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Semantic Web Service Composition in IRS-III: The Structured Approach

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Abstract

Semantic Web Services facilitate activities including automatic discovery and composition of Web Services. Research initiatives such as WSMO have been developing specifications for this technology. This paper describes a model for composition of Web services. The proposed model complements the WSMO orchestration in IRS-III, a framework for Semantic Web Services based on WSMO specification. We present a tool based on the above model that supports a user-guided interactive composition approach, by recommending component Web services according to the composition context.

1. Introduction

Research on Web services composition is gaining a considerable attention motivated by the need to support business interoperation and re-use or extension of available services. Semantic Web technology can support this complex task, whereby semantic descriptions associated with each Web service can be used to filter and match the services according to the users needs. In particular, IRS-III (Internet Reasoning System [2]) following the WSMO framework [7], provides at the semantic level a distinction between goals (i.e. abstract definition of tasks to be accomplished) and Web services (i.e. description of services that can achieve a goal) and as a result support capability-driven service matching and invocation.

OWL-S [1] and WSMO [7] are two prominent initiatives that address the service composition in the domain of Semantic Web services. This paper describes a model for Web service composition developed in the context of the IRS-III [2]. We present also a tool for semi-automatic composition of Web services developed on top of this model.

The Web Service Modeling Ontology (WSMO) [7] is a formal ontology for describing the various aspects related to Semantic Web Services. The main components of WSMO are Goals, Web services, Ontologies and Mediators. Goals represent the types of objectives that users would like to achieve, describing the state of the desired information space and of the world after the execution of a given Web service. WSMO Web services specifications describe the functional behavior of an actual Web service, including its capabilities and interfaces. The interface description contains two closely related notions of choreography and orchestration. Choreography describes information required to interact with a Web service. Orchestration, which is the focus of this work, can contain information describing a composite Web service. Orchestration provides the necessary details for the execution of all the component services and may be a proprietary item for the provider –i.e. not accessible to others. Ontologies support the semantic interoperability among the three other components. Mediators specify interoperability mechanisms and link the three components described above.

IRS-III [2] is a framework and implemented infrastructure for Semantic Web Services that implements the WSMO descriptions. IRS-III automatically transforms programming code into a Web service and supports capability-driven service discovery and invocation. In addition, any service published on IRS-III automatically appears as a standard Web service to other Web service infrastructures.

2. Composition Modeling

In this section, we show a simplified scenario for a service composition. We describe how we model service composition in a knowledge representation language (in OCML [5]) and how one can compose Web services in IRS-III by this model.

Figure 1 shows a composition tree for composition of five services in a virtual bookshop. FindISBN receives the book information and returns an ISBN for the book. FindBookstore finds a bookstore that has the book in stock. Finally, DispatchBook arranges sending the book from the appropriate bookshop to the clients address. Both of
the later components send an acknowledgement message to their output.

**Figure 1.** An example of a composition tree for buying a book in a virtual bookstore.

The structured composition in IRS-III is defined as an extension of WSMO Orchestration — i.e. it is a subclass of WSMO Orchestration class in [7]. The composition model is made of two types of components, namely control components and service components. Figure 2 shows the hierarchy of the composition component types. The control components provide the capability to define the control flow of the composition and they are of different types: sequence, concurrent, while and if-then-else. Figure 1 illustrates control components by ovals and service components by boxes. Listing 1 shows the definition of the root component for the example in Figure 1.

**Listing 1.** An example of a structured orchestration and its root component from Figure 1.

```
book-selling-orchestration
  (structured-orchestration)
    has-root-component :value sequence1
    sequence1 (sequence)
      has-components :value (find-isbn-SC find-bookstore-SC if-bookstore-found)
```

Listing 3 shows one of the bindings and its mediator description for the service described in Listing 2. The binding specifies that the mediator mapping-mediation01 should be applied to the output of the service component and produce required input for service-component-find-bookstore.

**Listing 2.** Description of a service component in the “sequence” described in Listing 1.

```
find-bookstore-SC (service-component)
  has-invocable-description :value find-isbn-goal
  has-internal-bindings :value (binding-to-dispatch-book binding-to-charge-card binding-to-if-bookstore-found)
  has-binding-to-composition-output :value output-binding2
```

Use of mediators is an important feature of IRS-III. IRS-III supports several types of mediators. The only type of mediator, that is specific to compositions, is Goal Invocation Mediator (GInv). GInv Mediator inherits source, target and mediation-service roles from super class Mediator described in IRS-III based on WSMO description — see [7]. The mediator in Listing 3 shows that the output parameters taken from FindBookstore (i.e. book-price) are passed to the mediation service and then provided as input for ChargeCard (i.e. cost).

