Reformulating user’s queries for Intentional Services Discovery using an Ontology-based Approach

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Abstract—The increasing growth in popularity of Web services has made it difficult for business users to fully benefit from these services if they remain specified at the software level. The introduction of intentional services is an alternative for bridging the gap between low level, technical software-service descriptions and high level, strategic expressions of business needs for services. The current Web services technology based on UDDI and WSDL does not reflect this “business intention”, and therefore fails to address the problem of matching between capabilities of services and business user needs.

The work presented in this paper is built on earlier research in which the Intentional Services Model (ISM) has been developed for modeling and describing services in business terms. In this paper, we present an ontological based solution to help matching user’s needs formulated in business terms as goals with the intentions of services published in an extended registry. The idea is simple: reformulating the user queries using ontologies to enrich them with more concepts, which will increase the possibility of matching relevant intentional services that could satisfy user’s business needs.

Keywords—Intentional Service, Ontology, Intentional Service Search, Query Reformulation.

I. INTRODUCTION

Service-Oriented Architecture (SOA) has emerged as a major trend towards the development of distributed applications [15]. An important issue when building applications using web services is to discover over the internet appropriate services that meet business needs [14, 15]. Due to the increasing number of available Web services, finding appropriate services has become a challenging issue. The currently available standards such as WSDL and UDDI are semantically poor and conceptually far from the concerns of users. There is a "conceptual mismatch" between the user’s needs expressed in business terms, and descriptors of services located on the provider side and expressed in functional and/or technical terms [8, 9, 17, 18]. To enhance the accuracy of a search, the trend is to develop goal-driven discovery methods [4, 7, 11, 12, 13, 14, 21]. Description of web services is enhanced by adding intentions to services’ advertisements based on specific domain ontology. Intentional services discovery finds matching relationships between users’ business needs and services’ intentions based on their goals.

The problem that is tackled here is related to the reformulation of user’s queries for the discovery of intentional services. We propose an approach in which user’s queries are expressed in structured natural language, and the reformulation of queries is made by using domain ontologies for verbs and terms.

This paper is organized as follows: Section 2 includes a review of research works related to the topic of goal-driven services discovery; in section 3 the intention and goal meta-models are briefly described; in section 4, the verb and product ontologies which are used to describe and annotate the intentional services are illustrated. In section 5, our algorithm for query analysis and refinement, and an example to show how this algorithm works is also introduced. Finally, the paper ends with conclusion and future work in section 6.

II. RELATED WORK

Understanding users’ needs is already achieved by traditional requirement engineering approaches that are extended and refined to meet them. To this end, goal modeling techniques such as TROPOS [2], KAOS [10], and MAP [19] are used to model users’ needs. MAP allows intentional-driven modeling of user’s needs by using the MAP formalism. The MAP elicits and analyses users’ needs in a set of graphs composed of intentions and strategies, called maps.

Our work fits into the family of research approaches of goal-driven services. Most of these approaches [4, 14], focus on specifying goals in the context of searching Web services that meet these goals. In these approaches, different models have been proposed to specify goals without focusing on the problem of their capture. SATIS [3, 12] proposed ways to assist end users in explaining their needs (goals). Moreover, the approach GODO [7] proposed models and tools to capture the goals of users with the help of ontology and natural language. SATIS differs from this approach by proposing a process of incremental refinement of user needs to specify the characteristics of web services sought, as is the case in [4, 11].

All the works mentioned above focus only on modeling services in a goal-driven manner. However, they do not provide solutions to goal-driven discovery and selection of services to ensure the satisfaction of the users’ needs.
The solution presented in this paper is complementary to [8, 9, 17, 18], where ISM model is used to specify intentional services, and to [1], where the intentional service descriptor is specified. Our approach permits not only goal modeling in terms of verbs and products but also the reformulation of the user’s request for the discovery and the selection of services that closely fit expected users’ business needs.

III. GOAL AND INTENTIONAL SERVICE META-MODELS

In this section the goal meta-model is presented by introducing the notion of an intentional service first, and presenting the Intentional Service Model ISM [8, 9] to model different types of intentional services. Then, the goal meta-model is presented to help in reformulating user’s queries.

