Chapter 3
RDF Syntax

RDF Overview

- RDF Syntax -- the XML encoding
- RDF Syntax – variations including N3
- RDF Schema (RDFS)
- Semantics of RDF and RDFS
  - Axiomatic Semantics
  - Operational semantics based on rules
- Querying RDF via RQL and SPARQL

Introduction

- Problem: What does an XML document mean?
  - XML is about data structures
  - Their meaning (semantics) is not apparent to a machine
- RDF is more a data model than a language
  - Is realized in many different formats
- RDF define basic semantics
  - RDFS and OWL define more RDF vocabulary for building rich data models
- RDF remains domain independent

Example

```
<academicStaffMember> Grigoris Antoniou </academicStaffMember>
<professor> Michael Maher </professor>
<course name="Discrete Mathematics">
  <isTaughtBy> David Billington </isTaughtBy>
</course>
```

- What does this mean?
  - Are professors also academic staff members?
  - If someone teaches a course, are they an academic staff member?
- Can't say in XML, but can say so in RDFS

Example

```
<course name="Discrete Mathematics">
   <lecturer>David Billington</lecturer>
</course>
<lecturer name="David Billington">
   <teaches>Discrete Mathematics</teaches>
</lecturer>
<teachingOffering>
    <lecturer>David Billington</lecturer>
    <course>Discrete Mathematics</course>
</teachingOffering>
```

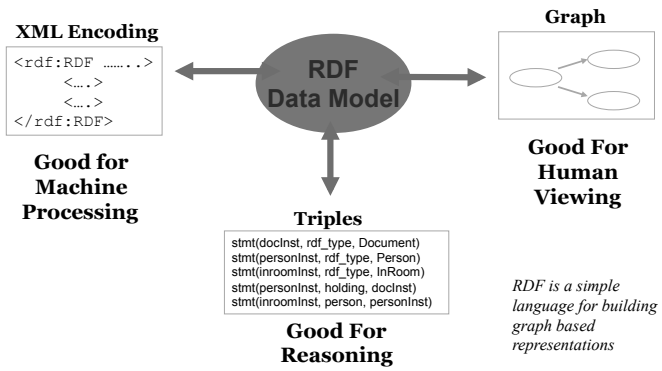
- Embedding of elements is just a syntactic constraint
- No meaning is defined
- It's in the documentation or the mind of the viewer
- Does the machine have a mind?

Key Documents

All at http://www.w3.org/RDF/

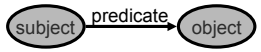
- RDF/XML Syntax Specification (Revised)
  Dave Beckett, ed.
- RDF Vocabulary Description Language 1.0: RDF Schema
  Dan Brickley, R.V. Guha, eds.
- RDF Primer
  Frank Manola, Eric Miller, eds.
- Resource Description Framework (RDF): Concepts and Abstract Syntax
  Graham Klyne, Jeremy Carroll, eds.
- RDF Semantics
  Patrick Hayes, ed.
- RDF Test Cases
  Jan Grant, Dave Beckett, eds.

RDF is the first SW language



The RDF Data Model

- An RDF document is an unordered collection of statements, each with a **subject**, **predicate** and **object** (aka **triples**)
- A triple can be thought of as a labelled arc in a graph
- Statements describe properties of web **resources**
- A resource is any object that can be referenced by a **URI**:
  - a document, a picture, a paragraph on the Web, …
  - E.g., http://umbc.edu/~finin/cv.html
  - a book in the library, a real person (?)
  - isbn://5031-4444-3333
  - …



- Properties themselves are also resources (URIs)

RDF Building Blocks

- Resources
  - Things we can talk about, URIs
- Properties
  - Special things that represent binary relations
- Literal data
  - Strings, integers, dates, … xmldatatypes
- Statements, aka triples
  - Subject Predicate Object or
  - Subject Property Value
- A graph defined by a collection of triples

