

# **Making the Web Machine-Readable: The Semantic Web**

**Recuperación de Información 2007  
Lecture 6.**

# Overview:

## Part I

- ◆ What is the „Semantic Web“?
- ◆ What is the „Semantic Web“ not?
- ◆ Why XML/XPath/XSLT is not enough
- ◆ RDF

## Part II

- ◆ SPARQL - Querying RDF
- ◆ RDFS and Ontologies

## Part III

- ◆ Where is the „Semantic Web“?
- ◆ Concrete applications

# What is the „Semantic Web“?

## ◆ What is the „Web“?

- Web =
  - ◆ HTTP (How to transfer data)
  - ◆ URI (How to address data?)
  - ◆ HTML (How to layout data?)

## ◆ The problem:

- Millions of different documents online:
  - ◆ How to find the right documents?
  - ◆ How to extract relevant information?
  - ◆ How to combine information from different sources?
  - ◆ Why do I have to do this at all? Why doesn't my computer do it for me? Why can't I just query the Web like a database?

# How to find the right documents?

Publikationen Polleres - Google-Suche - Mozilla Firefox

http://www.google.at/search?hl=de&q=Publikationen+Polleres&btnG=Suche&meta=

Google

Publikationen Polleres Suche

Suche:  Das Web  Seiten auf Deutsch  Seiten aus Österreich

Web Ergebnisse 1 - 10 von ungefähr 134 für **Publikationen Polleres**. (0,36 Sekunden)

Tip: [Suchen nur nach Ergebnissen auf Deutsch](#). Sie können Ihre bevorzugten Spracheinstellungen in [Einstellungen](#) angeben.

[Institut AIFB - Publikationen von Projekt](#) - [ [Diese Seite übersetzen](#) ]  
**Publikationen** zu dem Projekt SmartWeb. article ... Jos de Bruijn, Dieter Fensel, Pascal Hitzler, Michael Kifer, Axel **Polleres** ...  
[www.aifb.uni-karlsruhe.de/Publikationen/showPublikationenProjekt?id\\_db=50](http://www.aifb.uni-karlsruhe.de/Publikationen/showPublikationenProjekt?id_db=50) - 42k - [Im Cache](#) - [Ähnliche Seiten](#)

[Institut AIFB - Publikationen](#) - [ [Diese Seite übersetzen](#) ]  
**Publikationen** von Pascal Hitzler. Link zu den älteren **Publikationen** ... Jos de Bruijn, Dieter Fensel, Pascal Hitzler, Michael Kifer, Axel **Polleres** ...  
[www.aifb.uni-karlsruhe.de/Publikationen/showPublikationen?id\\_db=2084](http://www.aifb.uni-karlsruhe.de/Publikationen/showPublikationen?id_db=2084) - 39k - [Im Cache](#) - [Ähnliche Seiten](#)  
[ [Weitere Ergebnisse von www.aifb.uni-karlsruhe.de](#) ]

[Publikationen Institut für klinische Onkologie und photodynamische ...](#) - [ [Diese Seite übersetzen](#) ]  
Institut für klinische Onkologie und photodynamische Therapie, **Publikationen** 2003  
... Ulsperger, E., Fürnhammer, M., Weimar, A., Maca, S., **Polleres**, S., ...  
[www.ludwigboltzmann.at/institute/publikationen.php?year=2003&a\\_id=58](http://www.ludwigboltzmann.at/institute/publikationen.php?year=2003&a_id=58) - 14k - [Im Cache](#) - [Ähnliche Seiten](#)

[Publikationen Institut für klinische Onkologie und photodynamische ...](#) - [ [Diese Seite übersetzen](#) ]  
Institut für klinische Onkologie und photodynamische Therapie, **Publikationen** 2004  
... Ulsperger, E., **Polleres**, S., Benold, U., Prasch, F., Geissler, K., ...  
[www.ludwigboltzmann.at/institute/publikationen.php?year=2004&a\\_id=58](http://www.ludwigboltzmann.at/institute/publikationen.php?year=2004&a_id=58) - 11k - [Im Cache](#) - [Ähnliche Seiten](#)

[Publikationen / Publications](#) - [ [Diese Seite übersetzen](#) ]  
**Publikationen**. **Publikationen** der Jahre 1992 - heute · Bachelorarbeiten und Studienarbeiten ... Daniel Olmedilla, Rubén Lara, Axel **Polleres**, Holger Lausen ...

