

## Chapter 2.16

# Building a Health Care Multi-Agent Simulation System with Role-Based Modeling

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### ABSTRACT

Multi-Agent System (MAS) is a suitable programming paradigm for simulating and modeling health care systems and applications, where resources, data, control and services are widely distributed. We have developed a multi-agent software prototype to simulate the activities and roles inside a health care system. The prototype is developed using a framework called Role-based Agent Development Environment (RADE). In this chapter, the authors present an integrated approach for modeling, designing and implementing a multi-agent health care simulation system using RADE. They describe the definition of role classes and agent classes, as well as the automatic agent generation process. The authors illustrate the coordination problem and present a rule-based coordination approach. In the end, they present a runtime scenario of this health

care simulation system, which demonstrates that dynamic task allocation can be achieved through the creation of role instances and the mapping from role instances to agents. This scenario also explains how agents coordinate their activities given their local constraints and interdependence among distributed tasks.

### INTRODUCTION

Multi-Agent System (MAS) is a suitable programming paradigm for simulating and modeling health care systems and applications, where resources, data, control and services are widely distributed. We have developed multi-agent software to simulate the activities and roles inside a health care system. Such software can be used to assist the collaborative scheduling of complex tasks that involve multiple personals and resources. In addition, it can be used

DOI: 10.4018/978-1-60566-772-0.ch006

to study the efficiency of the health care system and the influence of different policies.

However, the application of multi-agent system has been limited by the difficulty of developing agent-based systems, and considerable amount of time and highly experienced programmers are required to develop a multi-agent system. After such system is built, it is also difficult to test and maintain the system because of its complexity. The reusability of such system is low; it is unlikely to use an existing system for another application domain with little or minor change. In this chapter, we will describe a role-based approach to building multi-agent systems for health care simulation and modeling. With this approach, we are able to separate the concern on domain knowledge and the concern on intelligent problem-solving capabilities. In this approach, conceptual roles, such as physicians, nurses and patients are defined with the domain related knowledge including goals, permissions, organizational relationship, and interaction protocols, etc; where an agent is a concrete entity equipped with motivations, resources and problem-solving capabilities, which can be used to represent a real person in a health care system. Each agent can be configured based on different specifications according to the real person's situation and needs. Then the agent instance is dynamically generated for the real person who enters the system.

In this chapter, we will also describe an automated agent generation process, which utilizes the existing tools and mechanisms as much as possible. We propose to create agents using a drag-and-drop mechanism where the user can select components to plug into the agent depending on application requirements. We adopt a utility-driven agent architecture with quantitative reasoning capabilities. Besides the logical reasoning on the matching of motivations and the conflicts among different roles, we adapt a quantitative model of motivation named MQ (motivation quantities) framework. Based on the MQ framework, an agent can perform

a quantitative reasoning on how important a role instance is, given its preference, its utility function and its current achievement. In the definition of a role, we introduce a formal language called RTÆMS (Role-based Task Analyzing, Environment Modeling, and Simulation) to represent the domain knowledge about how to achieve a goal. RTÆMS language is a hierarchical task network representation language with task interrelationships and quantitative descriptions of different alternatives to achieve a goal. The domain expert can specify how a complicated health service task should be performed with the collaboration of multiple roles inside the system. Each agent is also equipped with the capability for planning, scheduling and cooperation; hence, an agent can schedule its local activities with the consideration of the constraints from other agents. Meanwhile, a user of the system can choose different collaboration rules according to the organizational rules and the specific needs in the system.

In the rest of this chapter, we first discuss related work in several research areas. Afterwards, we describe how to construct a health care simulation system using the approach described above, and show how to define roles and their interrelationships, and how to define agent classes. Then, we present an automatic agent generation tool as well as a rule-based coordination approach. Finally, we use a runtime scenario to demonstrate how new role instances are created, how agents are taking new roles, planning and scheduling their tasks, and collaborating with each other to achieve a complex goal.

## **BACKGROUND**

Researchers have studied a number of approaches for defining and developing autonomous agents and multi-agent system from different directions. Here we discuss related research work in four areas: agent development framework, role-based

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