



OWL 2 Web Ontology Language Document Overview

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Abstract

The OWL 2 Web Ontology Language, informally OWL 2, is an ontology language for the Semantic Web with formally defined meaning. OWL 2 ontologies provide classes, properties, individuals, and data values and are stored as Semantic Web documents. OWL 2 ontologies can be used along with information written in RDF, and OWL 2 ontologies themselves are primarily exchanged as RDF documents.

This document, part 1 of 13 in the OWL 2 document set, serves as an introduction to OWL 2 and the various other OWL 2 documents. It describes the various syntaxes for OWL 2, the different kinds of semantics, the defined profiles (sub-languages), and the differences between OWL 1 and OWL 2.

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and the latest revision of this technical report can be found in the [W3C technical reports index](http://www.w3.org/TR/) at <http://www.w3.org/TR/>.

First Public Working Draft

Given the complexity of the OWL specification (a dozen parts, not including this one), this document was produced to provide a starting point suitable for both implementors and users. In their next versions, all the other documents will link to it, prominently, as the starting place and home of the document Roadmap.

Please Comment By 10 April 2009

The [OWL Working Group](#) seeks public feedback on this First Public Working Draft. Please send your comments to public-owl-comments@w3.org ([public archive](#)). If possible, please offer specific changes to the text that would address your concern. You may also wish to check the [Wiki Version](#) of this document and see if the relevant text has already been updated.

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1 Introduction

Ontologies are formalized vocabularies of terms, often covering a specific domain and shared by a community of users. They specify the definitions of terms by describing their relationships with other terms in the ontology. OWL 2 is an extension and revision of the [OWL Web Ontology Language](#) developed by the [W3C Web Ontology Working Group](#) and published in 2004. OWL 2 is being developed (and this document was written) by a follow-on group, the [W3C OWL Working Group](#). OWL and OWL 2 are designed to facilitate ontology development and sharing via the Web, with the ultimate goal of making Web content more accessible to machines.

2 Overview

Figure 1 gives an overview of the OWL 2 language, showing its main building blocks and how they relate to each other. The ellipse in the center represents the abstract notion of an ontology, which can be thought of either as an abstract structure or as an RDF graph (see [2.1 Ontologies](#)). At the top are various concrete syntaxes (see [2.2 Syntaxes](#)) that can be used to serialize and exchange ontologies. At the bottom are the two semantic specifications that define the meaning of OWL 2 ontologies (see [2.3 Semantics](#)).

Note that many users of OWL 2 will need only one syntax and one semantics; for them, this diagram could be much simpler, with only their one syntax at the top, their one semantics at the bottom, and rarely a need to see what's inside the ellipse in the center.

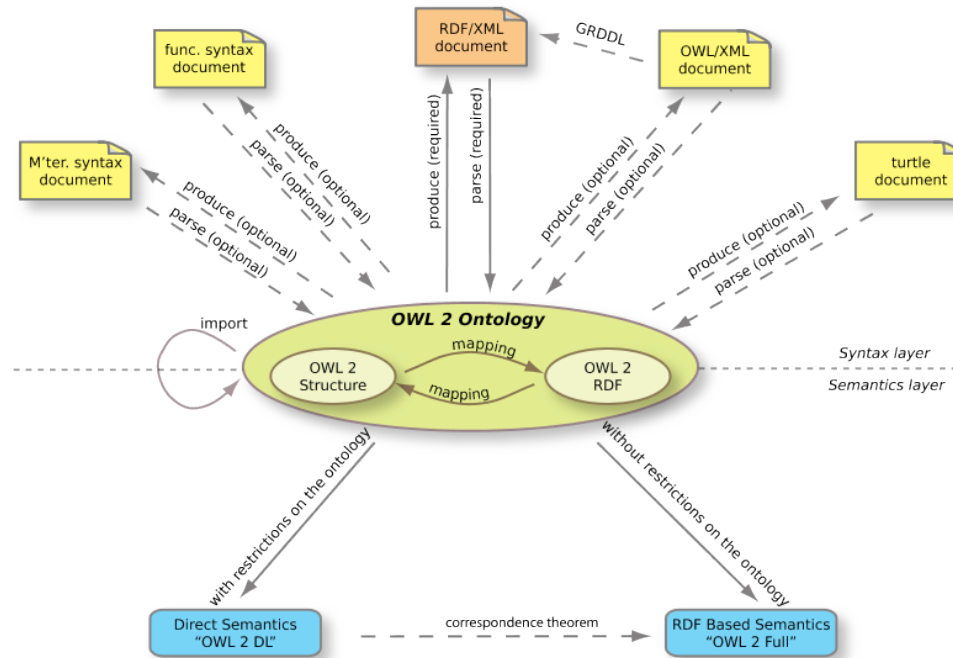


Figure 1. The Structure of OWL 2

Editor's Note: The exact nature of the GRDDL relation is not yet resolved.

