RDF Schema

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Semantic Web
RDF Schemas

- Describe rules for using RDF properties
- Are expressed in RDF
- Extends original RDF vocabulary
- Are not to be confused with XML Schemas

- RDFS defines a basic set of classes and properties, together with their **semantics** (interpretation) and **logic**
### RDFS Vocabulary

- **RDFS namespace**
  - http://www.w3.org/2000/01/rdf-schema#

- **rdfs:Resource**
  - rdfs:Class
  - rdfs:Literal
  - rdfs:Datatype
  - rdf:XMLLiteral
  - rdf:Property

- **rdfs:range**
  - rdfs:domain
  - rdf:type
  - rdfs:subClassOf
  - rdfs:subPropertyOf

- **rdfs:label**
  - rdfs:comment

- **rdfs:Container**
  - rdf:Bag
  - rdf:Seq
  - rdf:Alt
  - rdfs:ContainerMembershipProperty
    - rdf:_1, rdf_2 ...
  - rdfs:member

- **rdfs:ContainerMembershipProperty**
  - rdfs:member

- **rdf:List**
  - rdf:first
  - rdf:rest
  - rdf:nil

- **rdf:Statement**
  - rdf:subject
  - rdf:predicate
  - rdf:object

- **rdfs:seeAlso**
  - rdfs:isDefinedBy
  - rdf:value
RDF Classes

- Are groups of Web resources
- Have URLs to identify them
- The special class "rdfs:Literal" consists of all possible RDF string values
Property-centric classes

- In typical OO classes, each class specifies completely what properties it has and what their types are.
- In RDF classes, each property specifies what classes of subjects and objects it relates.
- Therefore, new properties can be added to a class without modifying the class.
To specify a class, create an RDF resource of type rdfs:Class

```xml
<rdfs:Class id="MyClass">
  <rdfs:label>My Class</rdfs:label>
  <rdfs:comment>Sample demonstration Class</rdfs:comment>
</rdfs:Class>
```
To specify a property, create an RDF resource of type rdfs:Property

```xml
<rdfs:Property id="myProperty">
  <rdfs:comment>Sample demo property</rdfs:comment>
  <rdfs:domain resource="#MyClass"/>
  <rdfs:range resource="..#Literal"/>
</rdfs:Property>
```
Schema URIs

- Ordinary XML namespace URIs are just to guarantee uniqueness: there is no assumption that the URI refers to anything useful (or even refers at all)
- URIs for namespaces used in RDF, though, should refer to an RDF schema document
Properties (1)

- "rdf:type" relates any resource to its class

- "rdfs:subClassOf" relates a subclass to its superclass (multiple inheritance is OK)
  
  baby rdfs:subClassOf child

- "rdfs:subPropertyOf" relates a subproperty to its superproperty
  
  mother rdfs:subPropertyOf parent
Properties (2)

- "rdfs:seeAlso" relates a resource to another resource explaining it (use a subproperty to specify the nature of the explanation)

- "rdfs:isDefinedBy" is a subproperty of "rdfs:seeAlso" and relates a resource to its definition, typically an RDF schema
“rdfs:domain” specifies the domain of a property (the classes of its subjects); if unknown, anything can be a subject.

“rdfs:range” specifies the range of a property (the single class of its objects); if unknown, anything can be an object.

domain and range effectively restrict classes that can be in specific relationship.
Properties (4)

- “rdf:subject” is the property relating a reified statement to its subject (resource)

- “rdf: predicate” is the property relating a reified statement to its predicate (property)

- “rdf:object” is the property relating a reified statement to its object (value)
Properties (5)

- "rdfs:label" specifies a human-readable name for this Class, Property, or whatever.

