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Review article

Semantic Web Services testing: A Systematic Mapping study

João B. de Souza Neto [a,*], Anamaria M. Moreira [b], Martin A. Musicante [a]

[a] Department of Informatics and Applied Mathematics (DIMAp), Federal University of Rio Grande do Norte (UFRN), Natal, Brazil
[b] Department of Computer Science (DCC), Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil

HIGHLIGHTS

- A systematic mapping study focused on testing initiatives for Semantic Web Services.
- 43 primary studies are mapped into a classification scheme that covers the main topics and techniques for the area.
- Results show the main goals and issues addressed by the testing initiatives and techniques applied.
- Evidence on the maturity of the area, trends and research opportunities are shown.

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ABSTRACT

A Semantic Web Service (SWS) is a web service attached with a description that defines its semantic in a computer-interpretable language. This semantic description plays an essential role in the automation of tasks in the web services lifecycle and fills a semantic gap existing in the standard web service technologies. Like any software, an SWS needs to be tested to ensure a certain level of quality. The semantics also plays an important role in the testing process since it can be used as input for testing activities such as the design of test cases and the definition of oracles. In this context, this paper aims to identify and characterize the existing testing initiatives for SWSs by conducting a Systematic Mapping. A rigorous process was followed by defining research questions, conducting a search for primary studies in scientific databases, selecting papers according to pre-defined criteria and analyzing the papers to answer the research questions and to identify trends and gaps in the area. As a result, a total of 43 papers were selected and analyzed concerning a defined classification scheme that reflects the area. The analysis showed the primary goals and issues addressed by the initiatives, the testing techniques applied, evidence on the maturity of the area and trends.

Contents

* Correspondence to: DIMAp, UFRN, Campus Universitário, Lagoa Nova, 59078-970, Natal, RN, Brazil.
E-mail addresses: jbsneto@ppgsc.ufrn.br (J.B. de Souza Neto), anamaria@dcc.ufrj.br (A.M. Moreira), mam@dimap.ufrn.br (M.A. Musicante).

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1. Introduction

Semantic Web Services (SWS) are web services whose properties, capabilities and behaviors are semantically-defined in a computer-interpretable language [1]. Semantic Web Services attach a semantic layer to traditional web services and can be seen as contracts that must be obeyed by both the service provider and service requester. It fills a semantic gap existing in the standard technologies for web services (WSDL, UDDI, and SOAP [2]). Semantics plays a fundamental role in the automation of tasks in the web service lifecycle [3], such as discovery, execution, and composition, because the standard technologies do not provide enough information to automate these tasks [4].

The activity of *testing* is an essential task in the development of any software application [5]. In particular, testing web services is more challenging than testing traditionally developed systems due to the complex nature of web services, such as dynamic runtime capabilities, and the limitations that occur due to the nature of Service-Oriented Architecture (SOA) [6]. Also, limitations arising from standard web service technologies, such as WSDL, impose other challenges in web service testing because tests are generated based on syntactic information only [7]. In this context, SWS present the advantage of having a defined behavior that may be used as a reference to the generation of tests.

Previous works [8–10] have investigated the area of SWS testing and the role of semantics in web service testing. They have found a limited number of works and have concluded that the area is still immature, due to the lack of works adequately validated and a limited tool support. In this paper, we continue to explore the area to (i) produce a more up-to-date view of the subject; (ii) discover which subjects appear most frequently in the literature; and (iii) identify trends and perspectives for future research.

In this context, we performed a Systematic Mapping (SM) [11] to identify and characterize the existing testing initiatives for Semantic Web Services. An SM is a type of literature review that aims to map out and categorize the existing literature on a specific topic, identifying trends and gaps in the area of study [12]. An SM differs from a Systematic Review (SR) by not trying to identify the best work in the area based on quality criteria, but it focuses on the classification and analysis of the papers to find directions [13], not needing to analyze papers in depth as it is done in an SR. We considered that an SM is more adequated for our purposes because it has been recommended for research areas where there is a lack of relevant and high-quality primary studies [11], something that has been confirmed by other works that investigate the area [8–10].

The remainder of this paper is organized as follows: Section 2 gives the background on Semantic Web Services and Software Testing and presents some related work; Section 3 describes the Systematic Mapping process and explains our research questions, search conduction, paper selection, classification, and data extraction; Section 4 presents an analysis of the results and shows charts to illustrate them, and provides answers to the research questions; Section 5 discuss some threats to the validity of this work; Lastly, Section 6 presents conclusions.

2. Background

2.1. Semantic Web Services

Traditional Web Services (WS) are self-contained, modular applications, accessible via the Web. WSs provide a set of functionalities [14] and allow a dynamic integration of different software applications being one of the standards distributed computing technologies [4]. WSs are standardized by WSDL, UDDI, and SOAP [2], that allow them to be described, discovered and invoked, respectively. Additionally, web services can be composed with the objective of providing a more complex functionality, using orchestration technologies such as BPEL [15].

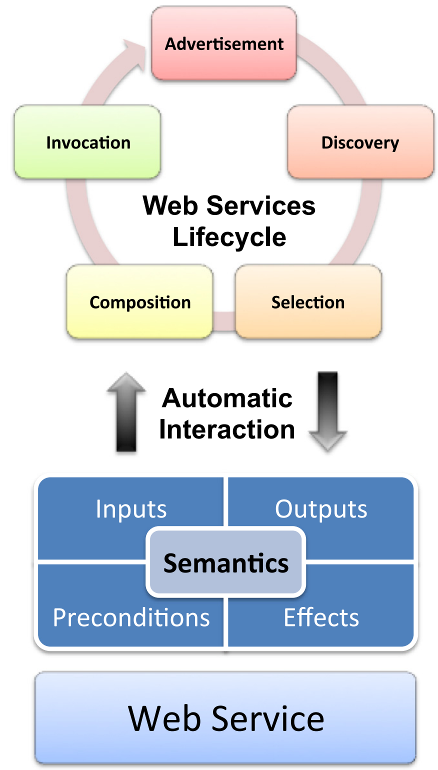

Fig. 1. The role of Semantic Web Services in the Web Services Lifecycle.

The set of web service standards was designed to describe *how* a web service can be used. However, these technologies are limited when the concern is to explain *what* the behavior of a service is since they do not describe the semantics [4]. This limitation precludes some of the desires of the web service community, concerning automatic discovery, execution, composition, and interoperation of web services. Semantics plays an important role in achieving these goals since a service requester may not be able to find a suitable service only by looking at syntactic information, due to the absence of interface patterns [4]. A semantic layer is necessary to help overcome these differences [3].

In this way, a Semantic Web Service (SWS) is a web service whose properties and capabilities are described in an unambiguous, computer-interpretable language [1], working as a contract that describes the behavior of the web service. Attaching a semantic layer to the web service has an essential role in the automation of tasks in its lifecycle and fills a semantic gap existing in the standard web service technologies, which is represented in Fig. 1. The semantics commonly brings information about inputs, outputs, preconditions, and effects (IOPE) of the web service. In this context, many efforts have applied concepts from Semantic Web [16], such as ontologies, to bring semantics to web services [4]. Some of the most popular initiatives are *OWL-S* [17], *WSMO* [18] and *WSDL-S* [19].

The Ontology Web Language for Services (OWL-S) [17] is an ontology based on OWL [20] that makes it possible to describe the