2.1 Ontologies

The conceptual structure of OWL 2 ontologies is defined in the OWL 2 Structural Specification document [[OWL 2 Structural Specification](#)]. This document uses UML [[UML](#)] to define the structural elements available in OWL 2, explaining their roles and functionalities in abstract terms and without reference to any particular syntax. It also defines the functional-style syntax, which closely follows the structural specification and allows OWL 2 ontologies to be written in a compact form.

Any OWL 2 ontology can also be viewed as an RDF graph. The relationship between these two views is specified by the Mapping to RDF Graphs document [[OWL 2 RDF Mapping](#)], which defines a mapping from the structural form to the RDF graph form, and vice versa. The OWL 2 Quick Reference Guide [[OWL 2 Quick Guide](#)] provides a simple overview of these two views of OWL 2, laid out side by side.

2.2 Syntaxes

In practice, a concrete syntax is needed in order to store OWL 2 ontologies and to exchange them among tools and applications. The primary exchange syntax for OWL 2 is RDF/XML [[RDF Syntax](#)]; this is indeed the only syntax that *must* be supported by all OWL 2 tools (see Section 2.1 of the OWL 2 Conformance document [[OWL 2 Conformance](#)]).

While RDF/XML provides for interoperability among OWL 2 tools, other concrete syntaxes may also be used. These include alternative RDF serializations, such as Turtle [[Turtle](#)]; an XML serialization [[OWL 2 XML](#)]; and a more "readable" syntax used in several ontology editing tools [[OWL 2 Manchester Syntax](#)]. Finally, the functional-style syntax can also be used for serialization, although its main purpose is specifying the structure of the language [[OWL 2 Structural Specification](#)]. It must be emphasized, however, that OWL 2 tools are *not* required to support any of these alternative syntaxes.

Name of Syntax	Specification	Status	Purpose
RDF/XML	Mapping to RDF Graphs, RDF/XML	Mandatory	Interchange (can be written and read by all conformant OWL 2 software)
OWL/XML	XML Serialization	Optional	Easier to process using XML tools
Functional Syntax	Structural Specification	Optional	Easier to see the formal structure of ontologies
Manchester Syntax	Manchester Syntax	Optional	Easier to read/write DL Ontologies
Turtle	Mapping to RDF Graphs, Turtle	Optional, Not from OWL-WG	Easier to read/write RDF triples

2.3 Semantics

The OWL 2 Structural Specification document defines the abstract structure of OWL 2 ontologies, but it does not define their meaning. The Direct Semantics [[OWL 2 Direct Semantics](#)] and the RDF-Based Semantics [[OWL 2 RDF-Based Semantics](#)] provide two alternative ways of assigning meaning to OWL 2 ontologies, with a correspondence theorem providing a link between the two. These two semantics are used by reasoners and other tools to answer queries about, e.g., class consistency, subsumption and instance retrieval.

The Direct Semantics assigns meaning directly to ontology structures, resulting in a semantics compatible with the model theoretic semantics of the *SROIQ* description logic—a fragment of first order logic with useful computational properties. The

advantage of this close connection is that the extensive description logic literature and implementation experience can be directly exploited by OWL 2 tools. However, some conditions must be placed on ontology structures in order to ensure that they can be translated into a *SROIQ* knowledge base, for example, transitive properties cannot be used in number restrictions (see [Section 3](#) of the OWL 2 Structural Specification document [[OWL 2 Structural Specification](#)] for a complete list of these conditions). Ontologies that satisfy these syntactic conditions are called *OWL 2 DL* ontologies.

The RDF-Based Semantics assigns meaning directly to RDF graphs and so indirectly to ontology structures via the Mapping to RDF-graphs. The RDF-Based Semantics is fully compatible with RDF Semantics [[OWL 2 RDF-Based Semantics](#)], and extends the semantic conditions defined for RDF. The RDF-Based Semantics can be applied to *any* OWL 2 Ontology, without restrictions, as any OWL 2 Ontology can be mapped to RDF.

The correspondence theorem in Section 7.3 of the RDF-Based Semantics Document [[OWL 2 RDF-Based Semantics](#)] defines a precise, close relationship between the Direct and RDF-Based Semantics. This theorem states, in essence, that given an OWL 2 DL ontology, inferences drawn using the Direct Semantics will still be valid if the ontology is mapped into an RDF graph and interpreted using the RDF-Based Semantics.

