Chapter XLIV
Toward an Agent-Oriented Paradigm of Information Systems

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ABSTRACT

This chapter presents a meta-model of information systems as a foundation for the methodology of caste-centric agent-oriented software development, which is suitable for applications on the Internet/Web platform and the utilization of mobile computing devices. In the model, the basic elements are agents classified into a number of castes. Agents are defined as active computational entities that encapsulate: (a) a set of state variables, (b) a set of actions that the agents are capable of performing, (c) a set of behaviour rules that determine when the agents will change their states and when to take actions, and (d) a definition of their environments in which they operate. Caste is the classifier of agents and the modular unit of the systems. It serves as the template that defines the structure and behaviour properties of agents, as class does for objects. Agents can be declared statically or created dynamically at runtime as instances of castes. This chapter also illustrates the advantages of agent-oriented information systems by an example.

INTRODUCTION

In recent years we have seen a rapid change in the hardware infrastructure and software platforms on which information systems operate. Notably, the Internet/Web as well as mobile devices, such as notebook computers, PDAs, and 3G mobile phones and wireless networks, are becoming ubiquitous. Proposals for effective utilisation of such flexible devices and the Internet infrastructure have been advanced, such as Web services, semantic Web, grid computing, and so on. These techniques provide a bright vision for the future computer applications, especially for management information systems. However, a big problem remains open: how software should be developed.

In the past two decades, object-orientation (OO) has been a successful mainstream paradigm for the analysis, design, and implementation of software, especially information systems. However, software engineers are currently confronted with a number of challenges

in the development of Web-based information systems, especially in the construction of service-oriented systems, due to the new features of the Internet and World Wide Web. One of the main challenges comes from the autonomous feature of the hardware and software resources on the Internet/Web. It is unnatural to model autonomous resources within the OO meta-model, which considers everything as objects.

In the past two decades, agent technology has been developed mostly as an artificial intelligence endeavour (cf. Huhns & Singh, 1997). It is partly inspired in the observations and modelling of autonomous and emergent behaviours in the societies of human beings or insects and animals. It has long been regarded as a viable solution to the development of complicated applications in dynamic environments such as the Internet (Jennings & Wooldridge, 1998). However, existing agent-based systems have been developed in *ad hoc* methods without proper methodology, language, and tool supports. It is widely recognised that the lack of rigour has hampered the wide adoption of agent technology in IT industry.

In this chapter, we adapt and extend the principles of OO and propose a new meta-model of information systems based on the concept of agents. We will first present a meta-model of such agent-oriented information systems (AOISs), and then demonstrate the features of AOISs with an example and compare agent-orientation (AO) with traditional approaches. The readers are referred to Shan, Shen, Wang, and Zhu (2006) for the aspects on the methodology, languages, and tools that support the development of such AOISs.

The remainder of the chapter is organised as follows. We will first give an informal introduction to AOIS, which is followed by a formal definition of the meta-model. We will then illustrate the features of an AOIS with an example and compares it with traditional approaches to the development of information systems. Finally, we conclude the chapter with a discussion of related works and further work.

BASIC CONCEPTS

In our conceptual model, the basic unit that forms an information system is agent. Because there is no widely accepted definition of the concept of agent and multi-agent systems (MASs), it is worthy clarifying what we mean by agent and MAS, and how such systems work. Our conceptual model can be characterized by a set of pseudo-equations. Each pseudo-equation defines a key feature of a MAS.

The Structures and Operations of Agents and Multi-Agent Systems

Pseudo-equation 1 states that agents are defined as real-time active computational entities that encapsulate data, operations, and behaviours, and situate in their designated environments.

$$Agent = \langle Data, Operations, Behaviour \rangle_{Environment} \qquad (1)$$

Here, data represent an agent's state. Operations are the actions that the agent can take. Behaviour is described by a set of rules that determine how the agent behaves in the context of its designated environment. By encapsulation, we mean that an agent's state can only be changed by the agent itself. Figure 1 illustrates the control structure of agent's behaviour.

There is a fundamental difference between objects and agents. In the structure of objects, there is no explicitly programmed behaviour rule. Instead, there is a fix behaviour rule for all objects: to execute a method if and only if it receives a message that invokes the method. In contrast, agents' behaviours are not simply driven by messages, although they can be so.

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