A literature survey on the performance evaluation model of semantics enabled web services

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Abstract: Semantically annotating web services is gaining lots of attention as a significant area to support the machine-driven matchmaking and composition of web services. Therefore, the support of ontologies and tools for the semantic annotation of web services is turning into a key concern to assist the dissemination of Semantic Web services. The target of this literature review is to summarise the progress of the annotation of web services and additionally the state-of-art of the performance analysis of such annotated services by providing answers to connected analysis queries. The review identified approaches offered for semantically expanding upon functional and non-functional aspects of web services. However, many of the approaches are either not valid or the validation done lacks quality. It is to be believed that a substantial amount of effort remains to be done to realise the state of research in Semantic Web services and in evaluating the performance of them.

Keywords: ontologies; web services; Semantic Web services; SWSs; functional and non-functional aspects; systematic literature review.

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1 Introduction

The W3C defines a web service (WS) as "a software system designed to support interoperable machine-to-machine interaction over a network". It's an interface described during a machine-processable format by means of WSDL. Different systems move with the web services in a manner prescribed by its description using SOAP-messages, generally conveyed using HTTP with an XML publication in conjunction with different web-related standards. SOAP-WSs agree with the service-oriented discipline paradigm. Recently, RESTful web services are gaining attention as a legitimate alternative to SOAP WSs, where the main paradigm moves from the idea of services to the one of resources based on resource-oriented architecture (Duggan, 2012). Web services are typically delineated solely syntactically, thus only the structure of the info is given, however not the semantics. This introduces a collection of issues like integration inconsistencies (Denaro et al., 2009) which will be partly addressed by the adoption of semantic WSs that support the semantic description of their behaviour. Within the semantic WS paradigm, information becomes machine-readable and perceivable. Semantic WSs will dynamically collaborate in the process information while not losing their meaning. Ontology-based service description languages, like OWL-S (Martin et al., 2012), WSMO (de Bruijn et al., 2005) and WSDL-S (Akkiraju et al., 2005), are generally used to describe WSs semantically. These completely different initiatives are usually non-compatible ontology languages for semantically annotation WSs and also the completely different approaches exhibit different levels of formality.

The literature review aims to explore the potential challenges associated in evaluating the performance of semantically annotated web services throughout its life cycle. The motive is to give the reader with the state of the art offered technologies and ontology languages able to support the method of annotation WSs with semantically-enriched data for each functional and non-functional aspect and measure the performance of such annotated web services throughout its life cycle. Functional annotation is bothered with tagging and enriching the specification of the functionalities exposed by the WS with semantic data, whereas non-functional annotation is bothered with marking up the specification of the service with SLA and QoS related info. The review isn't restricted solely to ancient SOAP WSs however additionally includes work associated with REST and RESTful WSs. The application of semantic WSs in industrial domains continues to be not pervasive, so it is vital to identify offered implementations of semantic WSs which will be used as starting point to favour the spread of this type of technology. In our survey, we apply a proper and precise approach to conduct the analysis of the offered state-of-the-art within the most comprehensive means and we mainly focus in implementation and performance of annotation evaluation aspects.

The remainder of this paper is organised as follows. Section 2 provides background information on two leading semantic WSs initiatives and the requirement of a generic evaluation model. In Section 3, we discuss the motivated research questions to be

answered. Section 4 discusses the literature review done for 35 research papers. In Section 5, the results of survey are discussed and directions for future research are proposed. Finally, we conclude in Section 6.

2   Background

There are two major initiatives within the area of semantic WSs, particularly WSMO and OWL-S. WSMO could be a modelling ontology supported by the WSMF framework that addresses the complete life-cycle of WSs, ranging from WS discovery to WS mediation and integration. The WSMO ontology formally describes varied aspects of semantic WSs. Within the WSMO abstract model for semantic WSs, WSs are represented explicitly in terms of their functional and non-functional properties and their interfaces using WSMO in a method that enables for automatic discovery, selection, composition, mediation, and execution of the WSs. The components of a WSMO web service are: Capability that describes the functionality of the web service; Interfaces that describes how the web service achieves its capability by means of interactions with its users (choreography) and by using different WSs (orchestration). WSMO follows a goal-based approach during which the user defines her/his goals by explicitly expressing her/his necessities on the WSMO WSs. The WSMO framework discovers the appropriate services by automatically matching user goals to the semantically represented capabilities of the available WSs. If necessary, the framework uses Mediators to handle interoperability issues or Orchestration that automatically combines services based on their capabilities to satisfy user goals.

