Non-Discrete P Systems
(Extended Abstract)

Andrés CORDÓN-FRANCO, Fernando SANCHO-CAPARRINI

Research Group on Natural Computing
Dpt. Computer Science and Artificial Intelligence
E.T.S.I.I. University of Seville
E-mail: {acordon,fsancho}@us.es

1 Introduction

Until now, the usual variants of P systems have only a finite number of options in every step of their computations (that is, an associated computation tree is defined for them). In this way, irrespectively whether they are non-deterministic or probabilistic P systems, we obtain a discrete space of computations where the system evolves.

Here we propose a variant of P systems which in every step can evolve in a non-discrete number of choices. For that, we do not use discrete multisets, but multisets where the multiplicity of the objects can be real (positive) numbers. The inspiration of this paper is that, in vitro, we can control neither the application of the rules nor the exact number of objects, but we deal with an approximate and non-natural number of applications (possibly, related with the concentration of the objects in the membrane). In this way, the multiplicity of an object does not reflect the exact number of identical copies of it in the membrane, but its concentration in the solution.

In this paper we present a formalization of the way to work with this kind of multisets in order to study and simulate the functioning of P systems that apply a non-discrete amount of times the rules over the content of the membranes. Of course, we obtain a variant where there is no computation tree, but a sequence of non-discrete spaces of configurations.

We begin by defining the tools for working with non-discrete multisets (called here ND-multisets), then we define a way to apply the rules a non-discrete number of times, and finally we propose some applications of this variant.

2 Non-discrete Multisets

As it was used also in [1], we can define a generalization of multisets by using non-integer multiplicities.

Definition 2.1 *Let V be an alphabet. A* non-discrete multiset *(ND-multiset) over V is an application; $w: V \to \mathbb{R}^+$. We denote by $NDM(V)$ the set of non-discrete multisets over V.*

In a similar way to multisets, we can define the *support* of an ND-multiset ($supp(w)$), the usual operations between them (addition, subtraction, external product by real numbers) and usual relations ($\leq$, $\neq$, $\subseteq$, etc).

3 Non-discrete application of rules

A formalization of transition P systems can be found in [3]. Once we fix how to apply the rules for a given configuration, if we have a non-discrete multiplicity of the objects in a membrane, we can allow applying the rules a non-natural number of times as well, in order to get a maximal parallel application of the rules.

We prove in the paper that the set of maximal applications for a given membrane is in the surface of the convex hull of some points depending on the structure of the rules and the content of that membrane.

Let $\{r_1 : s_1 \to s'_1, ..., r_n : s_n \to s'_n\}$ be the applicable rules of the membrane, x, and let $w \in NDM(V)$ be the content of x. Then the set of applications on x, Ap, is the following one:

$$Ap = \{(\alpha_1, ..., \alpha_n) : \sum_{i=1}^{n} \alpha_i \cdot s_i \subseteq w, \quad \alpha_1 \geq 0, ..., \alpha_n \geq 0\},$$

and the set of maximal applications is:

$$Extr = \{\alpha \in Ap : \; \forall \beta \neq \alpha \in Ap \; \exists i \leq n(\beta_i < \alpha_i)\}.$$

From the definition above it is easy to check that Ap is a convex set.

Here is a trivial example.

Given the rules $r_1: \; ab \to b$ and $r_2: \; a^2c \to b$ in a membrane, if the content of this membrane in a configuration is $w = a^2bc$, it is clear that, in the discrete case, we can apply the rules in a maximally parallel manner in two ways: $\{(1,0), \; (0,1)\}$. But, if we allow a non-discrete number of applications of the rules, then we obtain the following set of applications (each of them producing different computations in the evolution of the P system):

$$Ap = \{(\alpha_1, \alpha_2) : \; \alpha_1 + 2\alpha_2 \leq 2, \; \alpha_1 \leq 1, \; \alpha_2 \leq 1, \alpha_1, \alpha_2 \in \mathbb{R}^+\}.$$

In Figure 1 we represent this set of applications and the associated set of maximal applications.

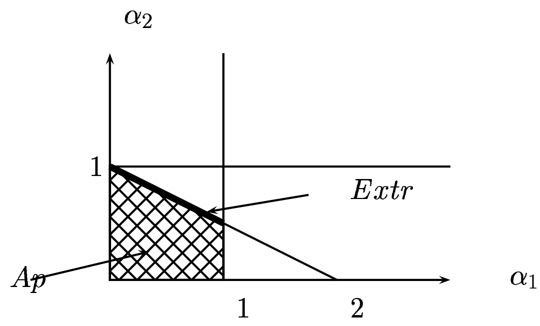

Fig 1. An example.

4 Conclusions

We propose a new variant of P systems where the obtained space of computations is not a discrete space, but a dense one where in every step of the evolution a non finite (and dense) space of configurations can be produced.

This work is intended as an attempt to provide a new variant of P systems where only some approximate behaviors of the real reactions inside the cell are known. This approach is currently used in the development of a probabilistic software tool allowing the user to work with concentrations of the reactants, not with the exact number of each of them, trying to be nearer of the real case in laboratory.

On the other hand, this variant can provide new problems related with the computational power of the model. If we examine the number of possible computations of a non-discrete P system, we realize that they are uncountably many, while in the discrete P systems this number is always countable. This raises the following question: how can we approximate the functioning of such a device by means of *classical* P systems?

Acknowledgment

The support for this research through the project TIC2002-04220-C03-01 of the Ministerio de Ciencia y Tecnología of Spain, cofinanced by FEDER funds, is gratefully acknowledged.

References

[1] T.Y. Nishida. Simulations of photosynthesis by a K-Subset transforming system with membrane, *Fundamenta Informaticae*, **49**, 1-3 (2002), 249–259.

[2] Păun, G. Computing with membranes, *Journal of Computer and System Sciences*, **61**(1), (2000), 108–143.

[3] M.J. Pérez-Jiménez; F. Sancho-Caparrini. A formalization of basic P systems, *Fundamenta Informaticae*, **49**, 1–3 (2002), 261–272.