Fertig

Which links show publications of Axel?

Why is my publications page not found?

<http://www.polleres.net/publications.html>

because I used German :-/

# How to extract relevant information?

The screenshot shows the Amazon website search results for the keyword 'web'. The browser window title is 'Amazon.com: All Products Search Results: web - Mozilla Firefox'. The search bar contains 'web' and the results are for 'web'. The first result is 'Professional Web Site Design from Start to Finish' by Anne-Marie Conception, a paperback book from January 2002. The price is \$23.10. The second result is 'Web Design in a Nutshell' by Jennifer Niederst, a paperback book. The price is \$19.77. The third result is 'Motorola ROKR E1 iTunes Phone (Cingular)', a cell phone with a list price of \$399.99 and a current price of \$149.99. The fourth result is 'Lipovarin - 150 Caps - Weight Loss Diet Pills' by Sterling Grant Laboratories, a health and personal care product. Red circles highlight the book titles and prices, and red arrows point from the text on the right to these elements.

Amazon.com: All Products Search Results: web - Mozilla Firefox

http://www.amazon.com/exec/obidos/search-handle-url/index=blended&field-keywords=web&pg=1/ref=s\_b\_xs\_ap\_

amazon.com Your Store See All 32 Product Categories Your Account | Cart | Wish List

Search Amazon.com web GO

Results for: web

Related Searches: [web design](#); [internet](#); [web development](#)

**Professional Web Site Design from Start to Finish** by Anne-Marie Conception (Paperback - January 2002)

Books: [See all 15,814 items](#) (Rate this item)

Buy new: **\$23.10** Used & new from **\$20.00** Usually ships in 5 to 10 days

Excerpt from Page 16: "... the Internet and surf the **Web** if you want to design ..."

See more references to **web** in this book.

Surprise me! See a random page in this book.

**Web Design in a Nutshell** by Jennifer Niederst (Paperback)

Books: [See all 2,074 items](#) (Rate this item)

Buy new: **\$19.77** Used & new from **\$8.40** Usually ships in 5 to 10 days

**Motorola ROKR E1 iTunes Phone (Cingular)**

Cell Phones: [See all 101 items](#) (Rate this item)

List Price: ~~\$399.99~~

Our Price: **\$149.99** (when purchased with new service plan)

You Save: **\$250.00** (63%)

Special Offers: **\$150.00**

Price After Special Offers: **Free**

Usually ships in 2 to 3 days

**Lipovarin - 150 Caps - Weight Loss Diet Pills** Sterling Grant Laboratories

Health & Personal Care (Beta): [See all 9,309 items](#) (Rate this item)

What here is a book about the Web?

What is the price?

# How to combine information from different sources?

Amazon.com: All Products Search Results: A semantic web primer - Mozilla Firefox

http://www.amazon.com/exec/obidos/search-handle-form/002-2531806-5064000

amazon.com Your Store See All 32 Product Categories Your Account | Cart | Wish List | Help |

Search Amazon.com A semantic web primer GO Find Gifts Web Search GO

Results for: A semantic web primer

Refine your search:  
Find A semantic web primer in these categories:  
Books (23)

**A Semantic Web Primer (Cooperative Information Systems)** by Grigoris Antoniou, Frank van Harmelen (Hardcover)  
Books: [See all 23 items](#) (Rate this item)  
Buy new: **\$34.82** Used & new from **\$29.95** Usually ships in 24 hours

I want the cheapest offer for „A Semantic Web Primer“?

Barnes & Noble.com - Book Search: a semantic Web primer - Mozilla Firefox

http://search.barnesandnoble.com/booksearch/results.asp?WRD=a+sem.