In WSMO-Lite (Fensel et al., 2010) a lightweight version of WSMO, the process of annotating WSs is based on five levels of annotation, from A1 to A5:

- Annotation A1: Ontological annotations of XML schema to carry reference annotations linking to WSDL classes from the service information model ontology.

- Annotation A2: Transformation annotations of XML schema to transform data between its semantic model and the service-specific XML message structures.

- Annotation A3: Functional annotations of WSDL interface and service to reference a service with its appropriate functional descriptions (both capabilities and categories).

- Annotation A4: Functional annotations of WSDL interface operations to reference interface operations with functional descriptions (both capabilities and categories) in order to indicate their particular functionalities.

- Annotation A5: Non-functional annotations of WSDL service to reference a service component with its appropriate non-functional properties.

Similar to WSMO, OWL-S provides another specification to explain WSs semantically. OWL-S WSs are represented in terms of three components, as follows. Service model in the main describes the management flow of the service process model. In addition, it provides a method for the automated composition and invocation of WSs. Service profile describes the capabilities of the service together with a functionality and quality of service parameters. Service grounding provides a mapping of the semantic description to the syntactically represented implementations of WSs in WSDL. It additionally specifies communication protocols, transport mechanisms, and message format. OWL-S WSs are

discovered by referencing their capabilities represented in the service profiles. If no single service matches the requested user service, the process Model describes how an automatic composition of various services supported their semantics can be achieved to satisfy the request.

2.1 Requirements for a generic evaluation model

This section describes the requirements that are expected to be in the performance analysis model so as to form it effective and usable to judge the semantic technologies, particularly Semantic Web services (SWSs). These requirements are particularly openness, tools independent, conciseness, preciseness, completeness, based on classical issues, usage of various quality levels, usage of common benchmarking, and versatile enough to permit remote communication so setting the subsequent queries based on totally different performance engineering aspects:

- How to explain the performance and resource consumption characteristics of services/components in a very advanced SWSs architecture?

- How to capture the performance and resource consumption characteristics in an automated approach with marginal overhead?

- How to derive benchmarking applications for SWSs and describe resource necessities in a very hardware independent way?

It is to be noted that the performance engineering aspects of the analysis model don't seem to be simply performance with reference to time (i.e. time taken in semantic matchmaking of services), however to spot all potential aspects that are necessary to be thought of within the analysis of SWSs itself and applications designed on top of it. The proposed analysis model relies on two major aspects, i.e.

- life cycle of SWSs

- the crucial factors of evaluation.

The crucial factors do not seem to be simply thought of on the SWSs as a whole, however may also be applied to every and each step within the lifecycle of SWSs for the sake of insights within the analysis. The subsequent matrix in Table 1 offers you a deeper insight into the analysis factors to be thought of for a productive implementation and efficient performance of SWSs as per their life cycle stages.

3 Research questions

Having understood the different stages in the life cycle as depicted in Table 1, defining research questions for the same is an essential part of a systematic review, as they drive the entire survey methodology. To achieve the objectives of this survey, we identified the following research questions.

- Are there available real time implementations for the complete life cycle of semantics enabled WSs, that use ontologies and semantic languages?

- Are there tools available to evaluate the performance of semantics enabled (using ontologies) web services throughout its life cycle as per the above performance matrix?