2.4 Profiles

OWL 2 Profiles [[OWL 2 Profiles](#)] are sub-languages (syntactic subsets) of OWL 2 that offer important advantages in particular application scenarios. Three different profiles are defined: OWL 2 EL, OWL 2 QL, and OWL 2 RL. Each profile is defined as a *syntactic restriction* of the OWL 2 Structural Specification, i.e, as a subset of the structural elements that can be used in a conforming ontology, and each is more restrictive than OWL DL. Each of the profiles trades off different aspects of OWL's expressive power in return for different computational and/or implementational benefits.

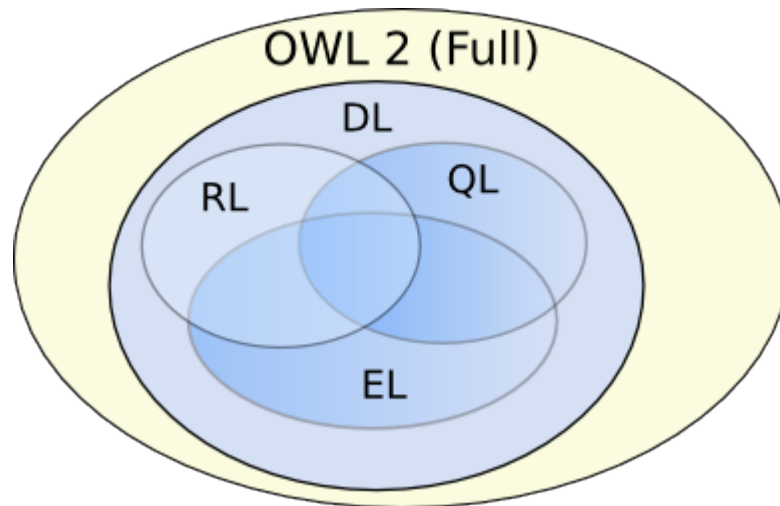


Figure 2. Venn Diagram of OWL Syntactic Subsets (Profiles)

OWL 2 EL enables polynomial time algorithms for all the standard reasoning tasks; it is particularly suitable for applications where very large ontologies are needed, and where expressive power can be traded for performance guarantees. **OWL 2 QL** enables conjunctive queries to be answered using standard relational database technology; it is particularly suitable for applications where relatively lightweight ontologies are used to organize large numbers of individuals or where it is useful or necessary to access the data directly via relational queries (e.g., SQL). **OWL 2 RL** enables the implementation of polynomial time reasoning algorithms using rule-extended database technologies operating directly on RDF triples; it is particularly suitable for applications where relatively lightweight ontologies are used to organize large numbers of individuals or where it is useful or necessary to operate directly on data in the form of RDF triples.

Any OWL 2 EL, QL or RL ontology is, of course, also an OWL 2 ontology and can be interpreted using either the Direct or RDF-Based Semantics. When using OWL 2 RL, a rule-based implementation can operate directly on RDF triples and so can be applied to an arbitrary RDF graph, i.e., to any OWL 2 ontology. In this case, reasoning will always be *sound* (that is, only correct answers to queries will be computed), but it may not be *complete* (that is, it is not guaranteed that all correct answers to queries will be computed). Theorem PR1 of the Profiles document states, however, that (in general) when the ontology is consistent with the structural definition of OWL 2 RL, a suitable rule-based implementation performing ground atomic queries will be both sound and complete.

3 Differences between OWL 1 and 2

The 2004 version of OWL [[OWL 1 Overview](#)] (referred to hereafter as “OWL 1”) has a very similar overall structure to OWL 2. Looking at Figure 1, almost all the building blocks of OWL 2 were present in OWL 1, albeit under a possibly different name.

- The role of the structure, as well as the functional syntax of OWL 2, was played by the OWL Abstract Syntax [Section 2 of [OWL 1 Semantics](#)]. The two syntaxes are different but their respective role within the overall structure of OWL is identical. The new functional syntax is much closer to the RDF graph representation and can capture more RDF graphs; it also has a formal equivalence to UML [[UML](#)].
- Like OWL 1, OWL 2 specifies a precise mapping from ontology structures (represented using the abstract/functional syntax) to RDF graphs. OWL 2, however, also benefits from an explicitly specified mapping from RDF graphs back to ontology structures.
- The two semantics (RDF-Based and Direct) of OWL 2 have their direct counterparts in OWL 1, under the name of RDF-Compatible Model-Theoretic Semantics [Section 5 of [OWL 1 Semantics](#)] and Direct Model-Theoretic Semantics [Section 3 of [OWL 1 Semantics](#)].
- An XML Presentation Syntax was also available for OWL 1 [[OWL 1 XML Syntax](#)] (although not as a Recommendation). On the other hand, the Manchester syntax did not exist for OWL 1.
- OWL 1 defined one sub-language (OWL Lite), where OWL 2 defines three (EL, QL, and RL). OWL Lite has not been re-specified for OWL 2, but because of backward compatibility, OWL Lite ends up as a sub-language of OWL 2.

