

Intelligent Internet Technologies



Lectures 12-14.

Resource Definition Framework (RDF)

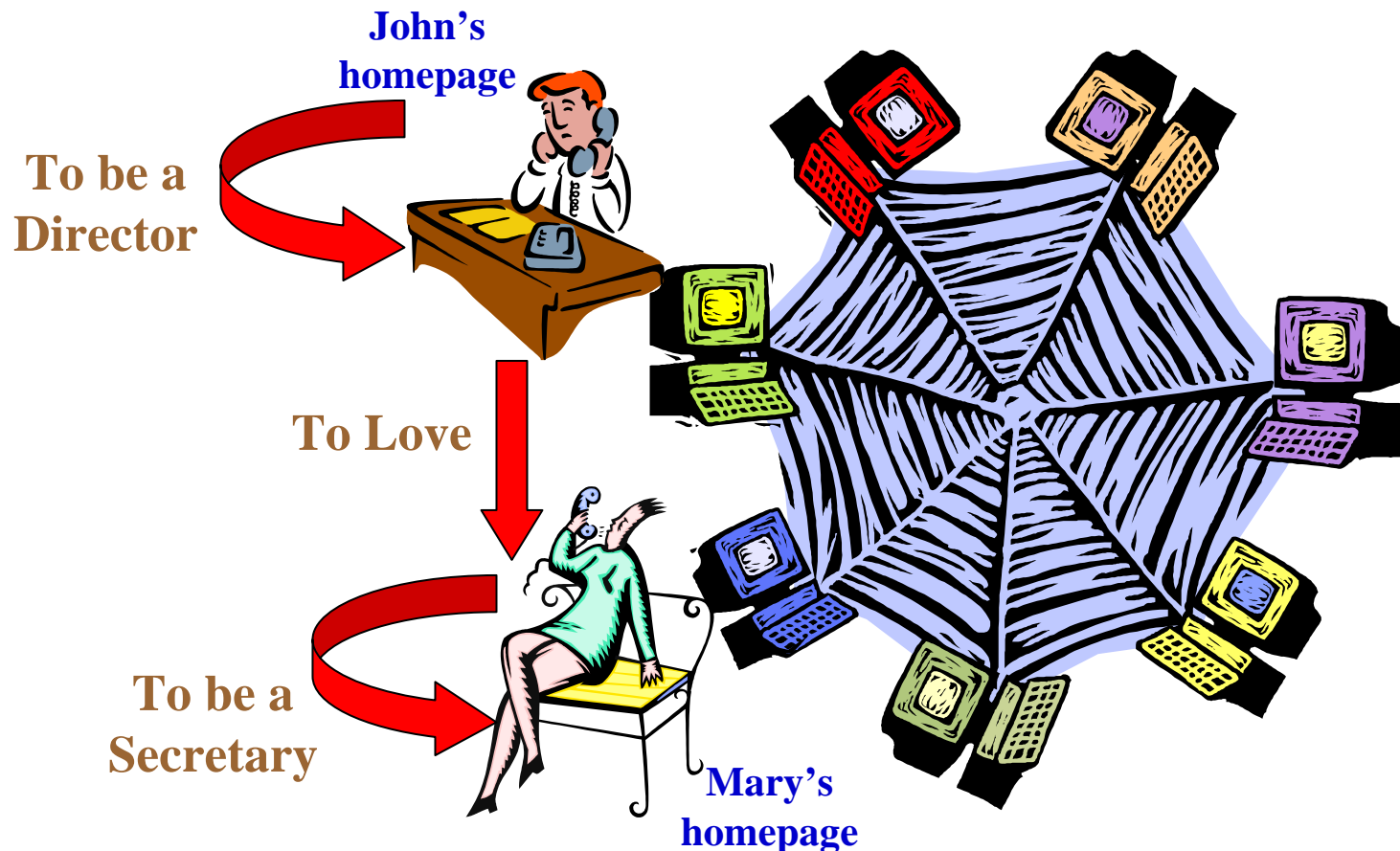
Alexandra V. Vitko

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Description of Semantic Properties of the Web Resources and Semantic Relationships between them is Extremely Important for the Intelligent Web Applications



Why Shift Towards More Semantics?



- Information Overload
 - Information on the Web currently aiming at Human Consumption
 - Information Consumption is too time consuming
- Search Engines fail more and more
 - combined coverage is less than 42% of the HTML-Web
- Data Interchange growing (e.g. B2B)
 - needs a common semantics

Can't we just use XML?

This is what a web-page in natural language looks like for a machine



林克昌 根留台灣 可能增高

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在台灣諸多公家樂團中，陳澄雄是以實際行動表達對林克昌肯定的樂界人士之一，曾多次公開表示對林克昌指揮才華的欽佩，而且幾乎每個樂季都邀請林克昌客席演出。

此外，林克昌上個月赴俄羅斯與頂尖的「俄羅斯國家管絃樂團」灌錄了柴可夫斯基晚期三大交響曲以及「羅密歐與茱麗葉」、「斯拉夫進行曲」、「義大利隨想曲」，最後的DAT母帶也在前兩天寄回台灣。製作人楊忠衡與林克昌試聽之後，都對錄音效果—尤其音質表現感到相當滿意，楊忠衡估計呈現了七分林克昌指揮神韻。

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XML helps



XML allows “meaningful tags” to be added to parts of the text

林克昌 根留台灣 可能增高

< name >

< education >

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< private >

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< CV >

XML \neq machine accessible meaning



But to your machine, the tags look like this....

林克昌 根留台灣 可能增高

< name >

<εδυσχαιτιον>

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<ωορκ>

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< Xς >

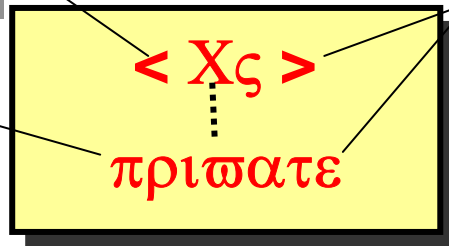
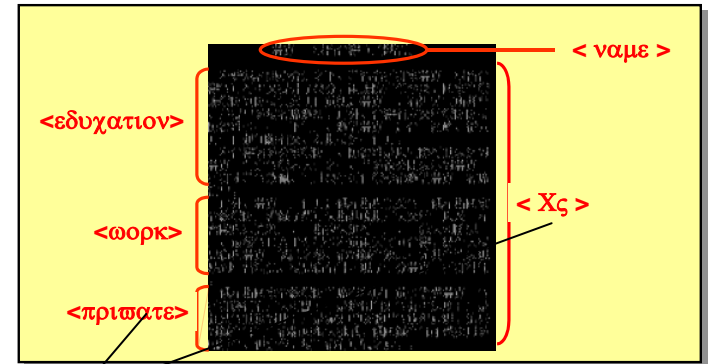
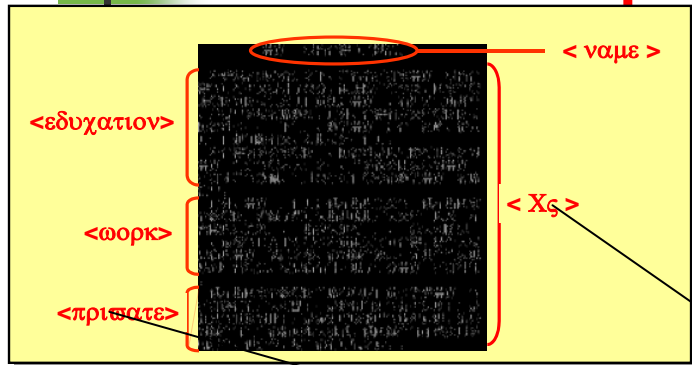
<πριωατε>

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Schemas take a step in the right direction



Schemas help....



...by relating
common terms
between documents

But other people use other schemas

Someone else has one like this....



