Chapter 2.19
Developing Intelligent Semantic Web Services

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ABSTRACT

This chapter introduces an approach to the development of intelligent Semantic Web services, which are envisioned as system cells that actively discover, learn, and communicate knowledge on the Web. The development of these systems often involves not only standardized Web technology, but also the integration of heterogeneous information. The approach in this chapter adopts the Semantic Web services specifications that are given by the DARPA agent markup language (DAML) program, utilizes a system behavior model to represent an intelligent agent, and proposes a high degree of automatic synthesis using code generation and program templates. The author reviews the various techniques that are available to aid the development process, and provides an example to illustrate the stages of software synthesis in the development of such systems.

INTRODUCTION

Intelligent Semantic Web services are envisioned as system cells that actively discover, learn, and communicate knowledge on the Web. Semantic Web services are intelligent in the sense that they are agents that act in the Web environment. An agent is anything that can perceive its environment through sensors and act upon its environment through effectors (Russell & Norvig, 1995; Nilsson, 1995). With the well-established artificial intelligence theories and techniques for the development of intelligent content, the emergent Semantic Web service specifications provide opportunities for the large-scale and reliable collaboration of Web agents in intelligent information systems.

A coalition of researchers is currently developing standardized Semantic Web services. Spearheading these efforts is the DARPA agent markup language DAML program (www.daml.

org), which has released several versions of a semantic markup language for Web services (DAML-S) since 2001. Researchers in the artificial intelligence community have proposed DAML-S extensions that turn Web services into agents with behavioral intelligence (Bryson, Martin, McIlraith, & Stein, 2002). After version 1.0, DAML-S was renamed OWL-S, as it is built on the ontology Web language (OWL) that was produced by the Web-Ontology Working Group at the World Wide Web Consortium (DAML, 2003; W3C, 2004).

Modeling is useful for building and maintaining intelligent Semantic Web services for business information systems. The author believes that the development approach to these systems should be based on the use of agent-oriented models that describe the behavior of Web services at a high level of abstraction. The final implementation should be made using code generation and code templates that enable the automation of software synthesis from this high level of abstraction as far as is possible. The implementation of these systems should utilize the Semantic Web as the universal platform to aid the integration of Web services and intelligent agents.

This chapter investigates the specifications for Semantic Web services, which are the foundations for building intelligent Web applications. A significant part of the design of such applications is focused on the interconnection of the services, and inside these services agents often determine reactions to incoming knowledge. In this chapter, an approach is suggested for weaving agents into the Semantic Web. An example will be demonstrated that uses parts of the event-driven customer relationship management system that was devised by Chiu et al. (2003).

The remainder of this chapter is organized as follows: the next section gives an introduction to Semantic Web service specifications. The following section discusses intelligent agent modeling. An approach to agent software synthesis on the Web is presented next. Then, an example of an intelligent Semantic Web service is given, and finally the conclusion of the chapter.

SEMANTIC WEB SERVICE SPECIFICATION

Efforts toward the creation of a Semantic Web are gaining momentum (W3C, 2004). W3C states on its Web site that "in February 2004, the World Wide Web Consortium released the resource description framework (RDF) and the Web ontology language (OWL) as W3C Recommendations. RDF is used to represent information and to exchange knowledge in the Web. OWL is used to publish and share sets of terms called ontologies, supporting advanced Web search, software agents and knowledge management." The Semantic Web is an answer to the increasing complexity of systems development in Web computing environments. More and more Web sites not only provide static information, but also services that are capable of performing tasks, and therefore applications can be integrated using the services in a distributed network. OWL is a fundamental tool that is designed to define an unambiguous, machine-comprehensible form for the interpretation of Web services on the Semantic Web.

A Semantic Web service operates as a process (DAML, 2003). The process can be triggered from an event input by outside users, and a response with a set of outputs is then delivered. The states of the process are maintained to determine the effects that generate the responses. For a complex service, the process can be composed of many subprocesses that are executed serially or simultaneously.

Process

In general, a process produces a set of inputs from a set of inputs to a set of outputs and a transition from one state to another, where the transition is defined by the preconditions and effects of the