Knowledge management
RDF and RDFS

Outline

- RDF
  - Semantic Web and Metadata
  - What is RDF and what is not?
  - Why use RDF?
  - RDF Elements
- RDF Schema (RDFS)
- RDF Storing

Semantic Web

- The Web today: Documents for humans.
- Problem: hard to machine-process on a semantic level.
- Vision: Make the information in the Web machine-processable, for intelligent services, better user interaction and autonomous agents
- Realization idea: Semantic annotation of objects + query and reasoning mechanisms
- Requirement: machine-processable languages for annotation and representation reasoning tools and a naming mechanism

Metadata

- Metadata describes other data (“Data about Data”)
  - One application’s metadata is another application’s data
  - Metadata can itself be described by metadata (but that doesn’t make it meta-metadata)
- Metadata is useful
  - e.g A lot could be gained from structured description of pages, servers, search services, and other resources
- Example(s):
  - a library catalogue contains information (metadata) about publications (data)
  - a file system maintains permissions (metadata) about files (data)

Resource Description Framework (RDF)

- **RDF** is a family of World Wide Web Consortium (W3C) specifications originally designed as a metadata model but which has come to be used as a general method of modeling information, through a variety of syntax formats.

Source: Wikipedia

RDF is a standard syntax to represent (edge labeled) directed graphs in XML

Why use RDF?

- Improve on HTML and XML
- Machine *understandable* metadata
- Support structured values
- Base for a variety of descriptions:
  - cataloging, privacy, accessibility, IPR, ...
- Store and query metadata

What is RDF?

- An abstract formalism
- A directed graph data model
- A set of binary statements ("triples")
  - Subject Predicate Object

→ RDF can be used to encode ontologies

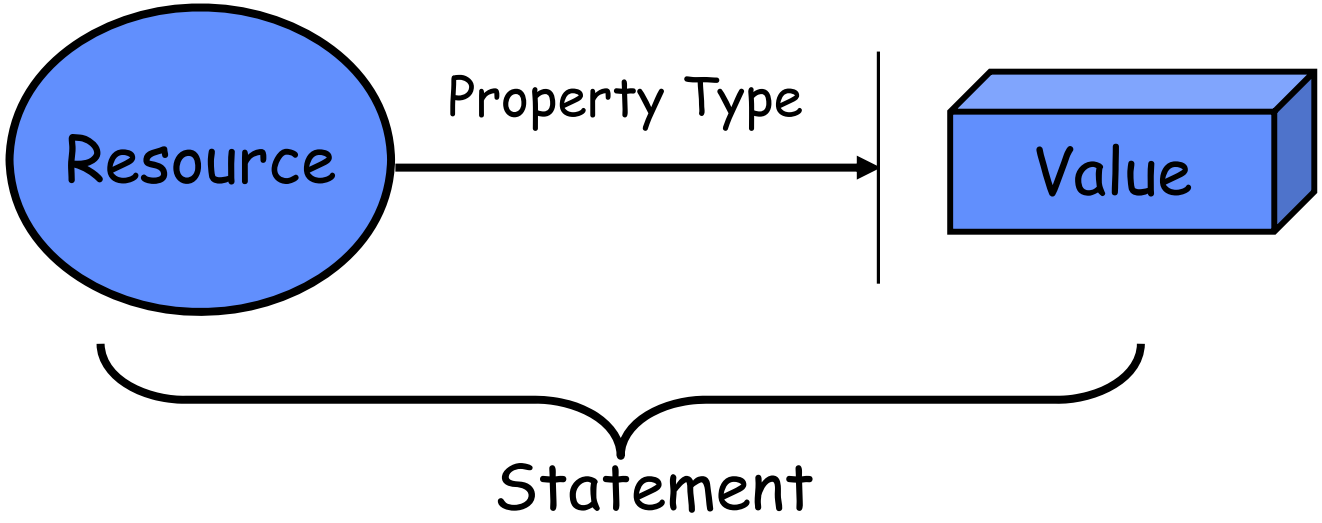
What is RDF not?

- A relational database
- A (database) management system
- A query language
- A file
- A new version of HTML or XML

