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

Rodica CETERCHI[1], and **Mario J. PÉREZ JIMÉNEZ**[2]

[1] Faculty of Mathematics and Computer Science, University of Bucharest
Academiei 14, RO-010014, Bucharest, Romania
`rc@funinf.cs.unibuc.ro`
[2] Research Group on Natural Computing
Department of Computer Science and Artificial Intelligence
University of Sevilla
Avda. Reina Mercedes s/n, 41012 Sevilla, Spain
`mario.perez@cs.us.es`

Abstract. We analize in this paper the possibility of simulating the parallel architecture **SIMD-MC**^{2}, 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.

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