Chapter V
Web Ontology Languages

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ABSTRACT

Web ontology languages will be the main carriers of the information that we will want to share and integrate. The aim of this chapter is to give a general introduction to some of the ontology languages that play a prominent role on the Semantic Web. In particular, it will explain the role of ontologies on the Web and in ICT, review the current standards of RDFS and OWL, and discuss open issues for further developments.

THE ROLE OF WEB ONTOLOGIES

The Role of Ontologies in ICT

The term ontology originates from philosophy. In that context, it is used as the name of a subfield of philosophy, namely, the study of the nature of existence (the literal translation of the Greek word Οντολογία, the branch of metaphysics concerned with identifying), in the most general terms, the kinds of things that actually exist, and how to describe them. For example, the observation that the world is made up of specific objects that can be grouped into abstract classes based on shared properties is a typical ontological statement.

In the early 1990s, a series of large-scale experiments took place in order to integrate multiple, heterogeneous databases (Bayardo et al., 1996; Chawathe, Garcia-Molina, Hammer, Ireland, Papakonstantinou, Ullman, & Widom, 1994; Wiederhold, 1992). These experiments revealed that database integration must ultimately be based on explicit, formal knowledge representation of the underlying common meaning of the involved data structures rather than on formal schema manipulation only. With the work of Thomas Gruber (1994) and others (Guarino, 1998; Sowa, 2000; Uschold & Gruninger, 1996) the extraordinary importance of formal ontology for the design and operation of information systems was widely
recognized towards 1998, and scientists started to see a series of previously disparate fields in this new light, such as automated Natural Language translation and semantic networks, conceptual modeling and subject indexing in information science. The word formal ontology, with the new plural ontologies, also became the term for the product of an ontology engineering process, that is, the process of identifying a set of concepts and their relationships that formalize a domain of interest.

For our purposes, we will use Nicola Guarino’s definition:

*An ontology is a logical theory accounting for the intended meaning of a formal vocabulary, that is, its ontological commitment to a particular conceptualization of the world. The intended models of a logical language using such a vocabulary are constrained by its ontological commitment. An ontology indirectly reflects this commitment (and the underlying conceptualization) by approximating these intended models.* (Guarino, 1998)

Implicit in this definition is the fact that a conceptualization resides in the human mind, and its precise formal structure is not directly accessible. On the one side, we have good reasons to believe (Fauconnier & Turner, 2002; Lakoff, 1987) that our real mental structure is richer than the logics we apply in computer science. On the other side, any formalization has practical value only, if it is computationally tractable, and practice shows that even relatively simple reasoning forms can yield valuable results.

The challenge of designing ontology languages can therefore be described as a compromise between the expressive power needed to approximate human conceptualization, and the minimal complexity needed to achieve a practical result in the target application area. In general, an ontology describes formally a domain of discourse. In the simplest form, an ontology consists of a finite list of terms and the relationships between these terms. The terms denote important concepts *(classes* of objects) of the domain. For example, in a university setting, staff members, students, courses, lecture theaters, and disciplines are some important concepts.

The relationships typically include hierarchies of classes. A hierarchy specifies a class C to be a subclass of another class C’ if every object in C is also included in C’. For example, all faculty are staff members.

Apart from subclass relationships, ontologies may include information such as:

- Properties (X teaches Y)
- Value restrictions (only faculty members can teach courses)
- Disjointness statements (faculty and general staff are disjoint)
- Specification of logical relationships between objects (every department must include at least ten faculty members)

**The Role of Ontologies on the Web**

In the context of the Web, ontologies can be used to formulate a *shared understanding of a domain* in order deal with differences in terminology of users, communities, disciplines and languages as it appears in texts. For instance, “car” in English means the same as “voiture” in French. “Wissenschaft” in German implies the meanings of both “science” and “humanities” in English. Even more, two applications may use the same term with different meanings: In one context, “school” refers to a place in a city, in another to a social institution, in a third to an artistic style. Such differences can be overcome by mapping the particular terminology to a shared ontology or by defining direct mappings between the ontologies (Kalfoglou & Schorlemmer, 2003). These cases demonstrate that ontologies support semantic interoperability.

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