Methods and Tools for Management Information Systems

Lecture 4

11. Mai 2009


Resource Description Framework (RDF)

- Language for representing information about resources in the World Wide Web, particularly intended for representing metadata about Web resources
- RDF uses a more general notion of *Web resources*—not only *things* that can be *retrieved* on the Web but also things that can be *identified* on the Web via its URI
- Resources are described in terms of *properties* and property *values*

- RDF provides a common framework for expressing information that can be processed/exchanged by/between *applications*
- RDF defines the fundamental vocabulary to formulate arbitrary statements about *resources*
- Most important application is the *Semantic Web* which extends the existing Web by machine-processable content/metadata
- RDF specification consists of two parts:
  - *RDF Graph* represents the fundamental data model
  - *RDF/XML* provides the XML syntax to serialize those data

- RDF Graph:
  - Information is kept in form of *statements*, triples of **subject**, **predicate** and **object**, identified by URI references (URIrefs)
  - Objects may also be constant values represented by text strings (so-called *literals*)
  - URIrefs are represented as ellipses, literals as boxes
  - Tripels are connected in form of a labeled directed graph where nodes refer to subjects and objects, and arcs (directed from the subject node to the object node) to predicates
  - Predicates themselves may also be resources and, as such, the subject of other statements (which can be used in other vocabularies, i. e., sets of URIrefs defined for a certain purpose)

Example:

There is a *Person* identified by `http://www.w3.org/People/EM/contact#me`, whose *name* is Eric Miller, whose *email address* is `em@w3.org`, and whose *title* is Dr.

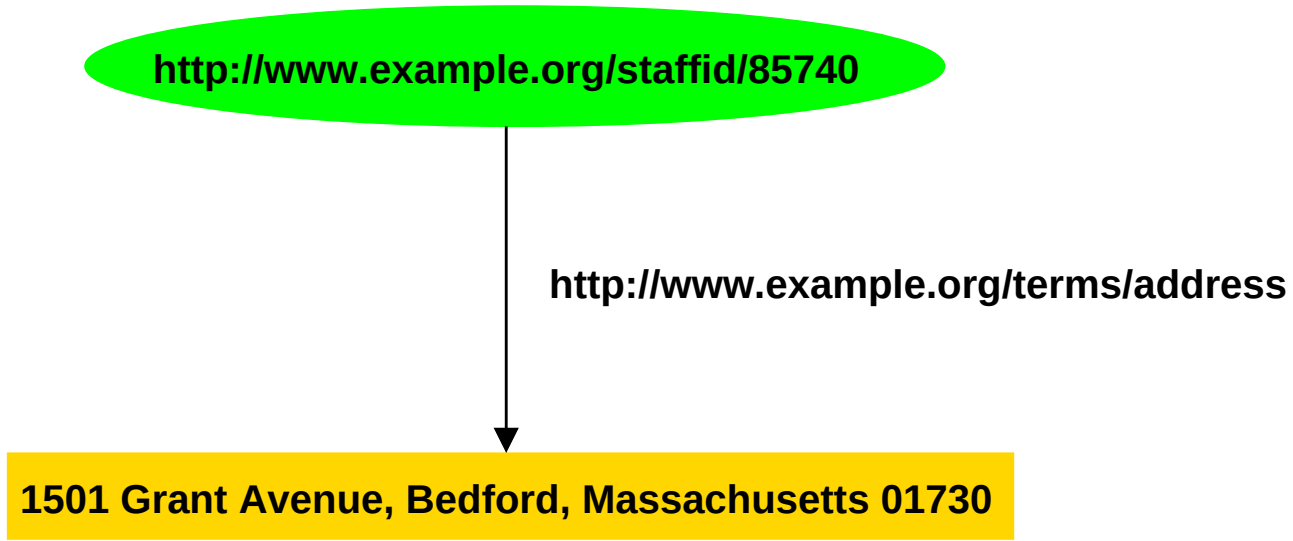
Serialization in RDF/XML:

