Image Schemata-Based Domain Ontologies - The Core Elements of Semantic Reference Systems

Florian Probst
Institute for Geoinformatics, University of Münster,
Robert-Koch-Str. 26-28, 48149 Münster, Germany
probst@ifgi.uni-muenster.de

Introduction

In open and distributed environments such as the emerging field of GI Web Services, the problem of discovering suitable information sources or services to achieve a certain task has become central. Solving this problem requires semantic interoperability (Harvey, Kuhn *et al.* 1999; Sheth 1999; Visser and Stuckenschmidt 2002; Buehler 2003). Formal ontologies have proven useful to capture the semantics of information sources. However, semantic interoperability between ontologically annotated information sources will be achieved only, when translation between ontologies becomes feasible.
Since an application ontology is a partial account of a conceptualization (Gruber 1995), the precondition for efficient use of such ontology is that the semantics of all concepts used to build an ontology are agreed upon and understood by its users. Currently most ontology engineering approaches assume that this is the case. However, this assumption will not hold true when ontologies are used to share information across application domains, which will be the case in open and distributed environments such as GI web services.
Using *domain ontologies* to achieve consistent use of concepts across several application ontologies is a possible solution. Yet this approach only shifts the problem of agreeing on the semantics from the application ontology to the domain ontology. In fact, one could shift the agreement problem to ever higher levels of abstraction. In order to break this vicious circle, a new approach in ontology engineering is called for.
The challenges to build a *domain ontology*, able to reference the semantics of the necessary concepts for application ontology building are

- to identify a set of basic concepts to which the users of the application ontologies agree upon *without further definition.*
- to prove that this set of concepts has sufficient expressive power to build application ontologies.

The restriction that the set of basic concepts needs to be agreed upon only by the users of the application ontologies avoids the attempt to search for the universally valid top-level ontology.
If both challenges could be mastered, a important step to achieve semantic interoperability would be taken. A domain expert could formalize her knowledge in an application ontology, which could be related to other application ontologies since they are based on the same domain-ontology concepts.

Position

Having identified the above problems, we intend to validate in our ongoing research the following position:
A domain ontology for vehicle navigation based on *image schemata* provides sufficient expressive power to build application ontologies for that domain.
Embedded in a semantic reference system, the proposed domain ontology enables translation between application ontologies committing to it.
When translation is based on the proposed, image schemata-based domain ontology the number of translatable concepts increases, compared to translation based on current state of the art domain ontologies.

Goal and Approach

Formal ontologies, as used in the IT-community, attempt to capture the semantics of information sources. Such attempt to formally describe a conceptualization is based on a commitment to a semantic theory of language. However, most ontology engineering approaches are not specific about this point and commit implicitly to the so-called *realist* semantic theory. This is that the linguistic expressions used in the ontology refer either extensional to one world or intensional to a set of possible worlds (figure 1). This kind of semantics aims to formulate truth conditions for the sentences in the language (Gärdenfors 2000).
Our approach is based on a *conceptualist (or cognitive)* semantic theory described by (Gärdenfors 2000). The central idea is that meanings of linguistic expressions are mental entities - meanings are elements of a cognitive structure in the heads of the language users respectively ontology engineers.
We propose to develop an image schema-based domain ontology for the vehicle navigation domain, a sub domain of the geospatial domain, acting as a core element of (a first version of) a semantic reference system as described by (Kuhn 2003). The concepts of the domain ontology are based on image schemas described by (Johnson 1987; Lakoff 1987; Gärdenfors 2000). Image schemas are supposed to represent perceptual and other bodily experiences. The very fact that humans have similar constitutions makes it likely that their representations are similar. Furthermore, if the image schema corresponding to a particular expression is noticeably different for two individuals, it is likely that this will lead to problems of communication. A desire for successful communication

will therefore lead to a gradual alignment among members of a linguistic community of the image schemas as well as their underlying conceptual spaces (Gärdenfors 2000). These arguments support our position mentioned above.