FAST & FREE DELIVERY  
DELIVERY IN 3 DAYS OR LESS  
PLUS  
FREE SHIPPING  
On Orders of \$25 or More  
SEE DETAILS >

SEARCH RESULTS  
We found 1 title with the keywords "a semantic Web primer."

1. **A Semantic Web Primer**  
Grigoris Antoniou, Frank Van Harmelen

Format: **Textbook Hardcover**  
Pub. Date: July 2004

**NEW FROM B&N**  
B&N Price: \$40.00  
**Member Price: \$36.00**  
[Become a B&N Member](#)  
Save 10% off the B&N price every day.

**Usually ships within 24 hours**

# How to combine information from different sources? Why do I have to do this at all? Why doesn't my computer do it for me?

The image shows two overlapping browser windows from Amazon.com. The top window displays search results for 'A semantic web primer'. The bottom window shows the checkout process, including shipping details and an order summary. A red arrow points from the search results to the shipping details section.

**Search Results:**

- Search: Amazon.com
- Results for: A semantic web primer
- Refine your search: Find A semantic web primer in these categories: Books (23)
- Product: A Semantic Web Primer by Antoniou, T. Buy new: \$34.82

**Checkout Page:**

- Page: Amazon.com Checkout: Place Your Order
- URL: https://www.amazon.com/gp/checkout/
- Buttons: SIGN IN, SHIPPING & PAYMENT, GIFT-WRAP, PLACE ORDER
- Text: Please review and submit your order. By placing your order, you agree to Amazon.com's privacy notice and conditions of use.
- Text: If placing a Marketplace order you are also agreeing to the Marketplace Participation Agreement
- Text: Review the information below, then click "Place your order."
- Table: Shipping Details and Order Summary

Shipping Details		Order Summary	
Shipping to:	<a href="#">Change</a>	Items:	\$34.82
Axel Polleres Dreiheiligenstrasse 3 Innsbruck, Tirol 6020 Österreich		Shipping & Handling:	\$8.98
Shipping Options:	<a href="#">Learn more</a>	Total Before Tax:	\$43.80
Ordering for the holidays? Your items will ship on time.		Estimated Tax:	\$0.00
		<b>Order Total: \$43.80</b>	
		<a href="#">Why didn't I qualify for FREE Super Saver Shipping?</a>	

I want the cheapest offer for „A Semantic Web Primer“ including shipping costs?

- 10 interaction „clicks“ until I get to the actual shipping costs...

# Semantic Web: The idea

- The Web (HTML) presents knowledge in
    - ◆ natural language (Spanish, German, Englisch, Hungiaran, Chinese,...)
    - ◆ Grafics, Multimedia, Layout
  - Humans can (combining these pages with their **background knowledge**):
    - ◆ deduce facts facts from incomplete information
    - ◆ draw connections, detect similarities
  - But...
    - ◆ Computers cannot do this:
      - incomplete information is useless
      - drawing connections only possible if rules are avaiable as a program
      - Problems with combining information:
        - Is <foo:creator> the same as <bar:author>?
        - How do I combine data from different XML Trees?
- Idea: Make machine understandable meta-information explicit!!! Effect: If everybody does that, the Web can be uses as a huge database!



# Meta-Data and Meta-Meta-data:

## Meta-Meta-Data:



### Meta-Data:

This page was created by Axel Polleres

Axel Polleres is a researcher

Axel Polleres worked for DERI

This is the telephone number of Axel Polleres

Researchers working at DERI know about the Semantic Web.

If someone knows about the Semantic Web, he/she also knows about RDF.

### A possible query to the Semantic Web:

We need someone who knows about RDF for a lecture at URJC

We need the Meta- und Meta-meta-Data available in **machine-readable Form!**

# What is the „Semantic Web“?

- ◆ Semantic Web = Web plus "meaning".
- ◆ *"If HTML and the Web made all the online documents look like one huge **book**, RDF, schema and inference languages will make all the data in the world look like one huge **database**,"*
  - *Tim Berners-Lee, Weaving the Web, 1999*
- ◆ *"The "Semantic Web" ist a meta-data based infrastructure to draw conclusions from the Web. It **extends** the Web but will not replace it."*
  - Klaus Birkenbihl, W3C German-Austrian office
- ◆ That means:
  - Meta-Data, which describes the content of Websites, Databases, Libraries by **standardised vocabularies** (RDF)
  - Ontologies, i.e. meta-meta-Data, which describes the structure and connections of this meta-Data (RDFS/OWL)
  - Intelligent inference machines on top (something like a "database engine for metadata")

