Methods and Tools for Management Information Systems

Lecture 4

17. November 2008
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
<?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:

```xml
<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

1501 Grant Avenue, Bedford, Massachusetts 01730
http://www.example.org/staffid/85740

http://www.example.org/terms/address

http://www.example.org/addressid/85740

http://www.example.org/terms/city
Bedford

http://www.example.org/terms/street
1501 Grant Avenue

http://www.example.org/terms/postalCode
01730

http://www.example.org/terms/state
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
Bedford 01730
1501 Grant Avenue Massachusetts

http://www.example.org/terms/postalCode
http://www.example.org/terms/state
http://www.example.org/terms/street
http://www.example.org/terms/city

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Representation in triples notation using *Blank Node Identifiers*:

```w3c
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:

```
http://www.example.org/staffid/85740

"27"^^<http://www.w3.org/2001/XMLSchema#integer>
```

Triples notation:

```
```
General rules:
⇒ resources without URI (e.g. blank nodes) cannot be referenced
⇒ RDF can only represent binary relationships
⇒ type safety accomplishable by *typed literals*
XML Syntax for RDF: RDF/XML

Serialization of RDF data in XML (*normativ*):

http://www.example.org/index.html

http://www.example.org/terms/creation-date

August 16, 1999
XML Syntax for RDF: RDF/XML

Serialization of RDF data in XML (normativ):

```xml
<?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
<?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
<?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
<?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
<?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
<?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
<?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.

⇒ provides the most direct representation of the graph structure
⇒ recommended for applications that process RDF/XML further
Other RDF capabilities:

- Using containers:
  - `rdf:Bag`:
    ⇒ group of resources or literals, possibly including duplicate members, without order
  - `rdf:Seq`:
    ⇒ group of resources or literals, possibly including duplicate members, where the order of the members is significant
  - `rdf:Alt`:
    ⇒ group of resources or literals that are alternatives
Example:

```xml
<?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
<?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#">
    <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:RDF>
```
Reification:

```
exproducts:triple12345   rdf:subject       exproducts:item10245 .
exproducts:triple12345   rdf:object       "2.4"^^xsd:decimal .
```
- `rdf:value` to represent the *main values* of a structured value:

```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: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
<?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:
Tripels notation:

<table>
<thead>
<tr>
<th>ex:MotorVehicle</th>
<th>rdf:type</th>
<th>rdfs:Class .</th>
</tr>
</thead>
<tbody>
<tr>
<td>ex:PassengerVehicle</td>
<td>rdf:type</td>
<td>rdfs:Class .</td>
</tr>
<tr>
<td>ex:Van</td>
<td>rdf:type</td>
<td>rdfs:Class .</td>
</tr>
<tr>
<td>ex:Truck</td>
<td>rdf:type</td>
<td>rdfs:Class .</td>
</tr>
<tr>
<td>ex:MiniVan</td>
<td>rdf:type</td>
<td>rdfs:Class .</td>
</tr>
</tbody>
</table>

| ex:Van                   | rdfs:subClassOf | ex:MotorVehicle . |
| ex:Truck                 | rdfs:subClassOf | ex:MotorVehicle . |

| ex:MiniVan               | rdfs:subClassOf | ex:Van . |
RDF/XML:

```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:RDF>
```
<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#Class"
    </rdf:type>
  </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:

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

or abbreviated:

```xml
<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
  
  \[
  \text{ex:weightInKg} \quad \text{rdf:type} \quad \text{rdf:Property} \ .
  \]

- Intended usage of properties can be described using the RDF Schema properties \text{rdfs:range} and \text{rdfs:domain}:
  
  - \text{rdfs:range}
  
  - Values of a property are instances of a designated class:
    
    \[
    \text{ex:Person} \quad \text{rdf:type} \quad \text{rdfs:Class} \ .
    \]
    
    \[
    \text{ex:author} \quad \text{rdf:type} \quad \text{rdf:Property} \ .
    \]
    
    \[
    \text{ex:author} \quad \text{rdfs:range} \quad \text{ex:Person} \ .
    \]
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 .
⇒ 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 explicitly 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:

  ```
  exthings:companyCar exterms:weight "2500"^^xsd:integer .
  ```

  ⇒ **exthings:companyCar** has to be an instance of both classes **ex:Book** *and* **ex:MotorVehicle**
Serializing in RDF/XML:

```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:

```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
<?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>

</rdf:RDF>
```
<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"/>

<rdfs:Property rdf:ID="registeredTo">
  <rdfs:domain rdf:resource="#MotorVehicle"/>
  <rdfs:range rdf:resource="#Person"/>
</rdfs: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
<?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 built-in 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
  ⇒ 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)
  ⇒ 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:
<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>title</td>
<td>A name given to the resource</td>
</tr>
<tr>
<td>creator</td>
<td>An entity primarily responsible for making the content of the resource</td>
</tr>
<tr>
<td>subject</td>
<td>The topic of the content of the resource</td>
</tr>
<tr>
<td>description</td>
<td>An account of the content of the resource</td>
</tr>
<tr>
<td>publisher</td>
<td>An entity responsible for making the resource available</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>contributor</td>
<td>An entity responsible for making contributions to the content of the resource</td>
</tr>
<tr>
<td>date</td>
<td>A date associated with an event in the life cycle of the resource</td>
</tr>
<tr>
<td>type</td>
<td>The nature or genre of the content of the resource</td>
</tr>
<tr>
<td>format</td>
<td>The physical or digital manifestation of the resource</td>
</tr>
<tr>
<td>identifier</td>
<td>An unambiguous reference to the resource within a given context</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>source</td>
<td>A reference to a resource from which the present resource is derived</td>
</tr>
<tr>
<td>language</td>
<td>A language of the intellectual content of the resource</td>
</tr>
<tr>
<td>relation</td>
<td>A reference to a related resource</td>
</tr>
<tr>
<td>coverage</td>
<td>The extent or scope of the content of the resource</td>
</tr>
<tr>
<td>rights</td>
<td>Information about rights held in and over the resource</td>
</tr>
</tbody>
</table>
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:

```xml
<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: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>
  </rdf:Description>
</rdf:RDF>
```
<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
<?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):

```xml
<!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