林克昌 根留台灣 可能增高

⑤ ④ ③ ② ①

< ① ② ③ ④ ⑤ >

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< ← ↑ ◎ ↓ >

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< ① ② ③ ④ ⑤ >

Why XML is Not Enough

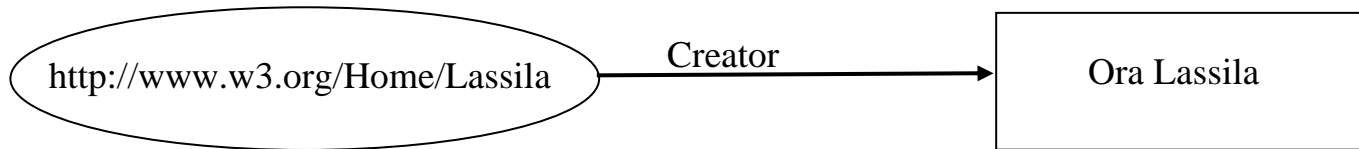
- Many different possibilities to encode a domain of discourse
- Leads to difficulties when understanding of foreign documents is required

==> Next step: separate content from structure!

Encoding of Knowledge: Example



“The Creator of the Resource “<http://www.w3.org/Home/Lassila>” is Ora Lassila



Endless encoding possibilities in XML:

```
<Creator>
  <uri>http://www.w3.org/Home/Lassila</uri>
  <name>Ora Lassila</name>
</Creator>
```

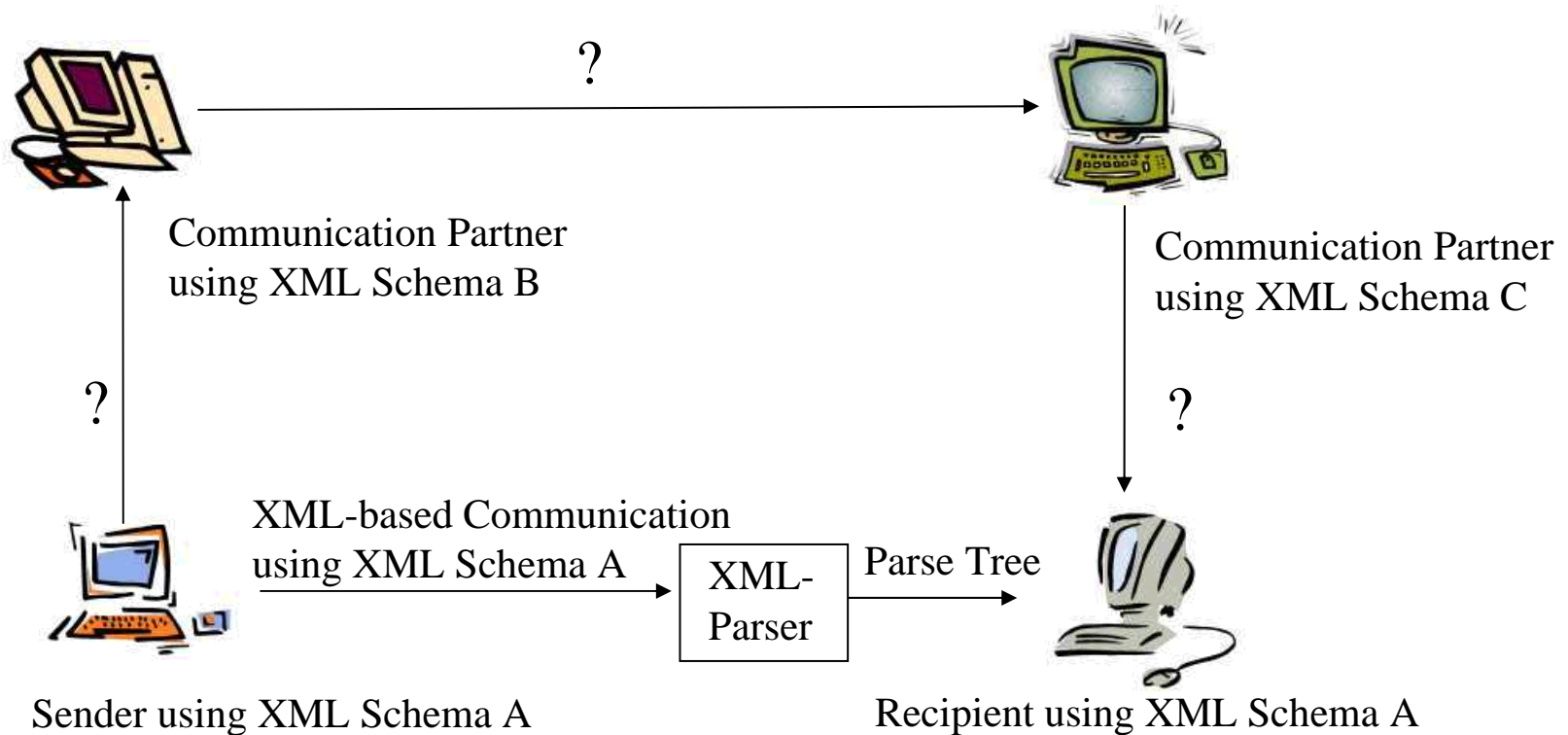
```
<Document uri="http://www.w3.org/Home/Lassila"
  <Creator>Ora Lassila</Creator>
</Document>
```

```
<Document uri="http://www.w3.org/Home/Lassila" Creator="Ora Lassila"/>
```

WWW - Many Previously Unknown Communication Partners



New Partners Don't Understand Each Other



Merging Steps Between Models

Costly and complicated

Steps

XML Schema A

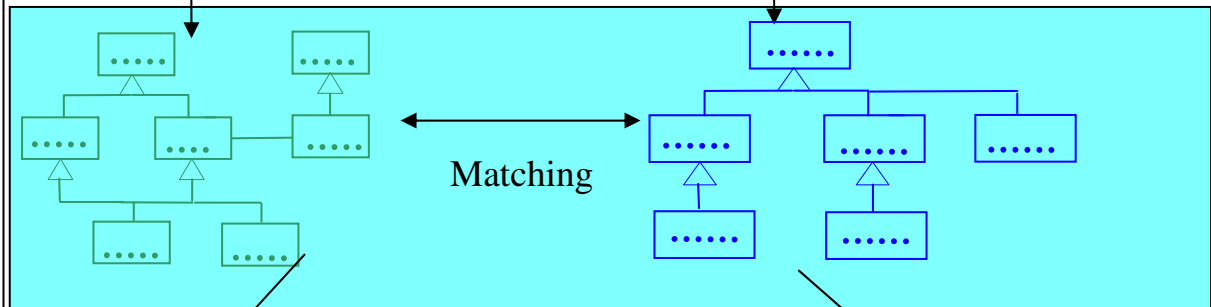
XML Schema B

Reengineering of the conceptual model

```
<xsd:schema
  xmlns:xsd="http://...">
  <xsd:annotation>A-Schema
</xsd:...
</xsd:schema>
```

```
<xsd:schema
  xmlns:xsd="http://...">
  <xsd:annotation>B-Schema
</xsd:...
</xsd:schema>
```

Matching



XML Document Translation Generation (e.g. in XSLT)

```
<xsl:stylesheet version="1.0"
  xmlns:xsl="http://....Transform"
  <xsl:template match="/">
  ....
</xsl:template>
</xsl:stylesheet>
```

```
<xsl:stylesheet version="1.0"
  xmlns:xsl="http://....Transform"
  <xsl:template match="/">
  ....
</xsl:template>
</xsl:stylesheet>
```

XML Document Translation from XML Schema A to schema B (and B to A)



Postulates: Fundamental Requirements for Knowledge Representation on the Web

1. Knowledge on the Web is distributed
2. Knowledge on the Web is subjective - there is no universal truth (it must be possible to dispute statements)
3. Many different user communities (extensibility and simplicity is needed)

==> Resource Description Framework (RDF)

RDF



- Resource Definition Framework:
 - from **Machine Readable**
 - to **Machine Understandable**
- W3C Recommendation
- RDF consist of two parts:
 - RDF Model
 - RDF Syntax

What is RDF ?



- Resource Description Framework (RDF) is a foundation for processing metadata in the Web;
- It provides interoperability between applications that exchange machine-understandable information on the Web;
- RDF emphasises facilities to enable automated processing of Web resources;
- It is a mechanism for describing resources that makes no assumptions about a particular application domain.

Why RDF ?



- for resource discovery to provide better search engine capabilities;
- for describing the content and content relationships available at a particular Web site;
- for intelligent software agents to facilitate knowledge sharing and exchange;
- for expressing the privacy preferences of a user as well as the privacy policies of a Web site;
- RDF with digital signatures will be key to building the "Web of Trust" for electronic commerce, collaboration, and other applications.



