8 - OWL Language and Semantic Web

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Recap - Semantic Web

RDF - Resource Description Framework

RDF - Resource Description Framework

Basic Idea

- Represent information about resources in the World Wide Web

- Statements using triples containing a subject, a predicate and an object

  - subject - who/what the statement is about

  - predicate - property/characteristic of the subject in the statement

  - object - associated value using the characteristic

- Use uniform resource identifiers (URIs) for each of them

- Example:

```
http://www.example.org/ hasCreator John Smith
```

RDF - Resource Description Framework

RDF formats - RDF/XML

- Example (modified) from Enzyme Commission numerical classification scheme for enzymes

- from Uniprot - protein sequence and annotation data

```
1.   <?xml version='1.0' encoding='UTF-8'?>
2.   <rdf:RDF xmlns="http://purl.uniprot.org/core/"
3.           xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
4.     <rdf:Description
5.        rdf:about="http://purl.uniprot.org/enzyme/1.14.11.2">
6.      <rdf:type rdf:resource="http://purl.uniprot.org/core/Enzyme"/>
7.      <name>Procollagen-proline dioxygenase</name>
8.      <name>Procollagen-proline 4-dioxygenase</name>
9.      <name>Prolyl 4-hydroxylase</name>
10.     <activity>L-proline-[procollagen] + 2-oxoglutarate + O(2) =
11.            trans-4-hydroxy-L-proline-[procollagen] + succinate + CO(2).
12.     </activity>
13.     <cofactor>Iron</cofactor>
14.     <cofactor>L-ascorbic acid</cofactor>
15.   </rdf:Description>
16. </rdf:RDF>
```

RDF - Resource Description Framework

RDF formats - RDF/XML

- Line 1: XML declaration

- Line 2: opens RDF element and defines default namespace of doc

- Line 3: namespace for RDF referred - rdf is its shortcut

- Line 5: specifies the subject

- Line 6: type specification (is an enzyme)

- Line 7-9: synonyms using name

- Line 10-12: activity (equation for chemical reaction)

- Line 13-14: cofactors

- Line 15 and 16: closing Description and RDF element

RDF - Resource Description Framework

RDF formats - N3

■ "Readable" RDF syntax

- Define namespaces as prefixes

- Define triples

- rdf:type expressed by "a"

- Use S P1 O1; P2 O2 for S P1 O1 and S P2 O2

```
@prefix : <http://purl.uniprot.org/core/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

:1.14.11.2 a :Enzyme ;
     :name   "Procollagen-proline dioxygenase",
             "Procollagen-proline 4-dioxygenase",
             "Prolyl 4-hydroxylase" ;
   :activity "L-proline-[procollagen] + 2-oxoglutarate+ O(2) =
             trans-4-hydroxy-L-proline-[procollagen] + succinate + CO(2)" ;
   :cofactor "Iron", "L-ascorbic acid" .
```
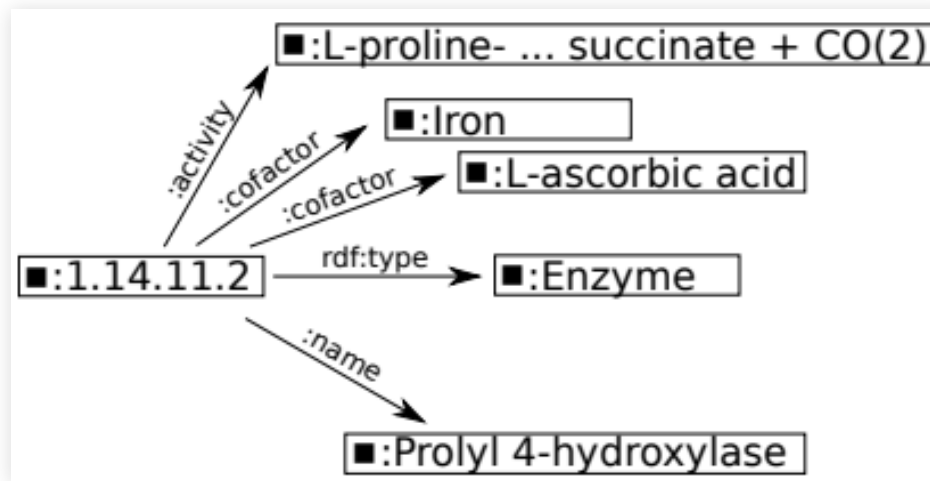
RDF formats - Graphs

- RDF triples can be represented as a graph

RDF - Resource Description Framework

RDF characteristics

- Basis of RDFS, OWL and Semantic Web

- Data stored in RDF/triple stores

- SPARQL as query language

- Capable of merging data different triple stores

RDF Schema

RDF Schema

Schema language

- Schema - formal definition of the syntax of a language

- Schema language - language for expressing that definition

- XML Schema - schema language for XML written in XML

- Overall a framework for interpreting the meaning of data

RDF Schema

RDF Schema (RDFS)

- Interpret the meaning of data written in RDF

- Extension of RDF vocabulary

- Vocabulary identified with "rdfs"

- Adds additional specifications and keywords

- Allows for simple inferences

RDF Schema

Subclasses

```
@prefix x: <http://www.my-example.org> .
x:Mouse rdf:type rdfs:Class .
x:Rodent rdf:type rdfs:Class .
x:Tom rdf:type x:Mouse .
x:Mouse rdfs:subClassOf x:Rodent .
```

- Allows the application of inferences rules

- Example: from

```
X rdfs:subClassOf Y .
b rdf:type X .
```

- infer

```
b rdf:type Y .
```

- We can infer that Tom is an instance of the class rodent.