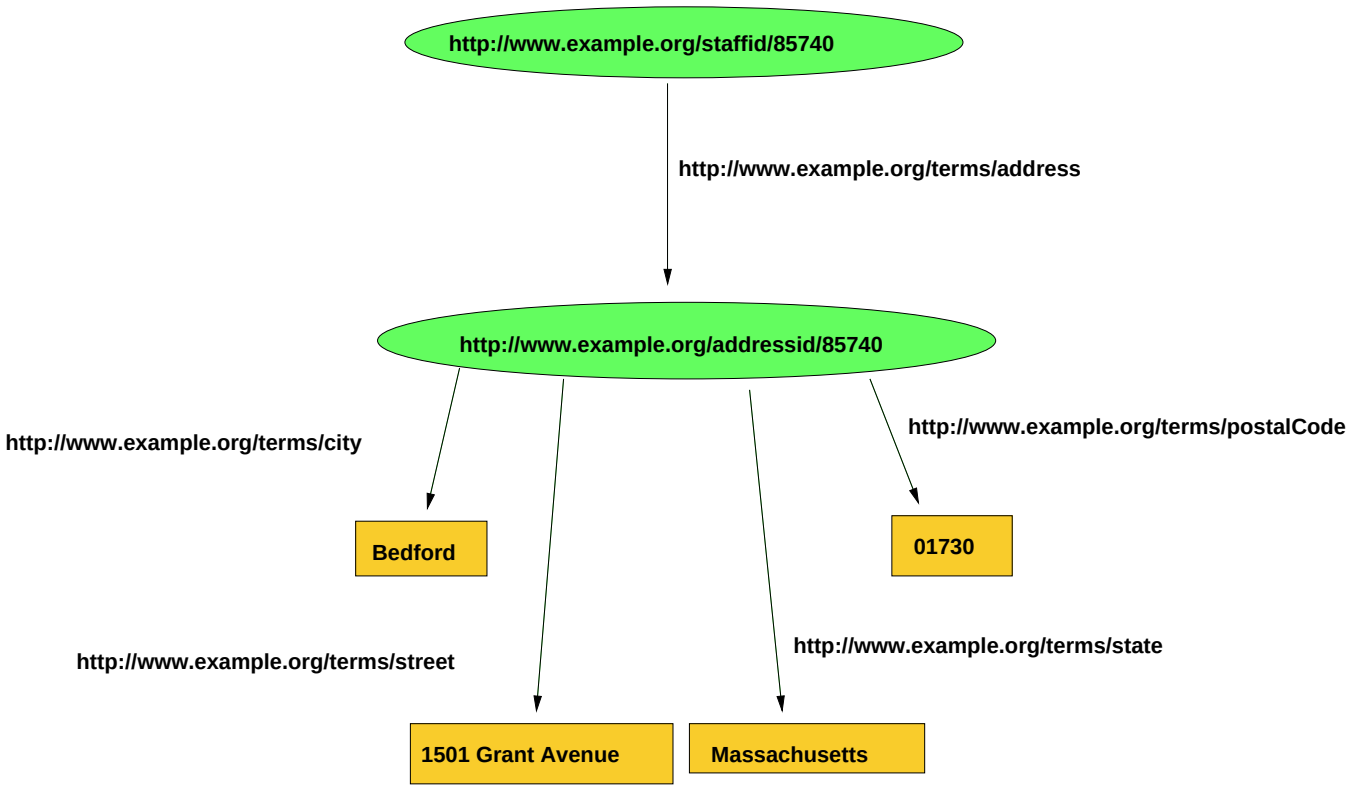
```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
      xmlns:contact="http://www.w3.org/2000/10/swap/pim/contact#">

  <contact:Person rdf:about="http://www.w3.org/People/EM/contact#me">
    <contact:fullName>Eric Miller</contact:fullName>
    <contact:mailbox rdf:resource="mailto:em@w3.org"/>
    <contact:personalTitle>Dr.</contact:personalTitle>
  </contact:Person>

</rdf:RDF>
```


Fragment of http://www.w3.org/1999/02/22-rdf-syntax-ns#type:

```
<rdf:Property
    rdf:about="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">
  <rdfs:isDefinedBy
      rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#"/>
  <rdfs:label>type</rdfs:label>
  <rdfs:comment>
    The subject is an instance of a class.
  </rdfs:comment>
  <rdfs:range
      rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
  <rdfs:domain
      rdf:resource="http://www.w3.org/2000/01/rdf-schema#Resource"/>
</rdf:Property>
```

