Towards Semantic Matching of Business Services and Electronic Services

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Abstract: Service oriented environments consist of business and electronic services. Business services encapsulate core business logic and activities whereas electronic services support the operation of business services by means of software applications. In environments with a large number of business and electronic services an approach for selecting electronic services that satisfy certain business services concerns is needed. This paper presents an approach for matching business and electronic services based on semantic entity similarity.

1 Introduction

In the context of environments which are defined according to the service orientation paradigm such as service-oriented enterprises [He08] and service-oriented computing platforms [PG03] the term service is defined as a self-contained, loosely coupled entity that encapsulates a limited piece of functionality, is reusable, able to be composed, and provides a well defined external interface. Services can be differentiated into business- and electronic services. A business service (BS) is an auxiliary artifact that structures a certain business concern according to the service-orientation paradigm. Electronic services (ES) describe technical aspects (also structured according to the service-orientation paradigm) with a special focus on enterprise software applications. Service orientation as a design paradigm for enterprise and computing environments promises a number of benefits – among them flexible re-configuration, dynamic binding, easy access to heterogeneous resources and processes, transparency across implementation details and last but not least a relatively stable set of standards for aspects such as interface, orchestration, choreography or contracting. Research on service orientation has been conducted in various directions. An area which has received insufficient support is the alignment of BS and ES. BS and ES are interrelated in a way that ESs support the operation of BSs. The spectrum of support ranges from partial to entire. In infrastructures with a large number of ES and BS implementations and which are subject to regular changes the decision on which ES provides the most suitable support for a certain BS becomes quite complex.

This paper presents an approach for matching business and electronic services based on semantic entity similarity. Matching addresses predominantly the evaluation and decision making process for selecting ES for certain BS. The objective is to filter the large number of available ESs to a distinct set of high potential ES candidates that support a certain BS. The approach is based on the hypothesis that the higher the similarity between BS and ES semantics, i.e. the similarity between semantic entities, the higher the match between a BS and an ES. Based on this hypothesis, an automatic quantifiable similarity measurement of all BS-ES combinations is possible and would reveal suitable BS-ES candidates. The paper is structured as follows: as a starting point assumptions and prerequisites are examined in detail in chapter 2. Chapter 3 presents the approach in detail, chapter 4 examines related work, and chapter 5 summarizes and presents next steps.

2 Hypothesis and Prerequisites

The approach is based on the hypothesis that a certain ES supports the operation of a BS if an ES and a BS are similar in their semantics[1]. Hence, the degree of similarity of the semantic entities of BS and ES determines the degree of support. This assumption includes that if an ES supports the operation of a BS, the ES-description represents (a part of) the BS-description. Further, an ES provides functionality that is implicitly stated in the BS description and, thus, required by the BS. The justification for that hypothesis is given by an analogy to the "SOA Common Information Model" (CIM) [Pa07]. A CIM contains a set of information objects and relations with business semantics (so called business objects). The definition of a CIM is domain specific (focused on a certain business area) and strictly independent from software implementations. According to [Pa07] in "Real SOA" the business objects have to be used on business level and on software level as well. Consequently, a proper software support is only accomplished, if the software contains semantics of the business domain. Adapted to ES and BS, this means that BS and ES should use similar semantics. As a reverse conclusion, BS and ES fit to each other (in a sense that an ES supports the operation of a BS) if both have similar semantic entities. Applied to the presented problem, a measurement of the similarity of semantic entities between a certain BS and a certain ES would reveal the fit-level.

In order to define a meaningful starting point the following prerequisites (italic) are defined. *There is a large number of already defined BSs and ESs.* The approach does not examine how to structure and describe BS and ES. *BS and ES are described on the basis of a common model.* The description of BS and ES is based on a common model in order to ensure basic comparability between BS and ES. The model defines the elements and the syntax of the BS and ES description. *BS and ES have different semantics.* Although the common description model defines basic elements of a service (syntax), the instantiations of this model are different. The differences are derived from the semantics. *BS and ES contain business semantics***.** BSs contain business semantics per se. However, there are ES which exist on technical level only (e.g. messaging service). Thus, a

[1] A service is represented by its service description. This paper does not consider any difference between a service and its description.

restriction is that ESs with a technical focus are not under consideration. Instead, ESs with business semantics are of interest.