RDF Data Model

- Resources
- Properties
- Statements

Resources



All things being described by RDF expressions are called *resources*:

- entire Web page;
- part of a Web page (e.g. a specific XML element within the document source);
- whole collection of pages (e.g. an entire Web site);
- an object that is not directly accessible via the Web (e.g. a printed book, a Web user).

“A resource is a thing you talk about (can reference)”

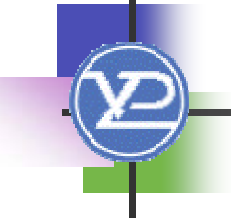
- RDF description is itself a resource



Resources and URIs

- A resource can be anything that has identity
- *Uniform Resource Identifiers* (URI) provide a simple and extensible means for identifying a resource
- Not all resources are network "retrievable"; e.g., human beings, corporations, and books in a library can also be considered resources

Properties



A *property* is a specific aspect, characteristic, attribute, or relation used to describe a resource.

Each property has a specific meaning, defines its permitted values, the types of resources it can describe, and its relationship with other properties.

Statements

A specific resource together with a named property plus the value of that property for that resource is an *RDF statement*.

«Resource R has the property P with the value V»



The value of the property can be either symbolic data or other resource

Subject, Predicate and Object



Parts of a Statement are

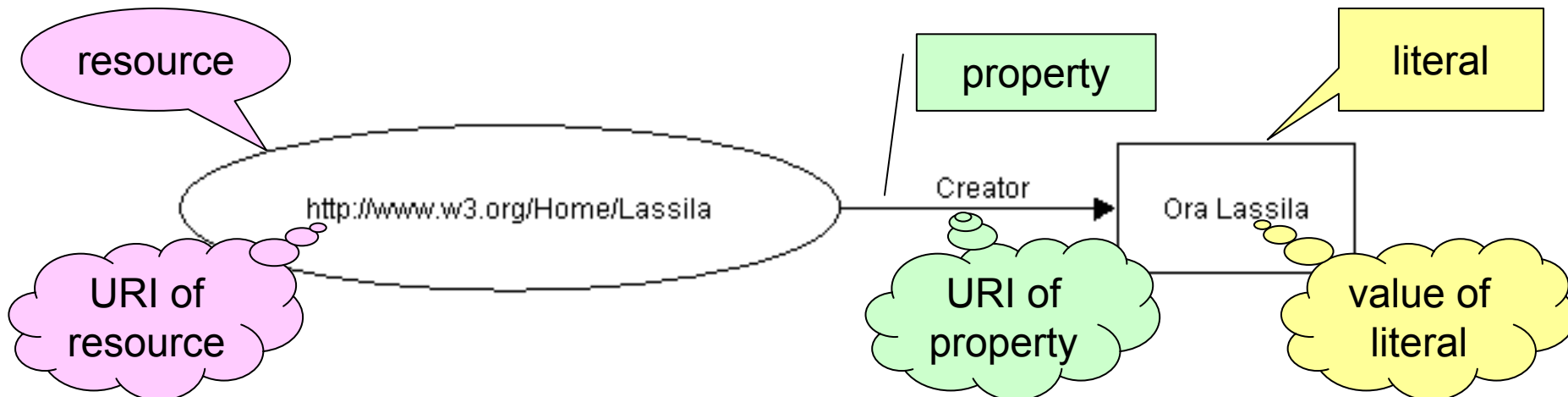
- ***Subject*** of an RDF statement is a resource
- ***Predicate*** of an RDF statement is a property of a resource
- ***Object*** of an RDF statement is the value of a property of a resource

Example of RDF Statement



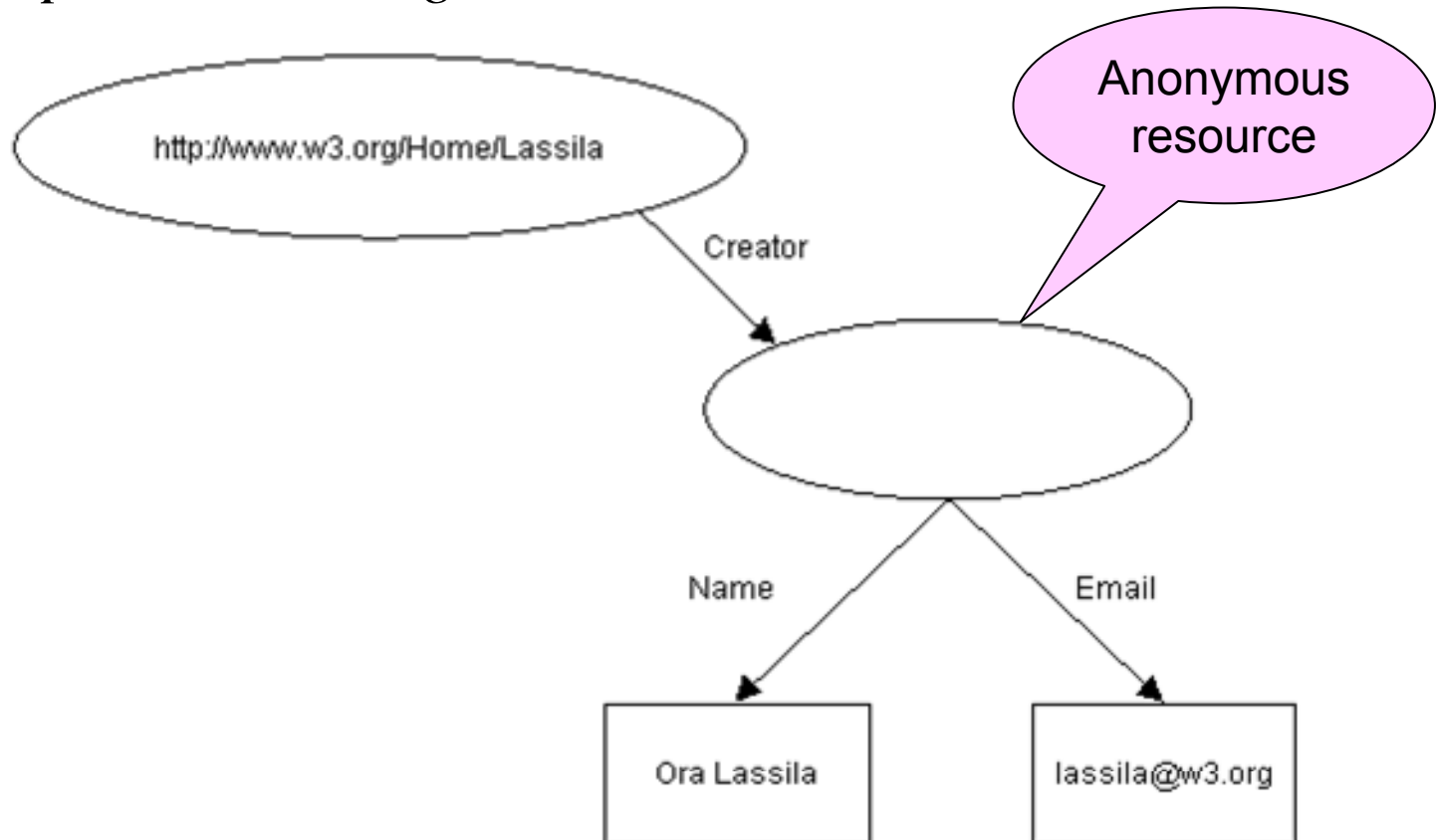
*Ora Lassila is the creator of the resource
<http://www.w3.org/Home/Lassila>.*

Subject (resource)	http://www.w3.org/Home/Lassila
Predicate (property)	Creator
Object (literal)	“Ora Lassila”



Property with Structural Value Example (1)

The individual whose name is Ora Lassila, email <lassila@w3.org>, is the creator of <http://www.w3.org/Home/Lassila>.



