Chapter IX

A Language for Specifying Agent Systems in E-Learning Environments

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Abstract

In this chapter, we use the Chemical Reaction Metaphor (Banatre & Le Metayer, 1990, 1993, 1996) to model the interactions among program units, including the agents, clients, servers, and databases, in a multiagent-based e-learning system. Through case studies, we demonstrate that the Gamma language (Banatre & Le Metayer, 1990; Le Metayer, 1994) is suitable for specifying a multiagent system, particularly, because an agent’s properties, such as autonomy and mobility, can be captured concisely. The use of the high-level specification paves the way for solving architectural-design issues in building an e-learning environment. The Gamma specification of an agent system can be implemented in a hierarchical running environment, which is composed of nodes in different
Introduction

Gamma (Banatre & Le Metayer, 1990, 1993, 1996) is a kernel language in which programs are described in terms of multiset transformations. It is a high-level programming language in which parallelism is left implicit and which is especially suitable for use with the data parallel paradigm. Existing work has demonstrated its significance for the construction of massively parallel programs. With the Gamma programming paradigm, programmers can concentrate on the logic of problems to transfer the tuple space (this terminology is borrowed from Linda, which shares some ideas with Gamma) (Carriero & Gelernter, 1989; Ma et al., 1995), and are free from considering the execution environment. Gamma has allowed for elaboration of the chemical-reaction model, such as the Chemical abstract machine (Cham) (Berry & Boudol, 1992), higher-order Gamma (Le Metayer, 1994), structured Gamma (Fradet & Le Metayer, 1998), and Multran (Ma et al., 1995).

The application of the chemical-reaction metaphor to the definition and the analysis of configuration programming (Kramer, 1990), coordination programming (Carriero & Gelernter, 1989; Holzbacher, 1996), and software architectures (Allen & Garlan, 1994; Garlan & Perry, 1995) is an important aspect of current research (Le Metayer, 1996; Fradet & Le Metayer, 1996; Ma et al., 1995). This application is significant, because a common and formally based language is lacking for describing the dynamic properties of a system composed of dynamic and interacting software units, and the chemical-reaction model can be used as a candidate (Inverardi & Wolf, 1995; Fradet & Le Metayer, 1996).

We used the chemical-reaction metaphor to model multiagent systems. We found that the behaviors of an agent can be described as a Gamma program. In our model, a multiset element represents a data item that can trigger the action of a Gamma program, which represents the transition of the states of the agent it models, and interactions among agents can be described by an action performed in a higher level of the multiset hierarchy of the higher-order Gamma program.

The contributions of this approach include a formal system that can be used to capture the properties of a multiagent system, and a method of designing a
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