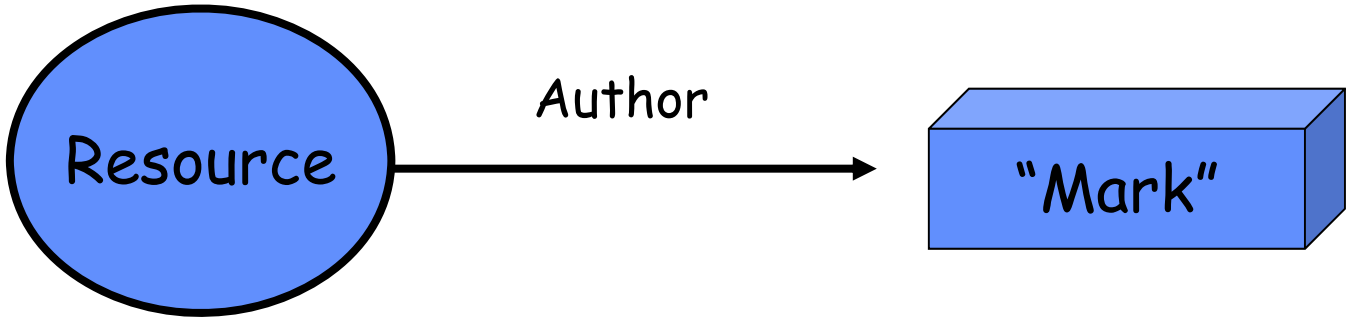
RDF Elements

- Resources
- Properties
- Literal values
- Statements (Assertions)
  - Resource Property Resource
  - Resource Property Literal
- Namespaces (disambiguation of homonym identifiers)

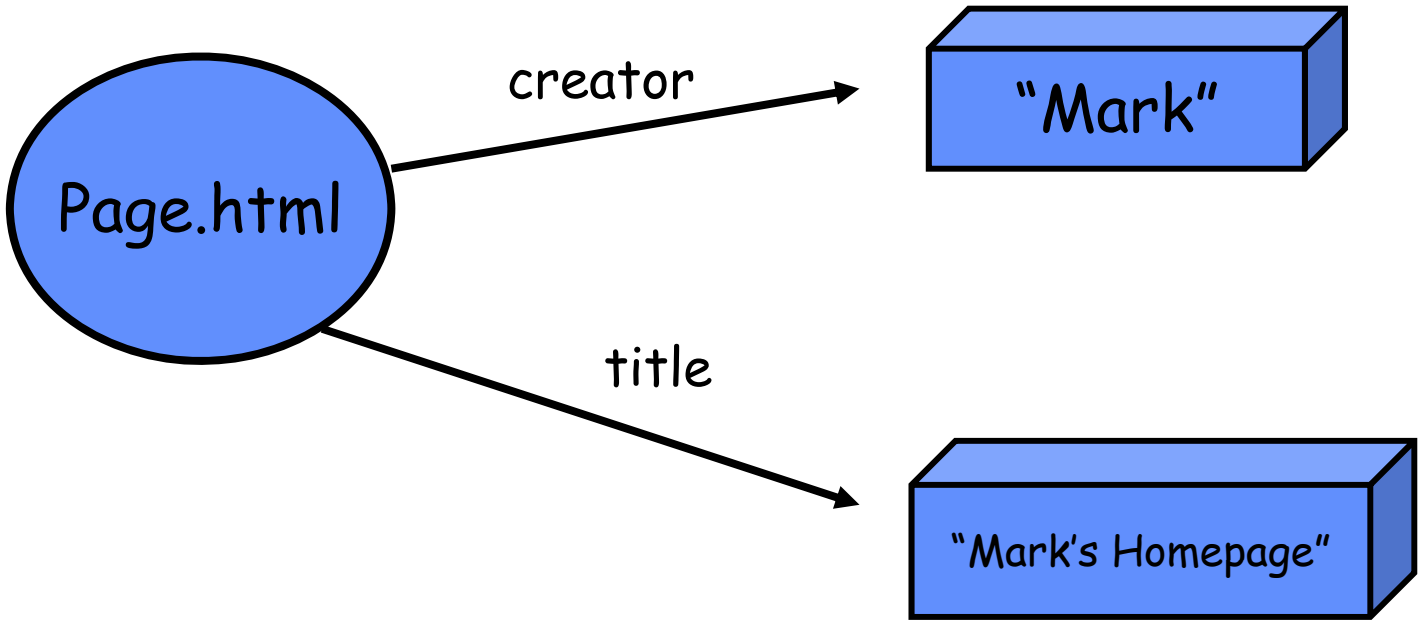
RDF Model Primitives



Simple Example



Simple Example



RDF Resources

- Almost everything is a resource
- RDF stores statements about resources:
  - Tangible things of the real world
  - Electronic objects
  - Abstract ideas such as classes/topics/…
- Resources are identified by URIs

URIs are rigid designators in a global domain

RDF Description

- **Attributes**

– ***about***

- refers to a URI of an existing resource

– ***ID***

- signals the creation of a new resource

```
<?xml version="1.0"?>
   <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">

   <rdf:Description rdf:about="http://www.www.fr/">
      .
      .
      .
   </rdf:Description>

   <rdf:Description rdf:ID="myID">
      .
      .
      .
   </rdf:Description>
   </rdf:RDF>
```

