Position Paper
Investigating the Applicability of DOLCE as Foundation for Service Descriptions

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Abstract

Ontology-based descriptions of Web Services serve the purpose of negotiating meaning. A consensus between service provider and service consumer needs to be installed. We argue that the process of installing a shared conceptualization between service provider and consumer requires an foundational ontology. With an experiment which exhibits four previously identified semantic problem types, we investigate applicability of the foundational ontology DOLCE and the possibility to automatically identify the occurring semantic problem types. The goal the experiment is to reveal potentials and practical problems of applying DOLCE in service content descriptions.

1 Motivation and Position

Two advantages of web services are often cited: 1. web services can be composed. 2. web services are applicable in contexts which were originally not intended by the service developer. In order to realize these advantages, semantic service discovery needs to be enabled.

Core elements for enabling this task are semantic descriptions of the services. A service description in form of an OWL ontology may provide some interpretation to the meaning of its terms. However, it cannot be assured, that the meaning of identical terms in two distinct ontologies is understood in the same way. Due to missing methods for comparing the meaning of terms in different ontologies, the possibility to fully access the semantic interoperability between GI Web Services is currently not given.

The meaning of terms used in service descriptions can only be made explicit and sharable when the descriptions share a common reference frame based on formal ontology. Following (Guarino 1997; Guarino 1998b), formal ontology can be seen as the theory of distinctions within the entities of the domain of discourse (physical objects, events, regions of space, amounts of matter) and the categories or universals we use to talk about them (concepts, properties, qualities, states, relations, roles, parts). Grounding the meaning of terms in a common reference frame will enable the comparison of service descriptions and thus the assessment of semantic interoperability between web services.[1]

We identified the ontology for linguistics and cognitive engineering (DOLCE) as a candidate reference frame. Its current status raised issues to be solved in order to establish a practically applicable method for making the semantics of web service content explicit.

This position paper argues the necessity and possible advantages of applying an foundational ontology to semantic service descriptions (section2), describes an experiment with which we investigate the benefit of establishing a common semantic reference frame for service content descriptions (section 3), presents preliminary results (section 4) and outlines further steps to take (section 5).

2 Why a Foundational Ontology is Needed

The semantics of markup languages such as OWL or RDF are defined explicitly (Hayes 2004; Patel-Schneider, Hayes *et al.* 2004), but this assures only that the elements of the language, not its applications, are understood consistently. The interpretation of an ontology specified in OWL

[1] If terms in service descriptions have the same meaning, the services are semantically interoperable with respect to these terms.

is based on model-theoretic semantics. Sentences are interpreted in terms of a model which represents an actual or possible state of the world (Farrugia 2003).
In a philosophical argument Putnam (Putnam 1981) has argued that symbol manipulation systems and thus IS ontologies, can not convey meaning by themselves. The meaning of the terms employed in ontologies necessarily comes from outside the system. When starting to build an ontology, the ontology engineer has readily assigned meaning to the symbols he will use in his ontology. This assignment of meaning to symbols is called ontological commitment. Within the scope of expressivity of the chosen logical language, he structures and orders the terms, and thus builds the ontology. The developed ontology restricts the possible interpretation of the terms and can be considered the formal specification of the ontology engineer's conceptualization(Guarino 1998a).
In figure 1, the semiotic triangle is used to illustrate the process of ontologically committing to the symbol /tree/ by establishing a reference to the concept of tree which in turn has referents in the domain of discourse. The term /tree/ is chosen by the ontology engineer to stand for his concept of a tree. Based on this commitment, the ontology engineer can model relations (e.g. hasPart) to other concepts for which he has chosen other symbols (e.g. /leaf/). It is important to note, that symbols have no direct or a priori relation to objects (or referents) in the domain of discourse. For this reason only a doted line connects symbol and referent in figure 1. A symbol can only refer to a referent via the concept in the ontology engineer's mind. This is, the meaning can only be in the mind of the ontology engineer and not in the ontology itself[2]. The crucial question is whether this formalized conceptualization can become meaningful to other humans.