- Note the difference between Tom is a rodent and mouse is a rodent.

RDF Schema

Some RDFS keywords

RDFS keyword	Explanation
rdfs : Resource	All things in RDFS are instances of this class.
rdfs : Class	Class of resources that are (RDF) classes.
rdfs : subClassOf	subject is subclass of object.
rdfs : subPropertyOf	subject is subproperty of object.
rdfs : domain	domain of a subject property.
rdfs : range	range of a subject property.
rdfs : label	property proving a humanreadable name for subject.

RDF Schema

Other inference rules

- Transitivity of subClassOf
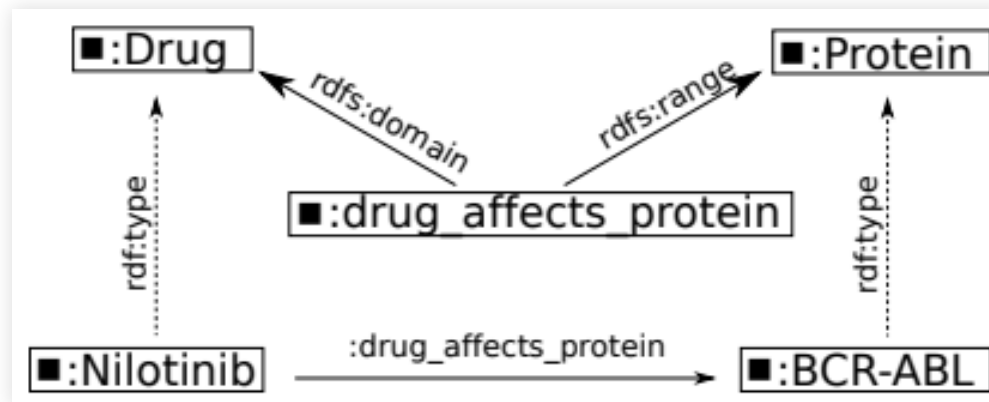
- E.g., (assuming defined classes Mouse, Rodent, and Mammal)

```
x:Mouse rdfs:subClassOf x:Rodent .
x:Rodent rdfs:subClassOf x:Mammal .
```

- Transitivity of subPropertyOf

- Property domains and ranges

Inference with domain and ranges

- Does not work like a database constraint

  • Does not yield an error if the objects are not known to be aligned with the given classes

- Rather adds the corresponding inference(s)

OWL Language

OWL Language

OWL

- Web Ontology Language (OWL - not WOL)

- An extension of RDF Schema? - Yes and No

- Adds expressive means for more inferences

- Direct RDF Extension

- Allows to view URIs simultaneously as classes and objects

OWL Language

Classes

■ Forms of defining classes

- Indicated by a URI

- Enumeration of individuals (oneOf - nominals in DLs)

- Property restriction

- Intersection of classes

- Union of classes

- Complement of a class

OWL Language

RDF-like Syntax

- Example (simplified from NCI Thesaurus)

```
1.   <owl:Class rdf:about="#A-Microtubule">
2.     <rdfs:label>A-Microtubule</rdfs:label>
3.     <rdfs:subClassOf rdf:resource="#Cilium Microtubule"/>
4.     <rdfs:subClassOf>
5.       <owl:Restriction>
6.         <owl:onProperty rdf:resource="#is Physical Part of"/>
7.         <owl:someValuesFrom rdf:resource="#Cytoskeleton"/>
8.       </owl:Restriction>
9.     </rdfs:subClassOf>
10.    <rdfs:subClassOf>
11.      <owl:Restriction>
12.        <owl:onProperty rdf:resource="#is Physical Part of"/>
13.        <owl:someValuesFrom rdf:resource="#Cilium"/>
14.      </owl:Restriction>
15.      </rdfs:subClassOf>
16. </owl:Class>
```

OWL Language

Class Definition

- Line 1: subject

- Line 2: label

- Line 3: subClass specification

- Line 4-9: subClass specification

- someValuesFrom - existential Restriction
- qualified with #Cytoskeleton

- Line 10-15: subClass specification

- someValuesFrom - existential Restriction
- qualified with #Cilium

- Line 16: closing the description

Property restrictions for all values

- Corresponds to universal quantification

```
<rdfs:subClassOf>
  <owl:Restriction>
    <owl:onProperty rdf:resource="P" />
    <owl:allValuesFrom rdf:resource="#V"/>
  </owl:Restriction>
</rdfs:subClassOf>
```

OWL Language

Other Constructors

- ■ Cardinality constraints
- • min: owl : minCardinality
- • max: owl : maxCardinality

- ■ Property characteristics
- • Transitivity owl : TransitiveProperty
- • Symmetry owl : SymmetricProperty
- • Inverses owl : InverseOf
- • Functionality owl : FunctionalProperty

- ■ Disjoint classes - owl : disjointWith
- ■ distinct individuals - owl : differentFrom
- ■ corresponding individuals - owl : sameAs

OWL Language and Semantic Web

Summary

- RDF

- RDF Schema

- OWL Language

- OWL Profiles

Further reading:

- Robinson and Bauer, Introduction to Bio-Ontologies, Chapter 2

- Antoniou et al., A Semantic Web Primer, Chapters 2 and 4