Foundations for Service Ontologies: Aligning OWL-S to DOLCE

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1 Foundational and Web Service Ontologies

Clarity in semantics and a rich formalization of this semantics are important requirements for ontologies designed to be deployed in large-scale, open, distributed systems such as the envisioned Semantic Web. Foundational ontologies fulfill these requirements being conceptualizations that contain specifications of domain independent concepts and relations based on formal principles derived from linguistics, philosophy, and mathematics. DOLCE, the Descriptive Ontology for Linguistic and Cognitive Engineering, is a foundational ontology that is (1) designed to be minimal in that it includes only the most reusable and widely applicable upper-level categories, (2) rigorous in terms of axiomatization and (3) extensively researched and documented[2].

Expressive formal semantics are also important for ontologies describing Web Services, which should enable complex tasks involving multiple agents. OWL-S [1], one of the first initiatives of the Semantic Web community for semantically describing Web Services, is an ontology of general concepts aiming at automatic discovery, composition and invocation of Web Services. We identified problematic aspects of this ontology and suggested enhancements through alignment to the foundational ontology. Another contribution of our work is the Core Ontology of Services that fills the epistemological gap between the foundational ontology and OWL-S and can be used to align other Web Service description languages as well.

2 Alignment to Foundational Ontologies

We found that OWL-S suffers from *conceptual ambiguity*. Since there is no clear conceptual framework behind OWL-S, it is often difficult for users to understand the intended meaning of some concepts, the relationship between these concepts as well as how they relate to the modelled services. Also, OWL-S *lacks concise axiomatization*: there is no firm concept or relation hierarchy. A further problematic

aspect of OWL-S is its *entangled design*, caused by the purpose of OWL-S to provide descriptions of various views on Web Services required to support a number of different service related tasks (discovery, composition). Finally, the currently *narrow scope* of OWL-S needs to be extended to represent real world services that naturally cross the lines between information systems and the physical world.

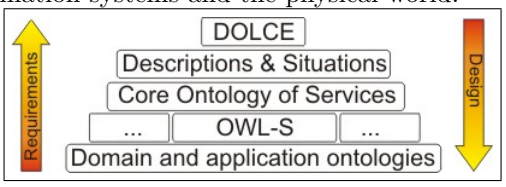

Figure 1: Ontology Stack.

Alignment to a foundational ontology means relating the concepts and relations of an ontology to the basic categories of human cognition investigated by philosophy, linguistics or psychology. The ontology stack in Figure 1 summarizes our alignment effort. We used DOLCE as a foundational ontology and extended it by the Descriptions & Situations (D & S) module, capable of describing various notions of context or frame of reference (topics, plans, beliefs etc.). As the epistemological gap between OWL-S and D & S is too large, we constructed a Core Ontology of Services, which was used to align OWL-S and a concrete domain ontology. Our method was a combination of a bottom-up and a top-down approach. On the one hand, ontologies in the lower layers provided representation requirements for the higher layers, which abstracted their concepts and relationships. On the other hand, the upper layers provided design guidelines to the lower layers. This also meant that although our goal was to preserve the structure of OWL-S, our method suggested a rearrangement of the ontology based on the backbone provided by the D & S ontology.

Our exercise of giving an ontological foundation to OWL-S is useful both for better understanding OWL-S and enriching it with additional formal semantics. As an example, ontological analysis explained the difference between an information object, its application domain counterpart and the role it plays in an information system. This indicated possible enhanced modelling: since the same information object is modelled both in the *ServiceProfile* and *ServiceModel* parts of OWL-S, it is more logical to consider a single instance playing multiple roles. This improvement is already implemented by the OWL-S coalition.

We see the presented results as an example for the benefits of alignment to foundational ontologies as our methodology is applicable also to other standards. As a matter of fact, our Core Ontology of Services can be applied as a framework for harmonizing the ongoing efforts to characterize Web Services (e.g. the ontology of the Web Services Architecture (WSA) Working Group of the W3C), because it does not commit to a specific software design reference framework, and it is based on a generic, social notion of service.

References

[1] The OWL-S Coalition. OWL-S 1.0 draft release, Dec 2003.

[2] A. Oltramari, A. Gangemi, N. Guarino, and C. Masolo. Sweetening ontologies with DOLCE. In *Proceedings of EKAW, Spain*, LNCS. Springer, 2002.