The central role of RDF/XML, the role of other syntaxes, and the relationships between the Direct and RDF-Based semantics (i.e., the correspondence theorem) have not changed. More importantly, the changes are backward compatible: all OWL 1 Ontologies remain valid OWL 2 Ontologies, with identical inferences (except in certain minor cases, detailed in [3.2 Modifications](#)).

3.1 New Features

OWL 2 adds new functionality with respect to OWL 1. Some of the new features are syntactic sugar (e.g., disjoint union of classes) while others offer new expressivity, including:

- keys;
- property chains;
- richer datatypes, data ranges;
- qualified cardinality restrictions;
- asymmetric, reflexive, and disjoint properties; and
- enhanced annotation capabilities

The OWL 2 New Features and Rationale document [[OWL 2 New Features and Rationale](#)] describes all the new features of OWL 2, while the OWL 2 Quick Reference Guide [[OWL 2 Quick Guide](#)] provides an overview of the various OWL 2 features in general, clearly indicating those that are new.

The restrictions applicable to OWL DL have also been relaxed somewhat in OWL 2. Whereas, in OWL 1, there was a very strict separation between, for example, classes and individuals, OWL 2's corresponding restrictions are a bit more relaxed.

Under some circumstances the same identifier (i.e., URI) can be used to denote, for example, *both* a class and an individual while still maintaining the usability of Direct Semantics. In other words, the set of RDF Graphs that can also be handled by Description Logics reasoners has become a bit larger in OWL 2 compared to OWL 1.

3.2 Modifications

Editor's Note: This section will be filled in, in a later draft, to enumerate all the cases where an OWL 1 ontology will have different semantics in OWL 2. The narrowness of the cases is expected to underscore the degree to which OWL 2 is substantially compatible with OWL 1.

4 Documentation Roadmap

The OWL 2 ontology language is normatively defined by five core specification documents describing its conceptual structure, primary exchange syntax (RDF/XML), two alternative semantics (Direct and RDF-Based), and conformance requirements. Three additional specification documents describe optional features that may be supported by some implementations: the language profiles, and two alternative concrete syntaxes (XML and Manchester).

These documents are, however, all rather technical and mainly aimed at OWL 2 implementers and tool developers. Those looking for a more approachable guide to the features and usage of OWL 2 may prefer to consult one of the user documents (Primer, New Features and Rationale, and Quick Reference Guide).

Editor's Note: At the time this Document Overview is being published for review, some of the documents below are still in active development, so the links point to the Working Group wiki version. We expect that in the next publication round, all the documents will be published together, and these links will be to the appropriate W3C Technical Report.

Part	Type	Document
1	For Users	Document Overview . A quick overview of the OWL 2 specification that includes a description of its relationship to OWL 1. This is the starting point and primary reference point for OWL 2.
2	Core Specification	Structural Specification and Functional-Style Syntax defines the constructs of OWL 2 ontologies in terms of both their structure and a functional-style syntax, and defines OWL 2 DL ontologies in terms of global restrictions on OWL 2 ontologies.

3	Core Specification	Mapping to RDF Graphs defines a mapping of the OWL 2 constructs into RDF graphs, and thus defines the primary means of exchanging OWL 2 ontologies in the Semantic Web.
4	Core Specification	Direct Semantics defines the meaning of OWL 2 ontologies in terms of a model-theoretic semantics.
5	Core Specification	RDF-Based Semantics defines the meaning of OWL 2 ontologies via an extension of the RDF Semantics .
6	Core Specification	Conformance provides requirements for OWL 2 tools and a set of test cases to help determine conformance.
7	Specification	Profiles defines three sub-languages of OWL 2 that offer important advantages in particular applications scenarios.
8	For Users	OWL 2 Primer provides an approachable introduction to OWL 2, including orientation for those coming from other disciplines.
9	For Users	OWL 2 New Features and Rationale provides an overview of the main new features of OWL 2 and motivates their inclusion in the language.
10	For Users	OWL 2 Quick Reference Guide provides a brief guide to the constructs of OWL 2, noting the changes from OWL 1.
11	Specification	XML Serialization defines an XML syntax for exchanging OWL 2 ontologies, suitable for use with XML tools like schema-based editors and XQuery/XPath.
12	Specification	Manchester Syntax defines an easy-to-read, but less formal, syntax for OWL 2 that is used in some OWL 2 user interface tools and is also used in the Primer .
13	Specification	Data Range Extension: Linear Equations specifies an optional extension to OWL 2 which supports advanced constraints on the values of properties.

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