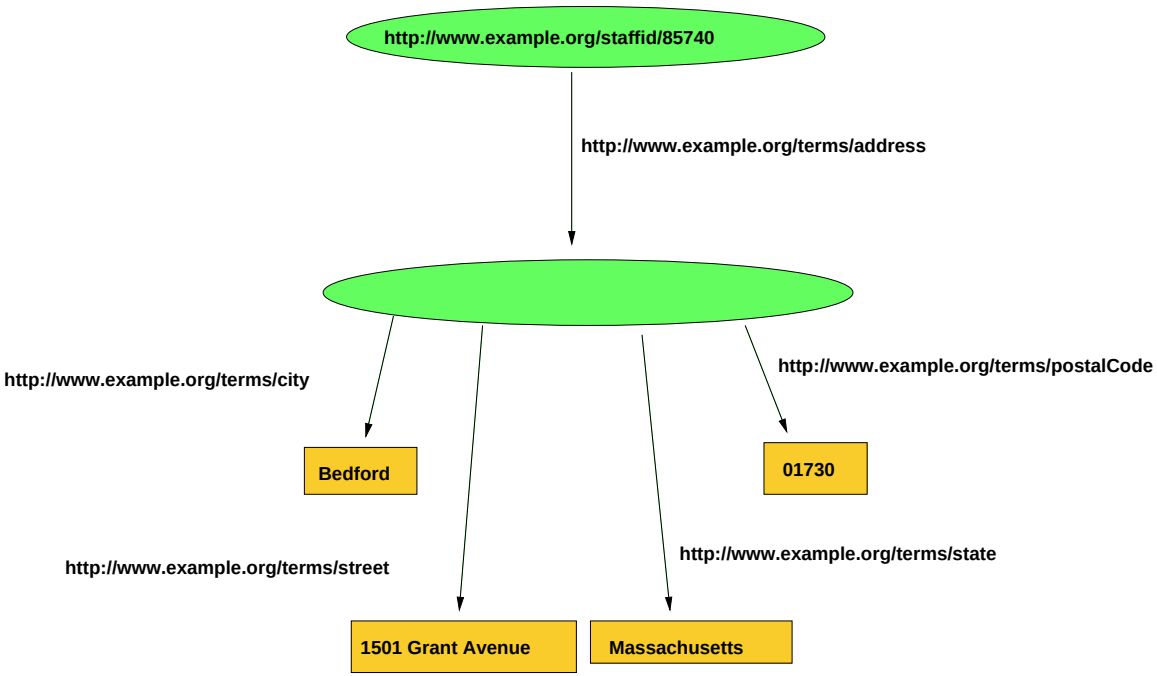

- Structured properties and blank nodes:




http://www.example.org/staffid/85740
http://www.example.org/terms/address
http://www.example.org/addressid/85740
http://www.example.org/terms/city
http://www.example.org/terms/postalCode
Bedford
01730
http://www.example.org/terms/street
http://www.example.org/terms/state
1501 Grant Avenue
Massachusetts

Triples notation:

```
exstaff:85740        exterms:address       exaddressid:85740 .
exaddressid:85740    exterms:street        "1501 Grant Avenue"
exaddressid:85740    exterms:city          "Bedford" .
exaddressid:85740    exterms:state         "Massachusetts" .
exaddressid:85740    exterms:postalCode    "01730" .
```

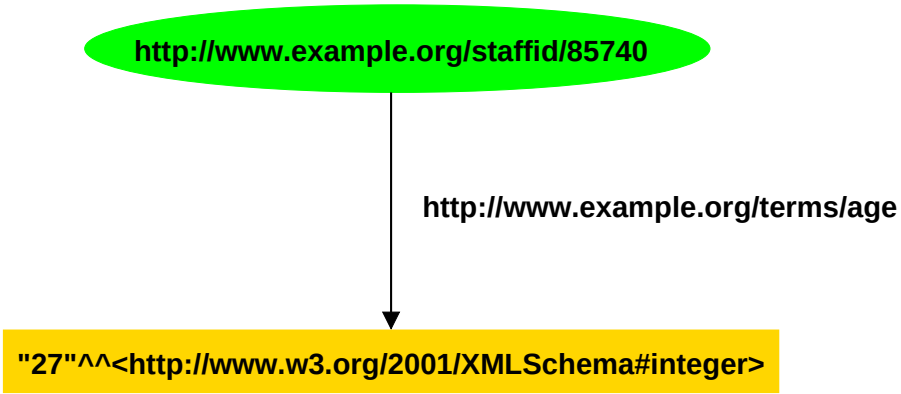

http://www.example.org/staffid/85740
http://www.example.org/terms/address
http://www.example.org/terms/city
http://www.example.org/terms/postalCode
Bedford
01730
http://www.example.org/terms/street
http://www.example.org/terms/state
1501 Grant Avenue
Massachusetts

- Representation in triples notation using *Blank Node Identifiers*:

```
exstaff:85740      exterms:address      _:johnaddress .
_:johnaddress      exterms:street       "1501 Grant Avenue" .
_:johnaddress      exterms:city         "Bedford" .
_:johnaddress      exterms:state        "Massachusetts" .
_:johnaddress      exterms:postalCode   "01730" .
```

- Blank nodes . . .
  ⇒ may not represent predicates
  ⇒ can illustrate certain relationships more precisely

- Typed literals:

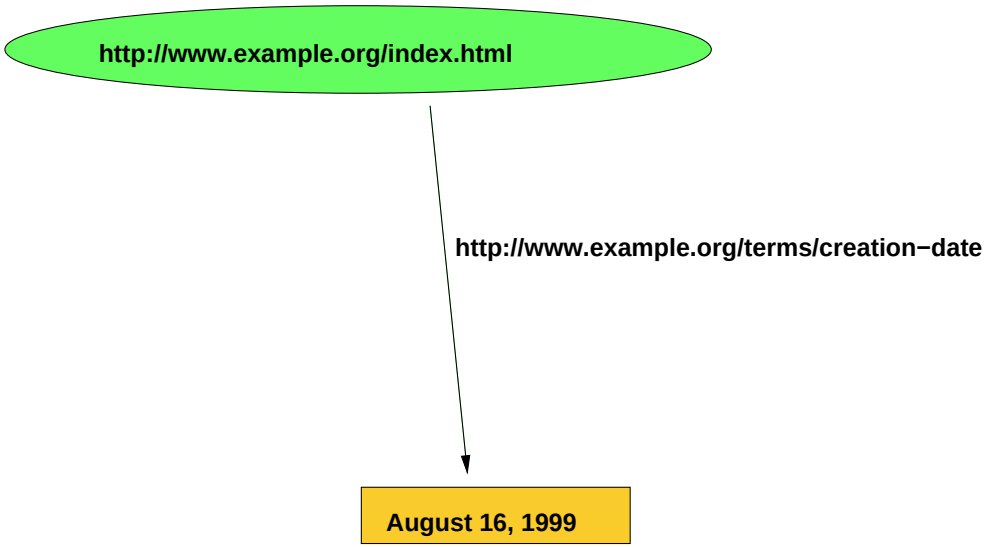


Triples notation:

```
exstaff:85740        exterms:age        "27"^^xsd:integer .
```

