OWL 2

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quotations from

OWL 2 Web Ontology Language Structural Specification and Functional-Style Syntax. http://www.w3.org/TR/owl2-syntax/#Metamodeling

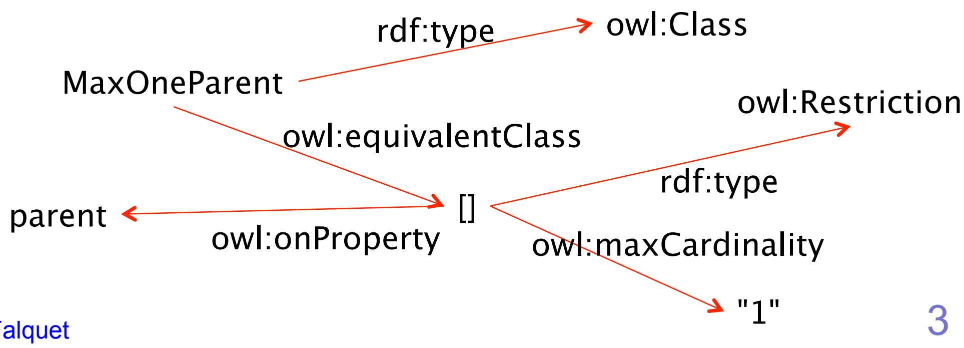
OWL 2 Web Ontology Language Document Overview. http://www.w3.org/TR/owl2-overview/

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

MaxOneParent = parent max 1 Thing

```
<owl:Class rdf:about="&ex;MaxOneParent">
        <owl:equivalentClass>
            <owl:Restriction>
                <owl:onProperty rdf:resource="&ex;parent"/>
                <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</
owl:maxCardinality>
            </owl:Restriction>
        </owl:equivalentClass>
    </owl:Class>
```



Human ≡ Animal and (parent only Human)

```
<owl:Class rdf:about="&Cycles;Human">
        <owl:equivalentClass>
            <owl:Class>
                <owl:intersectionOf rdf:parseType="Collection">
                    <rdf:Description rdf:about="&Cycles;Animal"/>
                    <owl:Restriction>
                        <owl:onProperty rdf:resource="&Cycles;parent"/>
                        <owl:allValuesFrom rdf:resource="&Cycles;Human"/>
                    </owl:Restriction>
                </owl:intersectionOf>
            </owl:Class>
        </owl:equivalentClass>
    </owl:Class>
```

Functional syntax

```
Declaration(Class(:Human))

EquivalentClasses(:Human
    ObjectIntersectionOf(
        ObjectAllValuesFrom(:parent :Human)
        :Animal))

Declaration(Class(:MaxOneParent))

EquivalentClasses(:MaxOneParent
    ObjectMaxCardinality(1 :parent))
```


Metamodeling (by punning)

DL limitation: entities are either classes or individuals, not both.

In some situations this causes modeling problems

In OWL2, an IRI *I* can be used to refer to more than one type of entity.

Goal: To state facts about classes and properties themselves.

> entities that share the same IRI should be understood as different "views" of the same underlying notion identified by the IRI.

Example

(1) ClassAssertion(*x:Dog x:Brian*) Brian is a dog.
(2) ClassAssertion(*x:Species x:Dog*) Dog is a species.

in (1) *x:Dog* is a class
in (2) *x:Dog* is an individual, member of *x:Species*

The individual *x:Dog* and the class *x:Dog* should be understood as two "views" of one and the same IRI — *x:Dog*.