Table 1   Performance matrix of SWS life cycle

	Service discovery S1	Service selection S2	Services composition S3	Service mediation S4	Service choreography and orchestration S5	Service invocation S6	External communication S7	Internal execution management EM = (S1 + S2 + S3 +….S7) S8	Overall execution time T S9
Response time C1	C1 for S1	C1 for S2	C1 for S3	C1 for S4	C1 for S5	C1 for S6	C1 for S7	C1 for S8	Response time for overall execution
Resource consumption C2	C2 for S1	C2 for S2	C2 for S3	C2 for S4	C2 for S5	C2 for S6	C1 for S7	C1 for S8	
Resource availability C3	C3 for S1	C3 for S2	C3 for S3	C3 for S4	C3 for S5	C3 for S6	C1 for S7	C1 for S8	
Service availability C4	C4 for S1	C4 for S2	C4 for S3	C4 for S4	C4 for S5	C4 for S6	C1 for S7	C1 for S8	
Meaningfulness of results C5	C5 for S1	C5 for S2	C5 for S3	C5 for S4	C5 for S5	C5 for S6	C1 for S7	C1 for S8	
Correctness of results C6	C5 for S1	C5 for S2	C5 for S3	C5 for S4	C5 for S5	C5 for S6	C1 for S7	C1 for S8	
Completeness of results C7	C7 for S1	C7 for S2	C7 for S3	C7 for S4	C7 for S5	C7 for S6	C1 for S7	C1 for S8	
Consistency of results C8	C8 for S1	C8 for S2	C8 for S3	C8 for S4	C8 for S5	C8 for S6	C1 for S7	C1 for S8	
Degree of decoupling C9	C9 for S1	C9 for S2	C9 for S3	C9 for S4	C9 for S5	C9 for S6	C1 for S7	C1 for S8	

4 Literature review discussion

The following paragraphs summarise each of the primary studies that address our research questions.

- 'Automated discovery, interaction and composition of Semantic Web services ' (Sycara et al., 2003):

  In this paper is reported an example of ontology for describing semantic WSs: DAML-S. DAML-S will be used to support capability matching and manage interaction between completely different WSs. The paper additionally discusses DAML-S service profile to explain functional and non-functional capabilities of a service. Moreover, the DAML-S method model is given to convey a lot of careful description of the web service. Finally, the paper presents a comparison between a web service fully supported XML and a web service implemented using ontology, discussing advantage and drawbacks of every alternative. An outline of the approach implementation is given (DAML-S virtual machine).

- 'A flexible approach for ontology matching' (He et al., 2004):

  In this article, the ontology matching approach (SGOM) is given. This approach uses a specific kind of graph, (change weights semantic graph) to favour the automated matching of ontologies. Performing in this manner of representing data, SGOM is in a position to search out similarities in unvaried computation, probing for similarity between totally different graphs. The most adopted approaches for detecting similarities are: semantic correspondences inside components and also the edit distance. The article demonstrates the effectiveness of using the projected ontology matching approach to search out analogies between totally different structures of information.

- 'Meteor-s web service annotation framework' (Patil et al., 2004):

  In this article, is showed an annotation framework able to catalogue four options of a web service: information semantics, functional semantics, execution semantics and QoS semantics. The authors apply a way for implementing and matching each part with the correspondent category. The approach uses graphs to induce relationships and completely different mathematic formulae to induce a measurement of the accuracy reached. The approach is valid against an existent project to validate the standard of the approach.

- 'Bringing semantics to web services: the OWL-S approach' (Martin et al., 2004):

  This study presents OWL-S and a few tools, technologies and few analysis directions in it. The structure of OWL-S and the way it should be accustomed specify inputs, outputs, preconditions, and results are provided. Moreover, some samples of OWL-S syntax are given. A list of tools and extensions that supports OWL-S is additionally provided.

- 'Annotation, composition and invocation of Semantic Web services' (Agarwal et al., 2004):

  This paper presents the OntoMat-Service framework that trades off between having a fairly straightforward user interface for WSs and therefore the complexness of an online service work flow. A case study to grasp all the aspects, that characterise the OntoMat-Service, is given throughout the paper.

