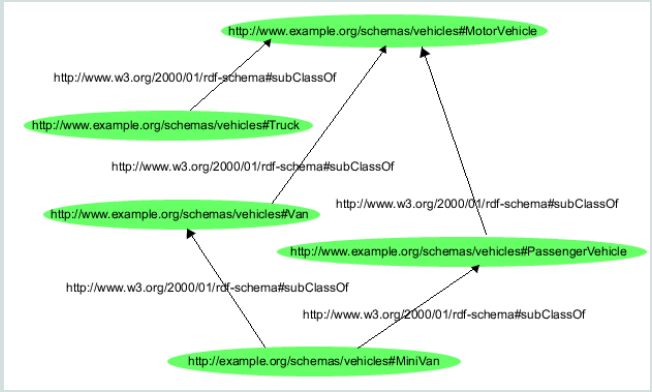
RDFS: RDF Vocabulary Description Language

We would like to define RDF types.

Quelle: http://www.w3.org/TR/rdf-concepts/



Expl. cont.

ex:MotorVehicle rdf:type rdfs:Class.
ex:PassengerVehicle rdf:type rdfs:Class .
ex:Van rdf:type rdfs:Class .
ex:Truck rdf:type rdfs:Class .
ex:MiniVan rdf:type rdfs:Class .

ex:PassengerVehicle rdfs:subClassOf ex:MotorVehicle .
ex:Van rdfs:subClassOf ex:MotorVehicle .
ex:Truck rdfs:subClassOf ex:MotorVehicle .
ex:MiniVan rdfs:subClassOf ex:Van .
ex:MiniVan rdfs:subClassOf ex:PassengerVehicle .

RDF vocabulary again

- Classes

  rdf:Property, rdf:Statement, rdf:XMLLiteral, rdf:Seq, rdf:Bag, rdf:Alt, rdf:List
- Poperties

  rdf:type, rdf:subject, rdf:predicate, rdf:object, rdf:first, rdf:rest, rdf:_n, rdf:value
- Resources

  rdf:nil

RDFS vocabulary

- Classes

  rdfs:Resource, rdfs:Class, rdfs:Literal, rdfs:Datatype, rdfs:Container, rdfs:ContainerMembershipProperty.
- Properties

  rdfs:domain, rdfs:range, rdfs:subPropertyOf, rdfs:subClassOf, rdfs:member, rdfs:seeAlso, rdfs:isDefinedBy, rdfs:comment, rdfs:label

Examples:

- Classes:
  Student rdf:type rdfs:Class
- Class hierarchy:
  Student rdfs:subClassOf Person
- Properties:
  hasName rdf:type rdf:Property
- Property hierarchies:
  hasMother rdfs:subPropertyOf hasParent
- Associating properties with classes:
  hasname rdfs:domain Person
- Associating properties with classes:
  hasName rdfs:range xsd:string

Examples cont.:

- Comment:
  Person rdfs:comment "A person is any human being"
- Label:
  Person rdfs:label "Human being"
- see also:
  person rdfs:seeAlso http://xmlns.com/wordnet/1.6/Human
- is defined by:
  person rdfs:isDefinedBy http://xmlns.com/wordnet/1.6/Human

Entailment rules

- RDFS semantics is defined by entailment rules.
- If an RDFS graph S, i.e. an RDF graph extended by statements referring to the RDFS vocabulary, contains triples on which such rules apply, then additional triples are added to S.
- After having applied entailment rules in all possible ways, we have produced the *realization* of S.
- S entails an RDF graph E, if E is a subgraph of the realization of S.

Some interesting entailment rules

- (a, rdf:type, rdf:property) $\longrightarrow$ (a, rdfs:subproperty, a)
- (a, rdfs:subproperty, b), (b, rdfs:subproperty, c) $\longrightarrow$ (a, rdfs:subproperty, c)
- (a, rdfs:subproperty, b), (c, a, d) $\longrightarrow$ (c, b, d)
- (a, rdf:type, rdf:class) $\longrightarrow$ (a, rdfs:subclass, a)
- (a, rdfs:subclass, b), (b, rdfs:subclass, c) $\longrightarrow$ (a, rdfs:subclass, c)
- (a, rdfs:subclass, b), (c, rdf:type, a) $\longrightarrow$ (c, rdf:type, b)
- (a, rdfs:domain, b), (c, a, d) $\longrightarrow$ (c, rdf:type, b)
- (a, rdfs:range, b), (c, a, d) $\longrightarrow$ (d, rdf:type, b)

Abbildung relationaler Datenbanken nach RDF

direkte Abbildung

- Relationsschema —> Klasse
- Tupel einer Relation —> Objekt (Resource)
- Attribut —> Eigenschaft (Property)
- Attribut-Mapping —> Kante
- Wert —> Literal oder Objekt (Resource)

Key, foreign key and other constraints?

These constraints should not be lost because otherwise problems arise

- if a user builds her own knowledge base by integrating several RDF graphs found on the internet,
- if an exported RDF graph is imported in a relational database at another place,
- if updates on a materialized RDF graph have to be performed such that key and foreign key properties and other constraints have to be checked.

