Chapter 4

An Algebra of Ontology Properties for Service Discovery and Composition in Semantic Web

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ABSTRACT

The authors address in this chapter the problem of the automated discovery and composition of Web Services. Now, Service-oriented computing is emerging as a new and promising paradigm. However, selection and composition of Services to achieve an expected goal remain purely manual and time consuming tasks. Basing our approach on domain concept definitions thanks to an Ontology, the authors develop here an algebraic approach that enables to express formal definitions of Web Service semantics as well as user information needs. Both are captured by the means of algebraic expressions of ontology properties. They present an algorithm that generates efficient orchestration plans, with characteristics of optimality regarding Quality of Service. The approach has been validated by a prototype and an evaluation in the case of an Health Information System.

INTRODUCTION

The number of available Web data sources and services has exploded during the last years. This enables users to access rich information in many domains such as health, life sciences, law, geography, and many other domain of interest. Thanks to this wealth, users rely more on various digital tasks such as data retrieval from both public and corporate data sources and data analysis with Web tools or services organized in complex workflows [Gao, 2005, Kinsi,2007]. However, human users have to spend uncountable hours to explore and discover Web resources that meet their requirements. In addition, in many cases, users need to compose a specific set of Web resources in order to fulfill a complex question. This situation is mainly due to the inability of present standards in capturing Web Service semantics, i.e. the precise meaning of what a given Web Service exactly delivers regarding a specific user context.

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Meanwhile, Service-oriented computing (SoC) is emerging as a new and promising computing paradigm that centers on the notion of service as the fundamental element for accessing heterogeneous, rich and distributed resources in an interoperable way [Roman, 2005]. Web services are self-describing components that support a rapid and significant reuse of distributed applications. They are offered by service providers, which procure service implementation and maintenance, and supply service descriptions. Service descriptions are used to advertise service capabilities, behavior, Quality of Service, etc. (UDDI, WSDL, OWL-S). Service descriptions are meant to be used by other applications (and possibly other services), and not only by humans. WSDL and UDDI are the basic standards used for Web Service capabilities descriptions and advertising. However, they focus on the description of interfaces and syntactic considerations.

So, at present, the development of powerful applications on the Web is still facing two major problems. The first one is related to the increasing difficulties of identifying services that perform a specific task. The second one concerns the difficulty to orchestrate and compose services in a smooth, automated, and, if possible, optimal way, regarding the Quality of Service (QoS). This is still very challenging for many reasons. The main raison is the present limited ability of languages and models to describe the semantic of Web Services, despite tremendous efforts driven by the semantic Web Services community [Roman 2005, Kopecki 2007, Martin 2007].

In order to increase the benefits gained from rich Web resources, it would be of the highest importance to express formal semantic descriptions of Web Services. Such descriptions are in fact the absolute requisite condition to enable assisted or automated selection of relevant Web Services, and generate meaningful compositions of them. In addition, *non functional aspects* such as QoS (performance, availability, …) should be taken into account at Services selection and for the generation of a composition plan. This remains at present challenging and hard issue.

BACKGROUND

Emerging infrastructures such as the Semantic Web [Berners-Lee, 2001], the Semantic Grid [Goble, 2005] and Service Oriented architectures [Roman, 2005], support on-line access to a large number of resources from data sources and Web services to knowledge representation models such as taxonomies and ontologies. Ontologies play an important role in the Semantic Web and provide the basics for the definition of concepts and relationships that make information integration possible. OWL-S is proposed as a way to express more detailed descriptions of Web Services via a provided ontology of Web Services. But it remains limited and fails in expressing what a Service really provides, although services should ideally export also their semantics.

The new Semantic Service-Oriented Architecture (SSOA) leverages rich, machine-interpretable descriptions of data, services and processes to enable software agents to automatically interact and achieve collaborative goals. The SSOA integrates the principles of Service-Oriented Computing with semantics-based computing, Typically, a Semantic Service-Oriented Architecture (SSOA) includes four layers: the *data* layer, the *resource* layer, the *ontology* layer, and the *community* layer, as depicted in figure 1. The *data* layer represents data published by Web resources, and the hyperlinks that interconnect theses data objects, for example PubMed publications or medical records stored in Google Health. The *resource* layer is comprised of Web resources and their links, Resources can be either data source, e.g., SwissProt which is a protein database, or a Web service, e.g., BLAST which is a bioinformatics Web-based alignment tool. In the case of a data source, a resource implements some concepts and individuals of the ontology level, while in the case of Web Services, they

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