

# A Multi-Level Framework for Validation of Ontology-Driven and Community-Based Web Services Composition

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## ABSTRACT

*This paper proposes an Ontology-driven and Community-based Web Services (OCWS) framework which aims at automating discovery, composition and execution of web services. The purpose is to validate and to execute a user's request built from the composition of a set of OCWS descriptions and a set of user constraints. The defined framework separates clearly the OCWS external descriptions from internal realistic implementations of e-services. It identifies three levels: the knowledge level, the community level and e-services level and uses different participant agents deployed in a distributed architecture. First, the reasoner agent uses a description logic extended for actions in order to reason about: (i) consistency of the pre-conditions and post-conditions of OCWS descriptions and the user constraints with ontologies semantics, (ii) consistency of the workflow matching assertions and the execution dependency graph. Then the execution plan model is generated automatically to be run by the composer agents using the dynamic execution plan algorithm (DEPA), according to the workflow matching and the established execution order. The community composer agents invoke the appropriate e-services and ensure that the non functional constraints are satisfied. DEPA algorithm works dynamically without a priori information about e-services states and has interesting properties such as taking into account the non-determinism of e-services and reducing the search space.*

*Keywords: Action, Description Logics, Ontology, OWL, OWL-S, Semantic Web, User Constraint, Web Service Composition*

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## INTRODUCTION

As the Internet grows, e-services are becoming more and more available for users. However, despite their ubiquity, web services are still unable to meet user's needs especially when

their requests are too complex to be satisfied by a single existing e-service. Creating automatically new services by means of composition of existing web e-services to satisfy a user request addresses many challenging research issues.

Web service composition is the process that specifies how to select, to combine and to execute a set of available web services in order

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to obtain a composite service which fulfills the features required by the user. With automatic composition, the application's capabilities can be extended at runtime so that theoretically an unlimited number of new services can be created from a given set of services, thus making applications no longer restricted to the set of actions specified at design time. A central problem, addressed by web services composition automation, is the inherent structural and behavioral heterogeneity of current web services caused by their strict autonomy.

Several efforts aim to build current web service technology around SOAP (Mitra & Lafon, 2007), WSDL (Booth & Liu, 2007) and UDDI (Bellwood *et al.*, 2002) which provide standard foundations for service discovery, description and messaging protocols. An initiative to standardize some aspects of web services composition is BPEL4WS (Andrews *et al.*, 2003). This language is based on a human driven process, and the coordination between web services described in WSDL language is manually specified and their bindings are known *a priori*. Obviously, this type of language is insufficient because automating the composition of web services requires the representation of their abilities in a way that is unambiguous and interpretable by a machine.

In this paper, we propose the Ontology-driven and Community-based Web Services (*OCWS*) framework for automating discovery, composition and execution of web services. The purpose is to validate and to execute a user's request built from the composition of a set *OCWS* descriptions accompanied with a set of constraints. Our framework uses a multi-level approach that separates clearly the *OCWS* external descriptions from internal realistic implementations of e-services and allows the use of the appropriate methods and tools at each level in order to validate and execute the user's request. It identifies three levels: the knowledge level, the community level and the e-services level and uses different participant agents deployed in a distributed architecture. The notion of community gathers a set of service descriptions which are based on differ-

ent domain ontologies and a set of e-services providers. So, a community is an integrator of services which offers a unified interface allowing the access to existing heterogeneous e-services that exhibit similar functionalities.

*OCWS* are represented using the W3C ontology web language for services OWL-S (Martin *et al.*, 2004). OWL-S provides richer semantics for describing the capabilities of web services. A web service is represented as a named process which produces a set of outputs from a set of inputs and generates effects starting from a state that satisfies the service pre-conditions and reaching a state that satisfies the service post-conditions. The non-functional attributes are also used for e-service evaluation (cost, service quality and security issues). A composite web service is represented as a complex service involving different web services descriptions related by OWL-S constructs such as split-and, split-or, sequence that constrain the order of web services executions. The assertions about domain-ontologies are described using OWL language (McGuinness & van Harmelen, 2004). They formally define semantics of web services attributes. The constraints on attributes set by the user are also described as OWL assertions.

At the first level the reasoner agent of knowledge level has to reason about: (i) consistency of the pre-conditions and post-conditions of *OCWS* and the user constraints with ontologies semantics, (ii) consistency of the workflow matching assertions and the execution dependency graph. Description Logics (DLs) are the basis of the W3C recommended web ontology language OWL (Baader *et al.*, 2003). To achieve the reasoning tasks about services composition, we define an extension of DL proposed in Baader *et al.* (2005) in order to describe services as actions.

The execution plan model is generated automatically from a consistent user's request and is run by the composer agents using the dynamic execution plan algorithm (*DEPA*). *DEPA* algorithm works without a priori information about e-services states. It runs the execution plan model at different levels. The composer agent of knowledge level ensures that

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