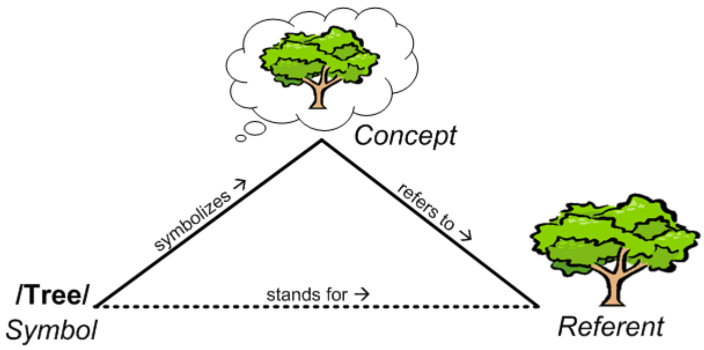

Figure 1: The semiotic triangle. Ontologies do not establish links between symbols and referents
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Information system ontologies are designed artifacts with the purpose of allowing a user community to share the intended meaning of a vocabulary (Guarino 1998a). However, to achieve this task, a subset of the ontology's vocabulary needs to be understood beforehand by the user community. This set of atomic symbols[3] with agreed-upon meaning can then be used for learning the meaning of further terms defined within the ontology. With respect to the semiotic triangle, all users of a certain ontology need to have established the same "dotted line" (see figure 1) for at least the atomic symbols in the ontology. A shared understanding can be established if all ontology users have the same (or very similar) ontological commitments for the atomic symbols used in the ontology.
In reverse we can assume that an ontology user, who is lacking that general ontological commitment, can not establish a reasonable interpretation of the additional terms defined in the ontology, because the link from the symbols to their referents (the objects in the domain of discourse) can not be established. This is, the user can not join the shared conceptualization which to establish is an ontology's reason of existence.

[2] How concepts are formed in the ontology engineers mind is not subject of this position paper, yet we assume them to be developed via bodily and social experiences.
[3] Atomic symbols are those which are not further constrained in the ontology. For example, in many semantic web ontologies the properties (in the RDF sense) are atomic symbols since their meaning is assumed to be shared.

Currently the approach of *shared vocabularies* is used to provide this required set of atomic symbols (Wache, Vögele *et al.* 2001). For small user communities it might be reasonable to assume such shared vocabularies to exist and it may be sufficient to define it extensionally, by listing the terms explicitly. In the open and distributed environment of the semantic web with its diverse user communities, such shared vocabulary does not exist and probably will not exist. In our research we investigate the possibility of using an existing foundational ontology as source of an explicit and formally defined shared vocabulary on an abstract level. The terms of the foundational ontology help in defining the terms which are currently provided by semi formal shared domain vocabularies. Aligning the terms of the shared vocabulary to the foundational ontology turns the shared vocabulary into a domain ontology.
A valid objection to the foundational-level approach is that the requirement of a shared vocabulary is shifted from the application or domain ontology level to the foundational ontology level. This is in fact happening. However, the idea is that a well designed foundational ontology could in fact account for a very large number of application and domain ontologies, thus providing the “seed” meaning to the symbols used on lower ontology levels. Formal and explicit conceptualizations become comparable if they share the same semantic reference frame. The foundational-level comprises only highly abstracted terms which do rarely show up in domain or application ontologies. Thus, the number of terms, which have to be understood beforehand, is relatively small. This is in accord with Gruber’s (Gruber 1995) request for a minimal ontological commitment. We will investigate the effort needed for an ontology engineer to learn and understand the abstract terms established on the foundational level. An advantage of employing the foundational-level as shared vocabulary is its formal structure which allows to perform automatic reasoning and consistency checking.
To summarize: In order to assess semantic interoperability between Web Services, the meaning of terms in ontologies for service description need to become automatically comparable. The meaning of a term is, however, never inherent to a free-floating ontology itself. A symbol in an ontology is only meaningful to an ontology *user* who is sharing the ontological commitment of the ontology *engineer*. Such a widely shared ontological commitment could be established with the help of a foundational ontology.

