From User Goals to Service Discovery and Composition

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Abstract. Goals are often used to represent stakeholder's objectives. The intentionality inherited by a goal drives stakeholders to pursuit the fulfillment of their goals either by themselves or by delegating this fulfillment to third parties. In Service-Oriented Computing, service client's requirements are commonly expressed in terms of inputs, outputs, preconditions and effects, also known as IOPE. End-users, i.e., human service clients, may have difficulties to express such requirements as they would have to deal with technical issues such as the request's language, and the type, format and coding of the IOPE. This paper presents the core concepts of the Goal-Based Service Ontology (GSO) that relates goals and services. By grounding GSO in a well-founded ontology we aim at clarifying the semantics for a set of relevant domain concepts that can support specialists in defining application ontologies based on goals and services.

1 Introduction

Service-Oriented Computing (SOC) has been gaining momentum in recent years with an increase in industry adoption and research efforts. SOC has been seeing as an approach to integrate legacy and new systems with a standardized set of protocols and interfaces in a distributed manner. Among the research efforts in this area we can include the pursuit of supplying semantics to service descriptions, message exchanges and service requests. The addition of semantics aims at supporting semantic interoperability for heterogeneous systems. Ontologies are being used in the realm of SOC for providing this semantic richness [1], [2].

Even when semantically enriched, service client's requirements are commonly expressed in terms of inputs, outputs, pre-conditions and effects, also known as IOPE. In this manner, the intentionality of the service client (why he wants the service) is not clear or explicit in the mix of technological details such as input and output parameter types and restrictions to the service selection and execution.

In this paper we present an ontology-based approach to support dynamic service discovery and composition. The main element of this approach is the

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Goal-Based Service Ontology (GSO). GSO includes concepts and relationships that (represented by the Goal-Based Service Metamodel) allows domain specialists to define their goal-based service-oriented models. Clarity and an appropriate formalization of semantics are important requirements for ontologies. These requirements are especially relevant in Service-Oriented Computing (SOC) to enable complex tasks involving multiple agents. GSO aims at providing ontologically sound concepts relating concepts of SOC (e.g., Service Provider, Service Client and Service) with concepts pertinent to our goal-based approach, such as Goal and Task. Nevertheless these concepts are not sufficient for a complete domain specification. Other domain-independent concepts and relations are necessary such as Description, Agent, Intention, Material Relation, among others. In order to provide these concepts and relations and at the same time supply semantic clarity we are working towards a domain ontology for the domain of goal-based service specification making use of the foundational ontology Unified Foundational Ontology (UFO) [3]. UFO is based on formal principles derived from formal ontology in philosophy, cognitive sciences, philosophical logics and linguistics.

GSO is part of a framework to support dynamic service discovery and composition called Goal-Based Service Framework (GSF). In GSO the concept of goal is used to express the service client's intention towards a service, i.e., why the service client used the service and why the selected service is beneficial to the service client. This paper is further structured as follows. Section 2 gives an overview of the architecture of the Goal-Based Service Framework. Section 3 details and discusses the proposed Goal-Based Service Ontology. Section 4 presents an example usage scenario of GSF in the Home Health Care domain. Section 5 presents some final considerations.

2 Goal-Based Service Framework (GSF)

In our work we consider the scenario of Pervasive Computing associated with SOC technologies and concepts. In this scenario we have human agents surrounded by and interacting with a plethora of computational devices and services. This motivates the need of a platform support to tackle with the issues of service discovery and composition in an unobtrusive way.

Our framework to support dynamic service discovery and composition is based on goal modeling and assumes that the involved stakeholders (service clients, service providers, supporting platform) share the same conceptual models, i.e., the same set of domain ontologies. This requirement is necessary because the approach relies on the availability of domain-specific ontologies. The elements of this Goal-Based Service Framework (GSF) are described as follows:

– *Goal-Based Service Ontology (GSO).* This ontology defines domain- independent concepts such as service, service client, service provider, goal, task and their relations, among others. This domain independency is however limited to domains and applications within the scope of the aforementioned scenario of Pervasive and Service-Oriented Computing.