Property with Structural Value Example (2)



Subject (resource)	http://www.w3.org/Home/Lassila
Predicate (property)	Creator
Object (resource)	SOMETHING

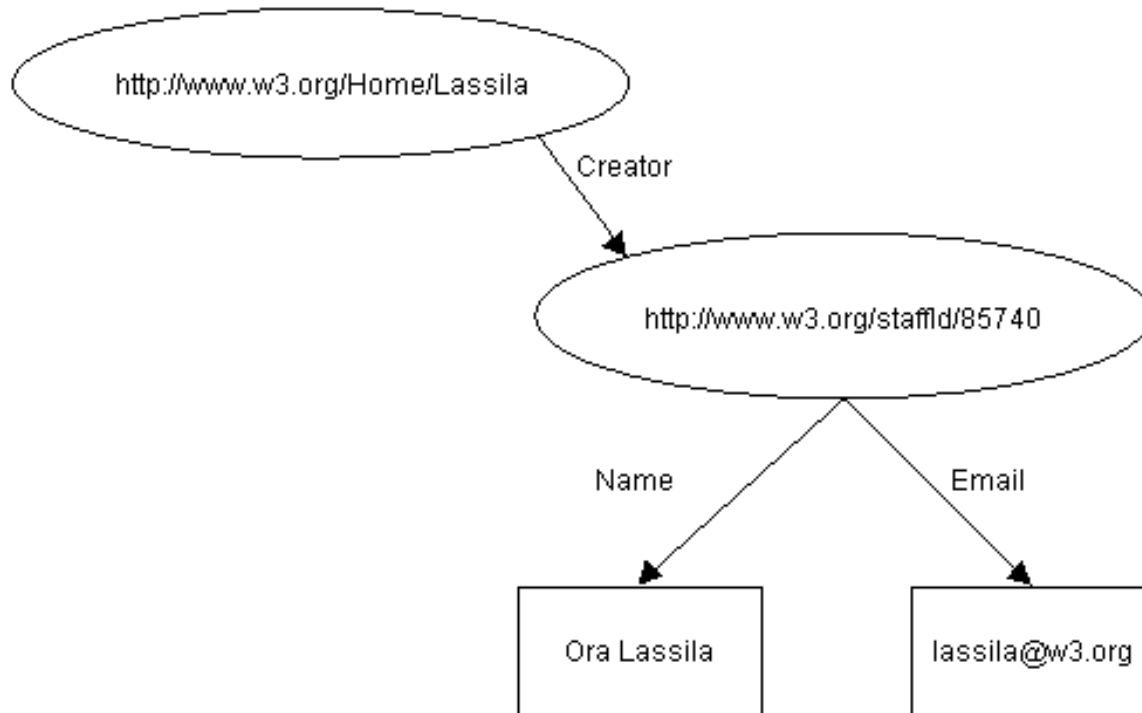
Subject (resource)	SOMETHING
Predicate (property)	Name
Object (literal)	“Ora Lassila”

Subject (resource)	SOMETHING
Predicate (property)	Email
Object (literal)	lassila@w3.org

Property with Structural Value Example (3)



The individual referred to by employee id 85740 is named Ora Lassila and has the email address lassila@w3.org. The resource <http://www.w3.org/Home/Lassila> was created by this individual.



Property with Structural Value Example (4)



Subject (resource)	http://www.w3.org/Home/Lassila
Predicate (property)	Creator
Object (resource)	http://www.w3.org/staffid/85740

Subject (resource)	http://www.w3.org/staffid/85740
Predicate (property)	Name
Object (literal)	“Ora Lassila”

Subject (resource)	http://www.w3.org/staffid/85740
Predicate (property)	Email
Object (literal)	lassila@w3.org

RDF Serialisation Syntax



- [1] `RDF ::= ['<rdf:RDF>'] description* ['</rdf:RDF>']`
- [2] `description ::= '<rdf:Description' idAboutAttr? '>' propertyElt* '</rdf:Description> '`
- [3] `idAboutAttr ::= idAttr | aboutAttr`
- [4] `aboutAttr ::= 'about=' URI-reference ''`
- [5] `idAttr ::= 'ID=' IDsymbol ''`
- [6] `propertyElt ::= '< propName '>' value '</ propName '>' | '< propName resourceAttr '>'`
- [7] `propName ::= QName`
- [8] `value ::= description | string`
- [9] `resourceAttr ::= 'resource=' URI-reference ''`
- [10] `Qname ::= [NSprefix ':'] name`
- [11] `URI-reference ::= string, interpreted per [URI]`
- [12] `IDsymbol ::= (any legal XML name symbol)`
- [13] `name ::= (any legal XML name symbol)`
- [14] `NSprefix ::= (any legal XML namespace prefix)`
- [15] `string ::= (any XML text, with "<", ">", and "&" escaped)`

+ обязательный, не менее 1 раза
 * необязательный, любое кол-во раз
 ? необязательный, только 1 раз
 | или

RDF Example



*Ora Lassila is the creator of the resource
<http://www.w3.org/Home/Lassila>.*

```
<rdf:RDF>
  <rdf:Description rdf:about=
    "http://www.w3.org/Home/Lassila">
    <s:Creator>Ora Lassila</s:Creator>
  </rdf:Description>
</rdf:RDF>
```

's' is a specific namespace prefix, e.g.

xmlns:s="http://description.org/schema/"



RDF Example

*Ora Lassila is the creator of the resource
<http://www.w3.org/Home/Lassila>.*

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

```
<rdf:RDF
```

```
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:s="http://description.org/schema/">
```

```
    <rdf:Description rdf:about=
```

```
      "http://www.w3.org/Home/Lassila">
```

```
      <s:Creator>Ora Lassila</s:Creator>
```

```
    </rdf:Description>
```

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

's' is a specific namespace prefix, e.g.

xmlns:s="http://description.org/schema/"

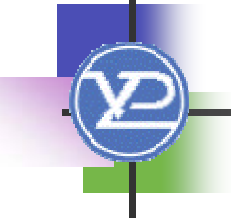
RDF Validator

- Online: W3C RDF Validator

<http://www.w3.org/rdf/validator>

! Now demands everywhere prefix **rdf:**

RDF Abbreviated Syntax

- 
- While the serialisation syntax shows the structure of an RDF model most clearly, often it is desirable to use a more compact XML form.
 - The RDF **abbreviated syntax** accomplishes this.

RDF Abbreviated Syntax



- [2a] description ::= '<rdf:Description' idAboutAttr? propAttr* '/>'
| '<rdf:Description' idAboutAttr? propAttr* '>'
propertyElt* '</rdf:Description>'
| typedNode
- [6a] propertyElt ::= '<' propName '>' value '</' propName '>'
| '<' propName resourceAttr? propAttr* '/>'
- [16] propAttr ::= propName '=' string ''
(with embedded quotes escaped)
- [17] typedNode ::= '<' typeName idAboutAttr? propAttr* '/>'
| '<' typeName idAboutAttr? propAttr* '>'
property* '</' typeName '>'



Abbreviated Syntax Example

*Ora Lassila is the creator of the resource
<http://www.w3.org/Home/Lassila>.*

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

  <rdf:Description
    rdf:about="http://www.w3.org/Home/Lassila"
    s:Creator="Ora Lassila" />

</rdf:RDF>
```

Serialisation vs. Abbreviated Syntax Example (1)

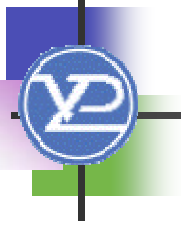


The individual referred to by employee id 85740 is named Ora Lassila and has the email address lassila@w3.org. The resource <http://www.w3.org/Home/Lassila> was created by this individual.