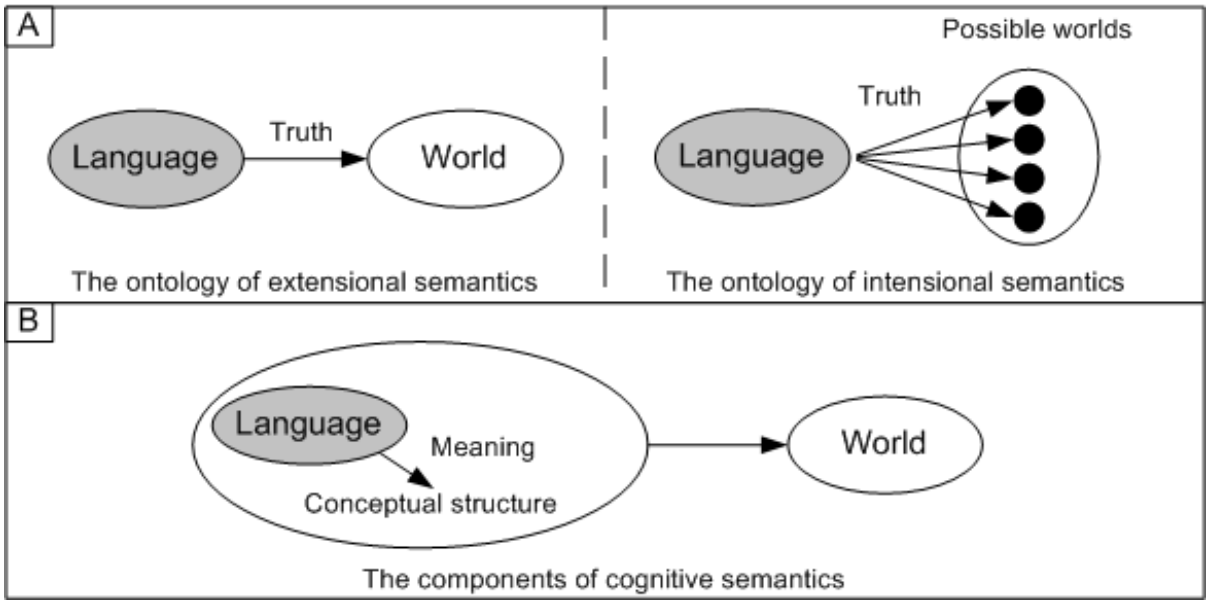

Figure 1: Realist (A) and conceptualist (or cognitive) (B) semantic theory (Gärdenfors 2000).

To establish an image schema-based domain ontology, following steps have to be taken (in communication with W. Kuhn):

1. Set up use cases in the navigation domain, a sub-domain of the geospatial domain.
2. Build a start-up application ontology for the navigation domain using a common approach.
3. Identify image schemata needed to describe the use-cases in the navigation domain. This will most probably result in an incomplete set of image schemata, since the use-cases will cover only parts of the navigation domain.
4. Derive a "seed" domain ontology based on the image schemata identified as relevant for the navigation domain.
5. Connect the start-up application ontology to this domain ontology, by writing axioms that explain the abstract data type semantics (types, attributes, operations) in terms of the image schema-based domain ontology concepts.
6. Test extended domain ontology for sufficiency of expressive power and internal consistency with respect to navigation ontology.
7. Extend domain ontology by missing concepts.
8. Repeat steps 5 to 7 for a second (third) application ontology for the vehicle navigation domain. Leading to an extension and consolidation of the image schema-based domain ontology.
9. Have two groups of domain experts write application ontologies for a certain task. One group references the employed concepts to the image-schemata based domain ontology; the other group references the employed concepts to a state of the art domain ontology.
10. Perform translations between the developed application ontologies within both groups.
11. Evaluate the quality of the translations.

References

Buehler, K. (2003): OGC Reference Model: http://www.opengis.org/info/orm/03-040.pdf, last access: 2003-04-07.

Gärdenfors, P. (2000). *Conceptual Spaces - The Geometry of Thought*. Cambridge, MA, Bradford Books, MIT Press.

Gruber, T. R. (1995). "Toward Principles for the Design of Ontologies Used for Knowledge Sharing." *International Journal of Human-Computer Studies* **43** (5/6): 907-928.

Harvey, F., W. Kuhn, et al. (1999). "Semantic Interoperability: A Central Issue for Sharing Geographic Information." *The Annals of Regional Science* **33**: 213-232.

Johnson, M. (1987). *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason*. Chicago, The University of Chicago Press.

Kuhn, W. (2003). "Semantic Reference Systems." *International Journal of Geographical Information Science* (accepted for publication).

Lakoff, G. P. (1987). Women, Fire, and Dangerous Things. What Categories Reveal about the Mind. Chicago, University of Chicago Press**:** 614.

Sheth, A. P. (1999). Changing Focus on Interoperability in Information Systems: From System, Syntax, Structure to Semantics. *Interoperating Geographic Information Systems*. M. F. Goodchild, M. Egenhofer, R. Fegeas and C. A. Kottman, Kluwer**:** 5-30.

Visser, U. and H. Stuckenschmidt (2002). *Interoperability in GIS - Enabling Technologies*. 5th AGILE Conference on Geographic Information Science, Palma de Mallorca, Spain.