Chapter V

Cellular Solutions to Some Numerical NP-Complete Problems: A Prolog Implementation

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ABSTRACT

This chapter is devoted to the study of numerical NP-complete problems in the framework of cellular systems with membranes, also called P systems (Păun, 1998). The chapter presents efficient solutions to the subset sum and the knapsack problems. These solutions are obtained via families of P systems with the capability of generating an exponential working space in polynomial time. A simulation tool for P systems, written in Prolog, is also described. As an illustration of the use of this tool, the chapter includes a session in the Prolog simulator implementing an algorithm to solve one of the above problems.
INTRODUCTION

The race to miniaturize silicon microchips to get more and more powerful (smaller and faster) processors is expected to hit its own physical limits very soon. This is why it is necessary to look for new unconventional models of computation. One of the main research lines in this direction is focusing on obtaining new computational paradigms inspired from various well-established natural phenomena in physics, chemistry, and biology. This approach is generically known as natural computing.

This chapter is part of the framework of one of these nature-inspired models, namely, cellular computing with membranes. This model abstracts from the structure and the functioning of a living cell. At the moment it is just at the theoretical level, and it is not likely that it would be implemented in vivo in the near future. However, some simulations in silico (i.e., software implementations) have been recently presented, written in various programming languages (Java, C, Scheme, etc.). Although they are not able to actually implement the massive parallelism inherent to the original model, these approaches may be regarded as a proof of concept for this new computational paradigm in dealing with hard problems and as a tool that is able to support both research and pedagogical purposes.

The simulator presented here is written in Prolog, and it was created with the aim of assisting in theoretical research in cellular computing. That is, it is not intended to get an efficient implementation, but to be an intuitive tool that provides faithful and detailed information about the computations taking place within cellular systems. More interestingly, during the development of this tool simulator, we realised that we needed new information that helped the formal verification process of cellular computing.

From Nature to Membrane Computing

In recent years the research field generically named natural computing has been under enormous scrutiny and development. This discipline has started off the investigation of both mathematical models and technological requirements for the implementation of bio-inspired computing paradigms. The research within this field studies the way nature computes, conceiving and abstracting new paradigms and computing models.

There are several areas within natural computing that are now well established. Genetic algorithms (or, more generally, evolutionary computing), introduced by J. Holland (1975), uses some operations inspired by natural evolution and selection in order to improve the process of finding a good
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