RDF Resource

```
<rdf:Description rdf:about="http://www.w3.org/TR/rdf-
  syntax-grammar">
  <ex:editor>
      <rdf:Description>
            <ex:homePage>
               <rdf:Description
                  rdf:about="http://purl.org/net/dajobe/">
                </rdf:Description>
            </ex:homePage>
      </rdf:Description>
  </ex:editor>
</rdf:Description>
```

RDF properties

- Properties
  - Properties: special kind of resources
  - A specific aspect, characteristic, attribute, or relation used to describe a resource or binary relations between two resources
  - E.g., “WorkFor”, “hasAuthor”, “father-of”

RDF properties

- Property names must be associated with a schema
- Qualify property names with a namespace prefix

Example:

```
<?xml version="1.0"?>
  <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
           xmlns:dc="http://purl.org/dc/elements/1.1/">
    <rdf:Description about="http://www.www.fr/">
      <dc:creator>myID</dc:creator>
    </rdf:Description>
  </rdf:RDF>
```

RDF literals

- Literals
  - Concrete data values
  - E.g “John Smith”, “1”, “2005-03-07”
  - Literal values are data
  - Untyped literals are just strings
  - Typed literals borrow from XML Schema Datatypes: String, date, float ...

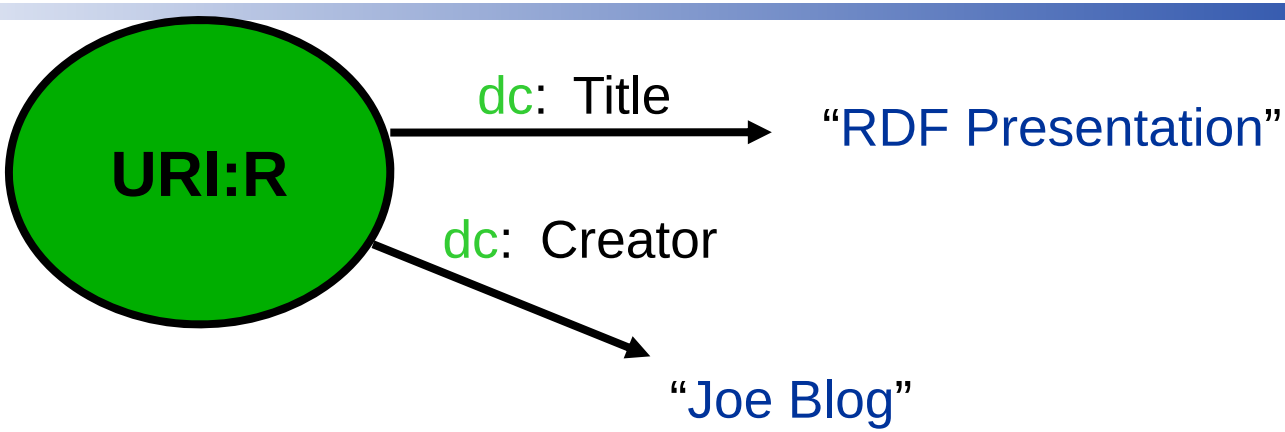
RDF Literal

```
<rdf:Description rdf:about="http://www.w3.org/TR/rdf-
  syntax-grammar">
  <dc:title>"RDF Syntax Specification"</dc:title>
  <ex:editor>
      <rdf:Description>
            <ex:fullName>“Joe Blog"</ex:fullName>
            <ex:homePage
           rdf:resource="http://purl.org/net/dajobe/"/>
      </rdf:Description>
  </ex:editor>
</rdf:Description>
```

RDF statements (assertions)

- Statements
  - Different name: Assertion = Triple = Statement
  - Express facts about resources
  - A statement contains three parts: subject, predicate, and object
  - A set of assertions creates a graph
  - A graph cannot contain only resources
  - Example of statements:
    - http://www.w3.org/ has the format text/html
    - http://www.debruijn.net/ has first name Jos
    - http://www.polleres.net/page.html is the Web page of http://www.polleres.net/axel

RDF Syntax Example




```
<rdf:RDF xmlns:rdf = "http://www.w3.org/TR/WD-rdf-syntax#"
     xmlns:dc = "http://purl.org/dc/elements/1.0/">
   <rdf:Description about = "URI:R">
     <dc:Title> RDF Presentation </dc:Title>
     <dc:Creator> Joe Blog </dc:Creator>
   </rdf:Description>
</rdf:RDF>
```

- **Exercise**: Use RDF to describe these resources:
  - A bank named KMB
  - KMB has client John

