Chapter XII
Role-Based Multi-Agent Systems

Haibin Zhu
Nipissing University, Canada

MengChu Zhou
New Jersey Institute of Technology, USA

ABSTRACT

Agent system design is a complex task challenging designers to simulate intelligent collaborative behavior. Roles can reduce the complexity of agent system design by categorizing the roles played by agents. The role concepts can also be used in agent systems to describe the collaboration among cooperative agents. In this chapter, we introduce roles as a means to support interaction and collaboration among agents in multi-agent systems. We review the application of roles in current agent systems at first, then describe the fundamental principles of role-based collaboration and propose the basic methodologies of how to apply roles into agent systems (i.e., the revised E-CARGO model). After that, we demonstrate a case study: a soccer robot team designed with role specifications. Finally, we present the potentiality to apply roles into information personalization.

INTRODUCTION

Artificial intelligence is the discipline aimed at understanding intelligent beings by constructing intelligent systems (Castelfranchi, 1998). From a behaviorist’s perspective, intelligent systems are those that can simulate human beings’ work that requires intelligence, including logic reasoning, problem solving, deduction, and induction. A distributed system is composed of many computers interconnected via communication networks, which cooperate and coordinate to accomplish a common task or goal (Coulouris, Dollimore, & Kindberg, 2005). Multi-agent systems are intelligent systems built on a distributed computer system. They are based on the use of cooperative agents and organized with hardware/software components. In such systems, each agent independently handles a small set of specialized tasks and cooperates to achieve the system-level goals.
Role-Based Multi-Agent Systems


Multi-agent systems are becoming more relevant to artificial intelligence (AI) (Bowling & Veloso, 2002) and can be used to implement distributed AI (DAI). The agent concept evolves from objects. It is a combination of object-orientation and AI. The AI community claims intelligence as a natural quality of agents and uses the traditional symbolic representation to describe agents.

Maes (1994) defines agents as computational systems that inhabit a complex dynamic environment, sense and act autonomously in this environment, and by doing so realize a set of goals or tasks for which they are designed. Wooldridge and Jennings (1995; Jennings & Wooldridge, 1996) define agents as hardware-based or software-based computer systems that possess the following properties:

• **Autonomy:** Agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state.

• **Social ability:** Agents interact with other agents (and possibly humans) via a kind of agent-communication language.

• **Reactivity:** Agents perceive their environment, which may be the physical world, a user via a graphical user interface, a collection of other agents, or perhaps all of these combined, and respond in a timely fashion to changes that occur in it.

• **Pro-activeness:** Agents do not simply act in response to their environment. They are able to exhibit goal-directed behavior by taking an initiative.

Normal objects can be thought of as passive because they wait for a message before performing an operation. Once invoked, they execute their method and go back to “sleep” until the next message arrives. A current trend is to design objects that not only react to events in their environment, but also behave proactively. Therefore, in addition to traditional object properties, an agent should also have the following characteristics:

• **Active:** An agent may act according to its internal states and goals. Note that an object in its conventional meaning can only respond to the messages sent to it even though many acclaim that everything is an object.

• **Autonomous:** An agent is not controlled directly by people.

• **Collaborative:** Agents need to collaborate with others to accomplish a complex task.

Every agent is responsible for accomplishing a certain task. It can be considered as a self-contained object of some class and involves itself with a specific environment. The environment exists before agents are created. Agents should be designed such that they can adapt to a constantly changing environment.

Agent design is a complex task challenging designers to simulate intelligent human behavior. Searching and retrieving are considered expressions of intelligence. Roles can reduce the complexity of agent design by categorizing agent responsibilities. Based on the theory of search and retrieval, such separation greatly shrinks the search space and tends to significantly increase agent efficiency in response to messages or events relevant to a specific role.

In fact, multi-agent systems are simulations of human societies or virtual societies. To simulate real societies, we need to understand their nature. A well-organized society should encourage member contributions (Mills & Simmons, 1999). Similarly, distributed intelligent systems should establish a healthy platform or environment for virtual participants who contribute and work effectively. One can consider agents as virtual citizens in intelligent systems. A capable political system promotes a harmonious and flourishing society. Good architecture leads to a beautiful and long-lasting building. Clearly, a distributed