What Is OWL (and Why Should I Care)?

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Abstract

OWL is the new ontology language produced by the W3C Web Ontology Working Group. OWL is thus poised to be a major formalism for the design and dissemination of ontology information, particularly in the Semantic Web. OWL has influences from several communities, including the RDF community, the Description Logic community, and the frame community. These influences resulted in a wide variety of requirements on OWL, some of which appear to be conflicting. OWL contains innovative solutions to several of these apparent conflicts, but it has not been possible to completely satisfy all the desired requirements for OWL.

The talk will describe the development and design of OWL, concentrating on what makes OWL important, the relationship of OWL to other formalisms, the place of OWL in the Semantic Web, the innovative solutions that were required in its design, and the impact of the conflicting requirements on OWL. I will propose a different foundation for the Semantic Web, one that I think would allow for easier and better development of new formalisms for the Semantic Web.

OWL is poised to be a major part of the Semantic Web, but what is OWL and how does it fit into the Semantic Web? Answers to these questions are intimately intertwined with the history and development of OWL, in particular the constraints that were placed on the design of OWL because of its positioning within the W3C's vision of the Semantic Web.

OWL (Dean *et al.* 2004) is the W3C recommendation that provides ontology services for the Semantic Web. Because OWL is part of W3C's Semantic Web, the official exchange syntax for OWL is XML/RDF (Beckett 2004), a way of writing RDF (Manola & Miller 2004) in XML. Because OWL is an ontology language descended from Description Logics, OWL has a model-theoretic semantics (Patel-Schneider, Hayes, & Horrocks 2004) that provides the official meaning for OWL documents. Again because OWL is part of W3C's Semantic Web, the model-theoretic semantics for OWL is compatible with the model-theoretic semantics provided for RDF (Hayes 2004).

An ontology language (in this context, at least) is a language in which it is possible to provide information about the different kinds of objects in the domain of discourse (i.e., the part of the world that is of interest). Collections of such information are called ontologies. An ontology thus provides a way of talking about the world.

There are different kinds of ontologies that have been proposed. These range from ontologies that structure the fundamental kinds of objects (for example, dividing the world into physical objects, imaginary objects, and so on) through ontologies that provide the basic for large areas of knowledge (for example, providing an ontology for electronic commerce) to ontologies for particular application domains (for example, dividing travel services into airline flight reservation services, car rental services, and so on).

There have also been many different kinds of language proposed as ontology languages. These languages have ranged from very powerful languages in which just about anything can be said, such as higher-order logics, through less expressive languages in which only certain kinds of things can be said, such as Description Logics, down to very simple languages, such as simple generalization taxonomies.

OWL can be used to build most kinds of ontologies, but it is not as expressive as higher-order or even first-order logic, and thus certain kinds of ontologies cannot be built in OWL. In particular, OWL is ill-suited to create and reason with an ontology for OWL itself.

OWL has been influenced from three sides. Because OWL is part of W3C's Semantic Web, OWL has been heavily influenced by W3C's vision of the Semantic Web, as layers built on top of RDF. From this vision comes the official OWL exchange syntax, namely RDF/XML. More importantly, OWL has a very close connection to the semantics of RDF with one version of OWL being a semantic extension of RDF Schema (Brickley & Guha 2004), itself a semantic extension of RDF.

Because OWL is closely related to Description Logics, OWL has many features that come from this family of knowledge representation systems. Description Logics provide the main knowledge-structuring capabilities of OWL. Further, the semantics of the knowledge structuring capabilities of OWL come directly from Description Logics, so that a construct in OWL has the same model-theoretic meaning as its analogue has in other Description Logics.

OWL has also been influenced by some of the knowledge-structuring capabilities of frame systems. From this influence comes some of the difference in syntax between OWL and most other Description Logics. In particular, OWL constructs can easily group information about a particular property into one construct, where in Description Logics this information must be divided into multiple constructs. These groupings allowed in OWL are designed to be easier for human users to comprehend and easier for user interfaces to present to humans.

An intermediate point in the development of OWL was DAML+OIL (Horrocks, Patel-Schneider, & van Harmelen 2002), the first attempt to produce an RDF-compatible Description Logic-based ontology language. Many of the above influences on OWL also influenced DAML+OIL.

The above influences have produced tensions in the design of OWL. It is impossible to have a Description Logic with a frame-like syntax that fully extends RDF, at least as an extension that satisfies the W3C's vision of the Semantic Web. In fact, OWL can be seen to be an attempt to satisfy as much of the above influences as possible, while still being an interesting and useful ontology language.

Because OWL has to fit into W3C's Semantic Web vision, its official syntax has to be that of RDF/XML. However, this syntax is widely viewed as being difficult for humans, as opposed to the much nicer frame and Description Logics syntaxes. OWL has side-stepped this conflict by providing two syntaxes, RDF/XML and a human-oriented syntax.

Because OWL has to fit into W3C's Semantic Web vision, it is supposed to use RDF's model-theoretic semantics. However, this semantics is sufficiently different from the well-understood model-theoretic semantics of Description Logics that completely basing OWL on RDF's model-theoretic semantics would mean that the complexity and inference algorithm results from Description Logics would not be useable for OWL. OWL has side-stepped this conflict by providing a semantics in the Description Logic style, thus allowing transfer of results from Description Logics, and also relating this semantics to an RDF-style semantics, thus showing how OWL relates semantically to RDF.

Because OWL has to fit into W3C's Semantic Web vision, it is supposed to be a semantic extension of RDF. However, a Description Logic built on all of RDF would be have undecidable inference, so a subset of OWL, OWL DL, has been provided that is known to have decidable inference. Further, the obvious semantic extension of RDF to OWL gives rise to certain paradoxes. For this reason, there are some inferences that one might expect in OWL that do not follow.

Because OWL, at least OWL DL, is supposed to be effectively implementable, its expressive power has been limited, so that it is less expressive than first-order logic. This has resulted in some difficult decisions, where the desires of different groups in the W3C Web Ontology Working Group have had to be balanced against this computational desire.

So OWL can be seen to be a balancing act, with the criterion to fit fully within W3C's vision of the Semantic Web traded off against various criteria related to human factors, utility, computational effectiveness, and avoiding paradoxes.

Given that it is mostly the W3C's vision of the Semantic Web that has caused problems for OWL, why not try to change this vision in an attempt to come up with a better foundation for the Semantic Web? My view is that this is easily possible, by simply allowing different syntaxes into the Semantic Web. Let OWL have its own syntax, designed to best suit the needs of OWL. Let a rule language for the Semantic Web have its own syntax. Admit XML documents that are not XML/RDF documents into the Semantic Web.

Yes, there are costs to this vision. Multiple parsers have to be written, but parsers are actually quite easy to build. Multiple syntaxes have to be described to users, but this is no different from the current situation, where the syntax of OWL has to be described to users.

Different Semantic Web languages can then be tied together by means of compatible semantics. This is also work, but probably much less work than went into producing the OWL semantics. Further, this vision allows XML dialects to be given special-purpose semantics, finally bridging the gap between the XML-based part of the World Wide Web and the RDF-based Semantic Web.

In conclusion, OWL is here. Like any standard, OWL is not ideal, but it does provide a useful ontology language for the Semantic Web with many more capabilities than the limited ontology features in RDFS. Further, OWL is usable (although more tools for it are needed). OWL does suffer somewhat from being shoehorned into the W3C's vision of the Semantic Web, but this can be alleviated by relaxing this vision to allow different Semantic Web languages to have different (XML-based) syntaxes.

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