- General rules:
  $\Rightarrow$ resources without URI (e. g. blank nodes) cannot be referenced
  $\Rightarrow$ RDF can only represent binary relationships
  $\Rightarrow$ type safety accomplishable by *typed literals*


- XML Syntax for RDF: RDF/XML
  - Serialization of RDF data in XML (*normativ*):



- XML Syntax for RDF: RDF/XML
  - Serialization of RDF data in XML (*normativ*):

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

  <rdf:Description rdf:about="http://www.example.org/index.html">
    <exterms:creation-date>August 16, 1999</exterms:creation-date>
  </rdf:Description>

</rdf:RDF>
```


- Basic idea of RDF/XML: encode an RDF graph as XML elements, attributes, element content, and attribute values
- URIrefs of predicates (as well as some nodes) are written as XML QNames, i. e., consisting of a prefix denoting a namespace URI and a local name
- URIrefs of subject nodes (as well as some object nodes) are written as XML attribute values
- Literal nodes (which are always object nodes) become element text content or attribute values


- An RDF graph consisting of multiple statements can be represented using multiple description elements:

```
<?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/"
    xmlns:exterms="http://www.example.org/terms/">

  <rdf:Description rdf:about="http://www.example.org/index.html">
    <exterms:creation-date>August 16, 1999</exterms:creation-date>
  </rdf:Description>

  <rdf:Description rdf:about="http://www.example.org/index.html">
    <dc:language>en</dc:language>
  </rdf:Description>
</rdf:RDF>
```

- A description element may also contain multiple predicates:

```
<?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/"
    xmlns:exterms="http://www.example.org/terms/">

  <rdf:Description rdf:about="http://www.example.org/index.html">
    <exterms:creation-date>August 16, 1999</exterms:creation-date>
    <dc:language>en</dc:language>
    <dc:creator
        rdf:resource="http://www.example.org/staffid/85740"/>
  </rdf:Description>

</rdf:RDF>
```

- Serialization of blank nodes using node identifiers:

```
<?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/"
    xmlns:exterms="http://example.org/stuff/1.0/">
  <rdf:Description
      rdf:about="http://www.w3.org/TR/rdf-syntax-grammar">
    <dc:title>RDF/XML Syntax Specification (Revised)</dc:title>
    <exterms:editor rdf:nodeID="abc"/>
  </rdf:Description>
  <rdf:Description rdf:nodeID="abc">
    <exterms:fullName>Dave Beckett</exterms:fullName>
    <exterms:homePage rdf:resource="http://purl.org/net/dajobe/"/>
  </rdf:Description>
</rdf:RDF>
```

- Using typed literals:

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

  <rdf:Description rdf:about="http://www.example.org/index.html">
    <exterms:creation-date
        rdf:datatype="http://www.w3.org/2001/XMLSchema#date">
      1999-08-16
    </exterms:creation-date>
  </rdf:Description>

</rdf:RDF>
```

- Using XML entities:

```
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF
    [<!ENTITY xsd "http://www.w3.org/2001/XMLSchema#">]>

<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:exterms="http://www.example.org/terms/">

  <rdf:Description rdf:about="http://www.example.org/index.html">
    <exterms:creation-date rdf:datatype="&xsd;date">
      1999-08-16
    </exterms:creation-date>
  </rdf:Description>

</rdf:RDF>
```

- Abbreviating URIrefs using *fragment identifiers*:

```
<?xml version="1.0"?>

<!DOCTYPE rdf:RDF
    [<!ENTITY xsd "http://www.w3.org/2001/XMLSchema#">]>

<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:exterms="http://www.example.com/terms/">
  <rdf:Description rdf:ID="item10245">
    <exterms:model rdf:datatype="&xsd;string">
      Overnighter
    </exterms:model>
    <exterms:sleeps rdf:datatype="&xsd;integer">2</exterms:sleeps>
    <exterms:weight rdf:datatype="&xsd;decimal">2.4</exterms:weight>
  </rdf:Description>
</rdf:RDF>
```

- Using the constructs described so far, an RDF graph is written in RDF/XML as follows:
  1. All blank nodes are assigned blank node identifiers
  2. Each node is listed in turn as the subject of an un-nested `rdf:Description` element, using an `rdf:about` attribute if the node has a URIref, or an `rdf:nodeID` attribute if the node is blank
  3. For each triple with this node as subject, an appropriate property element is created, with either literal content, an `rdf:resource` attribute specifying the object of the triple, or an `rdf:nodeID` attribute specifying the object of the triple