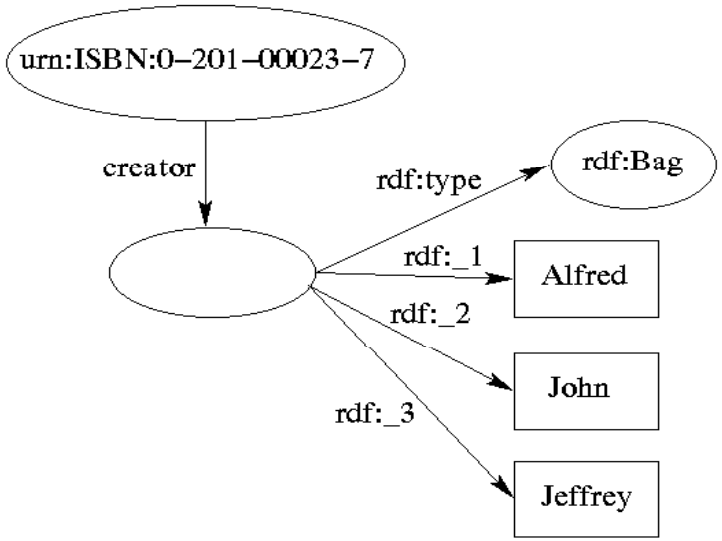
RDF Containers

- Bag
  - An unordered list of resources or literals
- Sequence
  - An ordered list of resources or literals
- Alternative
  - A list of resources or literals that represent alternatives for the value of a property

Using the Bag Container

- ***Statement:***
  - ***The authors of the book 0201000237 are Alfred, John and Jeffrey***

```
<?xml version="1.0"?>
  <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
           xmlns:dc="http://purl.org/dc/elements/1.1/">
    <rdf:Description about="urn:ISBN:0-201-00023-7">
      <dc:creator>
        <rdf:Bag>
          <rdf:li>Alfred</rdf:li>
          <rdf:li>John</rdf:li>
          <rdf:li>Jeffrey</rdf:li>
        </rdf:Bag>
      </dc:creator>
    </rdf:Description>
  </rdf:RDF>
```



Using the Seq Container

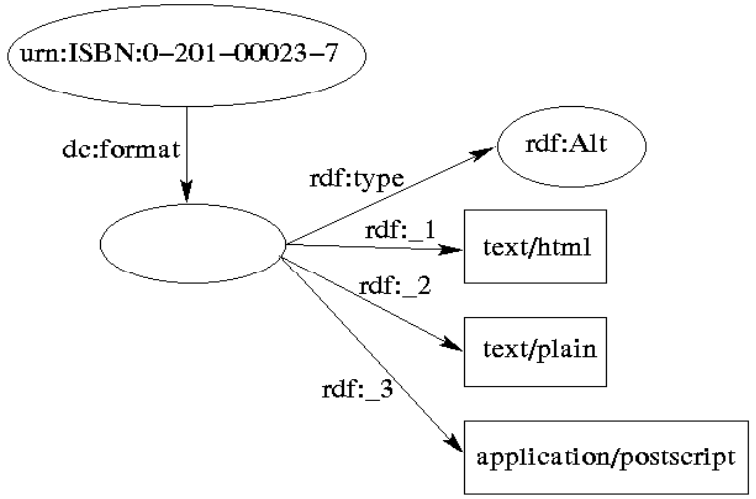
- ***Statement:***
  - ***The students of the course km in alphabetical order are Elizabeth, George and John***

```
<?xml version="1.0"?>
  <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
           xmlns:s="http://www.schemas.org/Course/">
    <rdf:Description about="http://www.www.fr/courses/km">
      <s:students>
        <rdf:Seq>
          <rdf:li rdf:resource="http://www.www.fr/students/er"/>
          <rdf:li rdf:resource="http://www.www.fr/students/gl"/>
          <rdf:li rdf:resource="http://www. www.fr/students/js"/>
        </rdf:Seq>
      </s:students>
    </rdf:Description>
  </rdf:RDF>
```

Using the Alt Container

- ***Statement:***
  - ***The formats of the book 0201000237 are plain text, html and postscript***

