Service Discovery in the SOA System

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Abstract. In the paper we present an ontology based service discovery in the SOA system. First we show an application of the following models: business motivation model (BMM) and business process model as well as information for an identification of the business services in a selected area of the university activities has been described. Then we show an importance of the conceptual specification of the services for their subsequent retrieval has been emphasized. Then we present the representation of these services in WSMO and ontology based service discovery with WSM Toolkit.

Keywords: Educational institution, business motivation model, business service, SOA, service discovery, WSMO**.**

1 Introduction

SOA (Service Oriented Architecture) is such an approach to create systems which helps to make independent business solutions from technological constraints. We can say that SOA methodology enables different business sectors to make crucial decision supported by technology instead of making business decision which are determined or constrained by technology [6].

Systems designed accordant to SOA paradigm are composed of service which are executed on user's demand. Each service is an implementation of business functionality which can be used in different applications or, in general, in different (business) processes. We can further stress that each of services in SOA system can combine complex services out of atomic ones. Moreover, in modeled business process it is possible to specify which services can and how their elements interacting with each other.

Today we can say that paradigm of Service Oriented Knowledge Utilities (SOKU) requires development of methods for acquisition, processing and integration of knowledge. Because of the complexity of problems arising in SOKU systems, there is a great need for development of methods of representation of descriptive and procedural knowledge. Hence, ontologies are employed for representation of knowledge about users and services.

The main issue in the work is service modelling, then application of ontology for knowledge representation and processing in SOA/SOKU architecture [5] as well as application of ontology in the service discovery. The service retrieval is SOA/SOKU systems has ever increasing importance. The number of atomic and complex services

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increases rapidly so users may have a great difficulty in identifying the appropriate services, especially when there are no exact matches in service specification and we need ontology to specify them.

2 Discovering the Services in Business Process of Enrolment for the Courses in Education System

The university of technology that educates students at several departments and carries out the scientific researches is an educational system on the basis of which the service identification was made. „Its mission is to shape creative and critical personalities of the students and to chart development directions of science and technology. The university fulfils its mission through a high standard of teaching and scientific research ensuring its prominent place among the universities in Europe and the whole world." [11].

According to the SOA methodology, the service identification should be preceded by an analysis of the organization objectives. From these objectives the services are derived directly or indirectly (through processes). The Business Motivation Model (BMM) [2] was the notion tool used by the authors in the identification of services and objectives. It enabled the authors to create the organization objectives and to connect them with the mission, processes and business rules.

2.1 Process Areas in Subjective Educational System

As in the other organizations of scientific-didactic services sector there are many mutually associated courses of action operated at the Wroclaw's University of Technology's educational system. The most important courses of action are the programming and planning of education, recruitment of students, planning of didactic activities, realization of activities with students and a supervision and control of their education. The courses of action have been identified using diagram (map) of the hierarchy of business processes. This approach allowed us to use the hierarchy of purposes formulated according to BMM to find elements of information technology system compatible with the SOA paradigm. A separation of the elements led to an assignment of coherent business processes and further detailed (deductive-inductive) analyses. These analyses allowed us to disclose the SOA services together with elements of knowledge necessary for their execution.

The detailed analysis concerned two business processes proceeding in planning and realization of the didactic activities. The former one is a process operating the enrolment of students (the customers of the system) for the activities (courses) offered in the multi-semester contracts made with the University (plans of education at Faculties). The didactic programs of courses offered in these contracts have to meet the hierarchy of formal-substantial, qualitative and quantitative requirements. It results from the conditionings of a statutory (the rules written in the law of higher education, ministerial minima), trade (Universities' minima) and academic (rules of the University's senate) character. The other analysed process concerned the assignment of the supervisors to particular groups provided in semester's schedule. This is a relevant internal activity of an organization directly affecting the quality of the whole system's functioning. In a strategic way it decides of preservation of an ability to compete at the educational services market.

3 An Example Discovering Services in the Process of Enrolment for Courses

The mentioned above sub-processes in the educational system, at the Faculty of Computer Science and Management at Wroclaw's University of Technology are the subjects of the identification. The presented examples concern two relevant aspects of revealing the SOA services: identification of repetitive services (according to the "*Select a class from an enrolment array*" process) and conceptualizing of business elementary services and their compounds taking into account a compliance with the business rules, derived from BMM (on the basis of „*Select a set of courses*" process).