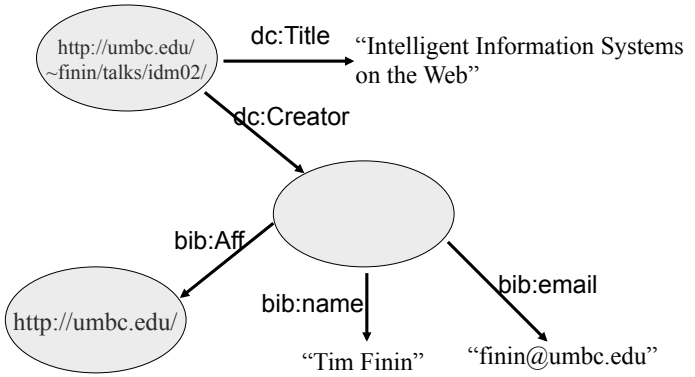
URIs are a foundation

- URI = **Uniform Resource Identifier**
  - "The generic set of all names/addresses that are short strings that refer to resources"
  - URLs (Uniform Resource Locators) are a subset of URIs, used for resources that can be *accessed* on the web
- URIs look like "normal" URLs, often with fragment identifiers to point to a document part:
  - http://foo.com/bar/mumble.html#pitch
- URIs are unambiguous, unlike natural language terms
  - the web provides a global **namespace**
  - We assume references to the same URI are to the same thing

What does a URI mean?

- Sometimes URIs denote a web resource
  - http://umbc.edu/~finin/finin.jpg denotes a file
  - We can use RDF to make assertions about the resource, e.g., it's an image and depicts a person with name Tim Finin, …
- Sometimes concepts in the external world
  - E.g., http://umbc.edu/ denotes a particular University located in Baltimore
  - This is done by social convention
- Cool URIs don't change
  - http://www.w3.org/Provider/Style/URI

Simple RDF Example



RDF Data Model is a Graph

- Graphs only allow binary relations
- Higher *arity* relations must be "reified" (i.e., turned into objects)
- Represent **give(John,Mary,Book32)** as three binary relations all involving a common object, *giveEvent32*
  - giver(giveEvent45 , John)
  - recipient(giveEvent45 , Mary)
  - gift(giveEvent45 , Book32)
- When using RDF, this has to be part of your vocabulary design
- This is a price we have to pay for using a simple representation based on binary relations

RDF Statements

- RDF has one predefined scheme (syntax and semantics) for the reification of RDF statements themselves
- Needed to support assertions about triples
  - Document32 asserts *"John gave Mary a book"*
  - Tom believes *John gave Mary a book*
  - *"John gave Mary a Book" has 0.33 probability*

XML encoding for RDF

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:dc="http://purl.org/dc/elements/1.1/"
   xmlns:bib="http://daml.umbc.edu/ontologies/bib/">
<rdf:Description about="http://umbc.edu/~finin/talks/idm02/">
  <dc:title>Intelligent Information Systems on the Web </dc:Title>
  <dc:creator>
    <rdf:Description >
      <bib:name>Tim Finin</bib:Name>
      <bib:email>finin@umbc.edu</bib:Email>
      <bib:aff resource="http://umbc.edu/" />
    </rdf:Description>
  </dc:creator>
</rdfdescription>
</rdf:RDF>
```

XML encoding for RDF

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:dc="http://purl.org/dc/elements/1.1/"
   xmlns:bib="http://daml.umbc.edu/ontologies/bib/">
<rdf:Description about="http://umbc.edu/~finin/talks/idm02/">
  <dc:title>Intelligent Information Systems on the Web </dc:Title>
  <dc:creator>
    <rdf:Description >
      <bib:name>Tim Finin</bib:Name>
      <bib:email>finin@umbc.edu</bib:Email>
      <bib:aff resource="http://umbc.edu/" />
    </rdf:Description>
  </dc:creator>
</rdf:Description>
</rdf:RDF>
```

Note that the document is a single RDF element which has attributes defining several namespaces.

- One for the rdf vocabulary
- One for the dublin core
- One for the bib vocabulary

XML encoding for RDF

```
<rdf:RDF xmlns:="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:dc="http://purl.org/dc/elements/1.1/"
   xmlns:bib="http://daml.umbc.edu/ontologies/bib/">
<Description about="http://umbc.edu/~finin/talks/idm02/">
  <dc:title>Intelligent Information Systems on the Web </dc:Title>
  <dc:creator>
    <Description >
      <bib:name>Tim Finin</bib:Name>
      <bib:email>finin@umbc.edu</bib:Email>
      <bib:aff resource="http://umbc.edu/" />
    </Description>
  </dc:creator>
</Description>
</rdf:RDF>
```

- An empty prefix means that this is the default namespace for the document
- Any non-literal symbols without a prefix are in this namespace
- E.g., <Description>