```
<rdf:RDF xmlns... >
  <rdf:Description rdf:about="http://www.w3.org/Home/Lassila">
    <s:Creator>
      <rdf:Description rdf:about="http://www.w3.org/staffId/85740">
        <v:Name>Ora Lassila</v:Name>
        <v:Email>lassila@w3.org</v:Email>
      </rdf:Description>
    </s:Creator>
  </rdf:Description>
</rdf:RDF>
```

Serialisation syntax used

Serialisation vs. Abbreviated Syntax Example (2)



```
<rdf:RDF>
```

```
<rdf:Description rdf:about="http://www.w3.org/Home/Lassila">
```

```
<s:Creator rdf:resource="http://www.w3.org/staffId/85740"
```

```
  v:Name="Ora Lassila"
```

```
  v:Email="lassila@w3.org" />
```

```
</rdf:Description>
```

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

Abbreviated syntax used

Containers



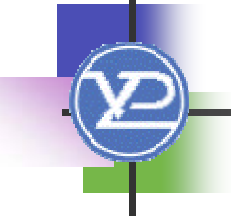
- Frequently it is necessary to refer to a collection of resources. RDF *containers* are used to hold such lists of resources or literals. There are three types of a container:
 - bag
 - sequence
 - alternative

Container Syntax



[18] container	::= sequence bag alternative
[19] sequence	::= '<rdf:Seq' idAttr? '>' member* '</rdf:Seq>'
[20] bag	::= '<rdf:Bag' idAttr? '>' member* '</rdf:Bag>'
[21] alternative	::= '<rdf:Alt' idAttr? '>' member+ '</rdf:Alt>'
[22] member	::= referencedItem inlineItem
[23] referencedItem	::= '<rdf:li' resourceAttr '/>'
[24] inlineItem	::= '<rdf:li>' value '</rdf:li>'

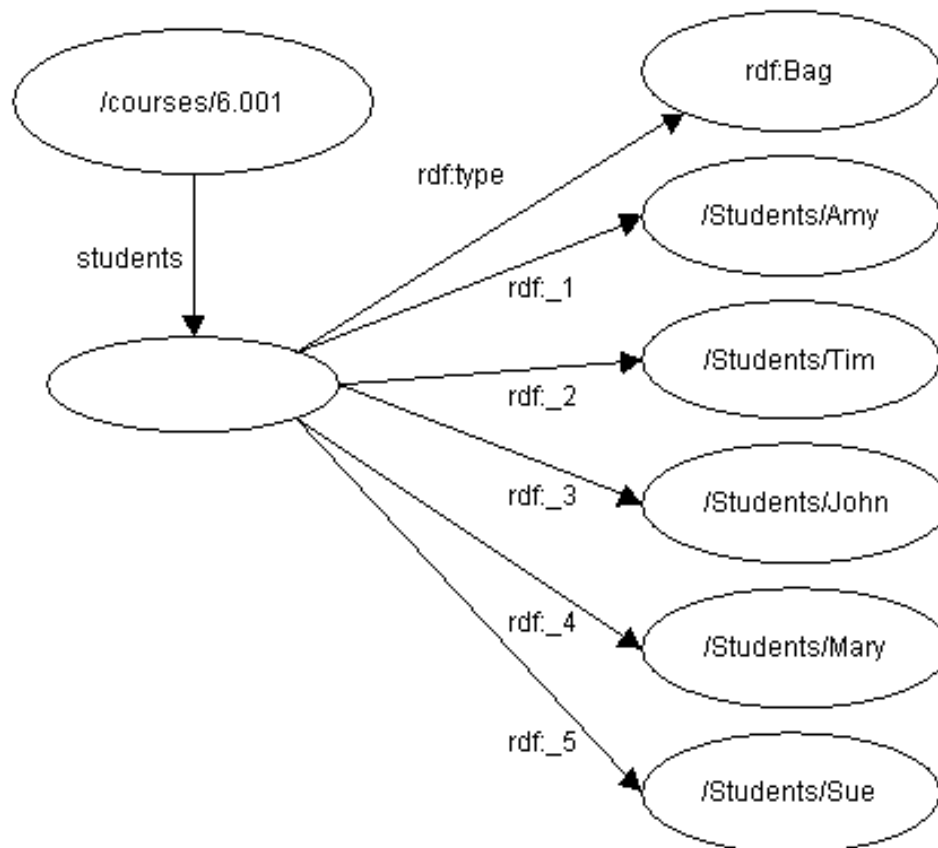
Containers. Bag.

- 
- An unordered list of resources or literals.
 - Bags are used to declare that a property has multiple values and that there is no significance to the order in which the values are given.
 - Bag might be used to give a list of part numbers where the order of processing the parts does not matter. Duplicate values are permitted.

Bag Example (1)

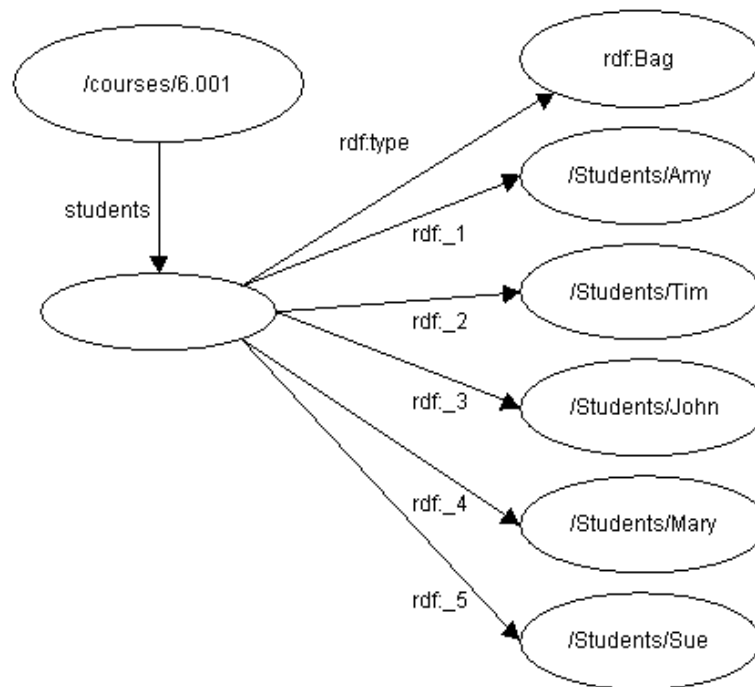


The students in course 6.001 are Amy, Tim, John, Mary, and Sue




Bag Example (2)

The graph has eight nodes and seven arcs. The first node is the resource [/courses/6.001](#). An arc labelled `students` connects this node to an unnamed node. An arc labelled `rdf:type` connects the unnamed node to a node labelled `rdf:Bag`. Five additional arcs labelled `rdf:_1`, `rdf:_2`, `rdf:_3`, `rdf:_4`, and `rdf:_5` connect the unnamed node to nodes labelled, respectively, [/Students/Amy](#), [/Students/Tim](#), [/Students/John](#), [/Students/Mary](#), and [/Students/Sue](#). All the nodes are represented as ovals.



Bag Example (3)



The students in course 6.001 are Amy, Tim, John, Mary, and Sue