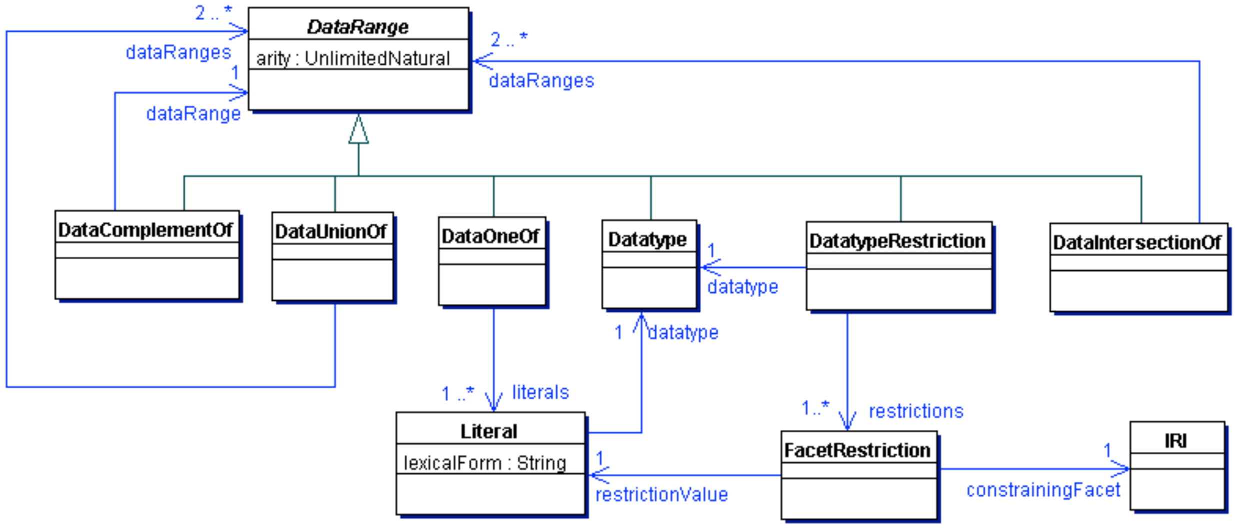
The OWL 2 Direct Semantics treats the different uses of the same name as completely separate, as is required in DL reasoners.

Metamodelling and Annotations

Two means to associate additional information with classes and properties.

- Metamodeling should be used when the information attached to entities should be considered a part of the domain.
- Annotations should be used when the information attached to entities should not be considered a part of the domain and when it should not contribute to the logical consequences of an ontology.

Data Ranges



'One Of' Class Constructor

```
ObjectOneOf := 'ObjectOneOf' '(' Individual
{ Individual }')'
```

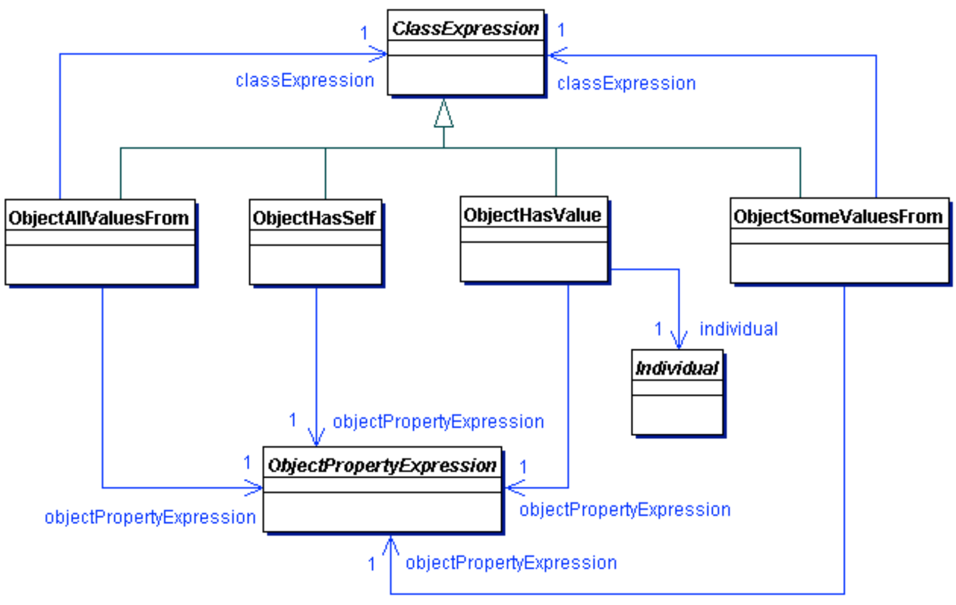
EquivalentClasses(*a:GriffinFamilyMember*
ObjectOneOf(*a:Peter a:Lois a:Stewie a:Meg a:Chris a:Brian*)
)

- The Griffin family consists exactly of Peter, Lois, Stewie, Meg, Chris, and Brian.