XML encoding for RDF

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:dc="http://purl.org/dc/elements/1.1/"
   xmlns:bib="http://daml.umbc.edu/ontologies/bib/">
<rdf:Description about="http://umbc.edu/~finin/talks/idm02/">
  <dc:title>Intelligent Information Systems on the Web </dc:Title>
  <dc:creator>
    <rdf:Description >
      <bib:name>Tim Finin</bib:Name>
      <bib:email>finin@umbc.edu</bib:Email>
      <bib:aff resource="http://umbc.edu/" />
    </rdf:Description>
  </dc:creator>
</rdf:Description>
</rdf:RDF>
```

- Here's the general way to introduce a "named subject" about which we want to assert some properties and values
- We name subjects by referring to their URI
- An element in the description tag specify a property and its value

Descriptions

- Every description makes a statement about a resource
- There are different ways:
  - An about attribute: referencing to an existing resource
    <rdf:Description rdf:about="http…"> …
  - An id attribute: creating a new resource
    <rdf:Description rdf:ID="foo3456"> …
  - Without a name: creating an anonymous resource
    <rdf:Description> …

rdf:about versus rdf:ID

- An element **rdf:Description** has
  - an **rdf:about** attribute indicating that the resource has been "defined" elsewhere
  - An **rdf:ID** attribute indicating that the resource is defined
- Formally, there is no such thing as "defining" an object in one place and referring to it elsewhere
  - Sometimes is useful (for human readability) to have a defining location, while other locations state "**additional**" properties
- A Description with neither produces a "blank node"
  - It can not be referred to either from with or outside the rdf document

XML encoding for RDF

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:dc="http://purl.org/dc/elements/1.1/"
   xmlns:bib="http://daml.umbc.edu/ontologies/bib/"
   xmlns:xsd="http://www.w3.org/2001/XMLSchema#" >
<rdf:Description about="http://umbc.edu/~finin/talks/idm02/">
 <dc:title>Intelligent Information Systems on the Web </dc:Title>
 <dc:creator>
  <rdf:Description >
   <bib:name>Tim Finin</bib:Na
   <bib:email>finin@um
   <bib:aff resource="ht
  </rdf:Description>
 </dc:creator>
</rdf:Description>
</rdf:RDF>
```

- dc:title is the property (or predicate)
- It's value is the literal string "Intelligent Information Systems on the Web"
- By default we assume the datatype is string
  - <ex:age rdf:datatype="&xsd;integer> 22 </ex:age>
  - <ex:age> "27"^^xsd:integer> 22 </ex:age>

XML encoding for RDF

```
<rdf:RDF xmlns:rdf="
   xmlns:dc="http://pu
   xmlns:bib="http://d
  xmlns:xsd="http://ww
<rdf:Description ab
 <dc:title>Intellige
 <dc:creator>
  <rdf:Description >
   <bib:name>Tim Finin</bib:Name>
   <bib:email>finin@umbc.edu</bib:Email>
   <bib:aff resource="http://umbc.edu/" />
  </rdf:Description>
 </dc:creator>
</rdf:Description>
</rdf:RDF>
```

- The value of creator is defined by the nested RDF
- The nameless description produces a "blank node"
- In this case, "a thing with a name="Tim Finin" and …"
- This style of XML encoding is called "striped"

<thing>
<property>
<thing>
<property>

XML encoding for RDF

```
<rdf:RDF xmlns:rdf="
   xmlns:dc="http://pu
   xmlns:bib="http://d
  xmlns:xsd="http://ww
<description about="
 <dc:title>Intelligent
 <dc:creator>
  <description >
   <bib:name>Tim Finin</b      me>
   <bib:email>finin@umbc.edu</bib:Email>
   <bib:aff resource="http://umbc.edu/" />
  </description>
 </dc:creator>
</description>
</rdf:RDF>
```

- Note the "self closing" tag
- The value of the bib:aff property is a resource, not a string
- Every resource has a URI, every URI refers to a resource
- How would this be interpreted?
  <bib:aff> http://umbc.edu/ </bib:aff>

N triple representation

- RDF can be encoded as a set of **triples**.
  <subject> <predicate> <object> .