3 Experiment

At the workshop we want to present the results of an experiment described in the following. The experiment establishes a controlled environment in which semantic matchmaking between six web services exemplify different semantic problem types.
The goals of the experiment are two fold. First, setting up the experiment will reveal insight into applying a foundational ontology to a practical problem setting. Providing answers to the following questions:

- How to establish a formal reference frame for efficient web service content descriptions?
- How to support an ontology engineer in applying such an abstract reference frame in ontology engineering?

Second, evaluation of the developed ontologies and the actual matchmaking experiment will provide answers to the questions:

- Will the ontological decisions taken on the foundational level provide structure to application ontologies, thus supporting alignment and comparison?
- Does an ontology architecture based on the foundational ontology DOLCE improve semantic matchmaking between (GI) web services?

Experiment Setting

Six web services are implemented. Three services are *providing* information about wind direction and wind speed (A, B, C). Three services are *requesting* information about wind direction and wind speed (X, Y, Z) (Figure 1). The design of the web services ensures that all relevant semantic problem types can be analyzed.

Each service provides one operation. For the services A, B, C the focus is on the output message. For the services X, Y, Z the focus is on the input messages. Note that we focus only on one matchmaking step, not on establishing a full composite service.

One application ontology is developed for each of the six services. The application ontologies use concepts provided on domain ontology level. The domain ontology in turn uses concepts provided by the foundational ontology.

Current State of Experiment

We use the OWL version of DOLCE Lite Plus (DLP) version 3.9.4.1 as basis for the foundational level in our ontology stack depicted in figure 2. In order to improve handling and performance the extensions of DLP which did not serve our purpose were removed. Several changes to the concepts of DLP were made.

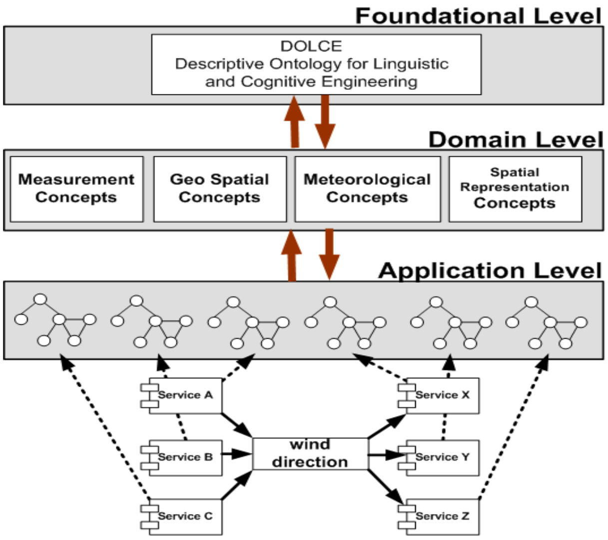

Figure 2: Three level ontology architecture and service setting

For the experiment, standard ontology engineering methods were applied. We started with the collection of informal terminology. Since we developed the services, we knew the modelling decisions taken for these services and were able to formulate the terms needed to describe the services on a general level. To facilitate the handling of the domain level, the terms of the informal terminology were sorted into four domain ontologies, one for meteorological concepts, one for geo spatial concepts, one for measurement concepts, and one for spatial representation concepts. Currently the domain level comprises 79 concepts which we identified useful to describe wind direction and wind speed on a general level. The goal is to introduce domain relevant term but keeping their definitions rather general, allowing to describe as many services models as possible.