  $\Rightarrow$ provides the most direct representation of the graph structure

  $\Rightarrow$ recommended for applications that process RDF/XML further


- Other RDF capabilities:
  - Using containers:
    - `rdf:Bag`:

      $\Rightarrow$ group of resources or literals, possibly including duplicate members, without order
    - `rdf:Seq`:

      $\Rightarrow$ group of resources or literals, possibly including duplicate members, where the order of the members is significant
    - `rdf:Alt`:

      $\Rightarrow$ group of resources or literals that are alternatives

- *Example:*

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

  <rdf:Description rdf:about="http://example.org/courses/6.001">
    <s:students>
      <rdf:Bag>
        <rdf:li rdf:resource="http://example.org/students/Amy"/>
        <rdf:li rdf:resource="http://example.org/students/Tom"/>
        <rdf:li rdf:resource="http://example.org/students/Jim"/>
      </rdf:Bag>
    </s:students>
  </rdf:Description>
</rdf:RDF>
```

- Using collections:

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

  <rdf:Description rdf:about="http://example.org/courses/6.001">
    <s:students rdf:parseType="Collection">
      <rdf:Description rdf:about="http://example.org/students/Amy"/>
      <rdf:Description rdf:about="http://example.org/students/Tom"/>
      <rdf:Description rdf:about="http://example.org/students/Jim"/>
    </s:students>
   </rdf:Description>
</rdf:RDF>
```


- Reification:

```
exproducts:triple12345   rdf:type        rdf:Statement .
exproducts:triple12345   rdf:subject     exproducts:item10245 .
exproducts:triple12345   rdf:predicate   exterms:weight .
exproducts:triple12345   rdf:object      "2.4"^^xsd:decimal .
```


- `rdf:value` to represent the *main values* of a structured value:

```
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF
    [<!ENTITY xsd "http://www.w3.org/2001/XMLSchema#">]>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:exterms="http://www.example.org/terms/">

  <rdf:Description
      rdf:about="http://www.example.com/2002/04/products#item10245">
    <exterms:weight rdf:parseType="Resource">
      <rdf:value rdf:datatype="&xsd;decimal">2.4</rdf:value>
      <exterms:units
          rdf:resource="http://www.example.org/units/kilograms"/>
    </exterms:weight>
  </rdf:Description>
</rdf:RDF>
```

- Literals to represent fragments of XML:

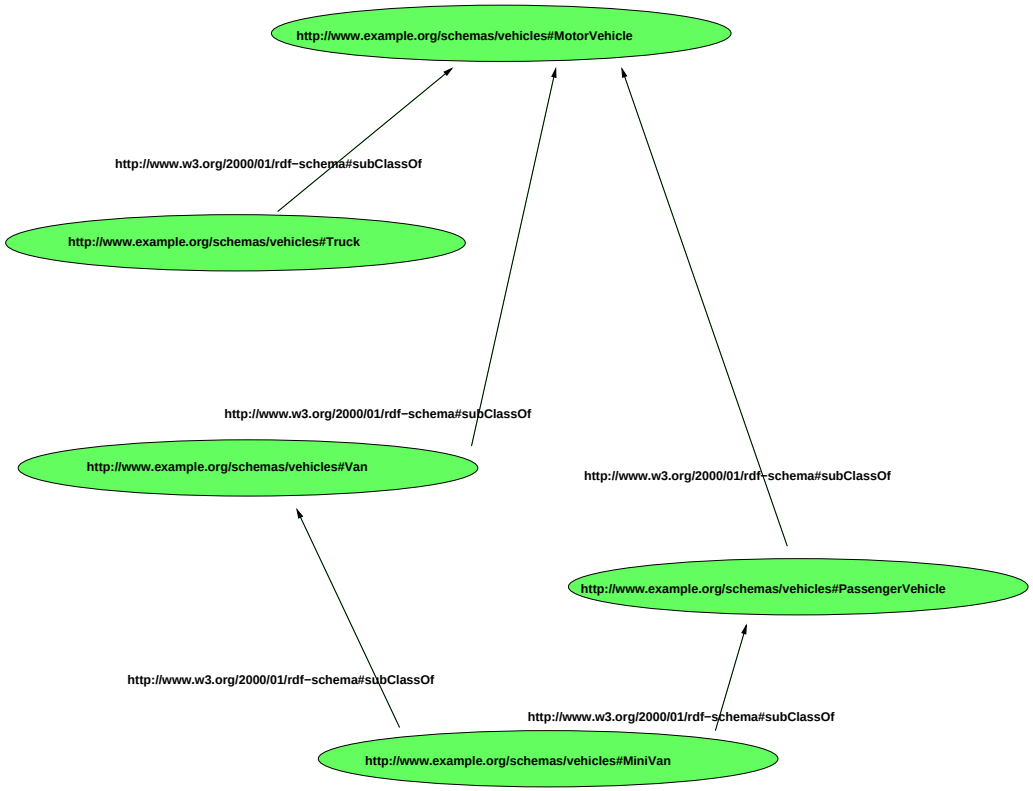
```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:dc="http://purl.org/dc/elements/1.1/"
    xml:base="http://www.example.com/books">

  <rdf:Description rdf:ID="book12345">
    <dc:title rdf:parseType="Literal">
      <span xml:lang="en">
        The <em>&lt;br /&gt;</em> Element Considered Harmful.
      </span>
    </dc:title>
  </rdf:Description>
</rdf:RDF>
```

