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Analysis of business process integration in Web service context☆

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Abstract

The integration of Web services is a recent outgrowth of the Business Process integration field that will require powerful meta-schema matching mechanisms supported by higher level abstractions, such as UML meta-models. Currently, there are many XML-based workflow process specification languages (e.g. XPDL, BPEL) which can be used to define business processes in the Web services and Grid Computing world. However, with limited capability to describe the relationships (schemas or ontologies) between process objects, the dominant use of XML as a meta-data markup language makes the semantics of the processes ambiguous. OWL-S (Ontology Web Language for Services) exploits the semantic description power of OWL to build an ontology language for services. It therefore becomes a candidate for an inter lingua. In this paper, we propose an integration framework for business processes, which is applied to Web services defined in OWL-S.

Keywords: Business process management; Web services; Semantic web; Specification integration; UML meta-models

1. Introduction

The Web services paradigm is poised to become the dominant form of distributed computing within this decade and beyond. An EDS global consultancy found that 75% of companies ranging from less than $50 million to more than $1 billion in revenues and across 20 vertical industries have already deployed one or more Web services [1]. Web services involve a family of XML-based protocols to describe, deliver, and interact with services. WSDL is the most important one in our context. WSDL files include a set of standard elements. These elements describe interfaces and usage of a particular Web service [2]. Workflow management systems have become promising solutions for organisations that need to automate their business processes [3]. Applying workflow to a business process brings the details of that process into focus and adds the required business rules and business logic to the process.

Typical XML-based workflow process definition and execution languages include BPEL4WS (Business Process Execution Language for Web services, BPEL in short) [4], XPDL (XML Process Description Language) [5], ebXML, etc. that can be used to describe workflow systems and business processes in the Web services world. Integration of these languages requires comprehensive and complex mappings between them [6]. Intuitively, UML meta models may meet these requirements to some extent, especially in providing visual forms for models of classes and respective associations. In this paper, we describe a set of business process integration

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options and a set of additional modelling constructs, especially for the synchronisation of activities and states within a process not easily described with full semantics. We have developed a transformation tool, BPEL2UML-AD [7], to transform BPEL specifications to UML activity diagrams [8] (referred to as UML-AD for short in the rest of the paper). The advantage of UML-AD is that they provide an effective visual notation and facilitate the analysis of workflow compositions.

As part of our analysis of workflow composition, we have identified a set of integration options which can be applied to Web services by mapping backwards from UML-AD to BPEL. This work started out from an attempt to support the decision between different integration options. A possible basis is the different semantic relationships between process objects. However the description of these relationships cannot be carried over directly to BPEL because BPEL documents solely represent descriptions of activity execution without describing the semantics of involved objects. Therefore we propose to use a mapping from BPEL to OWL-S (Ontology Web Language for services, formerly DAML-S). OWL-S, jointly developed by a consortium including industry and research institutions, is an attempt to provide an ontology for describing Web services [9–11]. In this paper, we introduce an approach (BPEL2OWL-S) which supports the mapping of business processes defined in BPEL onto an OWL-S-based process ontology [12].

The paper is organised as follows. Section 2 discusses some typical workflow and Web service specification languages. In Section 3 we analyse integration options on the basis of workflows. In the following section we deal with the mapping of BPEL to OWL-S. Section 5 discusses our findings and related work. The last section concludes our work.

2. The current state of workflow and Web service description languages

The current state of the art in workflow description languages in a Web service environment is based on two separate standards, WSFL (Web Service Flow Language) and XLANG. WSFL (xml.coverpages.org/wsfl.html), from IBM, addresses workflow on two levels: (1) it takes a directed-graph model approach to defining and executing business processes; and (2) it defines a public interface that allows business processes to advertise as Web services. XLANG (http:xml.coverpages.org/xlang.html), from Microsoft, plays the role of notation for Web services based business process automation. As the basis of automated protocol engines, it supports the exchange of messages among various Web services, tracks the state of process instances, and detects errors in message flows to some extent.

BPEL4WS (Business Process Language for Workflow Systems, or BPEL for short) was developed as an attempt to unify XLANG and WSFL and supersedes both these efforts. It allows businesses to describe sophisticated business processes that can both consume and provide Web services. The language is intended to support the modelling of both executable and abstract processes. An abstract process is a business protocol that specifies the message exchange behaviour between different parties without revealing their internal behaviour. An executable process specifies the execution order between a number of activities that constitute the process, the partners involved in the process, the messages exchanged between these partners, and the fault and exception handling that specify the behaviour to adopt in the cases of errors and exceptions [4]. A BPEL process is a flow-chart, where each element in the process is called an activity. An activity can be either primitive or structured. The set of primitive activities contains: ⟨invoke⟩, ⟨receive⟩, ⟨reply⟩, ⟨wait⟩, ⟨assign⟩, ⟨throw⟩ and ⟨empty⟩. Several structured activities are defined to enable the presentation of complex structures. These are ⟨sequence⟩, ⟨switch⟩, ⟨pick⟩, ⟨flow⟩, ⟨compensate⟩, ⟨scope⟩ and ⟨while⟩. A BPEL process definition provides and/or uses one or more WSDL services, and provides the description of the behaviour and interactions of a process instance relative to its partners and resources through Web service interfaces.

BPEL supports the implementation of any kind of business process in a very natural manner and has gradually become the basis of a standard for Web service description and composition. However, it has several shortcomings that limit the ability to provide a foundation for seamless interoperability. The semantics of BPEL are not always clearly defined, thus complicating the adoption of the language. Major limitations of the BPEL specification have been listed in [10,13]. At the heart of the problem is BPEL's reliance on describing services using pure XML and XML Schema.

Outside the pure Web services domain, the Workflow Management Coalition (WfMC) has been an active driving force in defining standard references to facilitate a process definition language, the interchange of process definitions and the interpretation of process definitions by different workflow management engines, and interoperability across different workflow management systems. The work conducted by WfMC allows developing composite workflow applications across different workflow management systems and organisations which work together as a single logical entity. For this endeavor, WfMC has published XPDL and interoperability specification Wf-XML [5]. XPDL belongs to the family of graph-structured process definition languages. There are also some other specific XML-based languages like e-Business XML (ebXML) and XML Routing Languages, which we have discussed elsewhere [14].

The authors in [15] have analysed workflow patterns to compare the expressiveness of existing business process languages and have examined the properties of BPEL in [16].

3. Analysis of workflow composition

In order to integrate different Web service based business process specification languages, we need to analyse constructs of process models at higher abstraction level. We used diagram notations, especially Activity Diagrams (UML-AD) of the Unified Modeling Language (UML) [8], because traditional techniques of structured analysis and design are being increasingly replaced by object-oriented modelling approaches in the development of business information systems. Another