```
<rdf:RDF>
```

```
<rdf:Description rdf:about="http://mycollege.edu/courses/6.001">
```

```
<s:students>
```

```
<rdf:Bag>
```

```
<rdf:li rdf:resource="http://mycollege.edu/students/Amy"/>
```

```
<rdf:li rdf:resource="http://mycollege.edu/students/Tim"/>
```

```
<rdf:li rdf:resource="http://mycollege.edu/students/John"/>
```

```
<rdf:li rdf:resource="http://mycollege.edu/students/Mary"/>
```

```
<rdf:li rdf:resource="http://mycollege.edu/students/Sue"/>
```

```
</rdf:Bag>
```

```
</s:students>
```

```
</rdf:Description>
```

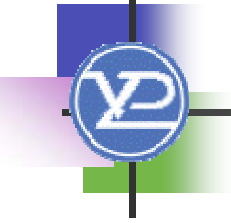
```
</rdf:RDF>
```



Containers. Sequence.

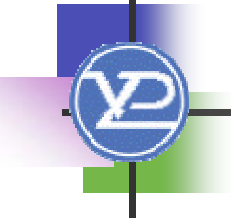
- An ordered list of resources or literals.
- Sequence is used to declare that a property has multiple values and that the order of the values is significant.
- Sequence might be used, for example, to preserve an alphabetical ordering of values.
- Duplicate values are permitted.

Sequence Example



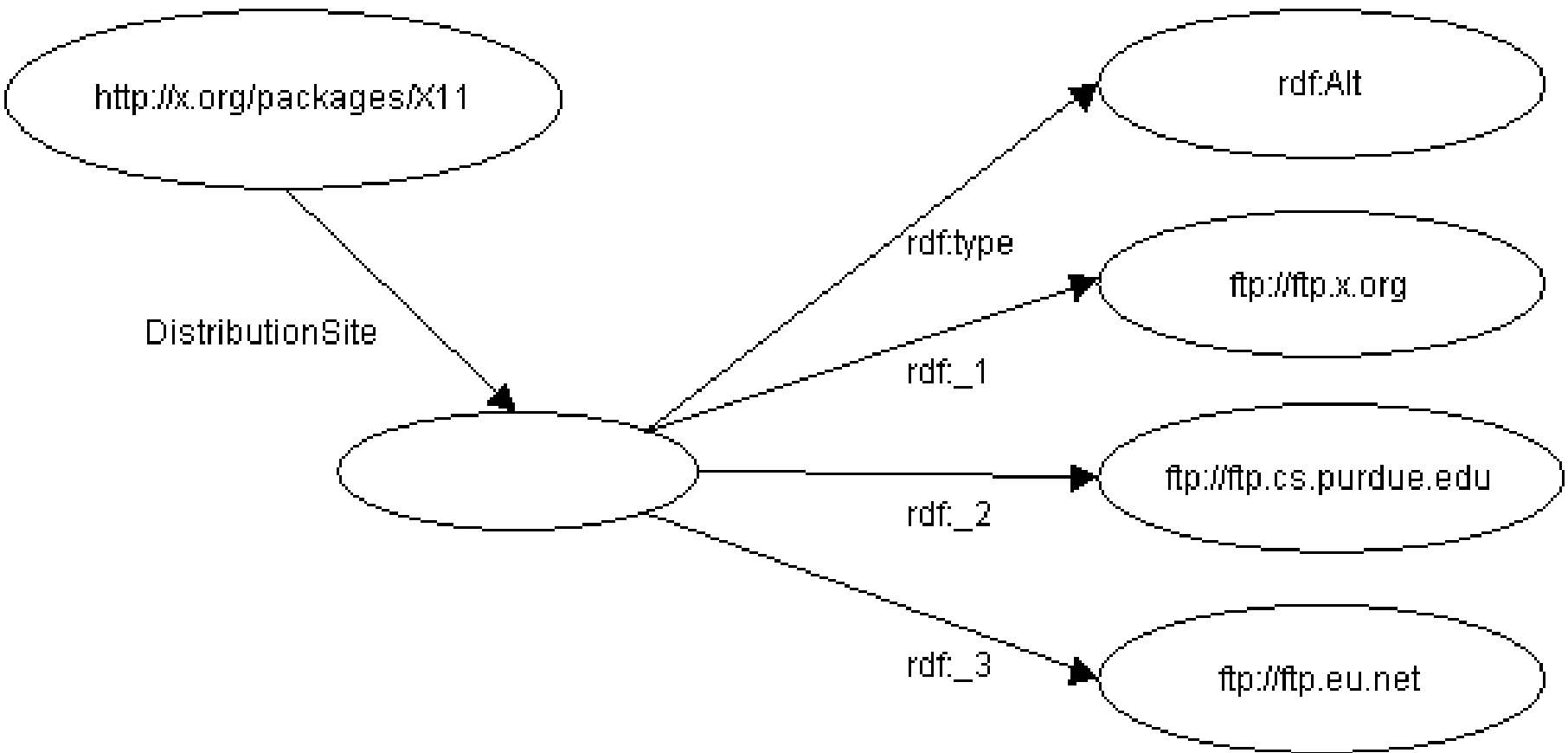
```
<rdf:RDF>
  <rdf:Description rdf:about="...">
    <s:students>
      <rdf:Seq>
        <rdf:li rdf:resource="..." />
        <rdf:li rdf:resource="..." />
        <rdf:li rdf:resource="..." />
      </rdf:Seq>
    </s:students>
  </rdf:Description>
</rdf:RDF>
```

Containers. Alternative.


- 
- A list of resources or literals that represent alternatives for the (single) value of a property.
 - An application using a property whose value is an *Alternative collection* is aware that it can choose any one of the items in the list as appropriate.

Alternative Example (1)

The source code for X11 may be found either at [ftp.x.org](ftp://ftp.x.org) or [ftp.cs.purdue.edu](ftp://ftp.cs.purdue.edu), or [ftp.eu.net](ftp://ftp.eu.net)



Alternative Example (2)



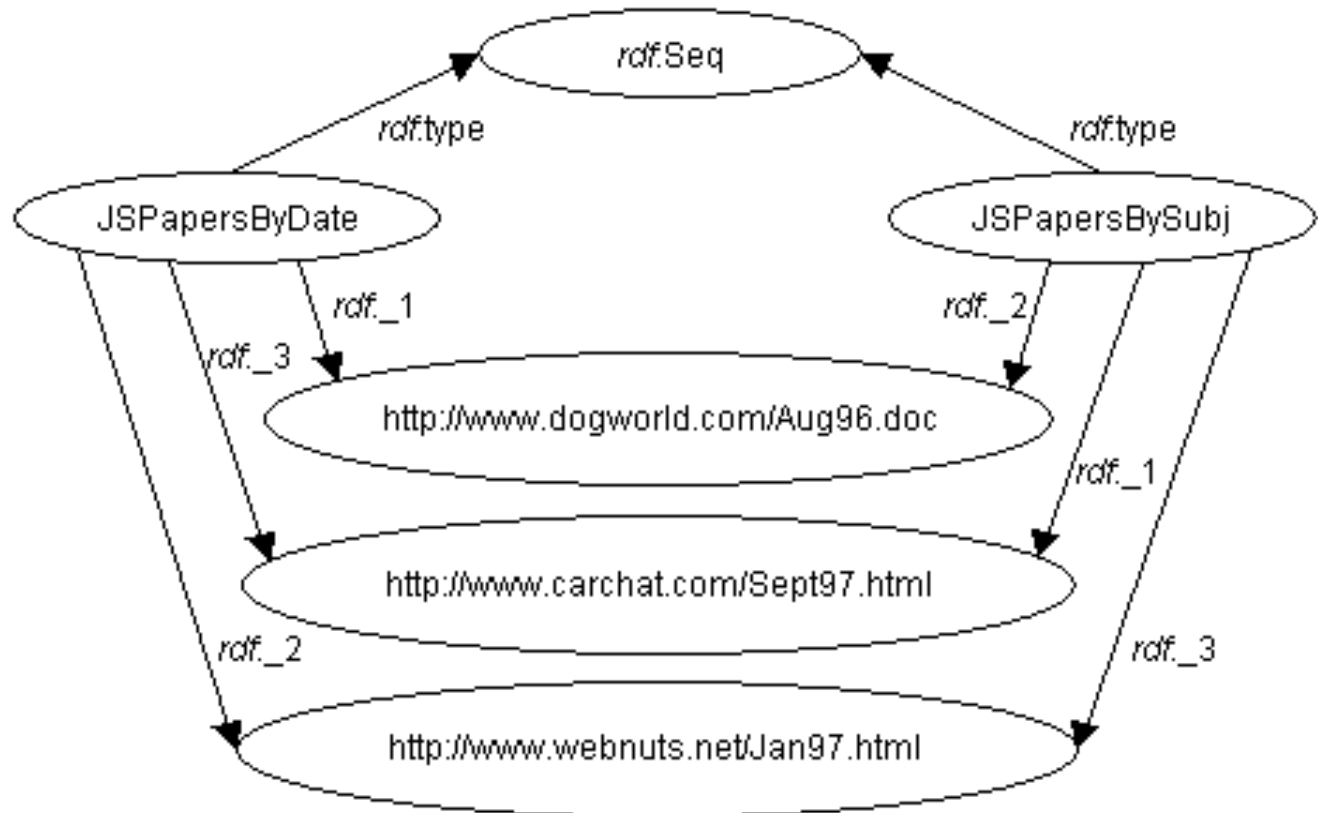
The source code for X11 may be found either at [ftp.x.org](ftp://ftp.x.org) or [ftp.cs.purdue.edu](ftp://ftp.cs.purdue.edu), or [ftp.eu.net](ftp://ftp.eu.net)