- "rdfs:comment" specifies human-readable documentation.
  - Multiple values are useful for specifying multiple languages.
Classes (1)

- "rdfs:Resource" is the class of all resources
- "rdfs:Literal" is the class of all strings
- "rdfs:Class" is the class of all classes
- "rdfs:Property" is the class of all properties
- "rdf:Statement" is the class of all asserted RDF statements
Classes (2)

- "rdfs:Container" is the superclass of all container classes

- "rdf:Bag", "rdf:Seq", "rdf:Alt" are the classes of Bags (multi-set), Seqs (sequence), and Alts (alternative)

- Any other class that is a subclass of "rdfs:Container" can be used in RDF syntax in place of a standard container
Classes - example

ex:Seminar rdfs:subClassOf ex:Meeting
ex:Proseminar rdfs:subClassOf ex:Seminarex:Lecture rdfs:subClassOf ex:Meeting
Classes

ex:Seminar rdfs:subClassOf ex:Meeting
ex:Proseminar rdfs:subClassOf ex:Seminar
ex:Lecture rdfs:subClassOf ex:Meeting
ex:Professor rdfs:subClassOf ex:Employee
All classes are instances of **rdfs:Class**

- **rdfs:Class**
  - **rdf:type**
  - **rdfs:subclassOf**
    - ex:Employee
      - **rdfs:subclassOf**
        - ex:Professor
    - ex:Meeting
      - **rdfs:subclassOf**
        - ex:ProSeminar
    - ex:Lecture
      - **rdfs:subclassOf**
        - ex:Seminar
    - ex:Seminar
All classes are sub-classes of **rdfs:Resource**
Such duality in RDF definition can be useful further in meta-modeling.
Orange arrows (connections) belong to RDFS standard and are always included in model.
Inference (2) - without property names

Orange connections belong to RDFS standard and are always included (or added) in model.
Inference (3) – transitivity of rdfs:subclassOf

- ex:Meeting
  - rdfs:subclassOf ex:Lecture
  - rdfs:subclassOf ex:Seminar
    - rdfs:subclassOf ex:ProSeminar
Instances and classes

ex:Ethics rdf:type ex:Lecture  ex:SOA rdf:type ex:Seminar  
ex:Kant rdf:type ex:Professor
Inference (4) - Polymorphism

ex:Ethics rdf:type ex:Lecture
ex:SOA rdf:type ex:Seminar
ex:Kant rdf:type ex:Professor

ex:Employee
  rdfs:subclassOf
  ex:Professor
  rdf:type
  ex:Kant

ex:Meeting
  rdfs:subclassOf
  ex:Lecture
  rdfs:subclassOf
  ex:ProSeminar
  rdf:type
  ex:Ethics
  rdfs:subclassOf
  ex:SOA
  rdf:type
  ex:Professor
  rdfs:subclassOf
  ex:Kant
  rdf:type
Multiple inheritance

ex:Employee

rdfs:subClassOf

ex:Professor

rdf:type

ex:Kant

rdfs:subClassOf

ex:Independent Researcher

rdfs:subClassOf

ex:Genius

rdf:type
ex:Professor and ex:University_Teacher define in fact the same class
Identity

ex:Employee

ex:Professor

ex:Kant

ex:Independent_Researcher

ex:University_Teacher

rdfs:subclassOf

rdf:type

rdfs:subclassOf

rdfs:subclassOf
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
         xml:base="http://example.org"
         xmlns:ex="http://example.org/">
  <rdfs:Class rdf:about="Proseminar">
    <rdfs:subClassOf rdf:resource="Seminar">
      <rdfs:subClassOf rdf:resource="Meeting"/>
    </rdfs:subClassOf>
  </rdfs:Class>

  <rdfs:Class rdf:about="Lecture">
    <rdfs:subClassOf>Meeting</rdfs:subClassOf>
    <rdfs:label>Lecture at the University</rdfs:label>
    <rdfs:comment>Comment goes here …</rdfs:comment>
  </rdfs:Class>