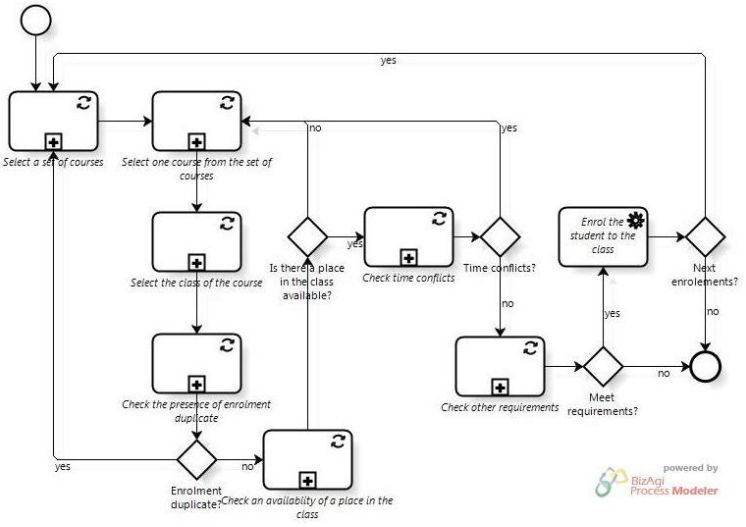

Fig. 1. Process "Select a class from an enrolment array"

In order to identify services a description of business processes, rules and information objects was necessary. The authors decided to use the widely known modeling standards: for business processes - BPMN [3] and for information objects – UML class diagram notation [10]. BizAgi Process Modeler (for BPMN) and Microsoft Office Visio 2007 (for class diagram UML) were the modeling tools: The service identification consisted in the process specification, establishing a relationship between activities from the process and the information objects defined by the class diagram. In the class diagram elaboration the authors tried to express the notions from the subject domain and relationships between them (ontologies). The specification of business rules was an important component of the process specification. Taking into account the goal of the Project, the decision was undertaken not to elaborate separated business rules description using Business Rule Management Tool. The rules were described right on the process diagram in the decision nodes and in the description of activities.

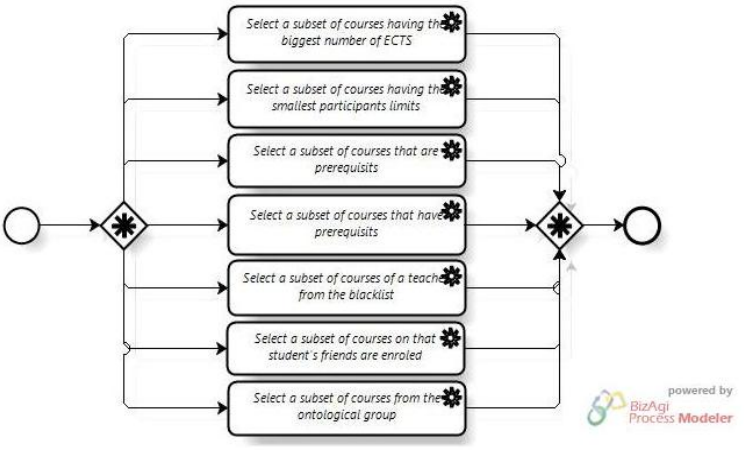

Fig. 2. The process "Select a set of courses", which selects a subset of courses from the input set by running a combination of chosen atomic services

The process "Select a class from an enrolment array". This process is one of several processes of a class choice for a given course, probably most often executed. All services are reusable (see fig. 1), but one service "*Enroll the student to the class"* is atomic. A knowledge needed for its execution is described by a simple procedure that transforms a given input into desired output. The remaining services are composed of the other atomic or multiple services, composed of the elementary business subprocesses. The models of their flows (runs) represent the identified business rules, formulated in the educational system. These are the universal rules, originating from the process environment (for example, "*Check time conflicts*") as well as the sets of behavioral rules originated from behavior of the system participants (for example, "*Check other requirements*").