- *Goal-Based Service Metamodel (GSM).* Generated from Goal-Based Service Ontology, this metamodel represents the concepts defined in GSO and defines the language used by domain specialists to create domain specifications.
- *Domain Specification.* GSF can be used in different application domains such as Health Care, Ambient Intelligence, etc. For each of these application domains a domain specialist defines a domain specification, namely the concepts and relations relevant to the domain, goals that users can have, valid tasks in the application, etc. GSM, representing GSO concepts, provides a modeling language that enables domain specialists to define domain specifications allowing a shared knowledge about particular domains. A domain specification is composed of: *(i)* a domain ontology including domain-specific concepts, the relations among these concepts and valid goals that users of that domain can have; and *(ii)* a task ontology which uses the concepts defined in the domain ontology and provides domain-specific definitions of valid tasks and how they can be related to user's goals fulfillment.
- *Context-Aware Service platform.* The context-aware service platform supports the interaction between service providers and service clients. From the service provider's perspective, the platform supports the publication of service descriptions. From the service client's perspective, the platform provides mechanisms for service discovery, composition, invocation and monitoring, among others. Moreover, the context-aware components of our supporting platform provide user's contextual information that is used *(i)* to select which of the tasks that support a given goal will be used in the service discovery and composition procedures and, *(ii)* as input data for the discovered services. The context information gathering reduces the need of direct user input and, thus, reduces also the need of user's interaction supporting a more autonomic behavior of the platform.

A normal deployment of GSF consists in the GSO, GSM and the CA Service Platform. A second step is the addition of domain specifications by domain specialists. Service providers can start to semantically annotate their services and service descriptions based on the concepts present on these domain specifications. The service descriptions are added to the CA Service Platform by the service providers.

3 Goal-Based Service Ontology

3.1 Goal Definition

The concept of goal has several different definitions depending on the domain the term is used, e.g., Philosophy, Sports, Economy, among others. Narrowing down to the Computer Science domain, a variety of definitions of the goal concept can also be found such as in [4]. Regarding the community of Semantic Web, in the goal definition of the Web Service Modeling Ontology (WSMO) [1] a goal is closely tied to Web services, i.e., a commitment is done already in the ontological level w.r.t. the specific technology to realize services. An example of this close tie

between a WSMO goal and Web services is in WSMO's goal description which includes the interface of the Web service the user would like to interact with. In our work we consider Web services as one possible technological solution for implementing services and do not limit our approach to this specific technology.

For the purposes of this framework, we define goal as the *propositional content of a service client's intention*. In other words, a service client (an intentional agent) has an intentional moment of the type *Intention*. Here, moment is used in its ontological sense of being an individual that can only exists in other individual, i.e., moments are existentially dependent of other individuals. Every intentional moment has a type and a propositional content. The propositional content is an abstract representation of a class of situations referred by that intention. In an intention, the intentional agent commits at pursuing the satisfaction of this intention. Therefore, by having a goal, a service client commits to pursue the fulfillment of that goal. Using this definition we can have that many alternative state of affairs can satisfy (in the logical sense) the goal. Belief is defined in UFO as an intentional state about a certain state of affairs in reality. Examples include my belief that the Moon orbits the Earth and, my belief that Paris is the capital of France.

3.2 Goals, Tasks and Services

Figure 1 depicts the *Goal* concept of GSO and how it is related to UFO concepts (grayed boxes). In GSO we added that a Goal is owned by a Service Client Type. This ownership relation defines a meta-commitment making that the individual instances of the Service Client Type have a goal of certain kind, i.e., let S be a service type and g a goal, we have that S owns g iff for every instance x of S there is an intention I which is an intrinsic property of x (inheres in x) and g is the propositional content of I. For example, when an individual is a patient (in this example a patient is a service client type) he/she is characterized by the goal GetMedicalTreatment.

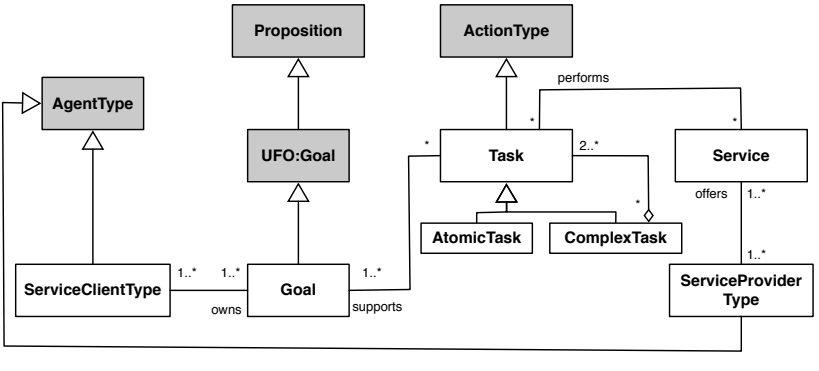

Fig. 1. Goal definition

Task in GSO is a specialization of the UFO concept of Action Type. An Action in UFO is an intentional event, i.e., an event performed by one or more agents in order to accomplish a goal. In figure 1, the relation *performs* between *Service* and *Task* (again, an Action Type) represents that instances of *Task* are executed when the associated service is executed. Finally, the relation *supports* between task and goal represents that a successful execution of that task satisfies that goal.