DifferentIndividuals

DifferentIndividuals(*a:Quagmire a:Peter a:Lois a:Stewie a:Meg a:Chris a:Brian*)

- Quagmire, Peter, Lois, Stewie, Meg, Chris, and Brian are all different from each other.



Self-Restriction

ObjectHasSelf := 'ObjectHasSelf' '(' ObjectPropertyExpression ')'

contains all those individuals that are connected by OPE to themselves.

- ObjectPropertyAssertion(*a:likes a:Peter a:Peter*)
- LTS ≡ ObjectHasSelf(*a:likes*)
  - those individuals that like themselves;
  - *a:Peter* is classified as an instance of LTS

Literal Value Restriction

DataHasValue(DPE lit)

contains all those individuals that are connected by DPE to lit.

a syntactic shortcut for the class expression

DataSomeValuesFrom(DPE DataOneOf(lt)).

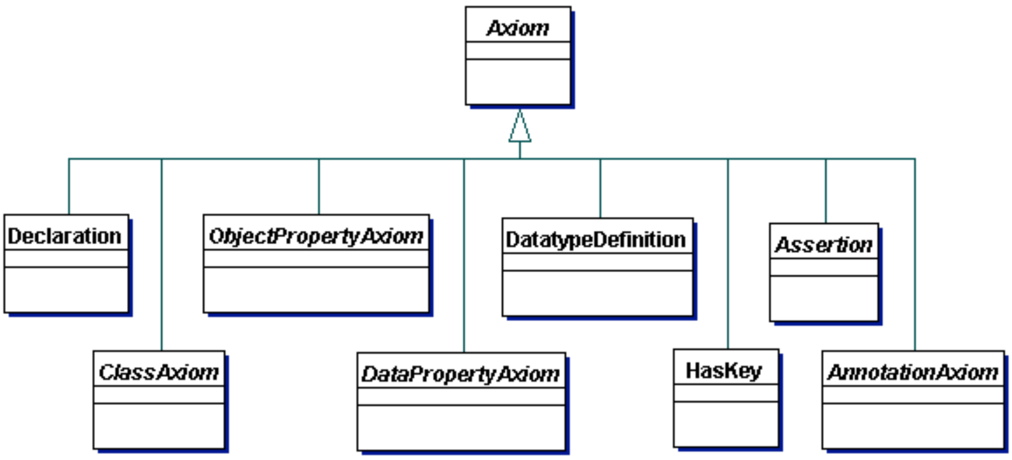
Example

DataPropertyAssertion(*a:hasAge a:Meg* "17"^^*xsd:integer*)

- Meg is seventeen years old.

DataHasValue(*a:hasAge* "17"^^*xsd:integer*)

- contains all individuals that are connected by *a:hasAge* to the integer 17;
- *a:Meg* is classified as its instance:



9.1.4 Disjoint Union of Class Expressions

DisjointUnion(C CE_1 … CE_n)

- states that a class C is a disjoint union of the class expressions CE_i, $1 \leq i \leq n$, all of which are pairwise disjoint.
- each instance of C is an instance of exactly one CE_i, and each instance of CE_i is an instance of C.
- a syntactic shortcut for the following two axioms:
  - EquivalentClasses(C ObjectUnionOf(CE_1 … CE_n))
  - DisjointClasses(CE_1 … CE_n)

