A commitment-based reference ontology for services

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ABSTRACT

The concept of "service" has been characterized in different disciplines and by different authors from various points of view. This variety of characterizations has emerged because although this notion seems intuitive, it is far from trivial, with many interrelated perspectives. Given their importance in enterprise computing and Service Science in general, we believe that a clear account of services and service-related concepts is necessary and would serve as a basis for communication, consensus and alignment among approaches and perspectives. In this paper we propose a commitment-based account of the notion of service captured in a core reference ontology called UFO-S. We address the commitments established between service providers and customers, and show how such commitments affect the service lifecycle. Moreover, we show that the commitment-based account can serve to harmonize different notions of service in the literature.

1. Introduction

The notion of "service" has had a major impact on Marketing, Business and Computer Science over the last decades, leading to cross-discipline efforts under the banners of "Service Science" and "Service Computing". Several authors from different disciplines have referred to this notion under various perspectives, leading to a variety of characterizations for "service", each emphasizing different aspects. For example, the *service as behavior* perspective focuses on the interactions among service participants to achieve results or generate effects [1–4]; *service as value co-creation* focuses on services as the basis of economic exchange [5–7]; *service as capability* focuses on the capability of a provider to produce benefits to customers [8,9]; *service as application of competences* focuses on the manifestation of one party's capability to act in benefit of another party [5]; finally, *service as software* focuses on pieces of software that can be accessed through well-defined interfaces [10,11].

We believe these characterizations are influenced by many aspects, such as the research community to which their authors belong (e.g., Service Science, or Service Computing), the targeted application area (e.g., Data Communication or Distributed Computing [12]), or the layer in an Enterprise

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Architecture (Business, Application, or Technology [2]). We claim that this variety of characterizations has emerged because although this notion seems intuitive, it is far from trivial. Under close inspection, we have observed that the term "service" often denotes different (possibly related) underlying concepts. A possible problem from this is that

> "even if different communities of practice can live with their own somewhat inconsistent views of service, conflicting views of service surely cannot facilitate effective communication between business and IT practitioners and between business and computer science researchers" [13].

Given the importance of services in Service Computing and Service Science in general, we believe that a clear account of the underlying concepts is necessary and would serve as a basis for communication, consensus and alignment of the various approaches and perspectives. Thus, we propose in this paper a *core reference ontology for services*, called UFO-S, that intends to address the notion of service broadly in such a way as to harmonize different service perspectives, and has application to both Service Science and Service Computing. Several conceptual models and ontologies of service have been proposed, including: OWL-S [14], WSMO [15], The Open Group's Service Ontology [16], the Reference Ontology for Semantic SOA [17], the HL7 SOA Healthcare Ontology [18], The Service Ontology [19], the Goal-Based Service Ontology (GSO) [20], The Onto-ServSys [21], and the model of services of Bergholtz et al. [22]. The focus of each of these models is on particular applications and/or perspectives, none of them serving as a reference ontology capable of harmonizing the various service perspectives.

A core reference ontology provides a semantic characterization of the core terms used in a specific field that spans different application domains, with the purpose of minimizing ambiguities and misunderstandings [23,24]. UFO-S is indeed designed to account for a conceptualization of services that is independent of a particular application domain, and is designed to be applied in an off-line manner to assist humans in tasks such as meaning negotiation and consensus establishment. To this end, we ground our axioms and definitions in a *foundational ontology*, namely the Unified Foundational Ontology (UFO) [25,26], which provides us with basic concepts for objects and events, their types, relations and properties, as well as intentional and social elements to account for agents, the social relations they establish, the actions they undertake, etc. By grounding UFO-S in a foundational ontology, we are able to reveal important conceptual distinctions that would otherwise be ignored in informal characterizations of services.

Our account builds upon earlier works that treat services under the perspective of the *commitments* involved in service relations [27–30]. This perspective emphasizes that, throughout the service life-cycle, commitments of several natures are established between service providers and service customers. We address three main aspects: (i) the characterization of commitments (and corresponding claims) in service relationships; (ii)

the roles played by agents in service relationships, as a consequence of the established commitments; and (iii) the dynamics of the relationships between the agents along the service life-cycle, in which commitments are established and fulfilled. As we shall see, it is exactly the capability of describing such dynamics (by means of the "relator" notion) that mainly motivates our choice of UFO with respect to other foundational ontologies (like, for instance, DOLCE, adopted in previous approaches [27,28]). This paper extends our previous work on UFO-S [31] by: (i) defining an axiomatization to increase the ontology's precision; (ii) showing how UFO-S explains and clarifies the relations between the various service perspectives, providing at the same time core notions which can account for the various perspectives; and, (iii) discussing a number of additional related service ontologies and conceptual models. The axiomatization presented here is the result of a formalization process employing a model simulation approach using the Alloy Analyzer [32]. Consistence of the axiomatization and diagrams is guaranteed by checking the satisfiability of the corresponding Alloy specification. Other quality aspects (such as completeness) are assessed by visual simulation following the approach discussed in [32]. Details of this formalization process are presented in an accompanying technical report [33].

This paper is further structured as follows: Section 2 motivates the commitment-based characterization of services; Section 3 presents the foundational ontology we adopt as a basis for UFO-S and justifies this choice; Section 4 presents UFO-S by means of well-founded models and correspondent axiomatization; Section 5 presents a complete running example of UFO-S in the car rental service application domain; Section 6 describes how UFO-S (based on the perspective of "service as commitment") can harmonize various service perspectives; Section 7 discusses related work; Section 8 presents a discussion about the polysemy of the term "service" and suggest a *core meaning* for the "service" concept; and, Section 9 presents the final considerations.

2. Service and commitments

A number of works in Service Science [13,28,30] and Service Computing [20,34,35] explicitly mention commitments/promises/obligations established between service participants in the service life-cycle. For Dumas et al. [35], a service instance is essentially a promise by one party (the *provider*), to perform a function on behalf of another party (the *consumer*). Ferrario and Guarino [28] associate the concept of service to an explicit commitment between provider and customer, and also to the corresponding service process. Santos et al. [20] define a service as a temporal entity related to the provider's commitment, on behalf of a client, to perform an action of a certain type whose outcome satisfies a client's goal. Sullivan [34] defines the notion of "obligation" for capturing the responsibilities of both the service provider and the service requester.

The benefits of a characterization based on commitments have been discussed from the perspective of business [30] as well as IT [29]. For example, Alter [13] points out that the mutual responsibilities associated with service