Chapter 2.16
Building a Health Care Multi-Agent Simulation System with Role-Based Modeling

Xiaoqin Zhang
University of Massachusetts Dartmouth, USA

Haiping Xu
University of Massachusetts Dartmouth, USA

Bhavesh Shrestha
University of Massachusetts Dartmouth, USA

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
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 auto-
mated 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 capabili-
ties. 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 func-
tion 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 interrelation-
ships 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 collabora-
tion 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 interrela-
tionships, 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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