<http://umbc.edu/~finin/talks/idm02/> <http://purl.org/dc/elements/1.1/Title>
"Intelligent Information Systems on the Web" .
_:j10949 <http://daml.umbc.edu/ontologies/bib/Name> "Tim Finin" .
_:j10949 <http://daml.umbc.edu/ontologies/bib/Email> "finin@umbc.edu" .
_:j10949 <http://daml.umbc.edu/ontologies/bib/Aff> <http://umbc.edu/> .
_:j10949 <http://www.w3.org/1999/02/22-rdf-syntax-ns#type><Description> .
<http://umbc.edu/~finin/talks/idm02/> <http://purl.org/dc/elements/1.1/Creator> _:j10949 .
<http://umbc.edu/~finin/talks/idm02/> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<Description> .

Note the gensym for the anonymous node :j10949

Triple Notes

- **RDF triples have one of two forms:**
  - <URI> <URI> <URI>
  - <URI> <URI> <quoted string>
- **Triples are also easily mapped into logic**
  - <subject> <predicate> <object> becoming:
    - <predicate>(<subject>,<object>)
    - With type(<S>,<O>) becoming <O>(<S>)
  - Example:
    - subclass(man,person)
    - sex(man,male)
    - domain(sex,animal)
    - man(adam)
    - age(adam,100)

; Note: we're not
; showing the actual
; URIs for clarity

- **Triples are easily stored and managed in DBMS**
  - Flat nature of a triple a good match for relational DBs

N3 notation for RDF

- N3 is a compact notation for RDF that is easier for people to read, write and edit.
- Aka *notation 3*, developed by TBL himself.
- Translators exist between N3 and the XML encoding, such as the web form on
  - http://www.w3.org/DesignIssues/Notation3.html
- So, it's just "syntactic sugar"
- But, XML is largely unreadable and even harder to write

N3 Example

```
@prefix rdf: http://www.w3.org/1999/02/22-rdf-syntax-ns# .
@prefix dc: http://purl.org/dc/elements/1.1/ .
@prefix bib: http://daml.umbc.edu/ontologies/bib/ .

< http://umbc.edu/~finin/talks/idm02/ >
  dc:title "Intelligent Information Systems on the Web" ;
  dc:creator
    [ bib:Name "Tim Finin“ ;
      bib:Email finin@umbc.edu ;
      bib:Aff: "http://umbc.edu/" ]  .
```

Note special […] syntax for an anonymous node

thing
  $prop_1$ = value ;
  $prop_2$ = value ;
  …
  $prop_n$ = value .

Example of University Courses

```
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:xsd="http://www.w3.org/2001/XLMSchema#"
  xmlns:uni="http://example.org/uni-ns">

  <rdf:Description rdf:about="949318">
      <uni:name>David Billington</uni:name>
      <uni:title>Associate Professor</uni:title>
      <uni:age rdf:datatype="&xsd:integer">27<uni:age>
  </rdf:Description>
```

Example of University Courses (2)

```
<rdf:Description rdf:about="CIT1111">
      <uni:courseName>Discrete Maths</uni:courseName>
      <uni:isTaughtBy>David Billington</uni:isTaughtBy>
</rdf:Description>

<rdf:Description rdf:about="CIT2112">
      <uni:courseName>Programming III</
uni:courseName>
      <uni:isTaughtBy>Michael Maher</uni:isTaughtBy>
</rdf:Description>

</rdf:RDF>
```

Data Types for Literals

- Data types are used in programming languages to allow interpretation
- In RDF, typed literals are used
- You can specify this with a special ^^ syntax

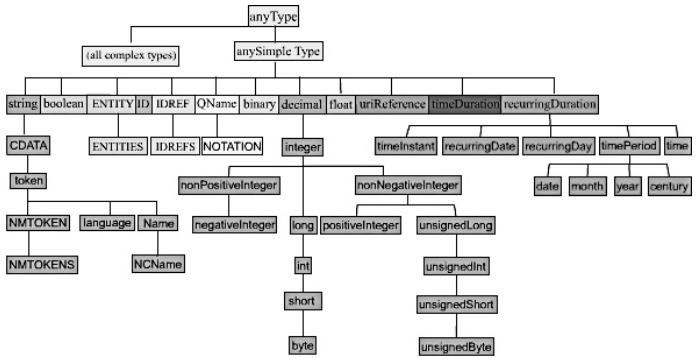
  (“David Billington”,
  http://example.org/age,
  “27”^^http://www.w3.org/2001XMLSchema#integer)
- or using the rdf:datatype attribute

  <uni:age rdf:datatype="&xsd:integer">27<uni:age>

Data Types for Literals

- **^^**-notation indicates the type of a literal
- In practice, the most widely used data typing scheme will be the one by XML Schema
  - But the use of **any** externally defined data typing scheme is allowed in RDF documents
- XML Schema predefines a large range of data types
  - E.g. Booleans, integers, floating-point numbers, times, dates, etc.