# What is the „Semantic Web“ not (yet)?

## ◆ “Artificial Intelligence for the Web”

- Although it uses logics and inference techniques...
- ... more down-to-earth
- It deals with proper representation, description and processing of metadata
- But: AI techniques *can use* SW metadata! (next step)

## ◆ “A purely academic research area”

- Many applications already exist (see examples later)
- „big players“ in industry use Semantic Web Technologies (Oracle, Sun, Adobe, HP, IBM, Nokia, Vodaphone, ...)
- E.g. EU-Projects with lots of industrial partners (SAP, IBM, BT, etc.)

# Why are XML/XPath/XSLT not enough?

- ◆ In XML, metadata can be expressed by element and attribute names... what more would I need?
- ◆ Problem:
  - XML ist ambiguous
  - XML doesn't prescribe an agreed convention for how to describe meta-data.
  - Parsing depends on the structure (expressed in DTD or XML Schema)
  - I cannot describe meta-meta information (e.g. every `<foo:creator>` is a `<bar:author>`)

“The **author** of ‘<http://www.polleres.net/index.html>’ is **Axel Polleres**.”

What is the “**right**” translation to XML?

```
<document href="index.html">
  <author>Axel Polleres</author>
</document>
```

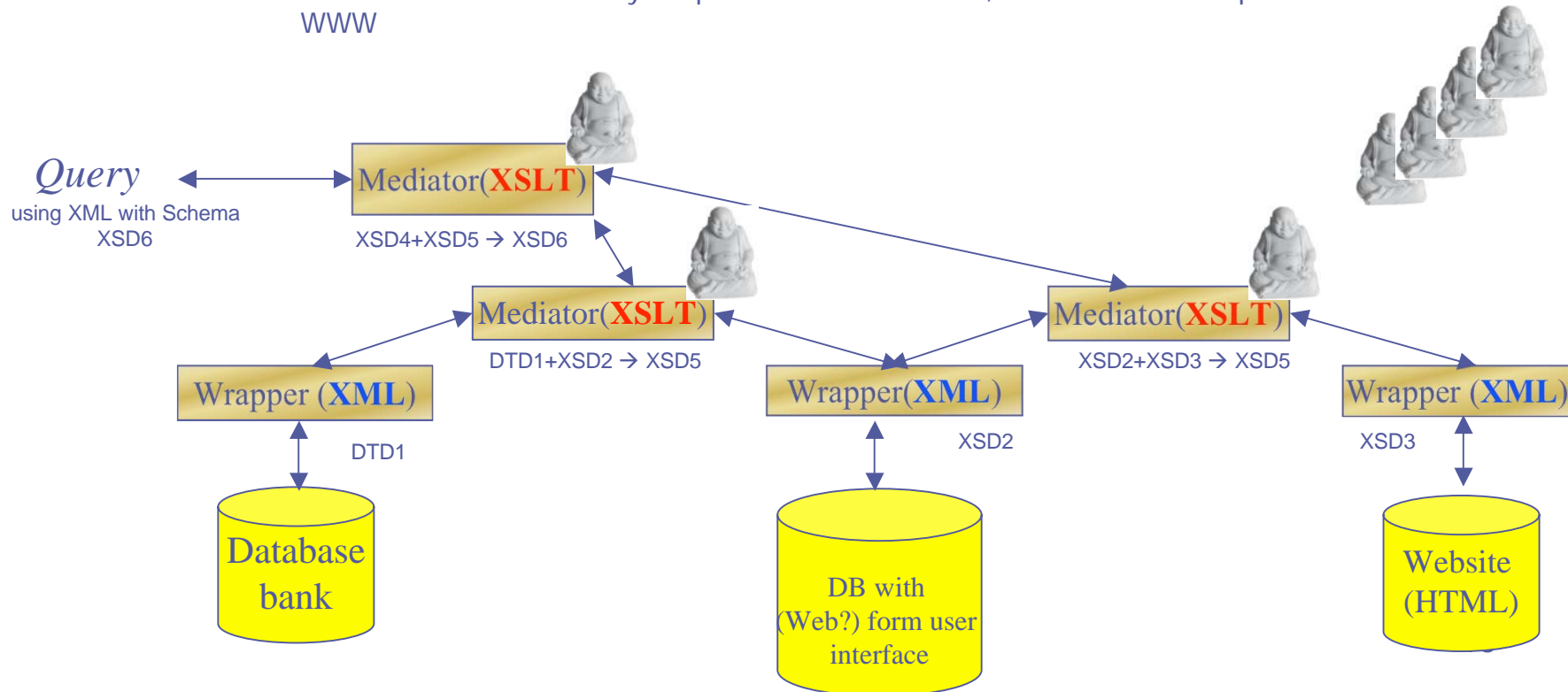
...

```
<author>
  <firstName>Axel</firstName>
  <lastName>Polleres</lastName>
  <documents>
    <uri>
      http://www.polleres.net/index.html
    </uri>
  </documents>
</author>
```