  <ex:Lecture rdf:ID="Ethics"/>
  <ex:Seminar rdf:ID="SOA">
    <ex:taughtBy>Staab</ex:taughtBy>
    <ex:taughtBy>Grimm</ex:taughtBy>
  </ex:Seminar>
</rdf:RDF>
Properties

ex:taughtBy
  rdf:type rdfs:Property
  rdfs:domain ex:Lecture
  rdfs:range ex:Professor

ex:Ethics ex:taughtBy ex:Kant

ex:Ethics rdf:type ex:Lecture
Properties

ex:taughtBy
  rdf:type rdfs:Property
  rdfs:domain ex:Lecturer
  rdfs:range ex:Professor

ex:Ethics ex:taughtBy ex:Kant

ex:Ethics rdf:type ex:Lecture

ex:taughtBy
  rdfs:domain ex:Book

ex:Ethics rdf:type ex:Book
Properties

This is NOT object-oriented

uni:taughtBy
  rdfs:domain ex2:Lecture
  rdfs:range ex1:Professor
  rdf:type rdfs:Property

ex1:Professor rdf:type rdfs:Class.

ex2:Lecture rdf:type rdfs:Class.
Sub-Properties

ex:worksAt
  rdfs:domain ex:Person
  rdfs:range ex:Institution
  rdf:type rdfs:Property

ex:teachesAt
  rdfs:domain ex:Professor
  rdfs:range ex:Institution
  rdf:type rdfs:Property

ex:teachesAt rdfs:subPropertyOf ex:worksAt
Sub-Properties

ex:worksAt
  rdfs:domain ex:Person
  rdfs:range ex:Institution
  rdf:type rdfs:Property

ex:teachesAt
  rdfs:domain ex:Professor
  rdfs:range ex:Institution
  rdf:type rdfs:Property

ex:teachesAt rdfs:subPropertyOf ex:worksAt

ex:Kant ex:teachesAt ex:University

ex:Kant ex:worksAt ex:University

ex:Kant rdf:type ex:Person
ex:Kant rdf:type ex:Professor

Kant must be BOTH Professor and Person
RDF Common Vocabulary

Commonly used vocabularies on the web
Widely used and accepted RDF Schema

- Dublin Core
  - Metadata initiative – annotation of resources

- RSS 1.0
  - RDF Site Summary 1.0

- FOAF
  - Friend of a friend – social networks

- SWRC
  - Semantic Web for Research Communities
Dublin Core

- Originally
  - A set of fifteen (15) basic properties for describing generalized Web resources

- Now
  - *Dublin Core Metadata Initiative*: open organization engaged in the development of interoperable online metadata standards that support a broad range of purposes and business models
  - Core set of metadata terms (DCMI Metadata Terms)
    - Core vocabulary size over 100 common agreed terms
  - Multiple working groups / communities dedicated to specific issues
Dublin Core “the original”

1. “**Title**”: the name given to the resource
2. “**Creator**”: the person or organization primarily responsible for the resource
3. “**Subject**”: what the resource is about
4. “**Description**”: a description of the content
5. “**Publisher**”: the person or organization responsible for making the resource available
6. “**Contributor**”: someone who has provided content to the resource other than the creator
7. “**Date**”: date of creation or publication
8. “**Type**”: type of resource, such as home page, technical report, novel, photograph…
9. “**Format**”: data format of the resource
10. “**Identifier**”: URL, ISBN number, …
11. “**Source**”: another resource that this resource is derived from
12. “**Language**”: the language of the content
13. “**Relation**”: another resource and its relationship to this one
14. “**Coverage**”: the portion of time or space described by this resource (atlases, histories, etc.)
15. “**Rights**”: the intellectual property rights adhering to this resource, or a pointer to them
RSS 1.0