```
<rdf:RDF>
  <rdf:Description rdf:about="http://x.org/packages/X11">
    <s:DistributionSite>
      <rdf:Alt>
        <rdf:li rdf:resource="ftp://ftp.x.org"/>
        <rdf:li rdf:resource="ftp://ftp.cs.purdue.edu"/>
        <rdf:li rdf:resource="ftp://ftp.eu.net"/>
      </rdf:Alt>
    </s:DistributionSite>
  </rdf:Description>
</rdf:RDF>
```


Sharing Values between Sequences (1)



Consider the case of specifying 3 collected works of an author, sorted once by publication date and sorted again alphabetically by subject.



Sharing Values between Sequences (2)

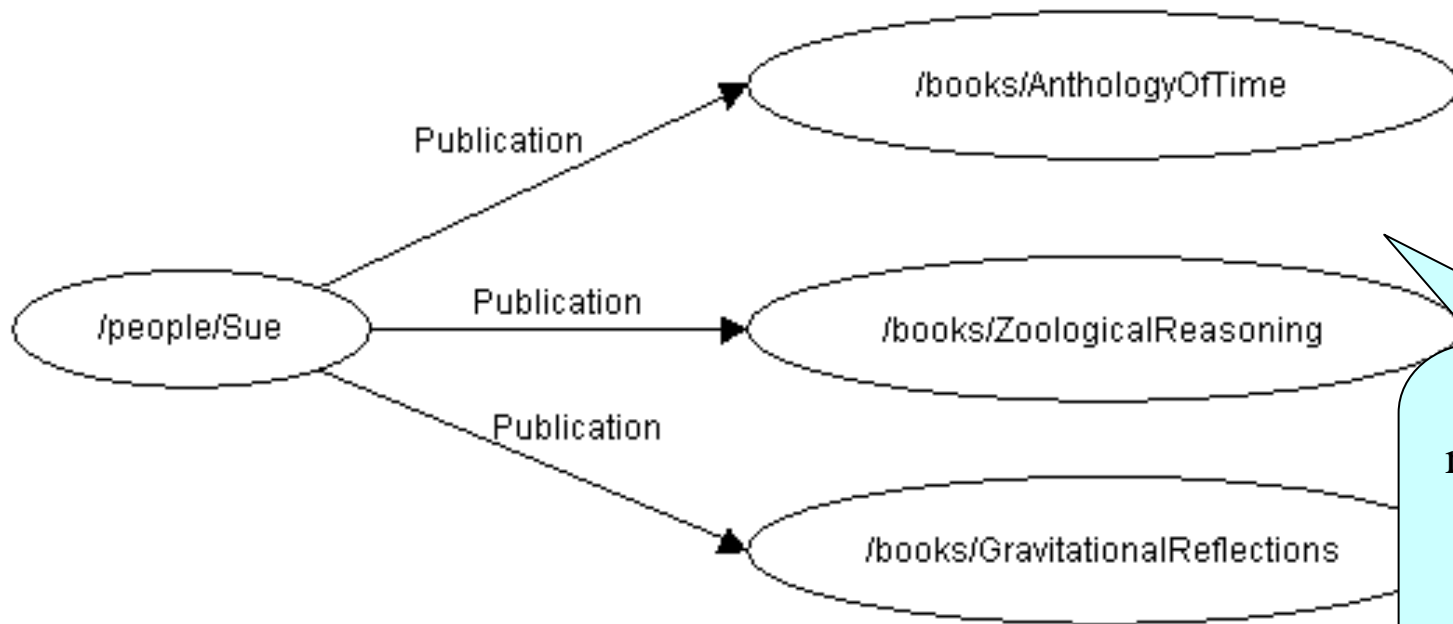


