



Facilitating the Specification of Semantic Web Services Using Model-Driven Development

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ABSTRACT

The Semantic Web promises automated invocation, discovery, and composition of Web services by enhancing services with semantic descriptions. An upper ontology for Web services called OWL-S has been created to provide a mechanism for describing service semantics in a standard, well-defined manner. Unfortunately, the learning curve for semantic-rich description languages such as OWL-S can be steep, especially given the current state of tool support for the language. This paper describes a suite of automated software tools that we have developed to facilitate the construction of OWL-S specifications. The tools operate in two stages. In the first stage, a model-driven architecture technique is used to generate an OWL-S description of a Web service from a Unified Modeling Language (UML) model. This allows the developer to focus on creating a model of the Web service in a standard UML tool, leveraging existing knowledge. In the second stage, an interactive approach for generating groundings is used. This paper describes both tools and demonstrates how the use of lightweight interactive tools facilitates creation of OWL-S specifications.

Keywords: model driven architecture; OWL-S; semantic Web services

INTRODUCTION

A Web service is a loosely coupled component that exposes functionality to a client over the Internet (or an intranet) using Web standards, such as HyperText Transfer Protocol (HTTP), eXtensible Markup Language (XML), Simple Object Access Protocol (SOAP), Web Service Description Language (WSDL) and Universal Description, Discovery, and Integra-

tion (UDDI) Protocol. Among the many challenges of using Web services are the problems of specification, search, discovery, selection, composition and integration. The current state of practice in Web services is dominated by the use of WSDL (Christensen, Curbera, Meredith, & Weerawarana, 2001) to specify access to services. This language lacks an ability to address the aforementioned challenges

due to a lack of semantic constructs, although the proposal for WSDL-S addresses it in part (Akkiraju, Farrell, Miller, Nagarajan, Sheth, & Verma, 2005). A semantic Web service extends the capabilities of a Web service by associating semantic concepts to the Web service to enable better search, discovery, selection, composition and integration. Semantically rich languages, such as Web Ontology Language for Services (OWL-S) (Martin, Paolucci, McIlraith, Burstein, McDermott, McGuinness, Parsia, Payne, Sabou, Solanki, Srinivasan, & Sycara, 2005), have been created to provide a mechanism for describing domain concepts and the semantics of Web services as ontologies. Unfortunately, for the common developer, the learning curve for such languages can be steep, providing a barrier to widespread adoption.

Model Driven Architecture (MDA) (Miller et al., 2003) is an approach to software development centered on the creation of models rather than program code. The primary goals of MDA are portability, interoperability and reusability through an architectural separation of concerns between the specification and implementation of software. In MDA-based approaches, the focus is on creation of software via development of models specified using standard and widely adopted languages, such as Unified Modeling Language (UML).

We are developing an approach that allows a developer to focus on creation of semantic Web services and associated OWL-S specifications via development of a standard UML model. By using an MDA approach, the technique facilitates creation of descriptions of semantic concepts while hiding the syntactic details associated with creating OWL-S specifications. By using transformations from equivalent UML constructs, difficulties caused by a steep learning curve for OWL-S can be mitigated with a language that has a wide user base, thus facilitating adoption of semantic Web approaches.

One of the advantages of OWL-S is its flexibility in allowing the creation of many groundings or bindings for a single semantic Web service. As part of our method, we have developed an interactive approach for generat-

ing OWL-S groundings. In this approach, the semantic and architectural concerns associated with specifying semantic Web services can be performed by software and knowledge architects. The mapping of Web services described using WSDL to operations contained in the profile and process specifications are intended to be performed by developers of Web services as they are constructed, or by architects as they identify existing services that meet the intended behaviors of the semantic services.

This paper describes our combined approach for specifying OWL-S specifications through the use of model-driven architecture to describe OWL-S profiles and process models, and user interaction to describe OWL-S groundings. In addition, we describe an example that demonstrates the full approach, including partial verification of correctness using Protégé (Gennari, Musen, Fergerson, Grosso, Crubezy, Eriksson, Noy, & Tu, 2002). The remainder of this paper is organized as follows: First, the background section describes background information relevant to our research. Next, the specifics of our approach and the details of a conversion tool are presented. We then present an example demonstrating the approach, discuss related work and, finally, draw conclusions.

BACKGROUND

This section provides a brief description of Web services, ontologies and XML-based technologies referred to throughout the paper.

Web Services

A Web service is a modular, well-defined software component that exposes its interface over a network. Applications use Web services by sending and receiving XML messages over HTTP as shown in Figure 1. Web services provide the foundation for loosely coupled, service-oriented software systems. They allow multiple organizations to interact in a uniform, well-defined manner. This is a major step towards interoperability between multiple heterogeneous distributed systems.

Web service interfaces are defined using WSDL (Christensen et al., 2001). WSDL is

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