A Query-Based Approach for Semi-Automatic Annotation of Web Services

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ABSTRACT

Semantic Web services (SWS) have attracted increasing attention due to their potential to automate discovery and composition of current syntactic Web services. An issue that prevents a wider adoption of SWS relates to the manual nature of the semantic annotation task. Manual annotation is a difficult, error-prone, and time-consuming process and automating the process is highly desirable. Though some approaches have been proposed to semi-automate the annotation task, they are difficult to use and cannot perform accurate annotation for the following reasons: (1) They require building application ontologies to represent candidate services and (2) they cannot perform accurate name-based matching when labels of candidate service elements and ontological entities contain Compound Nouns (CN). To overcome these two deficiencies, this paper proposes a query-based approach that can facilitate semi-automatic annotation of Web services. The proposed approach is easy to use because it does not require building application ontologies to represent services. Candidate service elements that need to be annotated are extracted from a WSDL file and used to generate query instances by filling a Standard Query Template. The resulting query instances are executed against a repository of ontologies using a novel query execution engine to find appropriate correspondences for candidate service elements. This query execution engine employs name-based and structural matching mechanisms that can perform effective and accurate similarity measurements between labels containing CNs. The proposed semi-automatic annotation approach is evaluated by employing it to annotate existing Web services using published domain ontologies. Precision and recall are used as evaluation metrics. The resulting precision and recall values demonstrate the effectiveness and applicability of the proposed approach.

Keywords: Compound Nouns, Ontology Learning, Semantic Matching, Semantic Web Services, Semi-Automatic Annotation of Web Services, Web Services

INTRODUCTION

Web services are software components that can enable flexible, low cost and platform-independent application communication and integration (Paolucci, Kawamura, Payne, & Sycara, 2002). The Web service framework is mainly composed of XML-based standards as follows (Curbera et al., 2002):

- SOAP (Simple Object Access Protocol), which is a messaging protocol that facilitates message exchange among services.
- WSDL (Web Service Description Language), which describes the service interface as a set of communication endpoints that enable message exchange.
- UDDI (Universal Description Discovery and Integration), which is a centralized directory of service description.

For Web services to meet the needs of future Web applications, it is essential to enable on-the-fly discovery and composition of services (Agarwal, Handschuh, & Staab, 2003). Unfortunately, the use of existing Web service standards alone does not enable the desired automation and agility of service discovery and composition – primarily because these standards lack the necessary semantic constructs (Sivashanmugam et al., 2003; Sycara, Paolucci, Ankolekar, & Srinivasan, 2003). The utilization of semantics, represented in the form of ontologies, in the area of Web services launched an active research area called "Semantic Web Services" (SWS) (McIlraith, Son, & Zeng, 2001; Sycara et al., 2003).

SWS has attracted increasing attention in computer science and information systems research (Feier, Roman, Polleres, Domingue, & Fensel, 2005; Jacek, Tomas, Carine, & Joel, 2007; Martin et al., 2007). Successful implementation of SWS, however, requires the existence of suitable methods for SWS description (Lara, Roman, Polleres, & Fensel, 2004), catering for service elements such as inputs and outputs annotated using suitable semantic metadata (Verma & Sheth, 2007). In this context, annotation means explicitly referencing the data and functional elements of a service using concepts from shared ontologies. The annotation process is currently performed manually and thus requires comprehensive human involvement. Automating the annotation task is highly desirable as the manual process is tedious, error-prone and difficult (Hepp, 2006; Patil, Oundhakar, Sheth, & Verma, 2004; Rajasekaran, Miller, Verma, & Sheth, 2005).

Few approaches have looked at the problem of semi-automatic annotation. Those approaches that exist can be categorized twofold: First, approaches that automatically build ontologies to represent semantics of given services using learning techniques. Examples of this class of techniques are the approaches of Chifu, Salomie, and Chifu (2007) and Heb and Kushmerick (2003). Second, approaches that require manual development of application ontologies that model implicit semantics of WSDL files. Such application ontologies are then matched against existing domain ontologies using semantic matching techniques in order to find appropriate correspondences that are then used to annotate service data. These approaches are called semantic matching-based approaches. Examples of this category are Patil et al., (2004) and Duo, Juan-Zi, and Bin (2005). Current approaches in both categories have limitations:

- Manual ontology building is difficult and requires extensive technical and domain knowledge. On the other hand, automatic ontology development using learning techniques is still under development and results in ontologies that are of questionable quality.
- Matching-based approaches utilize similarity measurement mechanisms that do not produce precise results when labels of ontological classes and Web service elements are composed of multiple words i.e. Compound Nouns (CNs).

In response to the increasing need for an effective semi-automatic Web service annotation approach; this paper proposes a novel annotation framework that can facilitate easier and more effective WSDL annotation in comparison to other approaches. This approach takes as inputs a WSDL file and a set of ontologies that cover domains of data of the given service. The proposed approach is easy to use because it does not require building application ontologies to represent service data. Rather, Web service data are extracted and used to fill a Standard Query

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