```
<rdf:RDF xmlns="http://w3.org/TR/1999/PR-rdf-syntax-19990105#">
  <rdf:Seq rdf:ID="JSPapersByDate">
    <rdf:li resource="http://www.dogworld.com/Aug96.doc"/>
    <rdf:li resource="http://www.webnuts.net/Jan97.html"/>
    <rdf:li resource="http://www.carchat.com/Sept97.html"/>
  </rdf:Seq>
  <rdf:Seq rdf:ID="JSPapersBySubj">
    <rdf:li resource="http://www.carchat.com/Sept97.html"/>
    <rdf:li resource="http://www.dogworld.com/Aug96.doc"/>
    <rdf:li resource="http://www.webnuts.net/Jan97.html"/>
  </rdf:Seq>
</rdf:RDF>
```

Containers vs. Repeated Properties (1)



Sue has written "Anthology of Time", "Zoological Reasoning", "Gravitational Reflections".

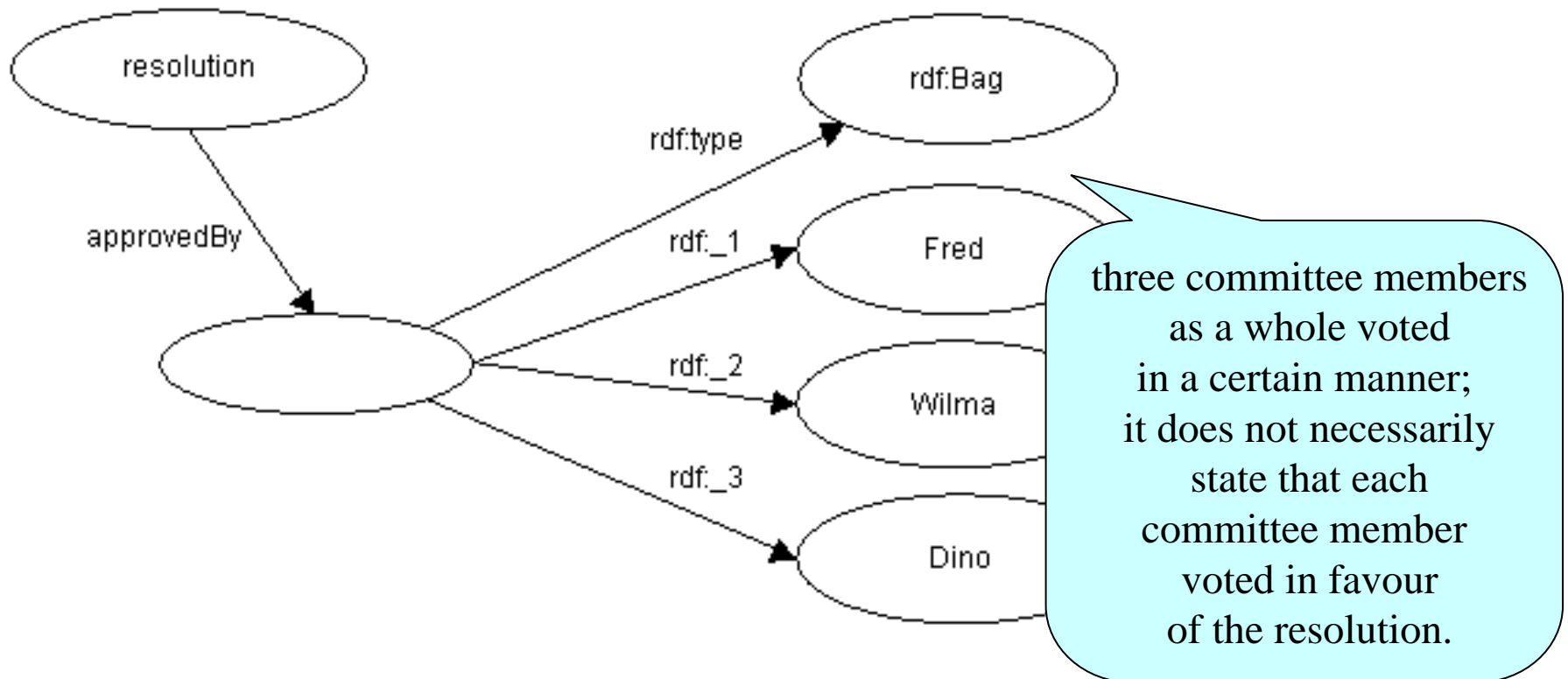


There is no stated relationship between the publications other than that they were written by the same person

Containers vs. Repeated Properties (2)



The committee of Fred, Wilma, and Dino approved the resolution.



Statements about Statements (1)



- For example, let us consider the sentence:

“Ora Lassila is the creator of the resource <http://www.w3.org/Home/Lassila>”.

- RDF would regard this sentence as a fact. If, instead, we write the sentence:

“Alexandra Vitko says that Ora Lassila is the creator of the resource <http://www.w3.org/Home/Lassila>”

- ... we have said nothing about the resource <http://www.w3.org/Home/Lassila>; instead, we have expressed a fact about a **statement** Alexandra Vitko has made.

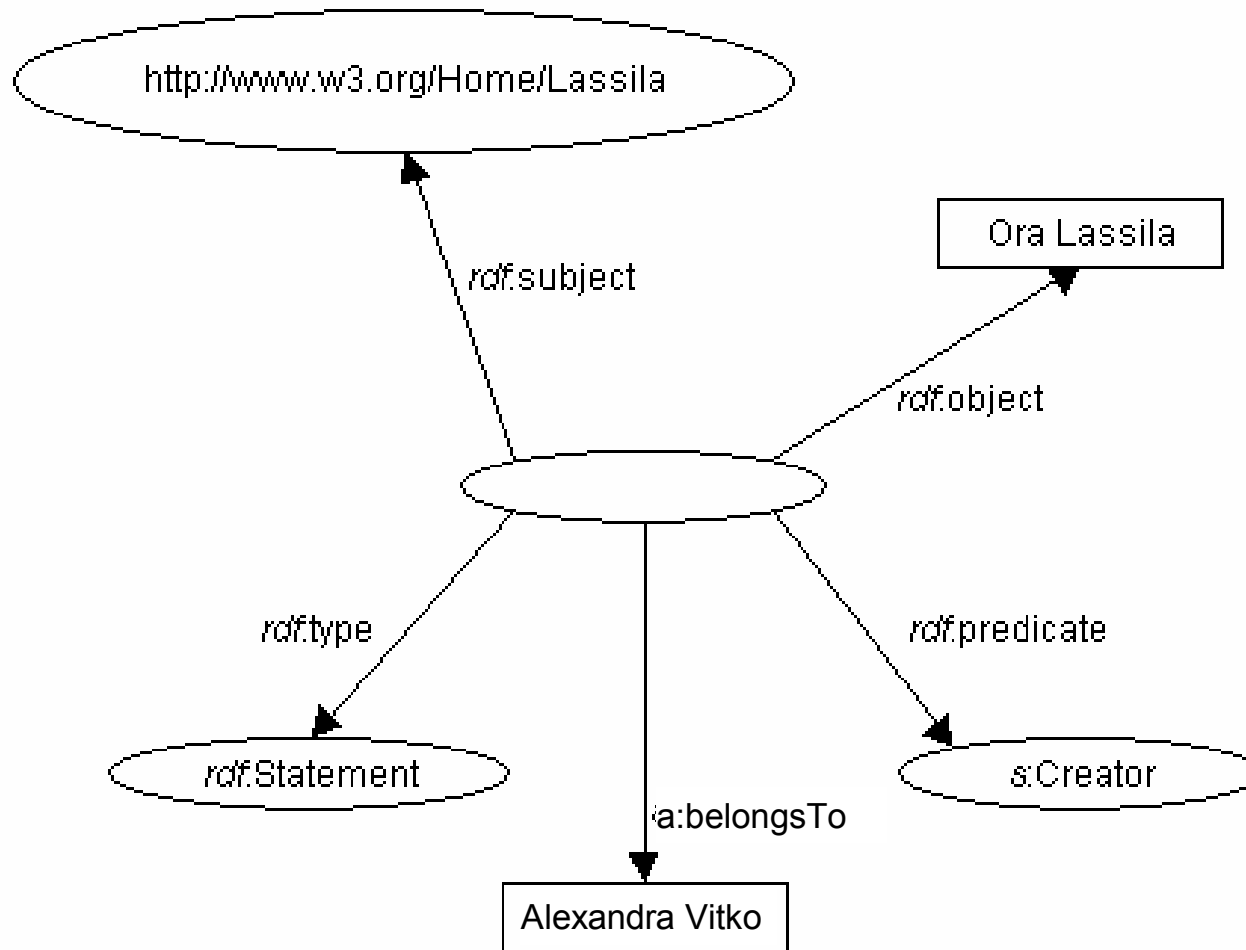
Statements about Statements (2)



- To model **statements** RDF defines the following properties:
 - **subject**
 - The subject property identifies the resource being described by the modelled statement; that is, the value of the subject property is the resource about which the original statement was made (e.g., <http://www.w3.org/Home/Lassila>).
 - **predicate**
 - The predicate property identifies the original property in the modelled statement. The value of the predicate property is a resource representing the specific property in the original statement (in our example, [creator](#)).
 - **object**
 - The object property identifies the property value in the modelled statement. The value of the object property is the object in the original statement (in our example, "[Ora Lassila](#)").
 - **type**
 - The value of the type property describes the type of the new resource. All reified statements are instances of [RDF:Statement](#); that is, they have a type property whose object is [RDF:Statement](#).

Example (1)

“Alexandra Vitko says that Ora Lassila is the creator of the resource <http://www.w3.org/Home/Lassila>”



Example (2)



“Alexandra Vitko says that Ora Lassila is the creator of the resource <http://www.w3.org/Home/Lassila>”

<rdf:RDF

xmlns:rdf="http://w3.org/TR/1999/PR-rdf-syntax-19990105#"
 xmlns:a="http://description.org/schema/">

<rdf:Description>

<rdf:subject rdf:resource="http://www.w3.org/Home/Lassila" />

<rdf:predicate rdf:resource="http://description.org/schema#Creator" />

<rdf:object>Ora Lassila</rdf:object>

<rdf:type rdf:resource="http://w3.org/TR/1999/PR-rdf-syntax-19990105#Statement" />

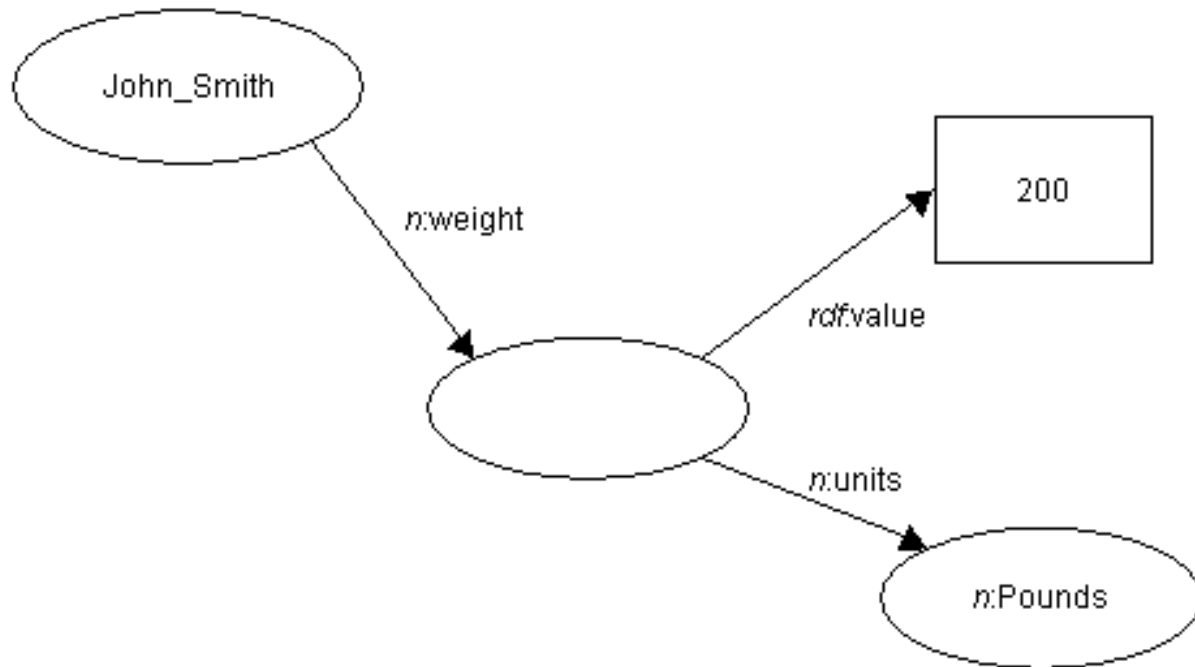
<a:belongsTo>Alexandra Vitko</a:belongsTo>

</rdf:Description>

</rdf:RDF>

Complex Values (1)

John Smith's weight is 200 pounds



Complex Values (2)



John Smith's weight is 200 pounds

<rdf:RDF

xmlns="<http://w3.org/TR/1999/PR-rdf-syntax-19990105#>"

xmlns:rdf="<http://w3.org/TR/1999/PR-rdf-syntax-19990105#>"

xmlns:n="<http://www.nist.gov/units/>">

<rdf:Description rdf:about="John_Smith">

<n:weight rdf:parseType="Resource">

<rdf:value>200</rdf:value>

<n:units rdf:resource="<http://www.nist.gov/units/Pounds>"/>

</n:weight>

</rdf:Description>

</rdf:RDF>

Read More in

World Wide Web Consortium

<http://www.w3.org/RDF/>