# How could a semantic Web based on pure XML look like?

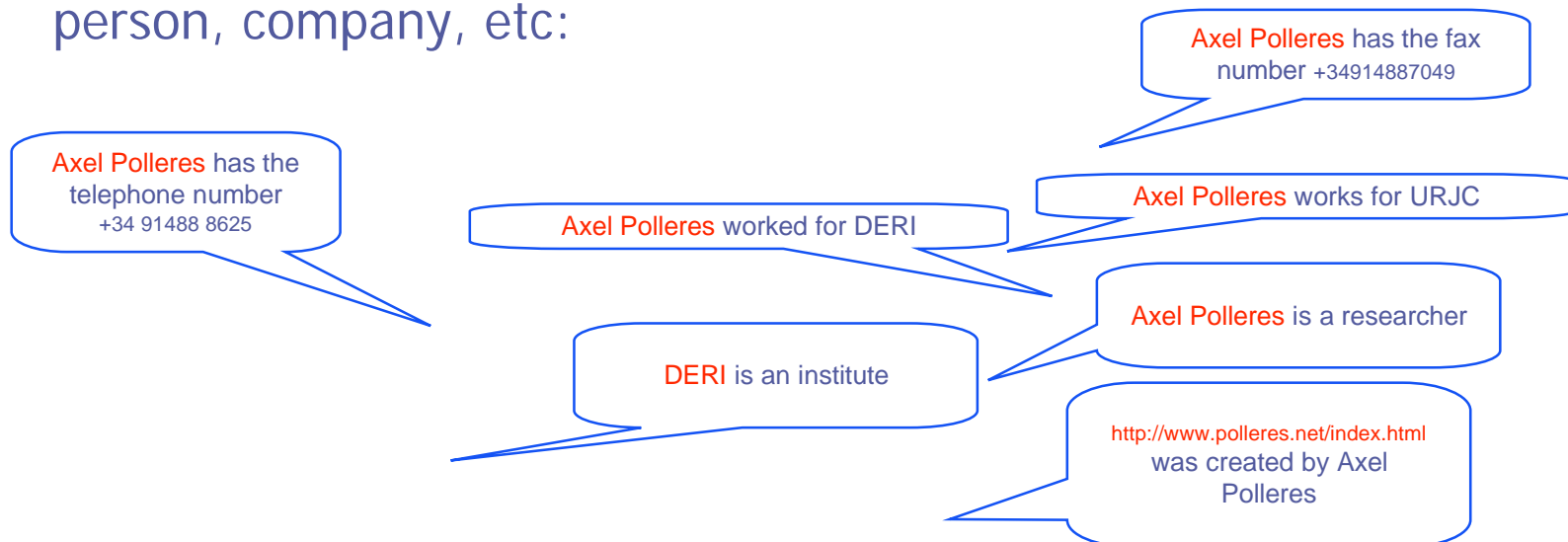
Possible "engineering" solution for the integration problem:

- ◆ Develop wrappers and mediators, using XML+XSLT
- ◆ ie. wrappers and XSLT-mediators for ANY POSSIBLE combination of data sources!
- ◆ Advantage:
  - ◆ unified format (XML)
  - ◆ simple language to describe transformations (XSLT)
- ◆ Disadvantage:
  - ◆ Doesn't scale to the Web!.
  - ◆ XML Documents are strictly coupled to the translations, it contradicts the open architecture of the WWW



# RDF – The Resource Description Framework

- ◆ Allows description of „Resources“
- ◆ A resource is not necessarily a web accessible document, but could also be e.g. a person, a company, a service, etc.
- ◆ Meta-data in RDF consists of a set of „statements“
- ◆ Each statement is about a **resource**
- ◆ Our example from before: meta-data to describe a website, person, company, etc:



# RDF Basics

- ◆ Statements can (mathematically) be expressed by triples:

Notation: **s** **p** **o**.

für **S**ubject, **P**rädikat, **O**bjekt, z.B.

**AxelPolleres** **worksFor** URJC.

You can also think of a triple as an attribute/value pair for a resource

- ◆ *RDF* is a general model for statements:
  - ... with machine-readable syntax (e.g., RDF/XML, Turtle, n3, ...)
  - RDF/XML is the “official” Metadata-format promoted by the (W3C)
  - thus on the same level as standards like HTML,XML!

# RDF data model:

<a href="http://www.polleres.net/page.html">http://www.polleres.net/page.html</a>	dc:creator	<a href="http://www.polleres.net/foaf.rdf#me">http://www.polleres.net/foaf.rdf#me</a> .
<a href="http://www.polleres.net/foaf.rdf#me">http://www.polleres.net/foaf.rdf#me</a>	foaf:name	"Axel Polleres".

## ◆ Resources

- objects identified by a URI (**U**niform **R**esource **I**dentifier)
- all things can have a URI, not only Web documents!
- z.B. "<http://www.deri.org/deri>", "<http://www.w3c.org/RDF>", "<http://www.polleres.net/index.html>", "<http://www.polleres.net/foaf.rdf#me>"
- Namespaces/URIs help to guarantee that people use unique ids for objects they describe.

## ◆ Properties:

- attributes or relations, a property can itself be a resource
- e.g. ex2:Lives-In, ex1:hasColor, **org:worksFor**, rdf:type, xyz:includedIn, **dc:creator**, foaf:name \*

## ◆ Statements: triple **<s,p,o>** for subject, predicate, Object, where

- **S: resource** (or blank node)
- **P: property**
- **O: resource or literal** (or blank node)
  - ◆ literals are strings, numeric values, or XML-fragments  
z.B. "Axel Polleres", "1"^^xsd:integer, <article><artNr>01024</artNr><Name>chocolate</Name></article>

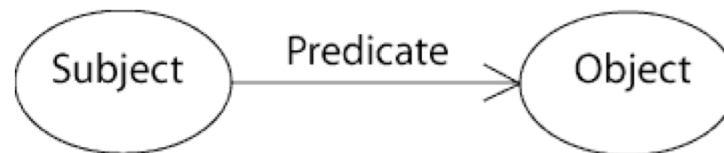
\* The notation prefix:name is an abbreviation for the full URI in RDF, e.g.. dc = <http://purl.org/dc/elements/1.1/>, i.e. **dc:creator** means in reality: <http://purl.org/dc/elements/1.1/creator> ... this is similar, to XML qnames (=namespace prefixed elements and attributes)