The process "Select a set of courses". Many of the identified elementary processes are the combination of services from the set of atomic services. The sub-process „Select a set of courses" (see Fig. 2) is a good example. Each service represents a specific criterion of a different complexity. The output of the process is an intersection of the results generated by the subset of selected services. The compound service of such a structure is widely applied at the initial stage of the decision making process, based on the multi-criteria decision analysis, breaking a classical paradigm of the optimality of a choice to favor a soft modeling of the decision maker preferences.

The research carried out showed the usefulness of the approach based both on the BMM and on the usage of the process specification in the discovery of the services that were necessary for the business goal achievements. The analysis of the identified processes allowed us to disclose their common fragments and in this way to find the reusable services. The input/output and the input to output transformation specification in the categories of the UML class diagram allowed us to make a conceptual description of each particular service. This description, in connection with ontologies embedded in the class model, could be a good basis for a retrieval of the databases in a consistency with the service contents.

4 Services Representation in WSMO

In previous sections business process and set of services, utilized to fulfill it, are presented. The aim of this part of work is to specify services, used in considered business process, by use of semantic description. One of the method, which may be used, to convey the meaning of the formal terminologies applying to describe some real-world processes (or objects) is *ontology* [4].

How can we apply ontology in service descriptions? The first language which was used to semantically descriptions of the services is RDF (Resource Description Framework). Extension of the RDF language is OWL (Web Ontology Language) which is more expressive than RDF. In the work other method to define service with semantic information which is called WSMO (Web Service Modeling Ontology) is applied.

The concept of WSMO to describe services is continually developing. The ultimate set of feature will contain tools for discovery, selection, composition, mediation, execution and monitoring. Some of intended aims were reached but some of them such as composition had not be finished yet [4]. Despite the fact, that WSMO is a tool which is still being developed, it can be used to solve some problems connected with ontological service description and service discovery. The second task is considered in next section in details.

The main four top-levels elements of WSMO language are:

- *Ontologies* are used to provide the terminology utilized by each element of service to describe the relevant aspects of the certain domains;
- *Goals* state the intentions that should be solved by services and define objectives which have to be fulfilled in order to execute service;
- *Services* is used to achieve defined goal. Descriptions can be related to various aspects of a service and consist of functional, non-functional and the behavioral aspects of a service;
- *Mediators* resolve interoperability problems and describe elements to overcome incompatibility problems between different elements on data, process and protocol level.

In our point of view, the most interesting aspect of WSMO language are Goals. Goals is used to describe user's desires connected with requested functionality of the service. Because these functionalities allow us to specify properties of desired services, thus this tool is very useful in the discovery process. Considered process can be described as follows: in the service repository a set of accessible services are stored. Some of services, which are in repository, may be used to fulfill user's requirements. The problem is to find subset of accessible services, which are helpful to provide user's requirements. In order to solve this task, we need the tool to semantic description of service and another, to search repository for proper services.

To describe service by making the most of WSMO an ontology or set of ontologies are needed using to provide necessary common terminology for used concepts and relations between concepts.

The last element of WSMO language which is interested in our point of view is Service. It is useful tool to describe functional and nonfunctional properties of the service. This description is applied to represent service and can be utilized in process

of discovery i.e. service's specification is matchmaking with user's requirements defined by Goals.

In the presented work, the problem of building the interface for service which is provided by Mediators, is not considered.

Now we are going to present main elements which constitute ontology by use of MOF notation (Meta Object Facility) [4]. The class of ontology has following elements: *nonFunctionalProperty, ooMediator, concept, relation, function, instance* and *axiom.*

It is worth stressing that all attributes are optional. In the listing shown below a fragment (header of *wsml* file and concept of *Student*) of proposed ontology for discussed Educational System is shown:

```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-rule"
namespace {  _"http://www.sti-innsbruck.at/ontologies#",
            dc _"http://purl.org/dc/elements/1.1/",
            xsd _"http://www.w3.org/2001/XMLSchema#",
            foaf _"http://xmlns.com/foaf/0.1/",
            wsml _"http://www.wsmo.org/wsml/wsml?syntax#" }
ontology EnrolmentFoTheCoursesOntology
concept Student subConceptOf Person
   nonFunctionalProperties
            dc#description hasValue "Student's Concept"
   endNonFunctionalProperties
            hasID ofType (1 1) _integer
            hasActivityStatus ofType (1 1) _integer
             hasRecordStatus ofType (1 1) _integer
            hasYearOfStudy ofType (1 1) _integer
            hasSemesterNumber ofType (1 1) _integer
            hasRegistrationStatus ofType (1 1) _boolean
            hasEnrolmentStatus ofType (1 1) _boolean
```