**Listing 3.** An example of a binding and its mediator for the service component in Listing 2.

```
binding-2-charge-card (internal-binding)
  uses-mediator :value mapping-mediation01
  to-component-service :value charge-card-SC
  mapping-mediation01 (GInvMediator)
    has-source :value find-bookstore-goal
    has-target :value charge-card-goal
    has-mediation-service :value mapping-mediation-goal
```

3. Semi-Automatic Composition Tool

In this section, we introduce a graphical tool based on our composition model. This tool supports users on
The definition of dynamic compositions in IRS-III by recommending Goals according to the context at each step of designing the composition. The full automation of the composition process is still the objective of ongoing research activities. This objective can be achieved in a semi-automatic fashion by supporting the user during the process of designing the composition [6]. We chose an approach similar to those described in [4] and [6] in the sense that humans retain control of the definition of the composition, but laborious work such as discovery and invocation of services according to the abstract representation of users' requirements is assumed by the machine. However, our approach introduces features such as dynamic invocation of Web services, control operator and mediation.

The Figure 3 depicts the composition tool and some of its functionalities. The tool guides users in a step-by-step composition process by selecting Goals, mediators, and control flow operators. The composition starts with the selection of the first Goal, when the user receives a list containing all the Goals defined in the IRS-III Server. Users can select a Goal to sub-goals that matches to one or more Web services. An advantage of our composition approach is the use of Goals, while other initiatives such as OWL-S [1] and BPEL4WS [3] compose only Web services. This feature provides a certain level of dynamism for compositions, that is, suitable Web services are discovered at the execution time. Another advantage of our tool is the use of mediators. All data bindings in our tool are using mediators which makes the visualization of the transformations in a composition more comprehensible, as compared to the approach used by OWL-S [1] and BPEL4WS [3], where no distinction between mediators and Web services is made. While the full automation of the composition is still subject of ongoing research, we provide the necessary means for users to define their expectations on a service composition through our composition tool. The composition tool suggests Goals according to a composition context and supports definition of mediators and control operators in an interactive composition process. Our composition model and tool are compliant with WSMO specifications.

### 4. Conclusion and Related Work

Web service composition is a new but essential issue to enhance B2B e-commerce over the Internet. This paper discusses a model for Web service composition in IRS-III. We present an approach to describe a composition by extending the existing WSMO ontology and describe different aspects of it. As WSMO is developing its orchestration model [8], it may adopt any approaches. Furthermore, we built a composition tool based on the model. This tool facilitates building compositions and it is a step towards an automatic composition tool.

In our approach, the composition designer breaks a Goal to sub-goals that matches to one or more Web services. An advantage of our composition approach is the use of Goals, while other initiatives such as BPEL4WS [3] compose only Web services. This feature provides a certain level of dynamism for compositions, that is, suitable Web services are discovered at the execution time. Another advantage of our tool is the use of mediators. All data bindings in our tool are using mediators which makes the visualization of the transformations in a composition more comprehensible, as compared to the approach used by OWL-S [1] and BPEL4WS [3], where no distinction between mediators and Web services is made. While the full automation of the composition is still subject of ongoing research, we provide the necessary means for users to define their expectations on a service composition through our composition tool. The composition tool suggests Goals according to a composition context and supports definition of mediators and control operators in an interactive composition process. Our composition model and tool are compliant with WSMO specifications.
Our composition tool is a step towards an automatic composition tool. The composition tool suggests Goals according to a composition context in an interactive process. CAT [4] uses a similar approach and integrates planning techniques to track relations among the composition components. However, CAT does not support the use of mediators as well as control components (similar to [6]). The OWL-S composer [6] supports users in the composition by narrowing the list of Web services based on the match of their inputs and outputs. We adopted a more flexible process, by recommending Goals through the match of their properties but allowing users to define mediators between Goals that do not match.

As for future work, we are considering to enhance our composition model by error handling and compensation. We are also investigating semantic aspects related to the automatic composition following an approach based on parametric design and incorporating planning techniques to our composition tool to support partial automation of the composition process.

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