Relational Databases

- A relational database schema $\mathbf{R}$ is a set of relation schemata identified by R, $\mathbf{R} = (R_1, ..., R_n)$.
  $Att(R)$ denotes the set of attributes of the relation symbol R.
  An instance $\mathbf{I}$ of $\mathbf{R}$ is a tuple $(I_1, ..., I_n)$, where for $i \in [n]$ I_i is a finite instance of R_i, i.e. a finite subset of the n-ary cartesian product over an underlying domain. An element $\mu \in I$ is called tuple.

A simple mapping RDB to an RDF-graph

Let R be a relation schema, where $Att(R) = A_1, \ldots, A_k$.

- Introduce a class C_R and properties $Q_{R,A_1}, \ldots, Q_{R,A_k}$.
- Let I be an instance of R.
- For every tuple $\mu = (a_1, \ldots, a_k) \in I$ introduce a unique blank node $\_n_\mu$ and a labelled edge $(\_n_\mu, rdf : type, C_R)$.
- For every nonnull value $\mu.A$ of μ, $A \in Att(R)$, introduce an edge $(\_n_\mu, Q_{R.A}, (\mu.A)_{\_n_\mu, Q_{R.A}})$.
  If $\mu.A$ is a key-value, then $(\mu.A)_{\_n_\mu, Q_{R.A}})$ is a URI; otherwise $\mu.A$ is a literal.

Constraint Checking by SPARQL

- Checking by `ASK`ing for a violation of a respective constraint.
- This differs from SQL, where we ask for fulfillment of a respective constraint.
- This is because SPARQL does nor provide a `NOT`-operator in front of a general expression, what is possible in SQL.

Key constraints:
do p1, ..., pn form a key for the instances of class C?

```
ASK {
  ?x rdf:type C.
  ?y rdf:type C.
  ?x p1 ?p1; [...]; pn ?pn.
  ?y p1 ?p1; [...]; pn ?pn.
  FILTER (?x!=?y)
}
```


Foreign key constraints:
do p1, ..., pn form a foreign key with respect to key q1, ..., qn?

```
ASK {
  ?x rdf:type C; p1 ?p1; [...]; pn ?pn.
  OPTIONAL {
    ?y rdf:type D; q1 ?p1; [...]; qn ?qn.
  } FILTER (!bound(?y))
}
```


max-Cardinality:
Does p have at most *n* different values?

```
ASK {
  ?x rdf:type C.
  ?x p ?p1; [...]; p ?pn+1.
  FILTER (allDist([?p1,...,?pn+1]))
}
```

allDist([?p1,...,?pn]) $\stackrel{def}{:=} \bigwedge_{1\leq i\leq n}(\bigwedge_{i<j\leq n}$?pi!=?pj)

enforces that variables ?p1, ..., ?pn are pairwise distinct.

min-Cardinality:
Does p have at least *n* different values?

```
ASK {
  ?x rdf:type C.
  OPTIONAL {
    ?y rdf:type C.
    ?y p ?p1; [...]; p ?pn.
    FILTER (allDist(?p1,...,?pn) && ?x=?y)
  } FILTER (!bound(?y))
}
```

Path-constraint:
Is the composition of predicates p1, ..., pn contained in q?

```
ASK {
  ?x  rdf:class  C;  p1 ?p1.
  ?p1 p2 ?p2. [...]. ?pn-1  pn ?pn.
  OPTIONAL  {  ?x q ?q. FILTER (?pn=?q)  }
  FILTER (!bound(?q))
}
```


Subclass and Subproperty-constraint

```
ASK {
  ?x1 rdf:type C.
  OPTIONAL { ?x1 rdf:type D. }
  FILTER (!bound(?x1))
}


ASK {
  ?x1 p ?x2.
  OPTIONAL { ?x1 q ?x2. }
  FILTER (!bound(?x1))
}
```


Intersection-constraint:
Is class C the intersection of classes D1 and D2?

```
ASK {
{ ?x1 rdf:type :C .
  OPTIONAL { ?y1 rdf:type :D1.
             ?y1 rdf:type :D2.
             FILTER(?x1 = ?y1)
           }
  FILTER(!bound(?y1))
}
UNION
{ ?x1 rdf:type :D1 .
  ?x1 rdf:type :D2.
  OPTIONAL { ?y1 rdf:type :C.
             FILTER(?x1 = ?y1)
           }
  FILTER(!bound(?y1))
}
}
```


Union-constraint:
Is class C the union of classes D1 and D2?

```
ASK {
{ ?x1 rdf:type :C .
  OPTIONAL { ?y1 rdf:type :D1. FILTER(?x1 = ?y1) } .
  OPTIONAL { ?y2 rdf:type :D2. FILTER(?x1 = ?y2) } .
  FILTER(!bound(?y1) && !bound(?y2))
}
UNION
{
  {  ?y1 rdf:type :D1 .
     OPTIONAL { ?x1 rdf:type :C. FILTER(?x1 = ?y1) } }
     UNION
  {  ?y2 rdf:type :D2 .
     OPTIONAL { ?x1 rdf:type :C. FILTER(?x1 = ?y2) } }
  FILTER(!bound(?x1))
}
}
```