3 Approach

Based on the hypothesis and the mentioned prerequisites, the approach has the objective to measure similarities between BSs and ESs. As a result each BS-ES combination gets a quantifiable and comparable similarity value. With this similarity value all possible BS-ES combinations can be ranked. Taking the highest similarity values for a certain BS, the large number of ESs are reduced to a significant small number of high potential candidates. These candidates can be taken for further examination. Hence, the approach will identify potential ES candidates and provide decision support.

In order to calculate the similarity value of a single BS-ES combination, first, the elements under consideration (i.e. semantic entities) have to be identified. Thus, semantic entities have to be extracted from BS and ES descriptions. Second, the semantic entities of BS have to be compared to the semantic entities of ES. A similarity value is measured and calculated for each BS-ES semantic entity combination. These values have to be aggregated in a third step in order to conclude about the similarity value for the BS-ES combination. Calculating the similarity values for each BS-ES combination requires an adequate visualization for decision support. The approach including the key steps extraction, measurement, aggregation and visualisation is illustrated in figure 1 and will be described in detail below.

The starting point is an environment with a large number of BSs (x) and a large number of ESs (y). All services are described by a service description which is based on a common meta-model (as depicted on the left-hand side of figure 1). To illustrate the approach an example BS x_i and an example ES y_j is chosen from the environment and their matching level is calculated. As the first step, semantic entities, i.e. concepts, relations, instances, and constraints, are extracted from the descriptions (cf. [FGJ97]). This leads to K semantic entities of the BS and L semantic entities of the ES respectively. Each BS semantic entity $n_{i,k}$ and each ES semantic entity $m_{j,l}$ form a BS-ES semantic entity combination. There are K*L BS-ES semantic entity combinations. In the next step, a similarity value $e_{i,j,k,l}$ is calculated for each BS-ES semantic entity combination. Since semantic entities for a certain domain form ontologies, ontology matching mechanisms [ES07] are applied in order measure the similarity for each combination $e_{i,j,k,l}$. Ontology matching comprises several matching techniques which can be divided into element- and structure-level techniques at first stage and into syntactic, external and semantic techniques at second stage. However, single matching techniques are not sufficient ([ES07] pp.115). Usually, matching techniques are combined in order to get a proper matching result. The success of matching techniques and strategies for similarity measurement depend on different circumstances, such as the application domain, the use case etc. Hence, providing a concrete matching strategy (including matching techniques) is out of scope of this paper. Nevertheless, after matching on an entity-level there are quantifiable similarity values $e_{i,j,k,l}$ for each BS-ES semantic entity combination. The similarity measurement based on ontology matching is represented by the function $f(n_{i,k}, m_{j,l})$ in figure 1. After having similarity measures on semantic entity-level, the values have to be aggregated for a certain BS-ES combination in order to conclude about similarity on service-level. The aggregation is embodied by the function $f(e_{i,j,1,1}, e_{i,j,1,2}, \ldots, e_{i,j,k,l}, \ldots e_{i,j,K,L})$ taking into account each $e_{i,j,k,l}$ for a certain BS-ES combination (i,j). The first draft of the approach contains a basic mean aggregation for that purpose (cf. figure 1). Future examinations will elaborate more sophisticated aggregation algorithms (including weighting and normalization for instance). There is a quantifiable similarity value for each BS-ES combination $s_{i,j}$ as a result of the aggregation. For achieving the goal of supporting decision making the pure values are not sufficient. They have to be presented and visualized. The approach provides a ranked list of high potential ESs for each BS as shown on the right-hand side of figure 1.