RDF Vocabulary Description Language (RDF Schema)

- RDF Schema is used to describe types and properties of resources
- Provides a type system similar to those used in object-oriented programming languages:
  - Class hierarchy
  - Resources as instances of one or more classes
- RDF Schema facilities are themselves provided in the form of an RDF vocabulary defined in a namespace that is bound to the URI `http://www.w3.org/2000/01/rdf-schema#`


- *Vocabulary descriptions* written in RDF Schema represent valid RDF graphs
- A class in RDF Schema corresponds to the generic concept of a *Type* or *Category* and can represent almost any category of thing, such as Web pages, people, document types, databases or abstract concepts
- Classes are described using the RDF Schema resources `rdfs:Class` and `rdfs:Resource`, and the attributes `rdf:type` and `rdfs:subClassOf`
- Properties are described using the RDF class `rdf:Property`, and the RDF Schema properties `rdfs:domain`, `rdfs:range`, and `rdfs:subPropertyOf`


- *Example:*


http://www.example.org/schemas/vehicles#MotorVehicle
http://www.w3.org/2000/01/rdf-schema#subClassOf
http://www.example.org/schemas/vehicles#Truck
http://www.w3.org/2000/01/rdf-schema#subClassOf
http://www.example.org/schemas/vehicles#Van
http://www.w3.org/2000/01/rdf-schema#subClassOf
http://www.example.org/schemas/vehicles#PassengerVehicle
http://www.w3.org/2000/01/rdf-schema#subClassOf
http://www.w3.org/2000/01/rdf-schema#subClassOf
http://www.example.org/schemas/vehicles#MiniVan

Tripels notation:

```
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/XML:

```
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF [<!ENTITY xsd "http://www.w3.org/2001/XMLSchema#">]>
<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/schemas/vehicles">
  <rdf:Description rdf:ID="MotorVehicle">
    <rdf:type
        rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
  </rdf:Description>
  <rdf:Description rdf:ID="PassengerVehicle">
    <rdf:type
        rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
    <rdfs:subClassOf rdf:resource="#MotorVehicle"/>
  </rdf:Description>
```

```
  <rdf:Description rdf:ID="Truck">
    <rdf:type
        rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
    <rdfs:subClassOf rdf:resource="#MotorVehicle"/>
  </rdf:Description>
  <rdf:Description rdf:ID="Van">
    <rdf:type
        rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
    <rdfs:subClassOf rdf:resource="#MotorVehicle"/>
  </rdf:Description>
  <rdf:Description rdf:ID="MiniVan">
    <rdf:type
        rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
    <rdfs:subClassOf rdf:resource="#Van"/>
    <rdfs:subClassOf rdf:resource="#PassengerVehicle"/>
  </rdf:Description>
</rdf:RDF>
```


- Describing classes:
  - Defining simple classes:

```
<rdf:Description rdf:ID="class_name">
  <rdf:type
      rdf:resource="http://www.w3.org/2000/01/rdf-schema
</rdf:Description>
```

  - Class definitions may be abbreviated:

```
<rdfs:Class rdf:ID="class_name"/>
```

  - Specialization of classes using `rdfs:subClassOf`:

```
<rdfs:Class rdf:ID="class_name">
  <rdfs:subClassOf rdf:resource="super_class"/>
</rdfs:Class>
```

- *Example:*

```
<rdf:Description rdf:ID="MiniVan">
  <rdf:type
      rdf:resource="http://www.w3.org/2000/01/rdf-schema#C
  <rdfs:subClassOf rdf:resource="#Van"/>
  <rdfs:subClassOf rdf:resource="#PassengerVehicle"/>
</rdf:Description>
```

or abbreviated:

```
<rdfs:Class rdf:ID="MiniVan">
  <rdfs:subClassOf rdf:resource="#Van"/>
  <rdfs:subClassOf rdf:resource="#PassengerVehicle"/>
</rdfs:Class>
```

- Describing attributes:
  - Properties in RDF are described as instances of class

```
exterms:weightInKg   rdf:type   rdf:Property .
```

  - Intended usage of properties can be described using the RDF Schema properties `rdfs:range` and `rdfs:domain`:
    - `rdfs:range`
    - Values of a property are instances of a designated class:

```
ex:Person   rdf:type      rdfs:Class .
ex:author   rdf:type      rdf:Property .
ex:author   rdfs:range    ex:Person .
```

- Properties may have more than one `rdf:range` property:

```
ex:hasMother    rdfs:range    ex:Female .
ex:hasMother    rdfs:range    ex:Person .
exstaff:frank   ex:hasMother  exstaff:frances .
```

  $\Rightarrow$ `exstaff:frances` has to be an instance of both classes `ex:Female` *and* `ex:Person`

- Using typed literals for the `rdf:range` property:

```
ex:age    rdf:type      rdf:Property .
ex:age    rdfs:range    xsd:integer .
```

  Remark: while it is possible to explicitely name types, e. g.:

```
xsd:integer    rdf:type    rdfs:Datatype .
```

  it is not possible to define new types using RDF Schema

- `rdfs:domain`
  - Property applies to a designated class:

```
ex:Book      rdf:type       rdfs:Class .
ex:author    rdf:type       rdf:Property .
ex:author    rdfs:domain    ex:Book .
```

  - Properties may have more than one `rdfs:domain` property:

```
exterms:weight        rdfs:domain     ex:Book .
exterms:weight        rdfs:domain     ex:MotorVehicle .
exthings:companyCar   exterms:weight  "2500"^^xsd:integer .
```

  $\Rightarrow$ `exthings:companyCar` has to be an instance of both classes `ex:Book` *and* `ex:MotorVehicle`

- Serializing in RDF/XML:

```
<rdf:Property rdf:ID="registeredTo">
  <rdfs:domain rdf:resource="#MotorVehicle"/>
  <rdfs:range rdf:resource="#Person"/>
</rdf:Property>

<rdf:Property rdf:ID="rearSeatLegRoom">
  <rdfs:domain rdf:resource="#PassengerVehicle"/>
  <rdfs:range rdf:resource="&xsd;integer"/>
</rdf:Property>

<rdfs:Class rdf:ID="Person"/>
<rdfs:Datatype rdf:about="&xsd;integer"/>
```


- Specialization of properties using `rdfs:subPropertyOf`:

```
ex:driver          rdf:type             rdf:Property .
ex:primaryDriver   rdf:type             rdf:Property .
ex:primaryDriver   rdfs:subPropertyOf   ex:driver .
```

- Serializing in RDF/XML:

```
<rdf:Property rdf:ID="driver">
  <rdfs:domain rdf:resource="#MotorVehicle"/>
</rdf:Property>

<rdf:Property rdf:ID="primaryDriver">
  <rdfs:subPropertyOf rdf:resource="#driver"/>
</rdf:Property>
```

- A property may have any number of `rdfs:subPropertyOf` relationships
- RDF schema properties that apply to a given property also apply to its subproperties


- *Example*
  - RDF Schema document:

```
<?xml version="1.0"?>

<!DOCTYPE rdf:RDF [
    <!ENTITY xsd "http://www.w3.org/2001/XMLSchema#">]>

<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/schemas/vehicles">

  <rdfs:Class rdf:ID="MotorVehicle"/>
  <rdfs:Class rdf:ID="PassengerVehicle">
    <rdfs:subClassOf rdf:resource="#MotorVehicle"/>
  </rdfs:Class>
```

```
<rdfs:Class rdf:ID="Truck">
  <rdfs:subClassOf rdf:resource="#MotorVehicle"/>
</rdfs:Class>
<rdfs:Class rdf:ID="Van">
  <rdfs:subClassOf rdf:resource="#MotorVehicle"/>
</rdfs:Class>
<rdfs:Class rdf:ID="MiniVan">
  <rdfs:subClassOf rdf:resource="#Van"/>
  <rdfs:subClassOf rdf:resource="#PassengerVehicle"/>
</rdfs:Class>
<rdfs:Class rdf:ID="Person"/>
<rdfs:Datatype rdf:about="&xsd;integer"/>
<rdf:Property rdf:ID="registeredTo">
  <rdfs:domain rdf:resource="#MotorVehicle"/>
  <rdfs:range rdf:resource="#Person"/>
</rdf:Property>
```

```
  <rdf:Property rdf:ID="rearSeatLegRoom">
    <rdfs:domain rdf:resource="#PassengerVehicle"/>
    <rdfs:range rdf:resource="&xsd;integer"/>
  </rdf:Property>
  <rdf:Property rdf:ID="driver">
    <rdfs:domain rdf:resource="#MotorVehicle"/>
  </rdf:Property>
  <rdf:Property rdf:ID="primaryDriver">
    <rdfs:subPropertyOf rdf:resource="#driver"/>
  </rdf:Property>
</rdf:RDF>
```


- Corresponding RDF instance document (`ex:PassengerVehicle`):