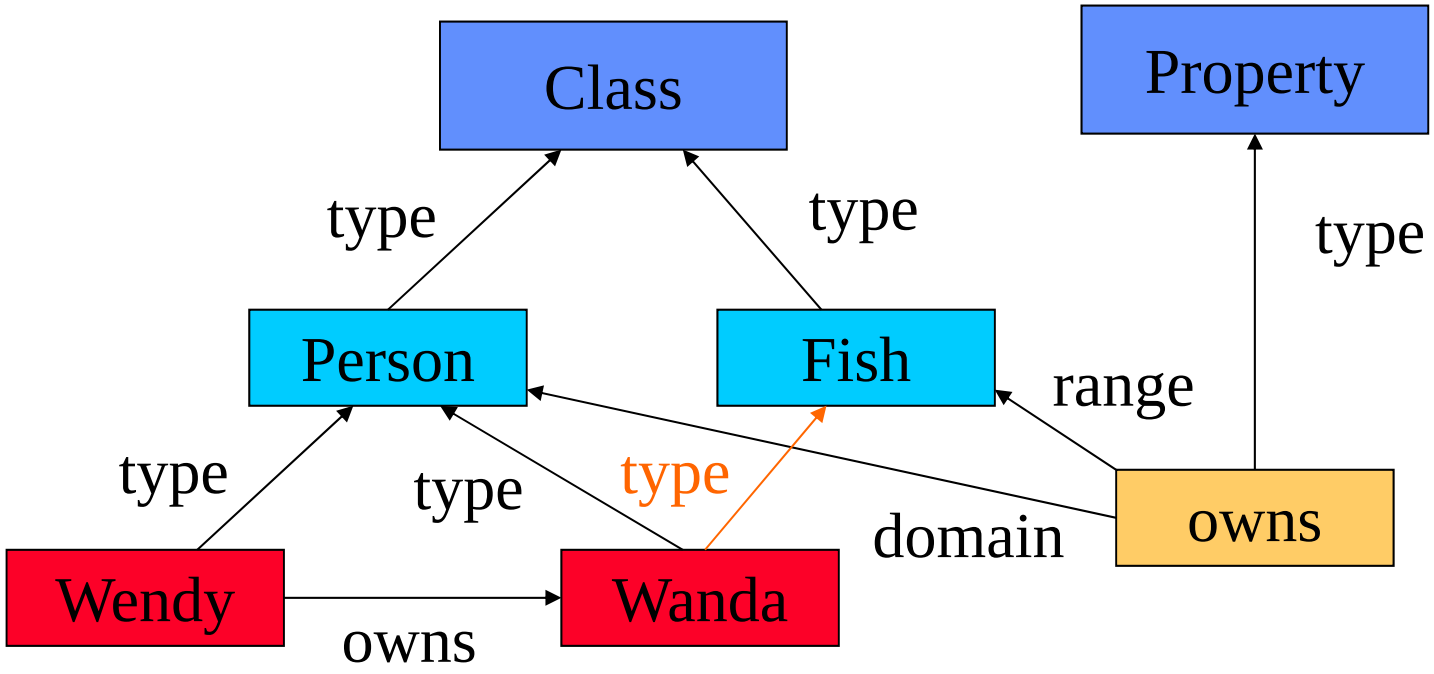
```
<?xml version="1.0"?>
  <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
           xmlns:dc="http://purl.org/dc/elements/1.1/">
    <rdf:Description about="urn:ISBN:0-201-00023-7">
      <dc:format>
        <rdf:Alt>
          <rdf:li>text/html</rdf:li>
          <rdf:li>text/plain</rdf:li>
          <rdf:li>application/postscript</rdf:li>
        </rdf:Alt>
      </dc:format>
    </rdf:Description>
  </rdf:RDF>
```



RDF Namespaces

- Namespaces are used to separate vocabularies
- A namespace is defined by a URI
- Example:
  - A book has a name and an author also has a name

Ontological Reasoning in RDF



Type constraint violation: The range of owns is Fish.

OR There is no inconsistency: Wanda is a fish!

RDFS

- RDF provides a data model to define relations between resources (on the Web).
- A framework for defining meta data for Web resources
- However the triple data model is insufficient without sharing the same (knowledge) vocabularies (+semantics)
- RDF-S allows to define RDF vocabularies
- RDF-S allows to define class hierarchies, property hierarchies, and allowed relations (triples)

RDFS Example

```
<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:owl="http://www.w3.org/2002/07/owl#">

<owl:Ontology rdf:about="http://www.w3.org/2000/01/rdf-schema#"/>

<rdfs:Class rdf:about="http://www.w3.org/2000/01/rdf-
 schema#Resource">
       <rdfs:isDefinedBy rdf:resource=
       "http://www.w3.org/2000/01/rdf-schema#"/>
       <rdfs:label>Resource</rdfs:label>
       <rdfs:comment>The class resource example</rdfs:comment>
</rdfs:Class>
</rdf:RDF>
```

RDFS

- RDFS is a vocabulary to create vocabularies (!)
  - properties defined by a particular community
  - characteristics of properties and/or constraints on corresponding values
- Comparable to XML Schema or XML DTD
- Used to standardize which tags the creator of a graph is allowed to use for annotating resources
- Introduces notions such as: Property, Class, SubClassOf, Domain, Range

RDF Schema (cont'd)

- Defines the types of relations a resource of a certain type may have

- **Important**: Compatibility check of a graph to a schema is not automatically performed upon parsing

  ➔RDF triples that are inconsistent can be added to a graph and are not detected unless a consistency check is performed

RDFS Constructs

- X rdf:type rdfs:class
  - Declares the resource X as a class for other resources
- R rdf:type rdf:Property
  - Declares resource R as a property
- R rdfs:domain X
  - Declares the subject of R as an X
- R rdfs:range Y
  - Declares the object of R as an Y

