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COMMUNICATION MEMBRANE SYSTEMS WITH ACTIVE SYMPORTS

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ABSTRACT

We consider membrane systems where the generation/transformation of objects can take place only if it is linked to communication rules.

More specifically, all the rules move objects through membranes and, moreover, the membranes *can* modify the objects as they pass through. The intuitive interpretation of such rules is that a multiset of objects can move from a region to an adjacent one, and moreover objects can engage into (biochemical) reactions while passing through (are in "contact" with) a membrane. Therefore such "twofold" rules are called symport-rewriting (in short, *sr*) rules, where symport refers to a coordinated passage of a "team" of molecules through a membrane.

In this paper we investigate the influence of the form of sr rules on the power of membrane systems that employ them (sometime in combination with simple antiport rules which allow a synchronized exchange, through a membrane, of two molecules

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residing in two adjacent regions). A typical restriction on the form of an sr rule requires that the passage described by the rule is such that the sort of exiting molecules is a subset of the sort of entering molecules (however the multiplicities of sorts do not have to be related).

We also compare the sequential passage mode with the maximally parallel passage mode.

Keywords: Natural computing, multiset rewriting, membrane computing

1. Introduction

Membrane computing, introduced in [10], is a computational model inspired by the functioning of membranes in living cells. The biological membranes within a cell divide the cell in a number of compartments (regions). This is the basic feature of this model with each region containing its own set of evolution rules, where each rule prescribes both the transformation and generation of molecules as well as the transport of molecules through membranes. In this way each evolution rule has both a rewriting and a communication component.

An important class of membrane systems allows only communication, i. e., their rules prescribe only the passage of objects (molecules) through membranes. Such systems are called symport/antiport membrane systems where both "symport" and "antiport" refer to types of rules that allow for a synchronized passage of molecules through a membrane. For symport rules this passage is unidirectional (a multiset of molecules is passing through a membrane together), while for antiport rules this passage is bidirectional (a passage of a multiset of molecules in one direction is synchronized with a passage of molecules in another direction through the same membrane).

In this paper we enrich symport rules by coupling them with a generative component: a multiset of molecules passing a membrane synchronously in the unidirectional fashion can be changed to a different multiset. Such rules are called *symport-rewriting rules*, or *sr rules* for short – they are biologically motivated, as the biological membranes do not only allow for the passage of molecules, but can also change them *during* a passage. Membrane systems using sr rules and antiport rules are called *communication membrane systems with active symports*, or CAS P *systems* for short.

In this paper we study the influence of the form of sr rules (sometimes in combination with antiport rules) on the generative power of resulting membrane systems. We also study the influence of the communication mode (sequential versus maximally parallel) on the generative power. In sequential mode, at any given time, at most one sr rule can be active for any given membrane, while (as usual) in maximally parallel mode an application of the rules is such that no more rules can be applied to the objects that are not already involved in the passage through membranes.

The paper is organized as follows. Section 2 recalls some basic notions from language theory – more specifically those of matrix grammars and register machines. Section 3 formally defines CAS P systems. Section 4 considers "alphabetically restricted" CAS P systems which can use only sr rules in which the type of every generated object (i. e., an object occurring at the right hand side) is already present at the "entrance to the membrane" (i. e., occurring at the left hand side). In Section 5 we consider CAS P systems operating in sequential mode. Section 6 considers CAS