A Context-Aware Service Discovery Framework Based on Human Needs Model

Nasser Ghadiri, Mohammad Ali Nematbakhsh, Ahmad Baraani-Dastjerdi, and Nasser Ghasem-Aghaee

Department of Computer Engineering,
University of Isfahan
Isfahan, Iran
{ghadiri, nematbakhsh, ahmadb, aghaee}@eng.ui.ac.ir

Abstract. In this paper we have proposed an approach to extend the existing service-oriented architecture reference model by taking into consideration the hierarchical human needs model, which can help us in determining the user's goals and enhancing the service discovery process. This is achieved by enriching the user's context model and representing the needs model as a specific ontology. The main benefits of this approach are improved service matching, and ensuring better privacy as required by users in utilizing specific services like profile-matching.

1 Introduction

During the past few years, semantic web services have been a major research area for making service-oriented architecture (SOA) more usable in real applications. Numerous efforts are undergoing both research and standardization, including OWL-S, WSMO, WSDL-S, IRS-III, SWSF [5,6] and SAWSDL [14]. Their common goal is exposing the capabilities of web services in a machine-understandable way, by annotating and adding semantics to web services advertisements, to be used by other services and clients for automated service discovery and composition.

However, automated composition of services is in its early stages. More adaptation to changes in customers and more dynamic service composition methods are required [13]. One of the primary reasons of service-orientation is fulfillment of the user's requirements. From the SOA point of view, user's goals, motivations and requirements are important factors to be taken into account. In the SOA reference model [12], these aspects form a major part of the architecture (Figure 1). This model says SOA is not done in isolation but must account for the goals, motivation, and requirements that define the actual problems being addressed. Also in OWL-S, user's goals are considered as a part of service profile [2], and in WSMO, user's desires are taken into account, but working on the user's needs, desires and expectations and mapping them to goal descriptions is a difficult step and is mostly neglected in the current web service discovery models [4].

The main question here is how user's needs are to be satisfied by selecting and composing the semantically annotated services? So we will require a deeper insight

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into user's needs, desires and goals, generally as the user's behavioral context, to improve the overall service matching quality. Although many of existing approaches towards service composition largely neglect the context in which composition takes place [13], two types of context-orientation in web services have been proposed: service context [8] which is used for orchestration of distributed services in service composition, and user context [5], which is discussed and extended in this paper.

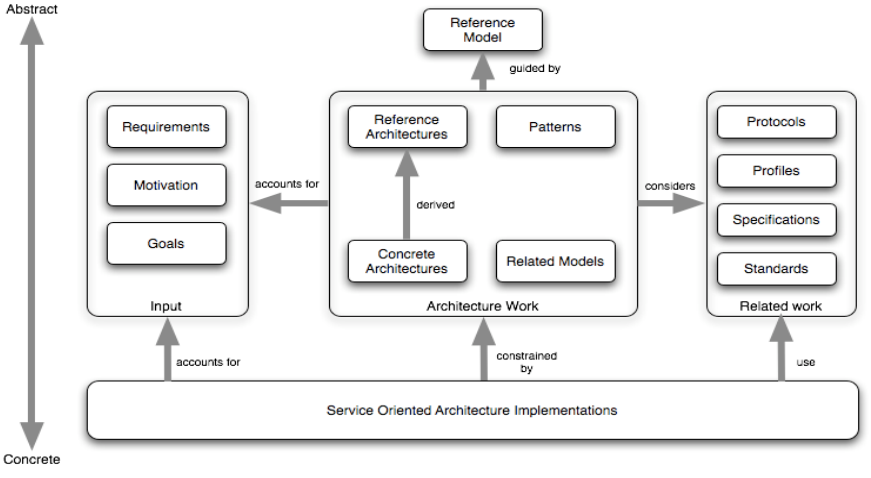

Fig. 1. Goals and motivation in SOA reference model [12]

The rest of the paper is organized as follows. Section 2 motivates the reader with giving a couple of example scenarios which demonstrate the need to model the user's needs. Section 3 introduces the human needs model. Our service discovery model based on human needs is presented in section 4. Section 5 contains some use cases and application areas, followed by a conclusion in section 6.

2 Motivating Examples

For a better understanding of the role of human needs, imagine these scenarios.