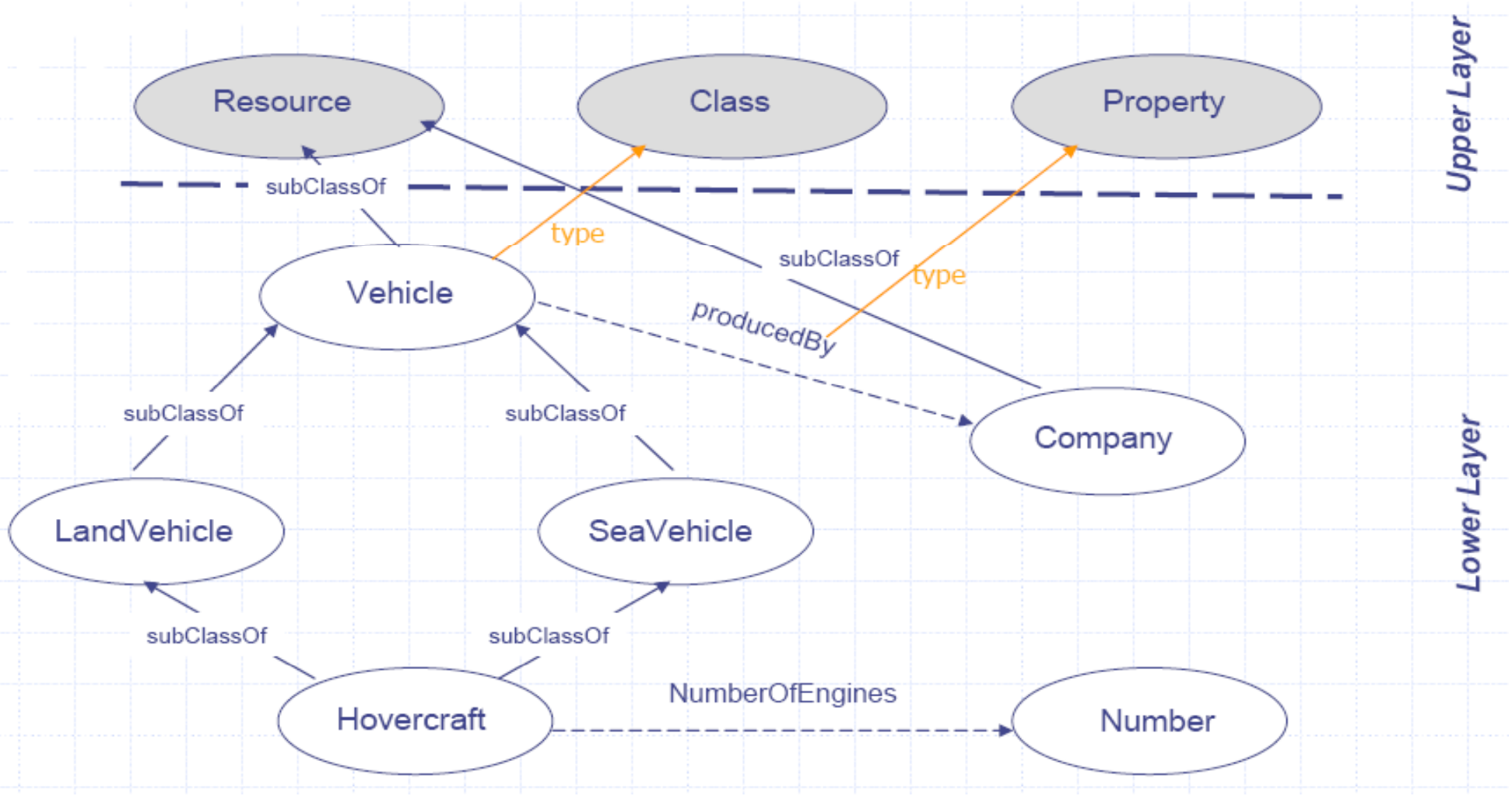
RDF-S

■RDFS extends the RDF vocabulary:
RDFS vocabulary is defined in the namespace:
http://www.w3.org/2000/01/rdf-schema# (associated with namespace prefix rdfs:)

- RDFS Classes:
  - rdfs:Resource
  - rdfs:Class
  - rdfs:Literal
  - rdfs:Datatype
  - rdfs:Container
  - rdfs:ContainerMembership Property

- RDFS properties
  - rdfs:domain
  - rdfs:range
  - rdfs:subPropertyOf
  - rdfs:subClassOf
  - rdfs:member
  - rdfs:seeAlso
  - rdfs:isDefinedBy
  - rdfs:comment
  - rdfs:label