List. 1. Fragment of proposed ontology in WSMO

To describe functional properties of service in WSMO language the main functionality is Capability. Defining capabilities of the service is, in our point of view, crucial part of the process of designing semantic description of the services because it is used to discover services in repository.

Service definition in WSMO contains following elements:

- *precondition* – definition of input parameters;
- *postcondition* – definition of output parameters;
- *assumption* – definition of real world conditions required for the service to run correctly;
- *effect* – definition of the change in real world after service invocation.

As it can be seen, service definition in WSMO allows us to describe the *state of the World* before service's execution (*assumption*) and when it is delivered successfully (*effect*). *Preconditions* and *Postconditions* are used to specify required input and output data which are required by service. It is worth stressing that these elements of service's definition are crucial for discovery process applied in WSMO.

Taking into account structure of service in WSMO and presented in previous section Educational System service, following definition is proposed (see Fig. 2):

```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-dl"
namespace { _"http://www.sti-innsbruck.at/services#",
                    educl _"http://www.sti-innsbruck.at/ontologies#",
                    discovery _"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#"}
webService SelectASubsetOfCoursesHavingTheSmallestParticipantsLimitsService
importsOntology {educl#EnrolmentForTheCoursesOntology}
capability SelectASubsetOfCoursesHavingTheSmallestParticipantsLimitsServiceCapability
nonFunctionalProperties
        discovery#discoveryStrategy hasValue discovery#LightweightDLDiscovery
        discovery#discoveryStrategy hasValue discovery#NoPreFilter
endNonFunctionalProperties
sharedVariables     ?y1
precondition SelectASubsetOfCoursesHavingTheSmallestParticipantsLimitsServicePre
        definedBy
            ?x1 memberOf _"http://www.examples.org/ontologies/example#Student" and
            ?x2 memberOf _"http://www.examples.org/ontologies/example#Course" and
            ?x3 memberOf _"http://www.examples.org/ontologies/example#StudentEnrolmentVector".
postcondition SelectASubsetOfCoursesHavingTheSmallestParticipantsLimitsServicePost
        definedBy
            ?y1 memberOf _"http://www.examples.org/ontologies/example#StudentEnrolmentVector".
```

List. 2. Fragment of proposed service in WSMO

For illustrative purpose one of the proposed service (called "*Select A Subset Of Courses Having The Smallest Participants Limits*") for Educational System is shown in the framework of WSMO. Some elements of the considered service, such as precondition and postcondition, are not being seen in BizAgi diagrams (see for example Fig. 2) but they are specified by authors and are accessible under BizAgi program. Obviously, they are used in considered definition of the service in pre- and postcondition section.

The last part of top-levels elements which is interesting in point of view of discovery process is Goals. As it was written, they provide the means to specify requester objectives. It is worth stressing that WSMO allows to specify objectives that would potentially satisfy user's desires which is helpful in discovery process [4].

As it was stressed, at the beginning of this section, one of the main feature of the system such as system supported educational process is ability to find service aggregated in repository. To describe such services and goals, which are used to define service capabilities and user's requirements respectively, WSMO language may be used.

5 Service Discovery

Let us assume that in Educational System service repository a set of services are stored (in Fig. 1 and 2 some services for considered problem are shown). By discovery problem, we mean the problem of finding services that can comply with user's required. Motivation for service discovery process, in considered system, is the problem of executing all possible user's tasks which can be called in proposed system.

It is clear that it is not possible to specify all possible service which satisfies user's requirements exactly. Therefore, we need the tool which helping us to search repository and find services with different degree of relevance i.e. different types of logical relationship between semantic description of the services and user's goals. It helps us to propose such service for user in correct order.