A domain specialist can define goals for different types of service client types in a domain. For instance, a *Doctor* (a type of service client) can be specified as having the goals *ProvideMedicalTreatment*, *KeepUpdatedWithMedicalAdvancements*, etc.

As depicted in Figure 2 (a model of instances), a Goal can be structured in two different ways, namely, in a decomposition structure (GoalANDDecomposition) and in a specialization structure (GoalORDecomposition). These two structures have different implications on goal fulfillment. In the decomposition structure, the fulfillment of the high-level goal is accomplished with the fulfillment of all the sub-goals. For instance, a high-level goal GetMedicalTreatment is fulfilled when its sub-goals GetMedicalConsult and GetMedicinePrescription have been fulfilled. Conversely, in the specialization structure, the fulfillment of a sub-goal implies the fulfillment of the high-level goal. For instance, the same hypothetical high-level goal GetMedicalTreatment is fulfilled when either one of the sub-goals GetHomeMedicalTreatment and GetHospitalizedMedicalTreatment is fulfilled. Figure 2 also shows the causal chain of goal satisfaction. An intention (of which a goal is its propositional content) causes an action (an instance of a Task) to be performed, i.e., since the agent is committed to the goal satisfaction, he acts accordingly to pursue its satisfaction. The action creates a situation that satisfies the goal. The use of situations to satisfy goals opens the possibility of using a Fuzzy mechanism to assess partial satisfaction (if necessary) of goals. Depending on the domain being specified using GSO, the domain specialists can define different goal satisfaction degrees.

In GSO, the ownership relation entitles the owner agent, i.e., a particular agent instantiating the specific service client type, to delegate the fulfillment of the goal to another agent. Moreover, by delegating a goal to an agent, the delegatee commits to the fulfillment of that goal. Therefore, the delegation relationship implies also a commitment between the delegator and the delegatee in relation to a goal. In GSO, this delegation relationship occurs when a service client delegates the fulfillment of a goal to a service provider. In the scope of this paper we are only considering the open delegation [5] of a goal. In this open delegation, a service client delegates the satisfaction of a goal to a service provider but does not prescribe any specific way of reaching this satisfaction. In other words, the service client only wants the goal satisfied without caring about how it is going to be satisfied. In contrast, in a close delegation the service provider should satisfy the service clients goal by means of a specific task. The relations of ownership, (close and open) delegations and satisfaction relations in GSO are also reflected in common goal-based requirements engineering languages such as i* and Tropos [6].

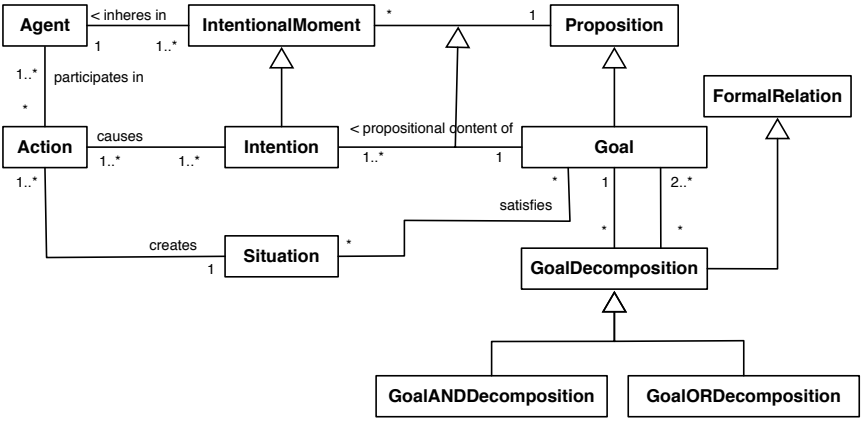

Fig. 2. Goal satisfaction and composition

3.3 Service

Although GSF aims at providing support for discovery and composition of computational services, at the ontological level we also consider services at the social level. This separation between social and computational services allows us to cope with situations where a computational service can be related to a social service and contribute to the fulfillment of a client goal. In GSO we define service as *a temporal entity related to the commitment (a service agreement) that a Service Provider, performs a task (a type of action) on behalf of a Service Client whose outcome satisfies a Service Client's goal*. This definition of service is based on the analysis of social services presented in [7].