RDFS-Example



RDFS-Example

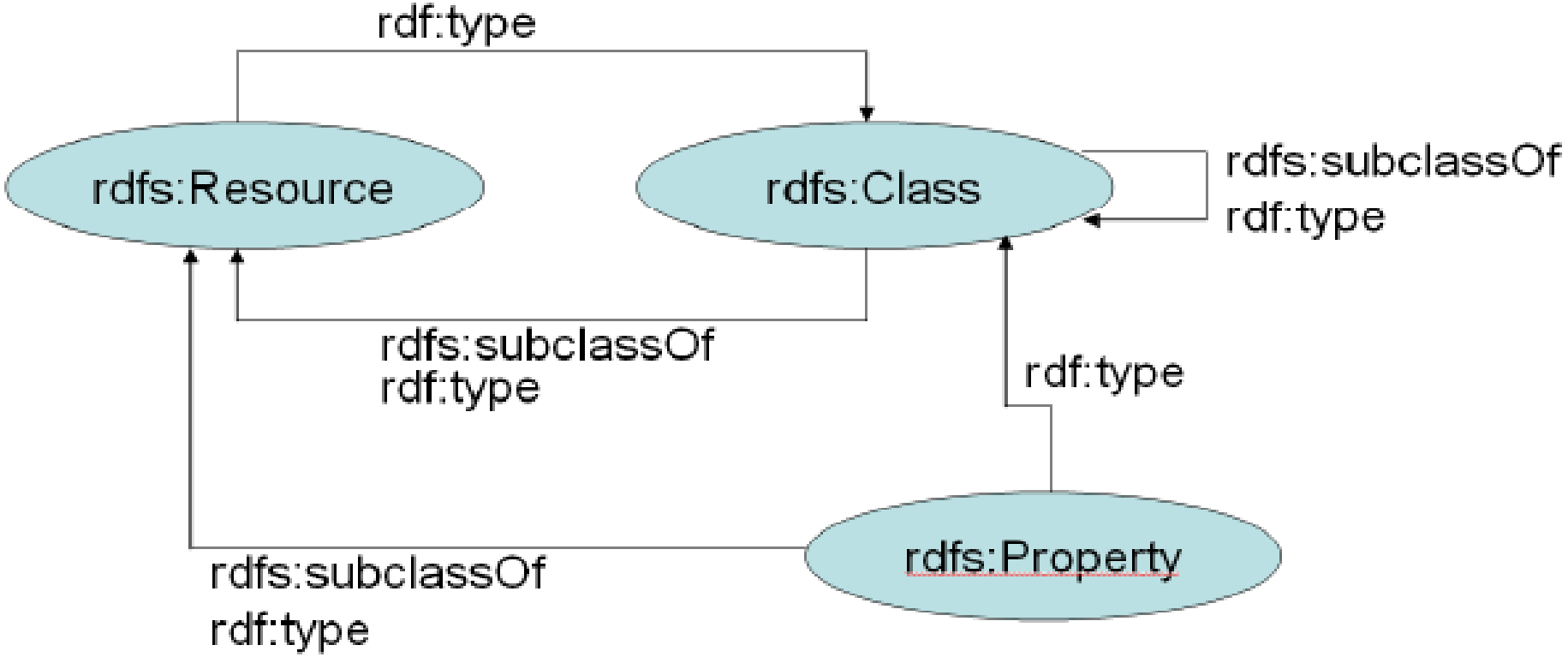


Figure taken from [de Bruijn et al., 2004]

RDFS meta-data

- Any meta-data can be attached to a resource, using:
  - rdfs:comment
    - Human-readable description of the resource, e.g.

      <ex:Person> rdfs:comment “A person is any human being”

  - rdfs:label
    - Human-readable version of the resource name, e.g.

    <ex:Person> rdfs:label “Human being”