- **RSS**
  - Really Simple Syndication protocol → RDF Site Summary
- **RSS 1.0** is a lightweight multipurpose extensible metadata description and syndication format.
- **Syndication**
  - making data available online for retrieval and further transmission, aggregation, or online publication.
- **RSS**
  - Almost anything that can be broken down into discrete items can be syndicated via RSS: news, recent changes page of a wiki, blog entries …
  - News aggregators are popular in the weblogging community
  - Many weblogs and sites make content available in RSS.
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns="http://purl.org/rss/1.0/">
  <channel rdf:about="http://www.xml.com/xml/news.rss">
    <title>XML.com</title>
    <link>http://xml.com/pub</link>
    <description>XML.com description</description>
    <items>
      <rdf:Seq>
        <rdf:li resource="http://..."/>
      </rdf:Seq>
    </items>
  </channel>
  <image rdf:about="http://xml.com/universal/images/xml_tiny.gif">
    <title>XML.com</title>
    <link>http://www.xml.com</link>
    <url>http://xml.com/universal/images/xml_tiny.gif</url>
  </image>
    <title>Putting RDF to Work</title>
    <description>Description goes here ...</description>
  </item>
  <item rdf:about="http://...">
    ...
  </item>
</rdf:RDF>
FOAF

- Friend-Of-A-Friend
- machine-readable **ontology** describing *persons*, their *activities* and their *relations* to other people and objects
- interlinks people and explicitly defines social relationships (friend), building a global social network

- facilitates the creation of the Semantic Web equivalent of the **archetypal personal homepage**
  - “My name is Leigh, this is a picture of me, I'm interested in XML, and here are some links to my friends.”
FOAF example

```xml
<rdf:RDF
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
   xmlns:foaf="http://xmlns.com/foaf/0.1/">
   <foaf:Person rdf:ID="me">
     <foaf:name>Maciej Janik</foaf:name>
     <foaf:title>Dr</foaf:title>
     <foaf:givenname>Maciej</foaf:givenname>
     <foaf:family_name>Janik</foaf:family_name>
     <foaf:mbox_sha1sum>809d...a3f</foaf:mbox_sha1sum>
     <foaf:homepage rdf:resource="http://isweb.uni-koblenz.de/~janik"/>
     <foaf:depiction rdf:resource="http://.../MaciejJanik.jpg"/>
     <foaf:phone rdf:resource="tel:00492612872718"/>
     <foaf:schoolHomepage rdf:resource="http://www.agh.edu.pl"/>
     <foaf:knows>
       <foaf:Person>
         <foaf:name>Steffen Staab</foaf:name>
         <foaf:mbox_sha1sum>ae8f...f90</foaf:mbox_sha1sum>
       </foaf:Person>
     </foaf:knows>
   </foaf:Person>
</rdf:RDF>
```
- **SWRC**
  - Semantic Web for Research Communities
  - ontology for modeling entities of research communities such as persons, organizations, publications (bibliographic metadata) and their relationships

- **Main concepts of the SWRC ontology**
In this work, control strategies for combining two potentially powerful buffer management techniques in object bases were devised and evaluated: (1) buffer pool segmentation with segment-specific replacement criteria, and (2) dual buffering consisting of copying objects from pages into object buffers. Two dimensions exist for exerting control on the buffer pool: (1) the \( \{ \text{it copying}\} \) time which determines at what time objects are copied from their memory-resident home page, and (2) the \( \{ \text{it relocating}\} \) time which determines when a copied object is to be transferred back to its home page. Along both dimensions, it is possible to differentiate between an \( \{ \text{eager}\} \) and an \( \{ \text{lazy}\} \) strategy. The extensive experimental results indicate that lazy object copying combined with an eager relocation strategy is almost always superior and significantly outperforms page-based buffering in most applications.
RDFS summary

- Extended vocabulary of RDF
- Class and property (relationship) inheritance
- Inference schemes
  - Classes
  - Properties
  - Transitivity of some properties (subClass, subPropertyOf)
- Division to schema (definitions) and instances (factual knowledge)
- Domain and range restrictions (with its implications
- Many widely used vocabularies
- Still not expressive enough …

→ OWL (Web Ontology Language)