Our definition encompasses some of the main characteristics of service as defined in the Marketing and Economics fields, namely, intangibility (as being a temporal entity) and the inseparability of production and consumption. As opposed to a product, when a service is delivered (the equivalent to the product's production) its outcome, which may satisfy the client's goal, is immediately perceived by the service client (the consumer). In [8], the authors state that the service's value "*is always uniquely and phenomenologically determined by the beneficiary*". In our framework this statement remains valid as the service client (the beneficiary) determined the service's value by the fulfillment of his goal.

In our definition two aspects can be considered, the service execution and the service agreement. Both have time-limited lifespan but represent different concepts. While the former represents that actual execution and consequent service provisioning, the later represents the validity of the service agreement. For example, the service execution of money withdraw from an ATM lasts as long as last the activities related to cashing out money from the teller. In this example, the agreement for the money withdraw service is valid for as long as the client has an account in his bank. This makes explicit that a service encompasses

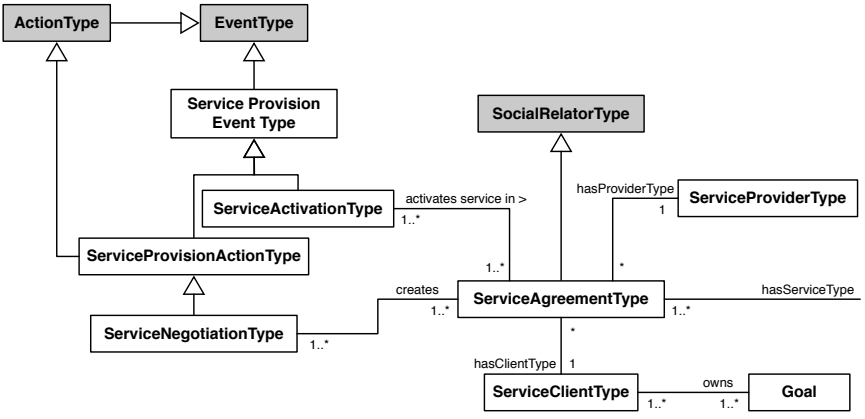

Fig. 3. Service negotiation and activation

a set of meta-commitments, e.g., commitments to commit to execute actions of a certain type [9].

Tying a service with a client's goal allows the analysis of the purpose of a service and its selection; namely, a service is selected because of its role on fulfilling a client's goal. Moreover, the relation between a goal and a service supports dynamic service discovery and selection by comparing situations that could satisfy a goal with the situations generated by services' outcomes. In other words, it is possible to discover services to fulfill a goal by verifying if the situation generated by the service's outcome is equivalent to a situation that can satisfy a goal.

Figure 3 depicts the relations between Service, Service Client Type and Service Provider Type. The *Service Provision Event Type* represents types of events that can participate in service provision such as *Service Negotiation Type* and *Service Activation Type*. When a service client discovers and selects a service, a negotiation takes place to determine the conditions and constraints for the service provisioning. A successful negotiation creates a service agreement type which is a social relator binding the service client and service provider and can be potentially composed of a set of commitments and claims, e.g., the commitment of providing the service under certain conditions and for an specified cost. This social relator (the *Service Agreement Type*) can be described in a contract (not depicted in the figure) which is a normative description [5].

4 Example Scenario

In this section we present an example scenario using GSF in the area of Home Health Care aiming at illustrating the feasibility and applicability of our approach. In this example we model the domain using GSO/GSM. The scenario is described as follows: "*John is a remote patient that receives health treatment at*

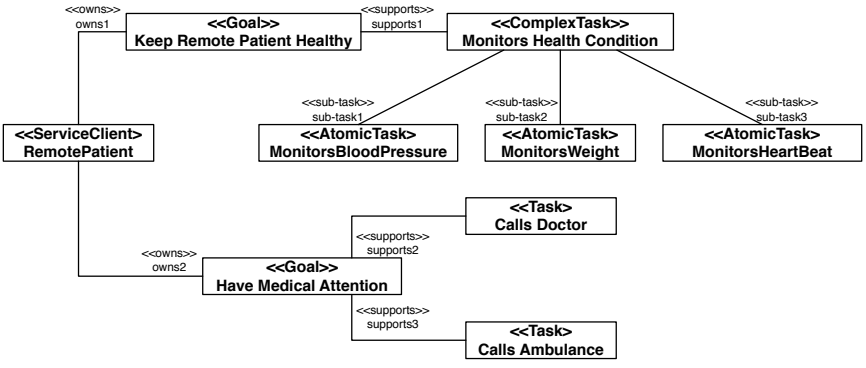

Fig. 4. Domain specification fragment

home. His house is equipped with several sensors that provide contextual information about his health condition such as weight, heart beat rate, blood pressure and glucose level. Moreover, movement sensors allow the determination of the householders' location and to assess whether their are in a responsive condition or not (e.g., asleep, fainted, etc). The main goal of John is to remain healthy. The house is equipped with the Context-Aware Service Platform, the Home Health domain has been specified and this domain specification is available to the platform. Several health-related services are available to the platform."