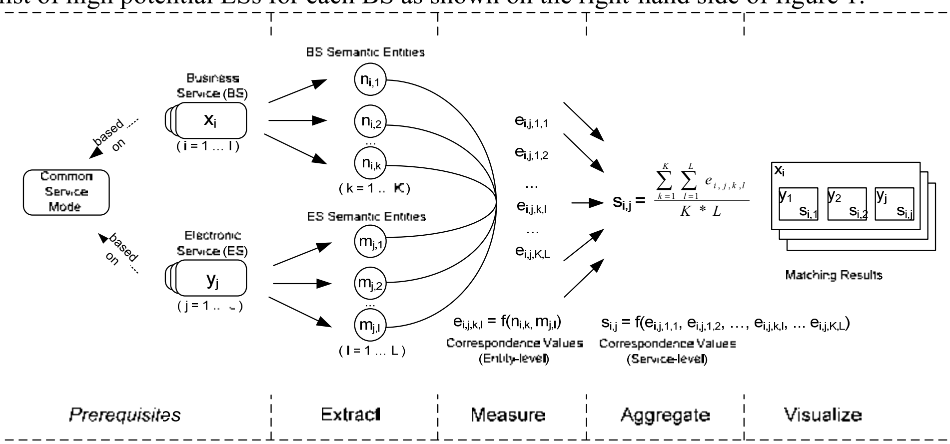

Figure 1. Four step approach for matching of business and electronic services

4 Related Work

The selection of services that fit consumer concerns is an integral part of the service oriented paradigm. The basic SOA model contains the service registry role (also known as service broker) for that purpose. A service consumer discovers a registry in order to find a service that fits its concerns (cf. [Pa07]). The selection of ES that fit a certain BS relates to this topic. The process of locating existing service is called service discovery [KK09]. The service description plays an important role in service discovery. Related work for semantic service description is examined first[2]. There are several semantic service description frameworks. WSMO [RLK06] and OWL-S [Ma04] are the most referenced ones in literature. Both provide a model for the description of Web services with functional and non-functional semantics. The description of Web service might be useful for the ES description. However, since ES are defined as software services, Web services are just a subset of ES. Further, there is no model with a distinct business focus, i.e. a semantic description of BS is not provided. Thus, the utility of WSMO and OWL-S

[2] Traditional service description mechanisms such as WSDL and UDDI are skipped due to their limited expressiveness for service discovery (cf. signature vs. specification matching in [KK04]).

is limited. Concerning service discovery, WSMO provides goals that define expectations for a (sought-after) service in terms of functional and non-functional requirements. Similar to the Web service description, a goal description is based on predefined ontologies. However, the definition of goals might be problematic, since “service requesters are not expected to have the required background to formalize their goals” [Ke05]. In contrast the proposed approach does not define goals (i.e. requirements) explicitly. It is assumed that the BS bears requirements for an ES support implicitly. Based on the semantic service description models there are some research efforts in the area of automatic service discovery (also Semantic Web Service Matching). One of them is [Pa02]. [Pa02] defines service capabilities as functional building blocks of a service and describes them on the basis of DAML-S (predecessor of the OWL-S). They suggest the description of requirements similar to the capabilities. However, it is assumed that requirements and capabilities are described on the basis of a common ontology. This is not realistic in case of BS and ES, since both are described by different stakeholders from different perspectives. Further, it is hard to specify the requirements in detail (cf. [Ke05]). Moreover, the correspondence values are ordinal scaled in [Pa02]. In order to get a ranked list of similarity values an interval scale of measurement is necessary. Furthermore, [Pa02] capabilities contain in- and output parameters only. Thus, [Pa02] match provided in- and outputs with required in- an outputs. This is not realistic since equality between in- and output parameters of services does not guarantee equal functionality (cf. [KK04]). Concerning service matching related work examines the matching of BS-BS and ES-ES [ZW97] but often it does not differentiate between ES and BS explicitly. Furthermore, WSMO-MX [KK09] is a Web service matchmaker which applies different matching filters on semantic Web services based on the language WSML-Rule [Br05]. As a result an ordered set of services including their matching value is generated. However, at the moment it cannot be judged whether WSML-Rule is a proper mechanism for the description of BS and ES.

5 Summary and Future Work

Business services describe business concerns structured as service according the service-orientation paradigm. Electronic services describe technical aspects as services (i.e. according to the service-orientation paradigm) with a special focus on enterprise software applications. Electronic service support operations of business service. There is a large number of business and electronic service available. The evaluation of a certain electronic service that supports a business service is time and cost consuming. This paper provides an approach which supports the evaluation process. Based on the hypothesis that a certain electronic service matches a certain business service if electronic service and business service are similar in their semantics, the approach provides a four step procedure for measuring similarity between business and electronic service. First, semantic entities are extracted from service descriptions, second similarity values are measured for each semantic entity combination, third aggregation is applied in order to gain similarity values on service-level, and fourth results are visualized for further examination, i.e. evaluation and decision making. Future work will address the application of the approach by a scenario of the logistics domain (e.g. transportation service as a BS and a transportation management software as an ES). In course of that, proper ontology matching techniques and strategies as well as aggregation algorithms are evaluated. Furthermore, a tool will be developed that supports the approach.

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