A. Intentional Service Model (ISM)

The concept of goal is originally used in ISM model [8, 9]. An intentional service is a service captured at the business level, in business comprehensible terms and described in an intentional perspective, i.e. focusing on the intention it allows to achieve rather than on the functionality it performs. The model defines each intentional service as a building brick in the application by associating it with the situational knowledge in the interface. Each intentional service fits a particular situation in order to achieve a particular intention.

The model of intentional service of [8, 9], takes the form of a composition of services based on graphs, AND/OR tree of goals. The composition of services driven by goals introduces a composition on several levels. The highest service level, which may be strategic in nature, is broken down itself into sub/intentional services, and may require a new de/composition to achieve the intentional services. Therefore, there is a recursive composition of services (Fig. 1).

B. Goal meta-model

We assume that user’s needs are formulated as goals, and are expressed in a language which can be easily understood by non-expert domain users. This language is different from service models definition languages that require technical knowledge of the area.

In this paper, we focus on user needs expressed in structured natural language. The concept of the basic goal presented in our work depends on a lexical formalism with verb, target and parameters representing semantic functions of the verb. We support, in this context, the formulation of goals of ISM [8, 9] based on a linguistic approach originally developed by [16]. This approach was inspired by the case grammar of Fillmore [6] and extensions [5] based on the fact that the semantics of a goal is captured by a verb and parameters that correspond to roles associated to the verb. This formalism allows representing the intentions of users and the goals of services (fig. 2). A goal is expressed by a verb, a target and one or more parameters so-called 'direction', 'ways', 'time', 'beneficiary', 'quality', 'quantity' and 'location'. The verb and the target are mandatory while the parameters are optional. In general, any non composed sentence can be expressed by goal formalism. This formalism allows representing user’s needs, and the goal that intentional services can meet.

IV. QUERY’S ONTOLOGIES

To match the concepts of user’s queries with those of intentional services, we propose to use ontologies. Sharing the same ontologies allows establishing mappings at the time of service discovery. For this reason, we can write queries using ontologies where each query is expressed as a verb, a target and parameters. We differentiate two types of ontologies:

Ontology of verbs representing syntactic and semantic concepts related to verbs. It gives the different meanings of verbs and characteristic of verb components in sentences of natural language. The specifications of the verb that agrees or refuses to construct sentences are syntactic concepts contained in the ontology.

Ontology of products defines the common vocabulary for all objects manipulated during the intentional services search. This ontology is domain based and is especially used to specify the inputs and outputs provided by the services.

The relation between these two ontologies defines the ontology needed for query resolution. In order to establish this relation, we relate each concept in the product ontology to a verb in the verb ontology.

In fig. 3, an image of the ontology of travel is shown where a concept “voyage” of the domain ontology of products is linked to another concept “organize” in the ontology of verbs. The concept “organize” represents the verb that goes with the product concept of “voyage”. We can notice that the verb “organize” is a member of the class “physical causative verbs” in the ontology of verbs, where we can find verbs like “arrange, manage…”.
V. QUERY ANALYSIS AND REFINEMENT

To address the problems identified in the previous section, we introduce the proposed algorithm to analyze the requests made by the user in natural language. Then, we propose an example to clarify our algorithm.

A. Query analysis algorithm

In order to have the best opportunity to discover the intentional services, we suggest extending the query with new concepts from both ontologies. To do so, we search for each term in the query, and then search for the related concepts in these ontologies.

We tend to believe that the point of concern for users when formulating their business goals is the “object” or the “product”. For instance, when you look for organizing a voyage, the most significant issue for us is the voyage itself and not the organization. That is why the goal always has an object according to our algorithm. We start by identifying if the query has a verb or not in order to propose one, and if it has one, we consider whether the verb and the product go together or not.

The search starts after being sure that we have identified at least the product and the verbs that go together. In this phase, we can start the discovery to find in the registry an intentional service that matches the query. If we could find the service and the user is satisfied with it, then the discovery is successful. If not, we repeat the following two steps: (i) we search in the product ontology. Typically, a matchmaking will look at subclasses in the first place, since instances of subclasses are also instances of superclasses, then it looks at superclasses. (ii) Each time, we reformulate our query with new concepts from the ontologies of products and verbs, fig. 4.