```
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF [
    <!ENTITY xsd "http://www.w3.org/2001/XMLSchema#">]>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:ex="http://example.org/schemas/vehicles#"
         xml:base="http://example.org/things">
  <ex:PassengerVehicle rdf:ID="johnSmithsCar">
    <ex:registeredTo
        rdf:resource="http://www.example.org/staffid/85740"/>
    <ex:rearSeatLegRoom
        rdf:datatype="&xsd;integer">127</ex:rearSeatLegRoom>
    <ex:primaryDriver
        rdf:resource="http://www.example.org/staffid/85740"/>
  </ex:PassengerVehicle>
</rdf:RDF>
```

- RDF Schema supplies a number of builtin properties:
  - `rdfs:comment` to provide a human-readable description of a resource
  - `rdfs:label` to provide a more human-readable version of a resource's name
  - `rdfs:seeAlso` to indicate a resource that might provide additional information about the subject resource
  - `rdfs:isDefinedBy` to indicate a resource that *defines* the subject resource (subproperty of `rdfs:seeAlso`)


- Differences between RDF Schema declarations and type systems of object-oriented programming language:
  - Instead of describing a class as having a collection of specific properties, an RDF schema describes properties as applying to specific classes of resources
    $\Rightarrow$ Independence of classes and properties
  - Properties are always defined on a global level
  - RDF Schema descriptions are not necessarily *prescriptive*, but additional *descriptions* of resources (which *may* be used in instance documents)
    $\Rightarrow$ Properties vs. constraints

- Schema capabilities not provided by RDF Schema:
  - Cardinality constraints on properties
  - Specifying that a given property is transitive
  - Specifying that a given property is a unique identifier (or key) for instances of a particular class
  - Specifying that two different classes (having different URIrefs) actually represent the same class
  - Specifying that two different instances (having different URIrefs) actually represent the same individual
  - Specifying constraints on the range or cardinality of a property that depend on the class of resource to which a property is applied
  - Description of new classes in terms of combinations of other classes (union, intersection, disjoint)

RDF in the Field: Dublin Core Metadata Initiative

- Minimal set of descriptive elements that facilitate the description and the automated indexing of document-like networked objects
- Originally developed in March 1995 at a Workshop on Metadata Management in Dublin, Ohio
- Suitable for use by resource discovery tools on the Internet
- Sufficiently simple to be understood and used by a wide range of authors and casual publishers and widely used in documenting Internet resources


- Elements of the Dublin Core are defined in the Dublin Core Metadata Element Set, Version 1.1: Reference Description, and contain definitions for the following properties:

Property	Description
`title`	A name given to the resource
`creator`	An entity primarily responsible for making the content of the resource
`subject`	The topic of the content of the resource
`description`	An account of the content of the resource
`publisher`	An entity responsible for making the resource available


Property	Description
`contributor`	An entity responsible for making contributions to the content of the resource
`date`	A date associated with an event in the life cycle of the resource
`type`	The nature or genre of the content of the resource
`format`	The physical or digital manifestation of the resource
`identifier`	An unambiguous reference to the resource within a given context


Property	Description
`source`	A reference to a resource from which the present resource is derived
`language`	A language of the intellectual content of the resource
`relation`	A reference to a related resource
`coverage`	The extent or scope of the content of the resource
`rights`	Information about rights held in and over the resource


- Additional vocabulary is defined in `http://purl.org/dc/terms`
- Dublin Core Metadata may be captured in any suitable language (even in the form of HTML meta tags), but RDF is an ideal representation:

```
<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 rdf:about="http://www.dlib.org">
    <dc:title>D-Lib Program - Research in Digital
        Libraries</dc:title>
    <dc:description>The D-Lib program supports the community of
        people with research interests in digital libraries and
        electronic publishing.</dc:description>
    <dc:publisher>Corporation For National Research
        Initiatives</dc:publisher>
    <dc:date>1995-01-07</dc:date>
```

```
<dc:subject>
      <rdf:Bag>
        <rdf:li>Research; statistical methods</rdf:li>
        <rdf:li>Education, research, related topics</rdf:li>
        <rdf:li>Library use Studies</rdf:li>
      </rdf:Bag>
    </dc:subject>
    <dc:type>World Wide Web Home Page</dc:type>
    <dc:format>text/html</dc:format>
    <dc:language>en</dc:language>
  </rdf:Description>
</rdf:RDF>
```


- Resource descriptions may either reside directly in the document:

```
<?xml version="1.0"?>
<svg width="4in" height="3in" version="1.1"
    xmlns = 'http://www.w3.org/2000/svg'>
  <metadata>
    <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 rdf:about="http://example.org/foo">
        <dc:creator>
          Mary Lambert
        </dc:creator>
      </rdf:Description>
    </rdf:RDF>
  </metadata>
</svg>
```

or in a separate file (being referenced in the original document):

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN">

<html>
  <head>
    <meta http-equiv="Content-Type"
        content="text/html; charset=us-ascii"/>
  </head>
  <body>
    <!-- .... -->
    <a href="http://www.example.org/metadata.rdf">Metadata</a>
  </body>
</html>
```

- The following documents contribute to the specification of RDF:
  - *RDF Concepts and Abstract Syntax*
  - *RDF/XML Syntax Specification*
  - *RDF Vocabulary Description Language 1.0: RDF Schema*
  - *RDF Semantics*
  - *RDF Test Cases*
  - *RDF Primer*