The application ontologies are rather small compared to the domain and foundational ontologies. The application ontologies establish “IS-A” relations to domain ontologies concepts and add additional restrictions. Enumeration classes provide the possibility to make general statements on domain level and restrict those on application level. For example, the application ontology which is describing *Service A* contains the enumerated class #Origin:

```
<owl:Class rdf:about=".../App#RefOrigin">
        <owl:equivalentClass>
            <owl:Class>
                <owl:oneOf rdf:parseType="Collection">
                    <rdf:Description rdf:about=".../Dom_GeoSpa#North"/>
                </owl:oneOf>
            </owl:Class>
        </owl:equivalentClass>
        <rdfs:subClassOf rdf:resource=".../Dom_Measurement#Origin"/>
    </owl:Class>
```

The class #RefOrigin is a subclass of the enumerated class #Origin of the *measurement domain ontology*:

```
<owl:Class rdf:about="… /Dom_Measurement#Origin">
    <rdfs:subClassOf rdf:resource="… /DOLCE-Lite#abstract-region"/>
        <owl:equivalentClass>
            <owl:Class>
                <owl:oneOf rdf:parseType="Collection">
                    <Msm:CardinalDirection rdf:about="…/Dom_GeoSpa#North"/>
                    <Msm:CardinalDirection rdf:about="…/Dom_GeoSpa#East"/>
                    <Msm:CardinalDirection rdf:about="…/Dom_GeoSpa#South"/>
                    <Msm:CardinalDirection rdf:about="…/Dom_GeoSpa#West"/>
                </owl:oneOf>
            </owl:Class>
        </owl:equivalentClass>
    </owl:Class>
```

Whereas on the domain level it is possible that the origin of a radial reference system take one of the values *north south*, *west* or *east*, the particular application ontology of Service A restricts the origin of its reference system to the value *north*.

4 Conclusion and Further Steps

DOCLE Lite Plus provides a very clean and promising approach yet the available documentation needs to be improved in order to speed up the ontology engineers learning process and thus facilitating the process of ontologically committing to the foundational level. Aligning the developed domain ontology concepts to DOLCE Lite Plus turned out to be a time consuming and is not being unambiguous yet. At the current stage of the experiment, all services are semantically annotated with application ontologies which draw the semantics of their terms from the domain ontology which in turn draw their semantics from the upper-level ontology. The next step of the experiment is to investigate whether the developed application ontologies allow to automatically reveal the semantic heterogeneities which where intentionally introduced to the experiment setting. Being able to automatically identify differences in service descriptions which are based on symbols with an agreed upon meaning is finally a step towards automatic assessment of semantic interoperability.

5 References

Farrugia, J. (2003). *Model-Theoretic Semantics for the Web*. The Twelfth International World Wide Web Conference, Budapest, Hungray.

Gruber, T. R. (1995). "Toward Principles for the Design of Ontologies Used for Knowledge Sharing." *Int. Journal of Human-Computer Studies* 43: 907-928.

Guarino, N. (1997). Semantic Matching: Formal Ontological Distinctions for Information Organization, Extraction, and Integration. *Information Extraction: A Multidisciplinary Approach to an Emerging Information Technology*. M. T. Pazienza, Springer Verlag**:** 139-170.

Guarino, N. (1998a). *Formal Ontology and Information Systems*. Formal Ontology and Information Systems, Trento, Italy.

Guarino, N. (1998b). *Some Ontological Principles for Designing Upper Level Lexical Resources*. First International Conference on Language Resources and Evaluation, Granda, Spain.

Hayes, P. (2004): RDF Semantics: http://www.w3.org/TR/rdf-mt/, last access: 2005-04-12.

Patel-Schneider, P. F., P. Hayes and I. Horrocks (2004): OWL Web Ontology Language Semantics and Abstract Syntax: http://www.w3.org/TR/owl-semantics/, last access: 2005-04-12.

Putnam, H. (1981). *Reason, Truth, and History*. Cambridge, Cambridge University Press.

Wache, H., T. Vögele, U. Visser, H. Stuckenschmidt, G. Schuster, H. Neumann and S. Hübner (2001). *Ontology-Based Integration of Information — A Survey of Existing Approaches*. IJCAI-01 Workshop: Ontologies and Information Sharing, Seattle, WA.