• *Scenario 1*: The need for security can be seen as an emerging dominant need. Suppose that you are using a virtual travel agency (VTA) [4] as a service-oriented application to plan your vacation by giving your preferences and constraints for selecting the most suitable services that fit your conditions. Meanwhile, suppose a security problem, for example a credit card fraud happens to you. It will draw all your attention to solving it first. You will probably suspend your travel planning, since the credit card problem is more important to you. You next efforts will be dominated by your personal criteria for selecting services that will potentially help you to solve the fraud problem. You will suspend your travel planning until returning to your secure position that was satisfying you before.

• *Scenario 2*: Finding a good job and keeping it. If the user or service requester is unhappy with his/her job, detected explicitly or implicitly by the service-oriented application, the service composition must be switched to a context for ensuring the user of his/her job security, as it might be more important than other needs, at least in current context of the user.

We can see that knowing more about the user's needs, might help us to understand why a client pays little attention to what we offer and prefers to follow other services, or to analyze the real causes of canceling or suspending the previous service requests an so on.

3 Modeling the Human Needs

Several approaches have been proposed for modeling human needs and motivation, mostly in 1950 to 1970. Among them, Maslow's hierarchy of needs [9][10] is a widely accepted model [7]. Despite some criticisms on Maslow's theory, there is little debate around the main concepts of this model, such as the hierarchical nature of needs and the dominance of a need which we will use for our SOA enhancement.

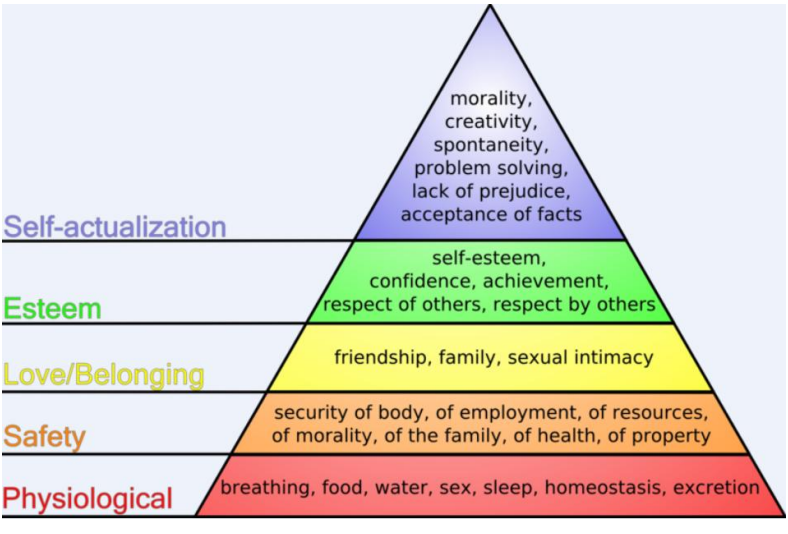

Fig. 2. Maslow's hierarchy of needs [11]

According to Maslow, human needs arrange themselves in hierarchies of pre-potency. That is to say, the appearance of one need usually rests on the prior satisfaction of another, more prepotent need [9]. Maslow's hierarchical classification is consisted of five layers as presented in Figure 2. There are at least five sets or layers of needs, which are grouped as physiological, safety, love, esteem, and self-actualization needs. The lowest layer represents our physiological needs such as warmth, shelter, food, etc. The next layer contains safety needs or security needs

which means protection from danger. Social needs such as love, friendship and comradeship are above it and the fourth layer is about esteem needs for self-respect, or self-esteem, and for the esteem of others. When lower layer needs are satisfied to an acceptable level, higher layer needs will emerge. The highest layer contains self-actualization needs, which are also called growth needs. Growth needs are satisfied by finding the way to "What a man can be, he must be" [9].

A nice and complex feature of human needs is the dynamic behavior which governs our needs. According to Maslow, as higher priority needs (lower level in hierarchy) are emerging, these needs will *dominate* our behavior until they are satisfied. If all the needs are unsatisfied, and the human is then dominated by the physiological needs, all other needs may become simply *non-existent* or be *pushed into the background.* A similar concept to dominance of a need is *context dominance*, which describes the concept of ordering context information according to importance, and is expressed as a set of rules that are restricted to a device, a user, or are globally applied to all participating services involved in fulfilling a given task [3]. The needs model can be used as those set of rules which restrict a user in context dominance, i.e. dominance of a need can determine context dominance from a user's perspective.

4 Service Discovery Model Based on Human Needs

Our user context model is the result of extending the object-oriented context model in [5]. The proposed context model is depicted in Figure 3. The general context includes location or spatial context, time or temporal context, environment context, device context user context, etc. Our proposed needs context is part of the *user context*, reflecting those parameters which directly present the user's needs and desires. As noted above, the other parts of context may also affect needs context. For instance, being in a certain geographic location, defined as part of spatial context, might trigger some of our needs, or educating as an undergraduate student, defined as part of temporal context, can be a basis for user needs model to be copied from a generic needs context of such a student.