At the end of these steps, we could have a list with many formulations to extend the query of the user; the algorithm could provide many intentional services to the user to select from, and halts when the user is satisfied by these services, or when it fails to find more adjacent concepts in the ontology.

As a result of this algorithm, the precision of the result will increase, the number of intentional services retrieved will decrease, and the user will have less effort to select relevant services.

1) Service selection: In general, some services will match the requested needs of the user, while others will not. To distinguish between them, we categorize them based on the match degree [12, 16]: Exact, Subsumes, Subsumed-by, Has-Same-Class, and Fail. Such a categorization also provides an (implicit) ranking amongst the potential intentional services (e.g. Exact match is given the highest rank).

2) Service Ranking: In general, in a real world scenario, given a service request, it is conceivable that there exist scores of service providers. As a result, it is of vital importance to specify some ranking criteria, which would rank the retrieved results (i.e. the list of potential intentional services). The traditional approach for ranking the results of matchmaking is completely based on the degree of match [12, 16] between the concepts of the query and those of intentional service descriptor. In our framework also, we add the degree of match to categorize (and implicitly order) the set of candidate service based on the links in the ontology.

B. Example

In our example, we use the tourist product domain ontology; an image is shown in (Fig. 3). Now, suppose a user, who wants to rent a car. The user formulates his business goal as “rent a car” using the product domain ontology.

In the user’s request above, we start by verifying that the object “car” is a valid concept in the ontology of products, then verifying the verb “rent” if it goes with the product “car”. Then we search the UDDI registry for intentional services that could satisfy this goal. In such a situation, it is possible for the user to discover candidate services from the registry because he is semantically using the same concepts in the ontology, and the service search engine can understand the concepts in the user’s request in terms of the concepts in domain ontologies,
and hence, can select candidate services (from the registry) by doing matchmaking. In case, there is none, we run the process of the query reformulation. The process starts by an empty list, and then we add the instances of the product “car” to the list with their verbs that go with. 

\[ S = \{ \text{rent a four-wheel, rent a sportive} \ldots \} \]

In the second step, we add the parent of the product “car” with the verb that goes with: rent a vehicle.

The third step is to add the brothers: book a bus, reserve a motorcycle, rent a bike…

At the end of this process, we have the list containing the new reformulation of the query.

\[ S = \{ \text{rent a four-wheel, rent a sportive, rent a vehicle, book a bus, reserve a motorcycle, rent a bike} \ldots \} \]

In this example, we can notice how we could modify the user’s request with more enriched concepts and possibilities of research. This process of reformulation could be in an interactive way in order to make the user’s query more precise and rich.

We created and published intentional services in the tourist domain, the intentional services are related to trip organization. Search in the extended registry with these new reformulations leads to find these intentional services: rent a four-wheel in Europe with the degree of match is Subsumption, or rent vehicle for limited duration with the degree of match is Subsumed-by. After the result is ranked, the user is now asked to select the service he believes the best to fulfil his query. Finally, the user decides if the services returned by our approach are related to this query or not.

VI. CONCLUSION

The work proposed in this paper provides an ontological based approach for the search of intentional services. We lay stress on the fact that users prefer to express their needs in natural language, which is the reason why ontologies are needed during service search. The same terms and concepts are used to build the descriptor of intentional service and to formulate user queries to discover these services.

We started from previous work: the intentional service meta-model ISM to propose the goal meta-model for expressing user’s needs and queries. This model allows exploring ontologies to find similarities between the elements of user’s queries and the attributes of intentional services. In this context, we briefly introduced the ontology of verbs and the ontology of products. These two ontologies are combined together to form the solution for presenting the intentional service descriptor and user’s goal.

Reformulating the user’s query is based on finding concepts related to the concepts used in the query in the ontologies. The algorithm for the analysis and refinement of user’s query is introduced in this article. Finally, we presented an example to show how our approach works with comments on the algorithm. Implementing and testing of this algorithm to define the degree of matching between the concepts of user’s query and those of intentional services published in the registry will be the objectives of our future work.

REFERENCES