One of the problem which has to be used in discovery task is the specification of user's requirements and, describe in previous section, service capabilities. Another issues, which has to be solved, is related to service matching algorithms with methods determining the degree of relevance of found services.

As it was stated earlier, WSMO supports the discovery process of services with semantic description. The general idea of services discovery is based on comparison of semantic description of the service's capabilities (*pre- and postconditions*) with description what the user wants to achieve (see Fig. 3).

As a result of using WSMO framework for service discovery, a set of candidate services which are met with user's demands are identified. It is worth stressing that services which are identified as useful, in user's point of view, providing with a relevance degree of semantic matchmaking. In WSMO there is a five matchmaking notions [7]:

- *Exact match* – holds if and only if all each possible ontology instance satisfies both service and user's goals and there is no ontology instance which satisfies only goal or service;
- *Plugin match* – hold if ontology instance is superset of relevant user's goal;
- *Subsumption match* – hold if ontology instance is subset of relevant user's goal;
- *Intersection match* – holds if one possible ontology instance which satisfies both service and goals;
- *No match* – there is any possible ontology instance which satisfies user's goals.

In List. 3 an example specification of user's goals ("*Select A Subset Of Courses Having The Smallest Participants Limits*") is presented. Taking into account presented definition of user's requirement and methods, which are used in WSMO, it is possible to discover and determine the degree of relevance of services from repository. As it was stated earlier to determine degree of relevance of service and user's goals five different notions are used. When discovery process is finished it is possible to consider which of accessible services are able to solve user problems defined as goals.

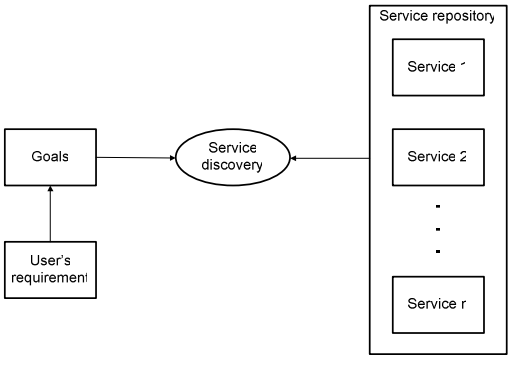

Fig. 3. General idea of service discovery in WSMO

```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-dl"
namespace { _"http://www.sti-innsbruck.at/goals#",
                    educl _"http://www.sti-innsbruck.at/ontologies#",
                    discovery _"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#"}
goal SelectASubsetOfCoursesHavingTheSmallestParticipantsLimitsGoal
importsOntology {educl#EnrolmentForTheCoursesOntology}
capability SelectASubsetOfCoursesHavingTheSmallestParticipantsLimitsGoalCapability
nonFunctionalProperties
        discovery#discoveryStrategy hasValue discovery#LightweightDLDiscovery
        discovery#discoveryStrategy hasValue discovery#NoPreFilter
endNonFunctionalProperties
sharedVariables     ?y1
precondition SelectASubsetOfCoursesHavingTheSmallestParticipantsLimitsGrupGoalPre
        definedBy
         ?x1 memberOf _"http://www.examples.org/ontologies/example#Student" and
         ?x2 memberOf _"http://www.examples.org/ontologies/example#Course" and
         ?x3 memberOf _"http://www.examples.org/ontologies/example#StudentEnrolmentVector".
postcondition SelectASubsetOfCoursesHavingTheSmallestParticipantsLimitsGoalPost
   definedBy
        ?y1 memberOf _"http://www.examples.org/ontologies/example#StudentEnrolmentVector".
```

List. 3. Fragment of proposed goals in WSMO

Solved problem of matching services from repository, which are met user's requirements, can be in different task connected with Educational Systems such service recommendation or service composition. These problems will be considered in future works of the authors.

5 Summary

In this work we present the process of the selected educational services modeling using BizAgi environment as well as application of WSMO and WSM toolkit for their representation and the process of discovery based on the ontology. It was shown that the selected tools are very useful for solving essential problems in the ever growing SOA systems. The solution of the problem of automatic service discovery may be used in the several different ways, first it may be used as a direct solution of the problem of retrieval of the relevant services, but also second, it may be used as an element of the process of the service composition when we have to find and select all elementary services that may be composed in a larger aggregate.

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