Figure 4 shows a fragment of the Home Health care domain specification. In this figure a *Remote Patient* which is a type of service client owns the two goals *Have Medical Attention* and *Keep Remote Patient Healthy*. The *Have Medical Attention* goal is supported by two tasks, namely, *Calls Doctor* and *Calls Ambulance*. Here we have an example of a goal being supported by two distinct tasks. The *Keep Healthy* goal is supported by the *Monitors Health Condition* complex task. This complex task is composed by the sub-tasks *Monitors Blood Pressure*, *Monitors Weight* and *Monitors Heart Beat*.

Figure 5 shows an UML object model of the instantiation of our illustrative domain specification. In this object model, *John* becomes a Remote Patient (a type of service client) when he pursues the fulfillments of his goals through services. Since *Keep Remote Patient Healthy* is a proposition, we have that *Keep John Healthy* represents a binding between an instance of *Remote Patient* and a generic proposition. However, for the sake of simplicity, we use a uniform representation for genuine instantiation and instance binding in a generic proposition.

Having John's goal, the GSF's Context-Aware Service Platform searches for instances of tasks that support John's goal *Keep John Healthy*. The supporting platform found that the complex task instance *Monitors Health Condition Inst* and its sub–classes *Monitors Weight Inst*, *Monitors Blood Pressure Inst* and *Monitors Heart Beat Inst* support John's goal. Having found the supporting tasks, the platform proceeds to search for services performing these tasks. In Figure 5 the platform found the services *Weight Monitoring Srv*, *Blood Pressure*

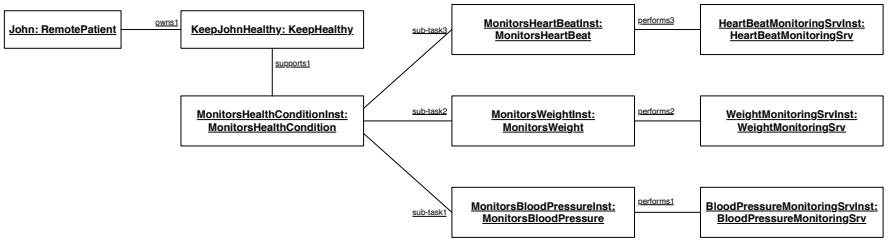

Fig. 5. John's instance model

Monitoring Srv and *Heart Beat Monitoring Srv* that perform the tasks *Monitors Weight Inst*, *Monitors Blood Pressure Inst* and *Monitors Heart Beat Inst*, respectively.

The Context-Aware Service Platform, acting on behalf of the service client negotiates a service agreement. In this example, this agreement stipulates the frequency of the monitoring activities and the threshold for emergency warnings in the case of abnormal health indicators' values, e.g., a blood pressure measurement above 200/160 or below 90/40.

5 Conclusions

This paper presented the main concepts comprising our characterization of a preliminary Goal-Based Service Ontology (GSO). This Ontology aims at providing the means for domain specialists to define domain ontologies. GSO is part of a framework (the Goal-Based Service Framework) for goal-based dynamic service discovery and composition. This framework is primarily target at application scenarios where the service clients are end-users without technological training in the scope of Pervasive and Service-Oriented Computing. For this purpose we propose the use of goal to express the service clients' requirements. In this manner, the service clients can express what they want to be accomplished by the services in a higher level of abstraction (by using goals).

Moreover, we presented and briefly discussed the ontological foundations of the main terms defined in this framework, i.e., goal, task, service client, service provider and service platform. This ontological foundation aims at providing an underlying conceptualization and at supporting the semantic definition of the terms used throughout our framework.

For the deployment of the framework, domain specialists should define their domain specifications (domain and task ontologies). Therefore, the framework is suitable for environments where the domain is clear and well known. Based on our experience in previous projects in the areas of Ambient Intelligence (AmI), Health Care and Mobile Pervasive Applications, we believe that these constitute examples of domains with suitable characteristics for our framework's deployment. A further investigation of the necessary characteristics and a more comprehensive list of suitable domains is in the scope of our future work.

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