisen (see [2], [3]).

The paper is organized as follows. First, we summarize basic notions on computational complexity in P systems. Section III recalls P systems with membrane creation. The concept of dependency graph is defined in Section IV, providing a characterization of standard class **P** in terms of recognizer P systems with membrane creation without using dissolution rules. A linear solution to QSAT by P systems with membrane creation is presented in Section V, showing a surprising role of dissolution rules: using them we go beyond tractability. Finally, some conclusions are given in Section VI.

[1] A detailed description can be found in [7] and further bibliography at [15].

[2] Membranes are created in living cells, for instance, in the process of vesicle mediated transport and in order to keep molecules close to each other to facilitate their reactions. Membranes can also be created in a laboratory - see [4].

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