- 'Benchmarking ontology-based annotation tools for the Semantic Web' (Maynard, 2005):

  In this article, there's an analysis of ontology-based annotation tools, specialising in totally different points like expected functionality. as an example, given a corpus of text and an existing ontology, it ought to be ready to produce semantic data by populating the texts with instances from the ontology. The paper focuses on interoperability aspects (i.e., outlined as the capability of being combined with alternative tools and systems), usability (i.e., evaluated as a crucial feature in industrial production), accessibility (i.e., the chance for everybody to use the tool), quantifiability, and reusability. The study evaluates performance and examines the exchange between the extent of automation acquired and therefore the quality of the output.

- 'An automated WSDL generation and enhanced SOAP message processing system for mobile web services' (Cheol Park et al., 2006):

  In this paper, a framework to automatically generate WSDL services ranging from HTML/XML services is discussed. The study proposes additionally some way to boost potency of SOAP WSs by optimising the SOAP processing and by removing the web Servlet container (i.e., Tom-cat). An in depth validation of the approach is mentioned.

- 'Automated Semantic Web service discovery with OWLS-MX' (Klusch et al., 2006):

  This paper discusses a hybrid OWL-S service matchmaker system called OWLS-MX. OWLS-MX exploits both logic-based reasoning and content-based information retrieval techniques for OWL-S service profile I/O matching. The experimental validation of OWLS-MX shows that under certain constraints this way of matching can outperform logic based only approaches. OWLS-MX is offered as a Java component.

- 'A manufacturing system engineering ontology model on the Semantic Web for inter-enterprise collaboration' (Lin and Harding, 2007):

  In this article, the ontology MSE is given. This ontology permits making a novel dictionary for info, which may be used from every company. The advantage of this approach is that data is simply shared. The beginning effort should be to create and use an equivalent vocabulary to classify information. The paper analyses the difficulties in creating a common-shared dictionary, however additionally highlights the simplicity that follows in creating applications for human interaction. The problem conferred is to normalise the used terms in every business-company that may be a manual operation that has got to be done, however after this section the

benefits of using an equivalent approach of representing info would be important. Finally this article discusses the utilisation of the given ontology, its capabilities and also the advantage that it'll herald info exchanging between enterprises.

- 'OWL-Q for semantic QoS-based web service description and discovery' (Kritikos and Plexousakis, 2007):

This paper introduces an extensible ontological specification referred to as OWL-Q to semantically annotate WSs with QoS and non-functional aspects. OWL-Q is an extension of OWL-S for QoS-based WS description of requests and offers. The authors conjointly discuss their semantic framework for QoS-based web Service description and discovery.

- 'SA-REST and (S) mashups: adding semantics to restful services' (Lathem et al., 2007):

This paper introduces the SA-REST annotation technique for restful services. In SA-REST, semantic annotations are embedded using the micro format technology projected by RDFa into the web page that describes the service, therefore creating the page both human and machine readable and making a single place to form an update if the service changes. A proper submission to W3C is made available online with a tool to annotate restful services is enforced.

- 'Ontology-based software engineering-software engineering 2.0' (Dillon et al., 2008):

This paper starts with explaining about ontologies their functionality and for what purpose they will be used as an example, to urge a robust mechanism to speak on the net, to mediate completely different information on the net, or to urge a definite definition of a keyword. Then, the paper discusses the relationships between ontologies and the semantic WSs. In effect, the paper reports on an alternate way to see ontologies to the end of engineering with reference to semantic WSs. The paper suggests the utilisation of ontologies and sub-ontologies additionally for the development phases associated with the elicitation of software necessities, s/w design, s/w construction and testing. Some examples of domain ontologies often used are listed, like ontology based multisite software development and ontology mediated information access.

- 'WSMO-Lite annotations for web services' (Vitvar et al., 2008):

This paper describes the development of WSMO-Lite, minimal light-weight ontology for semantic WSs, built on the newest W3C standards. WSMO-Lite fills in SAWSDL annotations, and therefore permits the semantic Service Stack, open for numerous customisations consistent with domain-specific necessities. an example that helps to grasp the syntax of the framework is given.

- 'hRESTS: an HTML microformat for describing restful web services' (Gomadam and Vitvar, 2008):

This article explains hRESTS: a machine-readable web API and service descriptions that has the privilege of providing a machine-readable illustration of common web service and API descriptions. It uses some html components, like class and rel

attributes. hRESTS micro format definitions and the way they have to be used is explained.

- 'Automatic annotation of web services based on workflow definitions' (Belhajjame et al., 2008):

This paper explores the repositories of trusty data-driven workflows as an extra source of data concerning semantic annotations. A workflow could be a set of service operations connected together using knowledge links. The advancement describes however the outputs of the operations are to be fed into the inputs of others and it assures the compatibility among parameters. The paper considers the semantic annotation developed in the project to discover parameter mismatches and it's primarily based upon three distinct OWL-based ontologies, i.e., domain, representation and extent ontologies to explain the various aspects of parameter semantics. A group of algorithms for the annotation and an annotation system are provided and a model annotation tool is mentioned. The tool provides developers with three main functionalities:

1   an annotation editor to launch the annotation derivation process

2   a panel to point out the ensuing annotations

3   an ontology explorer to look at the fragments of the ontology indicated by a loose annotation and to convert the loose annotation into a good one.

- 'Semantic Web service offer discovery for e-commerce' (Kopecky and Simperl, 2008):

This paper discusses a solution WSMO-Lite based for offer discovery based on the automation of service discovery to retrieve the set of services that best fit the users' needs. The proposed algorithm for offer discovery is instantiated on the semantically annotated 'hotel web service' to demonstrate the applicability and relevancy of the approach.

- 'Ontology matching with semantic verification' (Jean-Mary et al., 2009):

In this work, ontologies are the fulcrum of this study. The study presents an algorithm for ontology-matching (called ASMOV) written as a Java application. The foremost vital issue is that the scientific approach concerned, uses lots of mathematic formulae, with a high degree of issue, to urge a correct verification and validation of the ontology-matching algorithm. In the final half, authors show that the result reached may well be increased, especially for the performance and for the capabilities of the algorithm.

- 'Automatic web services generation' (Cho et al., 2009):

In this study there's the design and also the development of a service generator toolkit that enables WSs researchers to develop WSs with less effort. The beginning section of the creation of the toolkit relies on the generation of a graph, distinguishing the relation between a group of services, operation done and parameters required in input and output. Giving work done to a Java RPC service exporter we are able to get a feasible web service. The service generator toolkit additionally supports the outline of SWS. The test of the obtained web service is

completed using Java RPC J unit test explorer. Using this pipeline of operators, authors demonstrated that it's attainable to make mechanically an SWS.

- 'Semantic annotations for web services discovery and composition' (Talantikite et al., 2009):

In this paper, a model of semantic annotations for WSs discovery and its Composition is given. The projected approach uses an inter-connected network of semantic WSs represented in OWL-S by using the outputs and inputs similarity measure between ideas based on an ontology designed before submitting requests. There are several different ways to proceed and to model information that is explained within the article, for example petri nets, the Roman model, approach based on the exchange of messages. Authors show the benefits of their work, showing that reply time is reduced by using semantic annotations.

- 'SAWSDL-MX2: a machine-learning approach for integrating Semantic Web service matchmaking variants' (Klusch et al., 2009b):

This paper introduces SAWSDL-MX2, an extension of a previous matchmaker tool that integrates the structural comparison of WSDL descriptions with a tool to support semi-automated web service integration. SAWSDL-MX2 uses a support vector machine (SVM) to train a nonlinear aggregation function based on training data, instead of integrating all variants. SAWSDL-MX2 is experimented and clearly outperforms all other previous similar approaches.

- 'OWLS-MX: a hybrid Semantic Web service matchmaker for OWL-S services' (Klusch et al., 2009a):

The paper extends introduces OWLS-MX2, an extended version of OWLS-MX. The version OWLS-MX2 integrates syntactic similarity-based matching with logic-based subsumes and plug-in matching like the hybrid subsumed-by filter in OWLS-MX to avoid false-positives. OWLS-MX2 outperforms OWLS-MX and performed slightly better than text IR by avoiding syntactic similarity-based only false positives. The matchmaking process is supported by a set of tools and working examples that include the annotation process.

- 'Towards WSMO ontology specification from existing web services' (Bouhissi et al., 2009):

This article tries to clarify a new way to develop ontologies starting from existing WSs. It describes a reverse engineering method to extract info from a WSDL file of an existing web Service so as to make web service ontology in line with the WSMO abstract model. The approach is split into three main phases: extraction, analysis, and translation part. Through an example of a use case during which all the technical problems are treated and resolved.

- 'ASSAM: a tool for semi-automatically annotating Semantic Web services' (Yang and Liu, 2009):

In this paper, a tool referred to as ASSAM is represented. ASSAM will create semantic annotation of WSs just by employing a graphical program. ASSAM uses an algorithm ready to recommend the ontological category required to annotate every

component within the WSDL description. The paper explains additionally the machine learning algorithm that stands behind the application.

- 'Implementation issues for automatic composition of web services' (Zuniga et al., 2010):

  In this paper, an approach to induce an automatic composition of WSs is projected; employing an explicit design and so there's an implementation issue section. Every part of the design is explained with the outline of activities and input and output parameters required. A case study of an air company is additionally mentioned.

- 'RESTful web services for service provisioning in next-generation networks: a survey' (Belqasmi et al., 2011):

  In this article, there's a brief clarification of what REST WSs are and how are they created. There's additionally a table reporting variations between actions created with communications protocol instead of with a client-server design. An example is given and refers to an application that may manage conferences, called Parlay-X multimedia conference. In this study, authors analysed what's the state-of-art concerning standardisation efforts and a few non-standard points. The paper highlights that REST WSs have still some points to be investigated like service publication and discovery.

- 'Semantic annotation for web services based on DBpedia' (Zhen et al., 2013):

  This paper proposes an automated approach to semantic annotation for inputs and outputs of WSs based on the DBpedia knowledge base. By taking advantage of the cross-domain ontology, WSs can be annotated without classification and time-consuming construction of the service-oriented ontologies. The paper discusses also an evaluation framework in accordance with the annotation approach and it reports on the framework applicability to semantic annotation for a number of publicly available WSs.

- 'A provenance-based approach to Semantic Web service description and discovery' (Narock et al., 2014):

  This paper extends the Wroe's suite of DAML + OIL ontologies through the creation of a new ontology primarily based in provenance research and current Semantic Web standards. This ontology focuses on the history and explanation behind a web service by reusing several concepts from data provenance: the historical lineage (e.g. the steps that occurred) and the ability to describe how the service operates (e.g., applications, methodologies, and settings) to provide justification for why a service returns the results that it does. The paper shows how this ontology can be linked to SAWSDL.

- 'WSMO-Lite and hRESTS: lightweight semantic annotations for web services and restful APIs' (Romana et al., 2015):

  The paper discusses about WSMO-Lite, light-weight ontology of web service semantics that deals with four semantic aspects of services: function, behaviour, information model, and non functional properties. With the WSMO-Lite ontology, SAWSDL descriptions enable semantic automation beyond easy input/output

matchmaking that's supported by SAWSDL itself. To enrich the reach of WSMO-Lite and SAWSDL tools to restful services, the research work adds hRESTS and Micro WSMO, two HTML micro formats that mirror WSDL and SAWSDL within the documentation of restful services, enabling RESTful services with WSDL-based ones in a single semantic framework. To demonstrate the feasibility and flexibility of this approach, the paper presents algorithms for service discovery and composition tailored to WSMO-Lite.

- 'Research on Semantic Web service composition based on binary tree' (Mao et al., 2015):

  The paper proposes a SWS composition method based on the concepts of binary tree to solve the problem of low efficiency and accuracy of service composition and service discovery. The method uses the ontology semantic reasoning relationship and binary tree theory to composite web services. The composition relations between web service interfaces are mainly considered to form composite services with large granularity. The approach enhances the efficiency and accuracy of service composition, and the experiments are used to validate and analyse the proposed methods. It also discusses how to find the atomic services and set services which can be composited accurately and efficiently according to user's request. Finally, it uses experiments to validate the proposed methods.

- 'A novel lifecycle framework for Semantic Web service annotation assessment and optimization' (Chen et al., 2015):

  The paper presents a novel lifecycle framework aiming at quality of semantic annotation (QoSA) assessment and optimisation. Semantic annotation plays an important role for semantic-aware web service discovery, recommendation and composition. However, the QoSA is largely overlooked despite of its significant impact on the effectiveness of semantic-aware solutions. Moreover, improving the QoSA is time-consuming and requires significant domain knowledge. In order to facilitate this process, the authors have presented a four-phase annotation lifecycle framework to assist annotators in evaluating and improving the QoSA, including semantic annotation, annotation quality assessment, annotation optimisation and semantic-aware usage. The QoSA is formally defined as the success rate of web service invocations, associated with a verification framework. Based on a local instance repository constructed from the execution information of the invocations, a two-layer optimisation method including a local-feedback strategy and a global-feedback one is proposed to improve the QoSA.

- 'Automatic composition of Semantic Web services based on fuzzy predicate petri nets' (Cheng et al., 2015):

  The paper deals with an automatic web service composition technique with both input/output compatibility and behavioural constraint compatibility of fuzzy semantic services. First, user input and output requirements are taken as a set of facts and a goal statement within the horn clauses, respectively. A service composition drawback is remodelled into a horn clause logic reasoning problem. Next, a fuzzy predicate petri net (FPPN) is applied to model the horn clause set, and T-invariant technique is used to work out the existence of composite services fulfilling the user

input/output requirements. Then, two algorithms are discussed to get the composite service satisfying behavioural constraints, as well as to construct an FPPN model that enumerates the calling order of the chosen services.

- 'RESTful service composition at a glance: a survey' (Garriga et al., 2016):

In this paper, they have given a survey of recent proposals in the field of restful service composition. They have used two sets of options to investigate, compare and contrast current composition approaches. Their survey exposes that RESTful services still suffer from shortcomings on semantically describing, finding and composing services with the absence of a holistic framework covering the whole service life cycle. The main reason for these problems is that the lack of an agreed standard to materialise restful services and compositions. None of the projected approaches or their satellite languages has gained broad support to this point. Consequently, it's expected that analysis efforts within the area can concentrate on addressing these problems that are so crucial for the success of RESTful services and compositions.

- 'Ontology-based open API composition method for automatic mash-up service generation' (Il Kim and Kim, 2016):

In this paper, the authors have projected an open API ontology modelling and composition technique as a key technology for automatic mash-up service generation. Two types of open API ontology are modelled for the REST open API and for the JavaScript-based open API. The work classifies open APIs based on the output format of relevant APIs. Open APIs whose output format is outlined as XML, JSON, atom types are classified into Base APIs whereas alternative open APIs are classified into Main Apis. And, the projected composition technique in this paper divides open APIs into many parameter groups, each providing same function respectively. Once a base API is chosen by user for mash-up, a main API is selected among those whose parameter belongs to same parameter group with the parameter of base API. After a main API is chosen, similarity comparison test is performed so as to ascertain the compatibility between method parameters of both APIs. If the compatibility is verified, then mash-up between base and main APIs may be created automatically using method parameters.

- 'May the ontologies be with you! Towards a user-friendly web-based editor for Semantic Web service description' (Blakowski and Brune, 2016):

In this paper the author has proposed and evaluated an approach for a web-based editor for holistic web service descriptions together with the underlying service description language based on OWL-S. The feasibility of the approach was demonstrated by a first evaluation using a fictitious test service. The described editor in principle allows end users to describe web services using an elementary interface providing guidance and help. In addition, the approach needs further empirical evaluation with more realistic scenarios, multiple users and real world case studies. However, the presented approach provides a first step towards using ontologies for service descriptions in practice on a broader scale.

- 'A semantic selection strategy for composite web services based on conforming objects' (Boustil et al., 2016):

  In this paper, the authors have presented a semantic selection approach for the purpose of the composition which locates dependant services by considering the relationships between their related objects described in OWL DL ontology. Services are classified into specialised communities and user constraints are imposed on the related objects of the requested abstract services allowing inference of conforming objects. Only services which are related to conforming objects are identified by generating and executing SPARQL queries. So, using OWL DL ontology for Web service description which relates concepts of community, abstract service, provided service and their related objects by using description logic axioms, the work proposes a semantic selection strategy for optimisation selection to reduce the number of composed services and to select only the best conforming composite services.

5 Discussion and future directions

The study of survey papers addressing the research questions shows that the researchers focus is mainly related to the definition of new ontologies and tools, instead of the real time implementation of semantic WSs, thus keeping the discussion at an abstract level that does not help the wide implementation of these technologies. Figure 1 illustrates this fact as the survey reviewed the research articles published during the last 15 years. As the attention of the research world is still active and the research field is mature enough (even if the focus is moving from SOAP to REST-based services and to micro-formats for describing them), it is necessary to start filling the gap with the industrial world by implementing real cases of adoption of semantic WSs and provide benchmarking performance criteria and techniques for evaluating the complete life cycle of semantics enabled web services. Specifically, the survey shows that several methodologies and frameworks for defining ontology are already available in the literature. From the service implementation point-of-view, few implementations of real semantic services are discussed in detail in the survey, thus suggesting that the industrial adoption of semantic services is still on the way. Finally, from a tool support point-of-view, several up-to-date tools exist to support the annotation and matchmaking of semantic services, both for SOAP and RESTful solutions. For example, SA-REST and Apache Jena seem to be promising tools for supporting the development of semantic services. In any case, the focus of these solutions is on the functional aspects of the service, while non-functional aspects (such as QoS and SLA measures) are never addressed explicitly, expect for the OWL-Q ontology.

Figure 1   No. of publications related to SWS (see online version for colours)
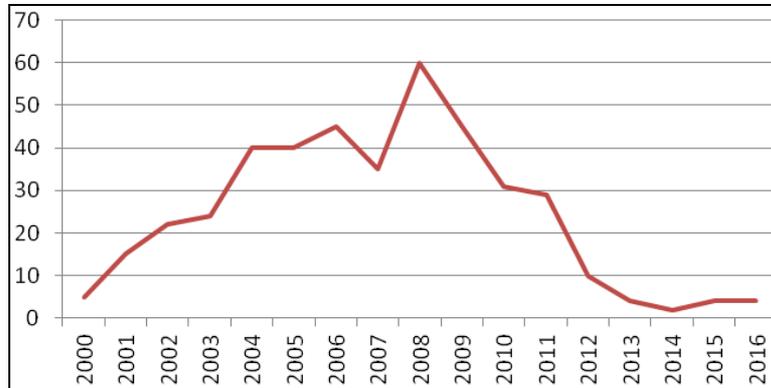
As a result of the above discussion, we propose the following directions for future research in this area:

- Investigate new software and service engineering approaches, supported by efficient tools, to simplify the implementation of semantic WSs life cycle fully and their diffusion in industrial settings. These approaches should focus on both the functional and non-functional aspects of services.

- Develop tools that support the performance evaluation for all the stages of the SWS life cycle as per the given performance matrix life cycle, so that it could trigger a lot of research analysis in the implementation issues.

6   Conclusions

The systematic literature review reported in this work was carried out to acquire knowledge on the state-of-the-art in the area of real time implementation of complete life cycle and performance evaluation of semantically annotating WSs with focus on well-defined and adopted ontologies. Real case studies and tools supports the implementations of complex and industrial semantic services to facilitate the match-making and selection processes of semantic services. The aim was to find answers to the research questions identified. We identified relevant primary studies. The identified primary studies revealed the fact that semantic WSs emerged only during the last decade. However, we believe that the survey present a good deal of material that can be used to provide answers to the research questions under focus and also help researchers to do a complete experimental research in the area of SWSs.

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