XMLSchema Datatypes



http://www.w3.org/TR/xmlschema-2/

The rdf:resource Attribute

- The relationships between courses and lecturers (in the example) were not formally defined but existed implicitly through the use of the same name
- The use of the same name may just be a coincidence for a machine
- We can denote that two entities are the same using the **rdf:resource** attribute
- By design, RDF explicitly rules out the common *unique name assumption* found in many representation systems

The rdf:resource Attribute

```
<rdf:Description rdf:about="CIT1111">
  <uni:courseName>Discrete Mathematics
      </uni:courseName>
  <uni:isTaughtBy rdf:resource="949318"/>
</rdf:Description>

<rdf:Description rdf:about="949318">
  <uni:name>David Billington</uni:name>
  <uni:title>Associate Professor</uni:title>
</rdf:Description>
```

Referencing Externally Defined Resources

- Refer to the externally defined resource CIT1111 using http://example.org/uni-ns#CIT1111 as the value of rdf:about
- Assuming that example.org/uni-ns is the URI where the definition of CIT1111 is found
- A description with an ID defines a *fragment URI*, which can be used to reference the defined description

Nested Descriptions: Example

```
<rdf:Description rdf:about="CIT1111">
    <uni:courseName>Discrete Maths</uni:courseName>
    <uni:isTaughtBy>
        <rdf:Description rdf:ID="949318">
            <uni:name>David Billington</uni:name>
            <uni:title>Associate Professor</uni:title>
        </rdf:Description>
    </uni:isTaughtBy>
</rdf:Description>
```

Nested Descriptions

- Descriptions may be defined within other descriptions
- Other courses, such as **CIT3112**, can still refer to the new resource with ID **949318**
- Although a description may be defined within another description, its scope is global

RDF types

```
<rdf:Description rdf:about="CIT1111">
   <rdf:type rdf:resource="&uni:Course"/>
   <uni:courseName>Discrete Mathematics</uni:courseName>
   <uni:isTaughtBy rdf:resource="949318"/>
</rdf:Description>
<rdf:Description rdf:about="949318">
   <rdf:type rdf:resource="&uni:Lecturer"/>
   <uni:name>David Billington</uni:name>
   <uni:title>Associate Professor</uni:title>
</rdf:Description>
```

- RDF has a trivial type system
- RDFS and OWL extend it greatly

RDF types, another syntax

```
<rdf:Description rdf:ID="CIT1111">
   <rdf:type rdf:resource="http://example.org/uni-ns#course"/>
   <uni:courseName>Discrete Maths</uni:courseName>
   <uni:isTaughtBy rdf:resource="#949318"/>
</rdf:Description>

<rdf:Description rdf:ID="949318">
   <rdf:type rdf:resource="http://example.org/uni-ns#lecturer"/>
   <uni:name>David Billington</uni:name>
   <uni:title>Associate Professor</uni:title>
</rdf:Description>
```

RDF types, yet another Syntax

```
<uni:course rdf:ID="CIT1111">
   <uni:courseName>Discrete Mathematics</uni:courseName>
   <uni:isTaughtBy rdf:resource="949318"/>
</uni:course>

<uni:lecturer rdf:ID="949318">
   <uni:name>David Billington</uni:name>
   <uni:title>Associate Professor</uni:title>
</uni:lecturer>
```

- This abbreviated syntax is very common

Abbreviated Syntax

- So we have two simplification rules:
  1. Childless property elements within description elements may be replaced by XML attributes
  2. For description elements with a typing element we can use the name specified in the **rdf:type** element instead of **rdf:Description**
- These rules create syntactic variations of the same RDF statement
  - They are equivalent according to the RDF data model, although they have different XML syntax