Object Subproperties

- analogous to subclass axioms

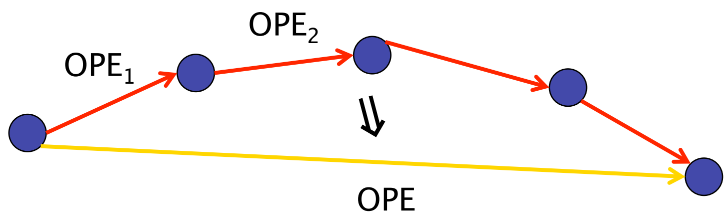
SubObjectPropertyOf(OPE_1 OPE_2).

- states that the object property expression OPE_1 is a subproperty of the object property expression OPE_2
- if an individual x is connected by OPE_1 to an individual y, then x is also connected by OPE_2 to y.

Object subproperty chains

SubObjectPropertyOf(ObjectPropertyChain(OPE_1 ... OPE_n) OPE).

- if an individual x is connected by a sequence of object property expressions OPE_1, ..., OPE_n with an individual y, then x is also connected with y by the object property expression OPE.
- also known as *complex role inclusions*.



Example

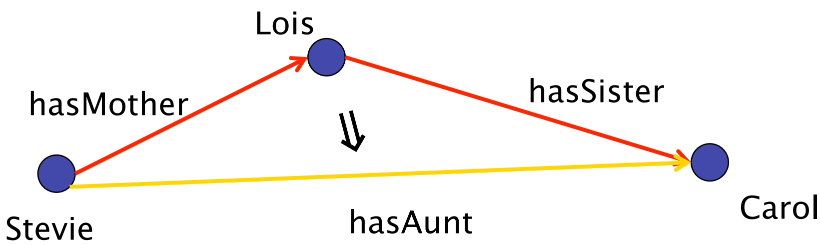
SubObjectPropertyOf(ObjectPropertyChain(*a:hasMother a:hasSister*) *a:hasAunt*)

ObjectPropertyAssertion(*a:hasMother a:Stewie a:Lois*)

ObjectPropertyAssertion(*a:hasSister a:Lois a:Carol*)

entails

ObjectPropertyAssertion(*a:hasAunt a:Stewie a:Carol*)



Object property axioms

- disjoint properties
- inverse
- domain
- range
- (inverse) functional
- (ir)reflexive, transitive, (a)symetric

9.5 Keys

HasKey(CE (OPE_1 ... OPE_m) (DPE_1 ... DPE_n))

- states that each (named) instance of the class expression CE is uniquely identified by the object property expressions OPE_i and/or the data property experssions DPE_j

- no two distinct (named) instances of CE can coincide on the values of all object property expressions OPE_i and all data property expressions DPE_j.

Key and InversFunctional

HasKey(*owl:Thing* (OPE) ())
is similar to
InverseFunctionalObjectProperty(OPE),

difference

- HasKey is applicable only to individuals that are explicitly named in an ontology,
- InverseFunctionalObjectProperty is also applicable to individuals whose existence is implied by existential quantification.

Profiles

An OWL 2 *profile* (commonly called a *fragment* or a *sublanguage* in computational logic) is a trimmed down version of OWL 2 that trades some expressive power for the efficiency of reasoning.

EL : polynomial time reasoning (large ontologies)
QL : LOGSPACE reasoing ("database" applications)
RL : polynomial time reasoning with a rule-based (database) system

OWL 2 EL Profile

- for applications employing ontologies that define very large numbers of classes and/or properties,
- captures the expressive power used by many such ontologies,
- consistency, class expression subsumption, and instance checking can be decided in polynomial time.

