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Supporting the semi-automatic semantic annotation of web services: A systematic literature review

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ABSTRACT

Context: Semantically annotating web services is gaining more attention as an important aspect to support the automatic matchmaking and composition of web services. Therefore, the support of well-known and agreed ontologies and tools for the semantical annotation of web services is becoming a key concern to help the diffusion of semantic web services.

Objective: The objective of this systematic literature review is to summarize the current state-of-the-art for supporting the semantical annotation of web services by providing answers to a set of research questions.

Method: The review follows a predefined procedure that involves automatically searching well-known digital libraries. As a result, a total of 35 primary studies were identified as relevant. A manual search led to the identification of 9 additional primary studies that were not reported during the automatic search of the digital libraries. Required information was extracted from these 44 studies against the selected research questions and finally reported.

Results: Our systematic literature review identified some approaches available for semantically annotating functional and non-functional aspects of web services. However, many of the approaches are either not validated or the validation done lacks credibility.

Conclusion: We believe that a substantial amount of work remains to be done to improve the current state of research in the area of supporting semantic web services.

Contents

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1. Introduction

Recently, the use of the web to convey services has become more and more attractive as a new paradigm for building software. W3C [52] defines a Web Service (WS) as "a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the WS in a manner prescribed by its description using SOAP-messages, typically conveyed using HTTP with an XML serialization in conjunction with other web-related standards." SOAP-WSs refer to the Service-Oriented architectural paradigm. Recently, RESTful WSs are gaining attention as a valid alternative to SOAP WSs, where the main paradigm moves from the concept of services to the one of resources (Resource-Oriented architecture) [14].

WSs are usually described only syntactically, so only the structure of the data is specified, but not the semantics. This introduces a set of problems such as integration inconsistencies [9] that can be partially addressed by the adoption of semantic WSs, which support the semantic description of their behavior. In the semantic WS paradigm, data become machine-readable and understandable. Semantic WSs can dynamically collaborate in processing data without losing their meaning. Ontology-based service description languages, such as OWL-S [50], WSMO [57] and WSDL-S [53], are typically used to describe WSs semantically. These different initiatives are often non-compatible ontology languages for semantically annotating WSs, and the different approaches exhibit different levels of formality. The more formal the description of the semantic WS, the more precise the automatic matchmaking can be.

This Systematic Literature Review (SLR) aims to identify possible challenges associated with semantically annotating WSs. The final objective is to provide the reader with the current state of the available technologies, ontology languages, and tools able to support the process of annotating WSs with semantically-enriched information for both functional and non-functional aspects. Functional annotation is concerned with tagging and enriching the specification of the functionalities exposed by the WS with semantic information, while non-functional annotation is concerned with marking up the specification of the service with SLA and QoS-related information. The SLR is not limited only to traditional SOAP WSs but also includes work related to REST and RESTful WSs. Moreover, the aim of this SLR is to understand whether there are ontologies that are much more used than others (de facto standards instead of de-iure standards).

We carried out a SLR according to the procedure outlined in Kitchenham and Charters [29]. Systematic literature reviews provide a precise methodology to analyze in a comprehensive manner the state-of-art and related literature of specific topics, and they are widely used by researchers in the medical domain (e.g., the Cochrane reviews [2]). Recently, SLRs were adopted in software engineering research [28] to address specific topics related to the software engineering research area. Specifically, SLR is a form of secondary study [29] that uses a well-defined methodology to identify, analyze, and interpret all available evidence related to specific research questions in a way that is unbiased and repeatable (to a degree). A SLR [28] is "a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest.