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Evaluating usage of WSMO and OWL-S in semantic web services

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Abstract

Applying ontologies is the most promising approach to semantically enrich Web services. To facilitate this, two efforts contributed the most in enabling the creation of ontologies: OWL-S from the US and WSMO in Europe. These two compete and promote their ontologies from the design perspective, reflecting their inventors' bias but not offering much help to Web service developers using them. To bypass existing biases and enable evaluation of ontologies expressed in these two languages, this paper provides a study of the two important facilitators, OWL-S and WSMO, surveying their usage in several SWS Projects and identifying their respective and outstanding gaps. The paper then proposes a set of evaluation criteria for usage measurement on the two prominent SWS ontologies.

Keywords

usage, evaluating, services, web, semantic, wsmo, owl

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Evaluating Usage of WSMO and OWL-S in Semantic Web Services

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Abstract

Applying ontologies is the most promising approach to semantically enrich Web services. To facilitate this, two efforts contributed the most in enabling the creation of ontologies: OWL-S from the US and WSMO in Europe. These two compete and promote their ontologies from the design perspective, reflecting their inventors' bias but not offering much help to Web service developers using them. To bypass existing biases and enable evaluation of ontologies expressed in these two languages, this paper provides a study of the two important facilitators, OWL-S and WSMO, surveying their usage in several SWS Projects and identifying their respective and outstanding gaps. The paper then proposes a set of evaluation criteria for usage measurement on the two prominent SWS ontologies.

Keywords: Web services, ontologies, OWL-S, WSMO.

1 Introduction

Web Services are software components that are accessible via the Web. However, their concomitant descriptive languages, Web Services Description Language (WSDL) (Christensen et al. 2001) and Business Process Execution Language for Web Services (BPEL4WS) (Andrews et al. 2003), do not offer sufficient semantic richness that can be machine-processable semantics. Human intervention is often needed to interpret the meanings in order to discover, compose, and invoke Web Services. This can be time-consuming and error-prone. W3C advocates the use of software agents for automating the above tasks, where an agent is defined as "a program acting on behalf of a person or organisation" (Haas and Brown 2004). Thus, an agent could perform discovery, composition and invocation task of Web services. Such agent requires a reference specification (i.e. formal specification) that contains informational domain knowledge, and operational knowledge of how to perform domain tasks. This is where the notion of ontology is seen as an effective way to provide that specification.

People use the word "ontology" to mean different things, for example, glossaries and data dictionaries, thesaurus and taxonomies, schemas and data models, and formal ontologies and inference. Ontologies applied in this study are defined as formal ontologies (Uschold and Gruninger 2004) in formalizing specific ontology of Web service as a semantic Web based representation language. Research into Web services ontologies has progressed at a rapid rate since the first work OWL-S (Martin et al. 2004), formerly DAML-S (Martin et al. 2003), was presented by OWL-S Coalition researchers. Two important groups focus on web services ontologies: OWL-S Coalition mainly based in the US and the second group is WSMO mainly based in Europe. Both OWL-S and WSMO aim to provide support for semantic Web services and more effective discovery, composition and interoperation of Web services. However, the two efforts take a very different implementation approaches in order to achieve results. WSMO stresses a mediation model in order to support automatic interoperation between Web services, while OWL-S stresses an action representation model to support planning processes that provide automatic composition. These two approaches compete, for example, as demonstrated by WSMO group claiming that the WSMO features are more advanced than OWL-S (Lara et al. 2004). At the same time, OWL-S group argues that OWL-S has more strong features for semantic Web services (Berardi et al. 2004). Both gained considerable interests providing Web service ontologies, enabling automatic discovery, interoperability and composition of Web services in many SWS projects. However, users are often caught between the two trying to determine which approach is most suitable for their problems (Balzer et al. 2004; Bijan et al. 2006; Hofman et al. 2010). In this paper, we argue that both are falling short in supporting stakeholders in determining the scope of their suitability and point out several basic questions: *How and when should either be a candidate used for a project? Why do some projects use OWL-S whilst others use WSMO? And what are the criteria influencing these SWS ontologies usage?*

The paper is organised as follows: An analysis of these models is conducted by surveying their usages in different projects in Section 2. Next, we propose evaluation through a set of criteria in Section 3, before we conclude the paper and outline future work in Section 4.

2 How and Why use OWL-S or WSMO?

This section surveys the usage of OWL-S and WSMO in a number of Semantic Web Service projects, before we discuss the analysis results in the related projects. We select five SWS projects, including: OntoGov (OntoGov Consortium 2006), TERREGOV (TerreGov Consortium

2007), SemanticGov (SemanticGov Consortium 2007), Access-eGov (Access eGov Consortium 2007) and FUSION (FUSION Consortium 2008). We only included projects that are publicly available as these offer enough detailed information to enable us to evaluate their applications.

Within these projects, chronologically, it was OntoGov project (OntoGov Consortium 2006) the first who claimed that it had been impossible to reuse OWL-S or WSMO. Stojanovic et al. (2004) argue that with respect to the weaknesses of OWL-S ontology not allowing using the domain ontologies entities as inputs/outputs of an activity in the process model, because in OWL Lite and OWL DL, classes and individuals form disjoint domains, while OWL Full is not decidable. On the other hand, the authors claimed that WSMO ontology does not contain the process model. Basically, OntoGov project develops their own service ontology along with annotation verification for describing e-Government services based on a combination of OWL-S and WSMO approaches. The new model extended OWL-S profile, process ontology and accepted WSMO state-based ontology, while bypassed using WSDL and BPEL. They also enhanced the semantic discovery from inexperienced ontology user's viewpoint in the e-government domain. In addition, OntoGov rather focused on static web services due to the governmental characteristics that require partial automation rather than full automation.

TERREGOV project (TerreGov Consortium 2007) adopts OWL-S for describing and discovering services, but uses BPEL language for composition of services (eProcedure) for their public servants' activities. Interestingly, TERREGOV claim that integration of rules with the semantic descriptions overcomes OWL limitations in terms of expressivity, particularly when it comes to define classes based on numerical comparisons. Rule-based extensions can be used to alleviate these restrictions. Moulin et al. (2008) developed a new formalism, namely SOL (Simplified Ontology Language) to overcome limitation of OWL expressiveness, TERREGOV not only provides support to novice ontology users who are civil servants so as to semantically indexing documents based on the ontology developed in the project, but also attaches to user interfaces and is able to analyze some questions in natural language entered by end users. Answers to these questions are extracted from the content of the ontology. Furthermore, TERREGOV also facilitate citizens activity with the selection of services in several e-Government processes by using SPARQL (Sbodio and Moulin 2007), in conjunction with OWL-S to provide semantic description of services for citizens.

SemanticGov project (SemanticGov Consortium 2007) claim that Public Administration (PA) specific concepts introduced in OntoGov project are rather limited and PA service is modeled with rather poor PA specific semantics. SemanticGov used both OWL-DL and WSML ontology representation in their GEA (Peristeras 2006) service ontology and the WSMO framework for SWS modeling and execution environment. SemanticGov (Xia et al. 2007) stated that one of the reasons leading to the selection of the WSMO framework for the implementation of the semantic PA web services was because service ontologies like OWL-S did not consider a client's perspective.

Access-eGov project (Access eGov Consortium 2007) adapts WSMO conceptual model for composition of government services into complex process definitions (Life Events) by enabling semantic interoperability of particular eGovernment services. The consortium modified WSMO process model because the current WSMO specification provides a process model based on abstract state machines and is not structured in the way suitable for interaction with human actors as it is required for eGovernment applications. As a result a workflow-based extension to the WSMO specification has been designed and implemented. The extended process model used within Access-eGov is based on the workflow CASheW-s model (Hreno et al. 2010). WSMO was chosen with several reasons (1) a little apprehension before using OWL-S due to the fact that the language must have been extended for traditional services.(2) disadvantages of OWL-S usage of single modelling element (Service Profile) for requester and provider and (3) the problem with rule language that lead to undecidability.

FUSION project (FUSION Consortium 2008) adopts the OWL-S approach for deploying its own semantic web services based solution for both intra- and inter-Enterprise Application Integration (EAI). FUSION uses the OWL-S Profile ontology for orchestration, but uses the choreography that described in BPEL (Kourtesis and Paraskakis 2008). The semantically enriched Web services run on an OWL-S Virtual Machine, while the complex processes, described in BPEL, run on a BPEL run-time engine. Between the OWL-S invocation and BPEL description, a special self-developed mediator (Magyar and Knapp 2008) service will be used. The reason of WSMO/WSML/WSMX is not chosen because do not attempt to provide semantic enhancements to UDDI but rather stand as independent WSMX environment components and are not integrated with UDDI.

The first two rows of each project in Table 1 (see the last pages of this paper) summarizes the results obtained from the analysis of SWS ontology usage in five SWS projects as examined above. The reason, in our opinion is important to indicate the user's rational of choosing SWS ontology. We could not access the artefacts of these ontologies because project websites are closed down after the project end, so that some information has not been available. However, we manage to obtain some publications from scholarly databases rather from the project websites. From the results, we have found there were various ways and reasons of using OWL-S or WSMO in several SWS projects. These different research projects adopted different approaches, particularly, underlying manipulation of logics and rules to fulfil their requirements, which normally are not standardized, as mentioned from Tim Berners-Lee's keynote talk at WWW2005. As a consequence, each of them may penetrate to different problems such as inaccuracy, inadaptability, uncertainty, inconsistency and many more. Therefore, there is no uniform methodology or guideline on how to use them in an appropriate way.

We believe that OWL-S and WSMO models have their own contributions and equal importance to SWS research due to different features, which they offer to the stakeholders. Apparently, their features were designed from different perspectives because OWL-S takes a service point of view to describe service activities while WSMO takes a client point of view to describe client's goals. The client may be either a human user or an agent acting on behalf of a user. However , it is considerable that deciding to use OWL-S/OWL or WSMO/WSML is not an easy task and this observation is truly reflected as what had been revealed by Bijan et al. (2006) and Cardoso (2007). It is however important to note that before any such semantic service discovery architecture can be implemented, or efficiently and widely used, any potential stakeholders first need to understand the ontology-based semantics (i.e. OWL-S, WSMO) very well, because an comprehensive understanding of semantics will enable project stakeholders to choose which ontologies can be used in their specific projects. Secondly, we need an understanding of how semantics can be used to help Semantic Web Services project developers to determine which semantic-based approaches will be beneficial to support their projects and therefore to be integrated in such web service discovery and integration architecture.

3 Evaluating Usages through Criteria

Considering the two SWS ontology namely OWL-S and WSMO, we require criteria for evaluating these languages to facilitate the selection of an appropriate model. In this section, we identify and discuss some relevant criteria that have been developed from SWS project artefacts and ontology literatures for evaluating SWS ontologies usage. After exhaustive research, we come to the four criteria that may influence the choice of SWS ontology, as follows:

Intended use: According to Gruninger et al. (2008), this criterion refers to the purpose(s) of using ontology. Resolving automation is an important issue to be addressed for a number of different tasks in web service management. Both OWL-S and WSMO use ontologies to facilitate the automation of Web service tasks such as web service discovery, web service invocation, web service composition and interoperation as well as web service execution and monitoring via providing semantic descriptions by enriching Web Services. From our observation, OntoGov and TERREGOV projects do not completely take advantage of SWS technology. For example, TERREGOV has opted for OWL-S for modelling, describing and selecting services but uses BPEL to compose services, whereas OntoGov does not consider dynamic composition services whose composition is explicitly predefined by the laws. These scenarios indicate automation of web service lifecycle is not essentially possible or necessary due to some projects still require particular tasks to be done by human actors for decision making, instead of the agent.

Expressiveness: This criterion is the most important criteria in the selection of ontology formalism for modeling ontology and considerably not an easy task. Hepp (2007) uses the criteria "expressiveness" to refer to the expressiveness of the formalism used for specifying the ontology. A higher expressiveness allows more sophisticated reasoning, but requires much more effort for producing the ontology and more difficult for users to understand an expressive ontology, because users need a better knowledge in logic. Significantly, expressiveness increases the computational costs in reasoning.OWL-S, which was written on OWL with three increasingly expressive sublanguages for different usages requirements (W3C 2004): OWL Lite, OWL DL and OWL Full. Similarly, WSML provided by WSMO also has increasingly expressive sublanguages (De Bruijn et al. 2006): WSML-Core, WSML-DL, WSML-Flight, WSML-Rule, and WSML-Full. However, it has been argued that WSML provides extra expressivity than OWL because it is comprised of rule-oriented languages: Logic Programming, First Order Logic (FOL) and Description Logic.

Automated Reasoning: This criterion refers to inference engine mechanism to resolve manual human interpretation via automated reasoning machine to process the web services requests on human users' behalf (Smith and Welty 2001). Gruninger et al. (2008) specify three kinds of reasoning supported in software applications that use the ontology, which is supposed to be simple for specially and/or generally automated reasoning. However, the reasoning that will be done with the ontology depends on the type of selected representational structure (Bettahar et al. 2009). In the context of web services this mechanism is well-known in helping users interested in searching, selecting or composing a certain set of target services.

User perception: This criterion refers to user's attitude (e.g. user satisfaction, acceptance) towards understanding the usage. We argue perceived usefulness and perceived ease of use influence the user's attitude, which in turn affect usage intentions. These SWS ontologies have been comfortably used in projects if its usage is understandable and it provides ease of use. For example, Access-eGov project noted that OWL-S is not understandable due to the language having been extended to traditional web services and perceived it as a disadvantage leading to the selection of WSMO (Sroga 2008). Likewise, TERREGOV reported their practical experiences with OWL-S by highlighting the fact that the knowledge about SWS field and Web Services enrichment is not yet widespread and there are very few already-deployed applications using such semantic information (Konstantas et al. 2006).

The last four rows of each project in Table 1 (see the last pages of this paper) indicate the criteria that influence the selection of SWS ontologies. In Table 1, information for SWS ontology in some projects has been omitted and indicated as N/A (not available), to indicate that either we could not found the information or it was not mentioned in the project artefacts.

Given the above set of criteria on intended use, expressiveness, automated reasoning and user perception, we will evaluate and benchmark two candidate SWS ontology with details in the future work. Apparently, not all applications will be possibly examined by all of the criteria above, which are mainly driven by the Web services case study setting, nevertheless we still argue that this setting can be generalized and applied to many real world distributed information systems.

4 Conclusions and Future Work

In this paper, five overarching conclusions emerge from our analysis of OWL-S and WSMO usage in SWS. First, despite the usefulness of a SWS ontology, we argue the fact that current SWS literature failed to demonstrate how to use their SWS ontology, which may lead to poor usability. Our hypothesis is supported by Mizoguchi and Ikeda (1998) who claim that many researchers say they "use" knowledge/ontology without defining what they mean by "use", that is, who uses it in what ways. Secondly, it does not come as a surprise that none of the languages surveyed is universally applicable, rather models suitability depends on the different purposes. From the analysis, it remains unclear which model is good for which task and how good it is. Our study aims at supporting the selection of the right models for the right job. Thirdly and more surprisingly, there is almost no information regarding difficulties projects faced while using SWS ontology. We would thus surmise that the SWS usage is to be agenda driven. Fourth, by surveying SWS projects, we can get insight in their usage and believe that these are the most valuable results of our analysis. Although we do not provide complete technical details, it is sufficient to illustrate opportunities to improve web services deployment. We already know that OWL-S and WSMO are useful, but we argue that their usage quality is still obscure. Based on this we claim that there is a need for a complementary between evaluation and the usage quality; we see a strong need for vigorous benchmarking. Fifth, while analysing the projects, we have found the selection of those SWS ontologies prior to usage has already been decided due to several reasons.

However, we still need to ask how do projects decide on SWS ontology usage and how should they decide? How is the process in arriving at the usage decision and what the criteria or methods used? We identify two outstanding gaps regarding with SWS ontology usage and identified a topic for our future work. First, the selection of SWS ontology prior to the usage and we propose a set of criteria for an evaluation that aims at filling this gap in section 4. The second gap is dealing with the process of using OWL-S and WSMO in which we propose a solution by using criteria to improve their usage in section 4. The reason for this claim is that we view the whole process of using these criteria as a cycle, so it's rather arbitrary where we start using OWL-S and WSMO. We should note that different user have different criteria driven by different requirements for where they start using SWS ontology. We are not aware of any research in the field of SWS that aims to qualitatively improve Web service ontologies or to facilitate the selection and the process of using these ontologies.

From the area of an evaluation study, we will evaluate these models with respect to criteria as proposed in section 4 in making the decision on SWS ontology usage. These criteria have significance for two reasons. First, the criteria either used or not used and the way in which they are applied or not applied, significantly impact the effectiveness with which SWS ontology usage decisions are made. They determine whether the "right" ontologies are selected. Second, the criteria are significant for the Web services management in terms of their role in optimizing web services ontologies in terms of cost versus benefit analysis decision. This research has throw up many questions in need of further investigation. Our future work is to investigate a meaningful method for measuring the proposed criteria dealing with SWS ontologies usage from SWS projects perspective in order to determine the effectiveness of using OWL-S or WSMO on fostering web services in these directions.

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OWL-S	OntoGov	Selection reason	Impossible to reuse both OWL-S and WSMO
		Ways of using SWS ontology	Use semantic technology without WSDL and BPEL. Developed a new language from a combination of OWL-S profile and process ontology with WSMO-state based
		Intended use	Modelling, automate discovery and compose services as a change management
		Expressiveness	Allow the least expressiveness
		Automated reasoning	Use KAON reasoner
		User perception	Perception refer to the selection reason above
	TERREGOV	Selection reason	OWL-S was the most mature formalism and W3C standard recommendation
		Ways of using SWS ontology	Use OWL-S in conjunction with WSDL and BPEL, in particular use OWL-S profile in providing semantics, but uses BPEL language to compose services
		Intended use	- Structuring knowledge for knowledge management cause to the enrichment of web services meta-data with semantic descriptors - Driving human-machine dialogs - Semantic indexing/retrieval of text and documents - Modelling, describing services, automated discovery services and automated service selection
		Expressiveness	Allow the least expressiveness
		Automated reasoning	Use JENA reasoner
		User perception	Perception refer to the selection reason above
	FUSION	Selection reason	OWL-S was selected as WSMO/WSMX/WSML do not attempt to provide semantic enhancements to UDDI but rather stand as independent WSMX environment components and are not integrated with UDDI
		Ways of using SWS ontology	Use OWL-S in conjunction with WSDL, BPEL and UDDI
		Intended use	Automation of web service discovery
		Expressiveness	Allow maximal expressiveness
		Automated reasoning	Use Pellet reasoner
		User perception	Perception refer to the selection reason above
WSMO	SemanticGov	Selection reason	OWL-S do not consider client and mediator features, thus WSMO is chosen
		Ways of using SWS ontology	Use WSMO in conjunction with BPEL
		Intended use	Automatic discovery, composition, mediation, and execution of web services
		Expressiveness	N/A
		Automated reasoning	Use WSML2Reasoner
		User perception	Perception refer to the selection reason above
	Access-eGov	Selection reason	(1) Perceived a little apprehension before using OWL-S due to the fact that the language must have been extended for traditional services; (2) Perceived disadvantages of OWL-S usage of single modelling element (Service Profile) for requester and provider and (3) the problem with rule language that lead to undecidability
		Ways of using SWS ontology	N/A
		Intended use	Reuse 25 existing eGov ontologies including OntoGov, TerreGov and SemanticGov ontology, and composition of eGov services into a complex business process
		Expressiveness	N/A
		Automated reasoning	Use WSML2Reasoner
		User perception	Perception refer to the selection reason above

Table 1: Analysis results of OWL-S and WSMO usage in Five SWS Projects