P Systems with Tables of Rules

Gheorghe PĂUN[1,2], **Mario PÉREZ JIMÉNEZ**[2],
Agustín RISCOS NÚÑEZ[2]

[1]Institute of Mathematics of the Romanian Academy
PO Box 1-764, 014700 Bucureşti, Romania

[2] Research Group on Natural Computing
Department of Computer Science and Artificial Intelligence
University of Sevilla
Avda. Reina Mercedes s/n, 41012 Sevilla, Spain
E-mail: {gpaun, marper, ariscosn}@us.es

Abstract. In the last time, several efforts were made in order to remove the polarization of membranes from P systems with active membranes; the present paper is a contribution in this respect. In order to compensate the loss of power represented by avoiding polarizations, we introduce *tables* of rules: each membrane has associated several sets of rules, one of which is non-deterministically chosen in each computation step. Three universality results for tabled P systems are given, trying to use rules of as few as possible types. One of these results use catalysts in order to inhibit the parallelism of rules. Then, we consider tables with *obligatory rules* – rules which must be applied at least once when the table is applied. Systems which use tables with at most one obligatory rule are proven to be able to solve SAT problem in linear time. Several open problems are also formulated.

1 Introduction

In membrane computing, the P systems with active membranes have a special place, because of the fact that they provide biologically inspired means to solve computationally hard problems: by using the possibility to divide membranes, one can create an exponential working space in a linear time, which can then be used in a parallel computation for solving, e.g., **NP**-complete problems in polynomial or even linear time. Details can be found in [7], [8], as well as in the comprehensive page from the web address http://psystems.disco.unimib.it).

One of the important ingredients of P systems with active membranes is the polarization of membranes: besides a label, each membrane also has an "electrical charge", one of + (positive), − (negative), 0 (neutral). These electrical charges correspond only remotely to biological facts; by sending ions outside, cells and cell compartments can get polarizations, but this is not a very common phenomenon. Starting from this observation and also as a mathematical challenge, in the last time several efforts were made to avoid using polarizations.

However, the question seems not to be a simple one, and the best result obtained so far was to reduce to two the number of "electrical charges"; this is achieved in [3], where both the universality and the possibility of solving SAT in linear time are proven for P systems with active membranes and only two polarizations. When completely removing the polarizations, similar results are obtained (see [2], [1]) only by compensating the loss of power (of "programming" possibilities) by using additional ingredients, such as the possibility of changing the labels of membranes, division of non-elementary membranes, etc.

The present paper goes into the same direction of research: we get rid of polarizations and we "pay" this by structuring the sets of rules associated with each membrane by considering *tables* of rules, like in Lindenmayer systems. Specifically, several sets of rules are associated with each membrane, and in each step of a computation we nondeterministically choose one of these sets, and its rules are used in the maximally parallel manner. The use of tables can have a biological motivation, in the same way as the tables from L system theory have a biological origin: the change of environmental conditions (for instance, of seasons) can select specific evolution rules for different times (different seasons).

The use of tables proves to be helpful in what concerns the computing power: we get universality for systems of a rather reduced forms, with only a few types of rules used, and without polarizations.

An important *problem* remains unsolved: can tables compensate polarizations also in what concerns the possibility to solve hard problems in polynomial time? A possible negative answer to this problem would be a very nice finding: in view of the result from [3], it would follow that passing from one polarization (all membranes neutral) to two polarizations makes possible the step from the complexity class **P** to **NP**.

If, however, we add a further ingredient – at the first sight not very powerful – to tabled P systems, namely designating in each table rules which should be used at least once when applying the table, then we can solve SAT in linear time. The construction uses at most one obligatory rule in each table.

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