We also briefly introduce our work towards formalizing the needs model for handling this extended user context. For *knowledge representation* about the needs model, we defined an ontology for needs. We used Protégé to build the required ontology based on the Maslow's hierarchical model. Our needs ontology defines every layer in Maslow's model as a class, with different types of needs in each layer as the subclasses. The ontology is designed to support other models of needs as well. The concept of satisfiers is also defined, as the services and others entities which can fulfill the needs and the relationship between needs and satisfiers are modeled by using attributes.

For *reasoning* based on the above representation, we propose using the service matchmaking algorithm in [1], slightly modifying it to handle the needs context. Considering their matchmaking algorithm, we can add the layers in Maslow's needs hierarchy at each layer with $\Sigma_{li}(a_1, a_2, \ldots, a_n)$ which means the activities in layer *i* can be done in any order.

Doing the matchmaking this way, ensures a match adapted with user's current status of satisfaction of needs, which is a more stable matching and closer to the goals and requirements of the user.

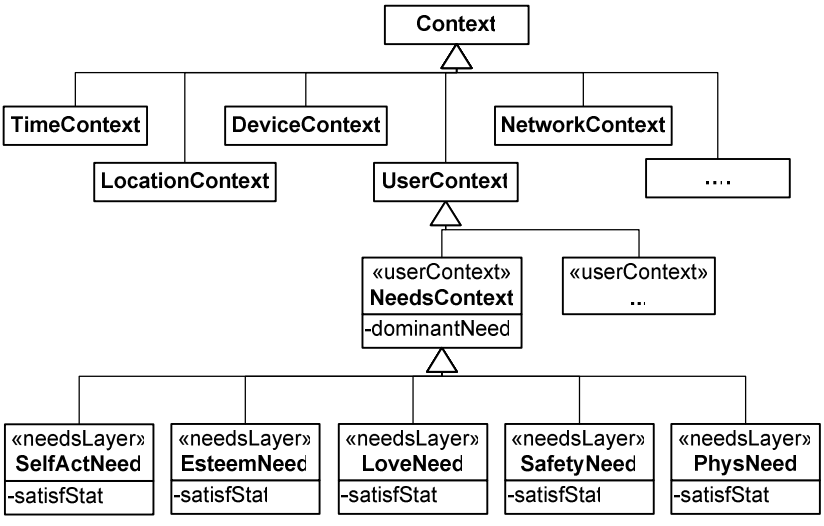

Fig. 3. Partial hierarchy of context focusing on needs as a part of user context

5 Applications Areas

Service composition process can be improved by using the needs model. Discovering the pre-requisites of each service is an important step in service composition. Based on our model, before executing any service for a user, all services which can satisfy lower layer needs must be selected and executed. The human needs model also can improve *web service personalization* process [6] by increasing the quality of similarity measurement. In other words, two users with similar status of their hierarchy of needs, might have similar contexts, which makes the personalization and recommendation more efficient. Another application area is *profile matching*, for example between two or more mobile users, which can be improved by taking the human needs model into account. Profile matching is generally based on comparing the contexts of users which are geographically or temporally near to each other, and ranking the potential users for establishing a relationship and so on. This process can use an enriched profile similarity measure, by taking into account the needs status of parties. The main benefits of adding the needs dimension to context-aware profile matching for the user are:

- Enhanced matchmaking, due to higher quality matching based on needs and filtering out those services which are far from current user's needs context
- Better privacy, by rejecting the people with unmatched needs from accessing user's profile and other private context information.

6 Conclusion and Future Work

In this paper we introduced an approach to extend current service selection methods by using the human needs model. The main contribution of this work is adding a new dimension to context-aware service selection and composition, by presenting a model which enables service selection algorithms to consider human behavior, needs and motivations in the reasoning process. Our approach is based on extending an object-oriented context model by Maslow's hierarchy of needs, which potentially can be used in every semantic web services model. Modeling the human's core needs, could also be a sound conceptual integration point between the different available semantic web services models.

Our future works will include building a proof-of-concept prototype for our proposed architecture and evaluating the modified matchmaking algorithm. We also plan to improve our approach by using inexact reasoning, since the needs model is an aspect of human behavior, which inherently contains some type of uncertainty and will benefit from inexact knowledge representation and reasoning techniques.

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