Abbreviated Syntax: Example

```
<rdf:Description rdf:ID="CIT1111">
  <rdf:type rdf:resource="http://example.org/uni-
    ns#course"/>
  <uni:courseName>Discrete Maths</
    uni:courseName>
  <uni:isTaughtBy rdf:resource="#949318"/>
</rdf:Description>
```

Application of First Simplification Rule

```
<rdf:Description rdf:ID="CIT1111"
        uni:courseName="Discrete Maths">
   <rdf:type rdf:resource="http://example.org/uni-
  ns#course"/>
  <uni:isTaughtBy rdf:resource="#949318"/>
</rdf:Description>
```

Application of 2nd Simplification Rule

```
<uni:course rdf:ID="CIT1111"
      uni:courseName="Discrete Maths">
  <uni:isTaughtBy rdf:resource="#949318"/>
</uni:course>
```

Container Elements

- Collect a number of resources or attributes about which we want to make statements as a whole
- E.g., we may wish to talk about the courses given by a particular lecturer
- The content of container elements are named **rdf:_1**, **rdf:_2**, etc.
  - Alternatively **rdf:li**
- Containers seem a bit messy in RDF, but are needed

Three Types of Container Elements

- **rdf:Bag** an unordered container, allowing multiple occurrences
  - E.g. members of the faculty board, documents in a folder
- **rdf:Seq** an ordered container, which may contain multiple occurrences
  - E.g. modules of a course, items on an agenda, an alphabetized list of staff members (order is imposed)
- **rdf:Alt** a set of alternatives
  - E.g. the document home and mirrors, translations of a document in various languages

Example for a Bag

```
<uni:lecturer
  rdf:ID="949352" uni:name="Grigoris Antoniou"
                uni:title="Professor">
  <uni:coursesTaught>
      <rdf:Bag>
            <rdf:_1 rdf:resource="#CIT1112"/>
            <rdf:_2 rdf:resource="#CIT3116"/>
      </rdf:Bag>
  </uni:coursesTaught>
</uni:lecturer>
```

Example for Alternative

```
<uni:course rdf:ID="CIT1111"
        uni:courseName="Discrete Mathematics">
    <uni:lecturer>
      <rdf:Alt>
            <rdf:li rdf:resource="#949352"/>
            <rdf:li rdf:resource="#949318"/>
      </rdf:Alt>
    </uni:lecturer>
</uni:course>
```

Rdf:ID Attribute for Container Elements

```
<uni:lecturer rdf:ID="949318"
              uni:name="David Billington">
    <uni:coursesTaught>
      <rdf:Bag rdf:ID="DBcourses">
            <rdf:_1 rdf:resource="#CIT1111"/>
            <rdf:_2 rdf:resource="#CIT3112"/>
      </rdf:Bag>
    </uni:coursesTaught>
</uni:lecturer>
```

RDF Container Elements

- rdf:Bag
  - unordered
  - may contain multiple occurrences
- rdf:Seq
  - ordered
  - may contain multiple occurrences
- rdf:Alt
  - a set of alternatives
- Content of container elements are named rdf:_1, rdf:_2, ...
- Containers seem a bit messy in RDF, but are needed

RDF Container Example

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

 <uni:lecturer rdf:about="949352" uni:name="Grigoris Antoniou“ uni:title="Professor">

   <uni:coursesTaught>
     <rdf:Bag>
       <rdf:_1:rdf:resource="CIT1112"/>
       <rdf:_2:rdf:resource="CIT1113"/>
     </rdf:Bag>
   </uni:coursesTaught>
 </uni:lecturer>

 <uni:course rdf:about="CIT1111" uni:courseName="Discrete Mathematics">
   <uni:lecturer>
     <rdf:Alt>
       <rdf:_1:rdf:resource="949352"/>
       <rdf:_2:rdf:resource="949318"/>
     </rdf:Alt>
   </uni:lecturer>
 </uni:course>
</rdf:RDF>
```

Bags and Seqs are never full!

- RDF's semantics is "open world", so…
  - There is no possibility "to close" the container, to say: "these are **all** elements, there are no more"
  - RDF is a graph, so: there is no way to exclude the possibility that there is another graph somewhere that describes additional members
- Collections for groups with only the specified members are described via a predefined collection vocabulary of the types:
  - rdf:List, rdf:first, rdf:rest, rdf:nil

RDF Lists

CIT 2112 is exclusively taught by teachers 949111, 949352, 949381

