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Review

Semantic web services: Standards, applications, challenges and solutions

Hassina Nacer [a,b,*], Djamil Aissani [c]

[a] Computer Science Department A/Mira University of Béjaia, Algeria
[b] Laboratory LIMED, Algeria
[c] Laboratory LAMOS University A/Mira of Béjaia, Algeria

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ABSTRACT

To share Knowledge coming from disparate and heterogeneous environments, we propose the use of semantic Web services to provide a common Knowledge format and meaning. Semantic Web services would require careful usage of combined technologies. On one hand, XML Web services technology because of their system agnostic nature and the ease of integration and, on the other hand, the semantic Web can define and link Web data in a way that it can be understood and used by software agents. This mixed technology may be a solution to functional interoperability, technical interoperabilty, semantic interoperability and flexible development in heterogeneous environments using the Internet as the main infrastructure. In this paper a survey of semantic Web services is realized to show that they ensure interoperability. Four aspects of Web services are presented: (1) Standards of XML Web services (eXtended Markup Language Web services) and their limits, (2) Languages and Tools of Semantic Annotation, (3) Web Services Composition, and (4) Performance Evaluation. Observations on some new challenges brought by semantic Web services are cited. Furthermore, a comparative study is presented, over the Internet and Intranet, based on numerical results using a discrete event between semantic Web services and distributed middleware, e.g. CORBA (Common Object Request Broker Architecture) and JAVA RMI (JAVA Remote Method Invocation).

Contents

* Corresponding author.
E-mail addresses: sino_nacer@yahoo.fr (H. Nacer), lamos_bejaia@hotmail.com (D. Aissani).

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1. Introduction

Globalization, cooperation and collaboration have substantially changed the software world and have contributed to the emergence of Knowledge sharing culture in open and large environments[1] (Beau et al., 2010; Sinderen, 2008). Actually, an individual human user cannot produce Knowledge and competencies but by collaboration with other human users and companies a rich source of Knowledge and competencies can be created. Thus, Knowledge representation becomes a central problem (Chein and Mugnier, 1992; Nonaka and Takeuchi, 1995; Davenport and Prusak, 1998; Gasmi et al., 2010). Knowledge should be used, shared, discovered and exchanged by any user (Human, Smart industrial device, Robot, Software agent, etc.) in heterogeneous and large environments. To solve the problem, a common format and meaning to represent a Knowledge is used. We refer to this design principle as "generic Knowledge". In order to realize, to represent and to save "generic Knowledge" over the Web, we propose the use of semantic Web services. These latter ones provide the necessary support by defining a standard mechanism for representing, publishing and locating Knowledge.

Semantic Web services would require a careful usage of combined technologies. On one hand, XML Web services technology because of their system agnostic nature, the ease of integration and communication and, on the other hand, the semantic Web can define and link Web data in a way that it can be understood and used by software agents. Semantics need to be introduced into the services so that functionalities can be identified on the meaning rather than on the syntax basis. Therefore, adding semantics enables structured information to be interpreted unambiguously. This mixed technology may be a solution for interoperability and flexible developments in heterogeneous environments (Mcllraith et al., 2001).

To address interoperability problems in some identified areas of research (e.g. Resource Sharing, Competence Sharing, Negotiation, Web Services Discovery, Web Services Composition, Web Services Security and Web Services Interactions, Benna et al., 2008; Boudries et al., 2008; Nacer-Talantikite et al., 2009; Gasmi et al., 2010; Niu et al., 2011; Syncar et al., 2002; Nacer-Talantikite and Aissani, 2010; Zhou et al., 2011), standards-based approaches have been proposed such as CORBA, JAVA RMI and XML Web services (Nester et al., 1999; Orfali and Harkey, 1997; Soley and Stone, 1995; Group, 1998; Yu et al., 2008; http://www.omg.org; http://JAVA.sun.com/j2se/1.4.2/docs/guide/rmi/index.html; http://www.WebServices.org; http://www.ws-i.org). However, as a new distributed computing infrastructure, XML Web services technology is an effective mechanism for data and application integration over the Internet. It is characterized by its openness, dynamics, and loose coupling. It provides good support for resources sharing and cooperative works in heterogeneous environments. In addition, the arrival of the semantic Web represents a revolution for Knowledge description and storage.

The semantic Web was defined by Lee et al. (2001) as an extension of the current Web in which Knowledge is given a well-defined meaning by using ontologies (Charlet et al., 2003; Perez et al., 2004; http://www.daml.org/ontologies). These latter ones play an essential role in interoperability because they provide structured vocabularies that describe a formal specification of shared conceptualization (Heflin and Hendler, 2000; Wache, 2001; Cruz and Xiao, 2003; Lin and Ding, 2005; Tsai, 2007; Gordon et al., 2011). Ontologies contribute to resolve semantic heterogeneity by providing a shared comprehension of a given domain of interest. Furthermore, the main challenge of interoperability and data integration is still ontologies matching. The work in semantic Web demonstrates how ontologies can be used to address interoperability problems at the application level. Specifically, ontologies have been used during discovery to express the capabilities of services, as well as the requests for capabilities. Ontologies are used to improve communication between any user by specifying the semantics of the symbolic apparatus used in the communication process. More specifically, Jasper and Uschold (1999) identified three major uses of ontologies: (i) to assist in communication between human beings, (ii) to achieve interoperability among software systems, and (iii) to improve the design and the quality of software systems.

Semantic Web services were introduced first by Mcllraith et al. (2001). Their goal was to provide a DAML-enabled agent programming capability that supports writing generic procedures for Web services-based task. And their vision was that agents will exploit users' constraints and preferences to help customize users' requests for automatic Web services discovery, execution, or composition and interoperation. But none of these ideas were entirely realized in 2001. However, these latter ones could be realizable nowadays. Semantic Web services can ensure interoperability at three levels regarding the most known distributed middleware proposed in the literature.

To our best Knowledge, there exist some research works, in the literature, that gave as overview containing several topics about Web services in the same paper in order to prove that Web services technology contributes to solve the problem of interoperability: Wang et al. (2004) studied four layers (Service Security, Service Composition, Service Semantic, and Grid Services) in order to show that Web services were designed to tackle the problem of integration of heterogeneous sources and make heterogeneous systems interoperable. However, Web services have shortcomings to fully satisfy the requirements of interoperability. Cardoso and Sheth (2005) discussed the Web process life cycle phases (Semantic Web Services Annotation, Semantic Web Services Advertisement, Semantic Web Services Discovery, Semantic Web Services Selection, Semantic Process Composition and Execution Web process). They showed that Web services promise universal interoperability and integration. The key to achieve this relies on the efficiency of discovering appropriate Web services and composing them to build complex processes. Dong et al. (2013) presented a survey of semantic Web Services matchmakers in order to obtain an overview of the state of the art in this research area and to show that Web services provide a standard means for the interoperable operations between electronic devices over the Internet. They summarized six technical dimensions from the past literature and analyzed the typical semantic Web Services matchmakers mostly developed during these years. Gayathridevi and Manikandan (2013) presented five layers (Standards, the Semantic Web, Representation of Semantic

[1] Large-scale virtual worlds like the Internet such as Pervasive networking environments and Internet.