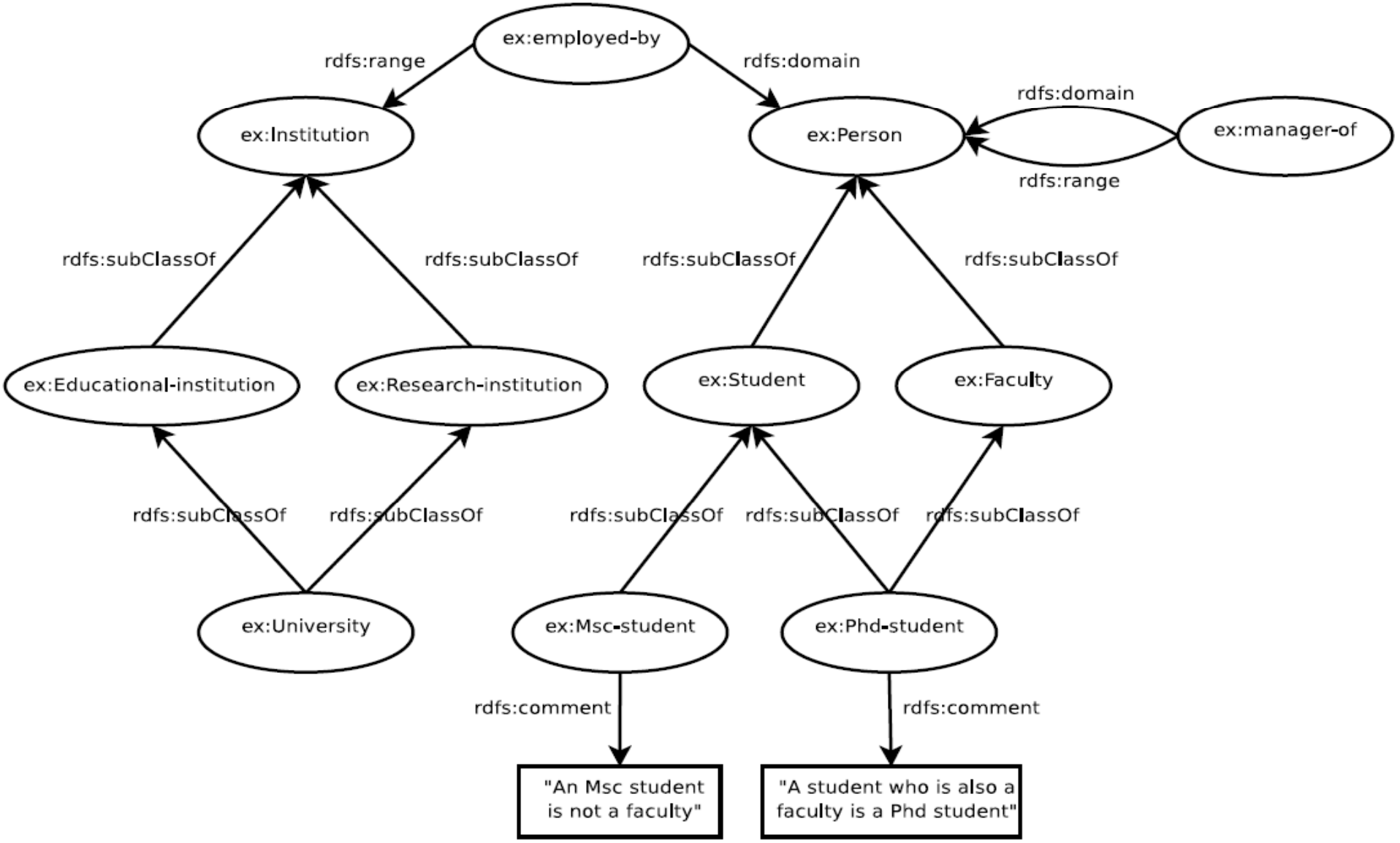
  - rdfs:seeAlso
    - Indicate additional information about the resource, e.g.

<ex:Person> rdfs:seeAlso <http://xmlns.com/wordnet/1.6/Human>

RDF-S: example – RDFS ontology about Persons and Universities

ex:Institution rdf:type rdfs:Class
ex:Person rdf:type rdfs:Class
ex:Research-institution rdfs:subClassOf ex:Institution
ex:Educational-institution rdfs:subClassOf ex:Institution
ex:University rdfs:subClassOf ex:Research-institution
ex:University rdfs:subClassOf ex:Educational-institution
ex:Faculty rdfs:subClassOf ex:Person
ex:Student rdfs:subClassOf ex:Person
ex:Phd-Student rdfs:subClassOf ex:Faculty
ex:Phd-Student rdfs:subClassOf ex:Student
ex:Msc-Student rdfs:subClassOf ex:Student
ex:Msc-Student rdfs:comment "An Msc student is not a faculty"
ex:Phd-Student rdfs:comment "A student who is also a faculty is a PhD Student“
ex:employed-by rdf:type rdfs:Property
ex:manager rdf:type rdfs:Property
ex:employed-by rdfs:domain ex:Person
ex:employed-by rdfs:range ex:Institution
ex:manager-of rdfs:domain ex:Person
ex:manager-of rdfs:range ex:Person

RDF-S: example – RDFS ontology about Persons and Universities



Storing RDF

- RDF graphs can be serialized as and stored in the file system
- For more DBMS-like applications, there are RDF repositories that provide
  - Query functionality
  - Access control
  - Distribution
- Examples:
  - Sesame
  - 3-Store
  - JENA
  - YARS

Outline

- Ontologies
- RDF
- RDF Schema (RDFS)
- Outlook at RDF Storing

References

- Semantic Web: www.w3.org/2001/sw
- Ontologies: www.ontology.org
- RDF and RDFS: www.w3.org/rdf
- RDF syntax: http://www.w3.org/TR/rdf-syntax-grammar/
- RDFS: http://www.w3.org/TR/rdf-schema/