```
<rdf:Description rdf:about="CIT2112">
  <uni:isTaughtBy>
    <rdf:List>
      <rdf:first><rdf:Description rdf:about="949111"/></rdf:first>
      <rdf:rest>
        <rdf:List>
          <rdf:first><rdf:Description rdf:about="949352"/></rdf:first>
            <rdf:rest>
              <rdf:List>
                <rdf:first><rdf:Description rdf:about="949318"/></rdf:first>
                <rdf:rest><rdf:Description rdf:about="&rdf;nil"/></rdf:rest>
              </rdf:List>
            </rdf:rest>
          </rdf:List>
        </rdf:rest>
      </rdf:List>
    </uni:isTaughtBy>
</rdf:Description>
```

Yuck!

RDF Lists Syntactic Sugar

The the rdf:parseType attribute helps

```
<rdf:Description rdf:about="CIT2112">
   <uni:isTaughtBy rdf:parseType="Collection">
      <rdf:Description rdf:about="949111"/>
      <rdf:Description rdf:about="949352"/>
      <rdf:Description rdf:about="949318"/>
   </uni:isTaughtBy>
</rdf:Description>
```

Reification

- Sometimes we wish to make **statements about other statements**
- We must be able to refer to a statement using an identifier
- RDF allows such reference through a reification mechanism which turns a statement into a resource

Reify

- Etymology: Latin *res* thing
- Date: 1854
- to regard (something abstract) as a material or concrete thing

Wikipedia: reification (computer science)

Reification is the act of making an abstract concept or low-level implementation detail of a programming language accessible to the programmer, often as a first-class object. For example,

- The C programming language reifies the low-level detail of memory addresses.
- The Scheme programming language reifies continuations (approximately, the call stack).
- In C#, reification is used to make parametric polymorphism implemented as generics a first-class feature of the language.
- …

Reification Example

```
<rdf:Description rdf:about="#949352">
  <uni:name>Grigoris Antoniou</uni:name>
</rdf:Description>
```

reifies as

```
<rdf:Statement rdf:ID="StatementAbout949352">
  <rdf:subject rdf:resource="#949352"/>
  <rdf:predicate rdf:resource="http://example.org/uni-
     ns#name"/>
  <rdf:object>Grigoris Antoniou</rdf:object>
</rdf:Statement>
```

Reification

- **rdf:subject, rdf:predicate** and **rdf:object** allow us to access the parts of a statement
- The **ID** of the statement can be used to refer to it, as can be done for any description
- We write an **rdf:Description** if we don't want to talk about a statement further
- We write an **rdf:Statement** if we wish to refer to a statement

RDF Critique: Properties

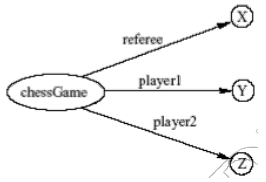
- Properties are special kinds of resources
  - Properties can be used as the object in an object-attribute-value triple (statement)
  - They are defined **independent** of resources
- This possibility offers flexibility
- But it is unusual for modelling languages and OO programming languages
- It can be confusing for modellers

RDF Critique: Binary Predicates

- RDF uses only binary properties
  - This is a restriction because often we use predicates with more than 2 arguments
  - But binary predicates can simulate these
- Example: **referee(X,Y,Z)**
  - **X** is the referee in a chess game between players **Y** and **Z**

RDF Critique: Binary Predicates

- We introduce:
  - a new auxiliary resource **chessGame**
  - the binary predicates **ref**, **player1**, and **player2**
- We can represent **referee(X,Y,Z)** as:



RDF Critique: : Reification

- The reification mechanism is quite powerful
- It appears misplaced in a simple language like RDF
- Making statements about statements introduces a level of complexity that is not necessary for a basic layer of the Semantic Web
- Instead, it would have appeared more natural to include it in more powerful layers, which provide richer representational capabilities

RDF Critique: Graph Representation

- The simple graph or network representation has more drawbacks
- Linear languages introduce ways to represent this with parentheses or a way to represent a block structure
- Scoping, for example, is clumsy at best in RDF
- Some of these are addressed through the notion of a *named graph* in RDF

RDF Critique: Summary

- RDF has its idiosyncrasies and is not an optimal modeling language **but**
- It is already a de facto standard
- It has sufficient expressive power
  - At least as for more layers to build on top
- Using RDF offers the benefit that information maps unambiguously to a model