

# On Two-Dimensional Mesh Networks and Their Simulation with P Systems

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**Abstract.** We analyze in this paper the possibility of simulating the parallel architecture **SIMD-MC**<sup>2</sup>, also known as the two-dimensional mesh, with P systems with dynamic communication graphs. We illustrate this simulation for an algorithm which computes the sum of given integers. Next, we show how to extend the formalism to the reduction problem.

## 1 Introduction

P systems are powerful computational devices, with a high degree of parallelism, whose functioning is inspired by biological processes at the level of the cells, and of their membranes ([6],[7]). Among these processes, communication plays an important role (see [5]).

We have started in previous work ([2], and [3]) to analyze the possibility of simulating (classical) parallel architectures with P systems. A parallel machine consists of a large number of processors (each one having an arithmetic logic unit with registers and a private memory) able to solve problems in a cooperative way. The “cooperation” (sharing of data among processors) is accomplished via a specific communication network which characterizes the architecture.

We have considered in [2], and [3], the case of the *shuffle-exchange* architecture. In the present paper we deal with a different type of architecture, the *two-dimensional mesh*, in which the processors are placed in the vertices of a 2D-lattice in the plane, and communication is possible only between adjacent processors.

In the course of this study, a new type of P systems has emerged: P systems with *dynamic communication graphs* of specific types. They are in a way similar to tissue-like P systems, the connections between elementary membranes being described by graph structures, but they have a dynamic behavior: the underlying graph structures change in time. Moreover, rules, which are generally associated

to regions inside membranes, are in this new version associated to underlying graphs. This new formalism covers both the simulation of internal processing, modeled by symbol rewriting rules, and the communication of data, modeled by symport/antiport rules.

The paper is organized as follows. Section 2 describes briefly the 2D-mesh parallel architecture. In section 3 we introduce the P systems *with dynamic communication of 2D-mesh type*, the tools with which we accomplish the desired simulation. Section 4 illustrates an application of the 2D-mesh architecture with an algorithm for computing the sum of a set of integers, and contains a proof of its correctness. In section 5 we discuss several simulations of the sum algorithm with P systems with dynamic communication of 2D-mesh type. In the next two sections we give some indications on how to extend the formalism to solve a general reduction problem.

## References

1. Ceterchi, R.; Martín-Vide, C. P systems with Communication for Static Sorting. In M. Cavaliere, C. Martín-Vide and Gh. Păun (eds.), *Proceedings of the Brainstorming Week on Membrane Computing*, Report GRLMC 26/03, 2003, 101–117.
2. Ceterchi, R., Pérez Jiménez, M. J.: Simulating Shuffle-Exchange Networks with P Systems. In Gh. Păun, A. Riscos, F. Sancho and A. Romero (eds.), *Proceedings of the Second Brainstorming Week on Membrane Computing*, Report RGNC 01/04, 2004, 117-129.
3. Ceterchi, R., Pérez Jiménez, M. J.: A Perfect Shuffle Algorithm for Reduction Processes and its Simulation with P Systems. In I. Dzitac, T. Maghiar, C. Popescu (eds.), *Proceedings of the International Conference on Computers and Communications ICC 2004, May 27-29, 2004, Baile Felix Spa - Oradea, Romania*, Editura Univ. Oradea, 2004, 92-97
4. Flynn, M. J.: Very high-speed computing systems, *Proceedings of the IEEE* 54, 12(December), 1966, 1901-1909
5. Păun, A., Păun, G.: The power of Communication: P Systems with Symport/Antiport. *New Generation Computers*, 20, 3(2002), 295–306.
6. Păun, G.: Computing with Membranes. *Journal of Computer and System Sciences*, 61, 1 (2000), 108–143, and *Turku Center for CS-TUCS Report No. 208*, 1998
7. Păun, G.: *Membrane Computing. An Introduction*, Springer-Verlag, Berlin, Heidelberg, 2002
8. Quinn, M.J. *Parallel Computing. Theory and Practice*, McGraw-Hill Series in Computer Science, 1994.
9. Ullman, J.D. *Computational Aspects of VLSI*, Computer Science Press, Rockville, MD, 1984.