Constructs not supported in EL

R only C

R min n C, R max n C

C or D

not C

$\{a_1, a_2, ..., a_n\}$ with n>1

On properties:

disjoint, irreflexive, inverse, fonctional and inverse functional, symetric, asymetric

QL Profile

- sound and complete query answering is in LOGSPACE
- many of the main features necessary to express conceptual models such as UML class diagrams and ER diagrams
- contains the intersection of RDFS and OWL 2 DL
- assertions stored in a standard relational database system can be queried through an ontology via a simple rewriting mechanism
  - rewriting the query into an SQL query

Restrictions on axiom structures

• a class • R some Thing • R some DataRange	$\sqsubseteq$	• a class • C and D • not C • R some C • R some DataRange

Constructs not supported

- R only C
- R value V
- {a, b, ...}
- R min/max n C
- C or D
- ...

Axioms not supported

- P1 o P2 o ... subPropertyOf P
- sameIndividual(a, b)
- not P(a, b)

Rewriting examples

A sub R some C
C sub D and E

Find all the instances of A:

select TA.id
from TA, TR, TC, TD, TE
where TA.id = TR.from and TR.to = C.id and C.id = D.id and C.id = E.id

OWL 2 RL

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 and where it is useful or necessary to operate directly on data in the form of RDF triples.

Restrictions on axiom structures

- a class
- {a, b, c, ...}
- C and D
- C orD
- R some C
- R some DataRange
- R value a
- ...

$\sqsubseteq$

- a class
- C and D
- not C
- R only C
- R value a
- R max 0/1 C
- R some DataRange
- ...

Reasoning rules

- Semantics based on first order implication
- Rules to infer triples
- Provide basis for the implementation of rule-based reasoners

T(?c, owl:intersectionOf, ?x) LIST[?x, ?c$_1$, ..., ?c$_n$] T(?y, rdf:type, ?c$_1$) T(?y, rdf:type, ?c$_2$) ... T(?y, rdf:type, ?c$_n$)	T(?y, rdf:type, ?c)
T(?c, owl:intersectionOf, ?x) LIST[?x, ?c$_1$, ..., ?c$_n$] T(?y, rdf:type, ?c)	T(?y, rdf:type, ?c$_1$) T(?y, rdf:type, ?c$_2$) ... T(?y, rdf:type, ?c$_n$)
T(?c, owl:unionOf, ?x) LIST[?x, ?c$_1$, ..., ?c$_n$] T(?y, rdf:type, ?c$_i$)	T(?y, rdf:type, ?c)
T(?c$_1$, owl:complementOf, ?c$_2$) T(?x, rdf:type, ?c$_1$) T(?x, rdf:type, ?c$_2$)	false

T(?x, owl:someValuesFrom, ?y) T(?x, owl:onProperty, ?p) T(?u, ?p, ?v) T(?v, rdf:type, ?y)	T(?u, rdf:type, ?x)
T(?x, owl:someValuesFrom, owl:Thing) T(?x, owl:onProperty, ?p) T(?u, ?p, ?v)	T(?u, rdf:type, ?x)
T(?x, owl:allValuesFrom, ?y) T(?x, owl:onProperty, ?p) T(?u, rdf:type, ?x) T(?u, ?p, ?v)	T(?v, rdf:type, ?y)
T(?x, owl:hasValue, ?y) T(?x, owl:onProperty, ?p) T(?u, rdf:type, ?x)	T(?u, ?p, ?y)
T(?x, owl:hasValue, ?y)	

T(?c1, rdfs:subClassOf, ?c2) T(?x, rdf:type, ?c1)	T(?x, rdf:type, ?c2)
T(?c1, owl:equivalentClass, ?c2) T(?x, rdf:type, ?c1)	T(?x, rdf:type, ?c2)
T(?c1, owl:equivalentClass, ?c2) T(?x, rdf:type, ?c2)	T(?x, rdf:type, ?c1)
T(?c1, owl:disjointWith, ?c2) T(?x, rdf:type, ?c1) T(?x, rdf:type, ?c2)	false
T(?x, rdf:type, owl:AllDisjointClasses) T(?x, owl:members, ?y) LIST[?y, ?c1, ..., ?cn] T(?z, rdf:type, ?ci) T(?z, rdf:type, ?cj)	false