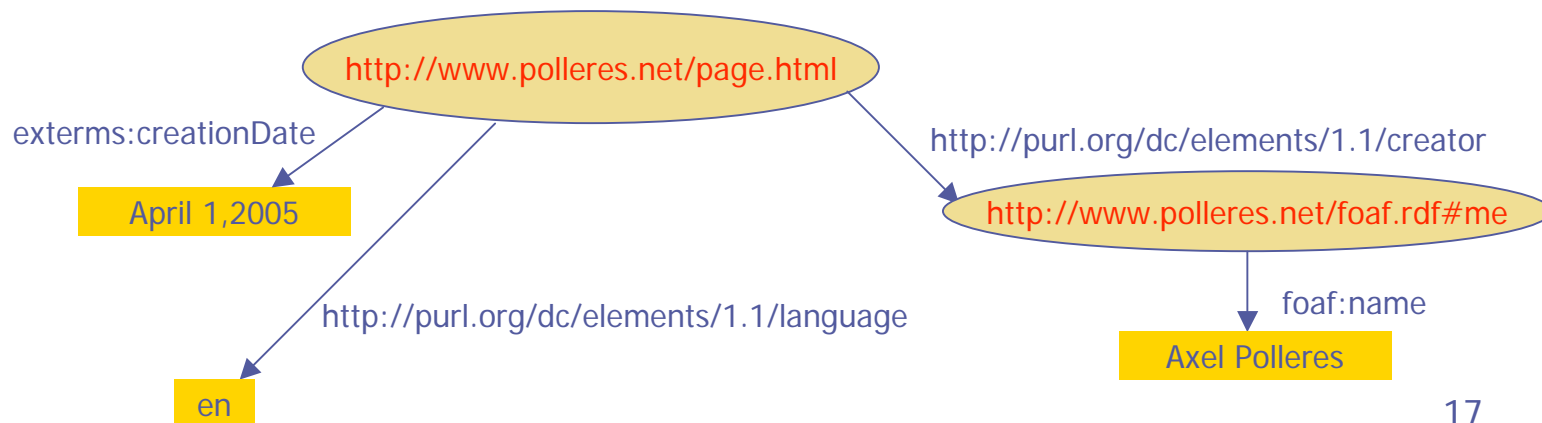
# RDF as a graph:

`http://www.polleres.net/page.html` `dc:creator` `http://www.polleres.net/foaf.rdf#me`.  
`http://www.polleres.net/foaf.rdf#me` `foaf:name` "Axel Polleres".  
`http://www.polleres.net/page.html` `dc:creationDate` "April 1,2004"  
`http://www.polleres.net/page.html` `http://purl.org/dc/elements/1.1/language` "en".

- ◆ You can view each triple as an edge in a graph...



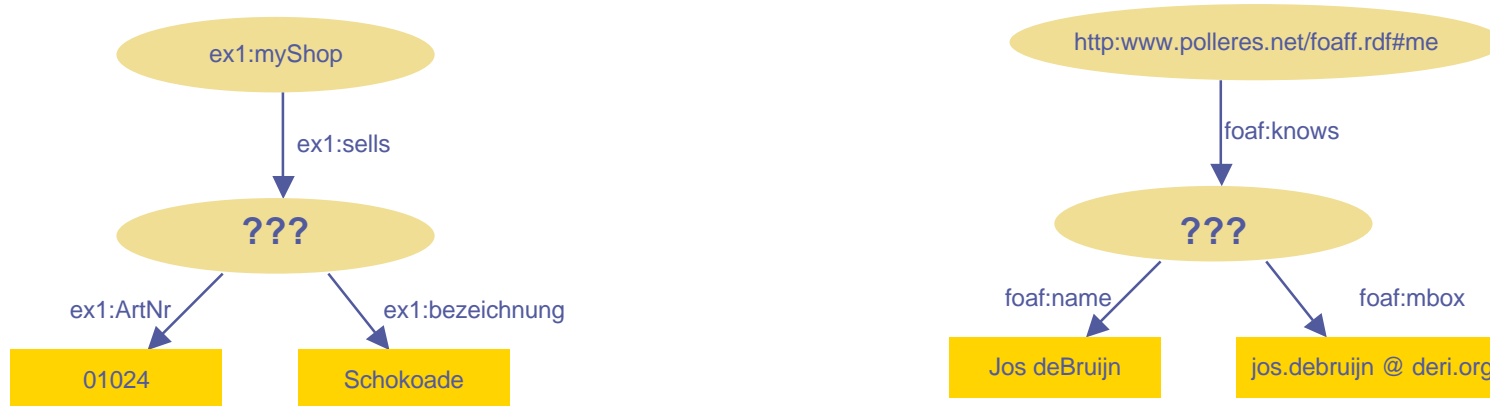
- ◆ ... and a set of triples as a graph.
- ◆ Graph notation is often more intuitive especially for tools:



# RDF Blank Nodes:

- ◆ z.B. statement with incomplete information:
  - „myShop sells the artikel with number 01024 and name 'chocolate' “
  - „Axel Polleres knows a person whose name is Jos DeBruijn and who has the email-address jos.debruijn@deri.org “

You cannot write such statements as single triples, but as a set of triples with "anonymous" nodes in the graph, sog. blank nodes:

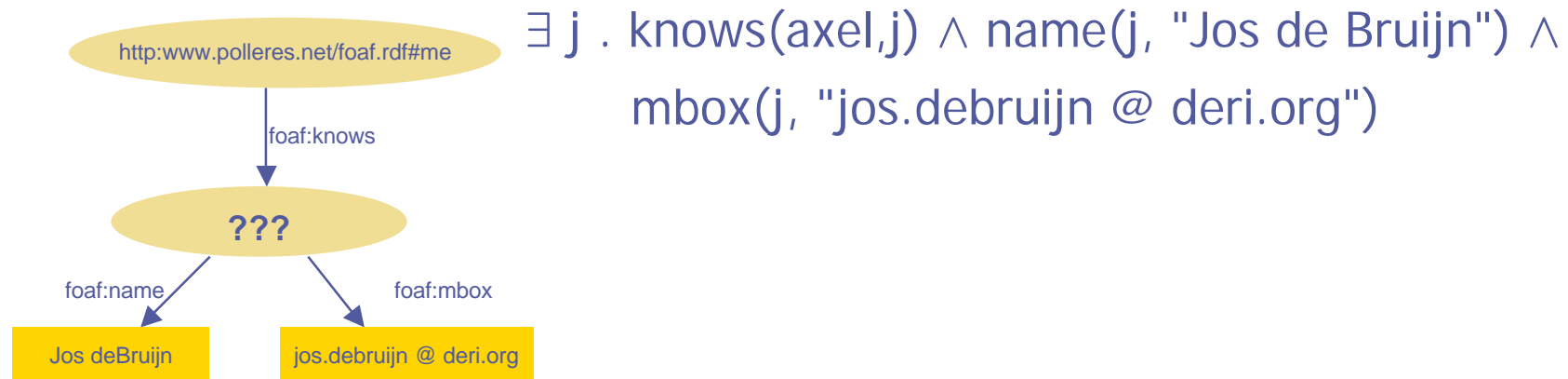


In triple-notation you have to give the anonymous nodes a label, here the prefix „\_:“ is used:

http://www.polleres.net/foaf.rdf#me	foaf:knows	_:jos.
_:jos	foaf:name	„Jos de Bruijn“.
_:jos	foaf:mbox	jos.debruijn@deri.org.

# RDF Blank Nodes:

- ◆ Note: A blank node is like an existential variable in first-order logic:



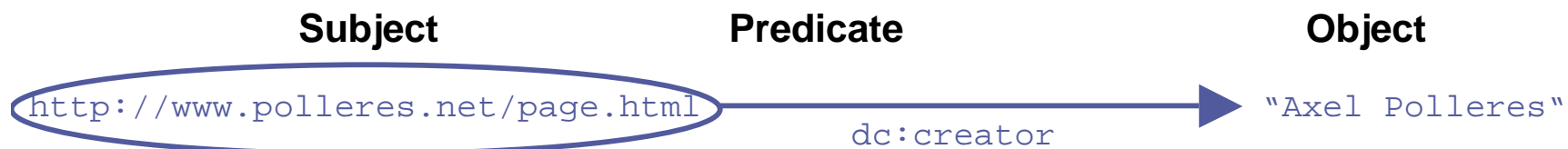
## 2 RDF syntaxes:

- ◆ A machine readable XML exchange syntax
  - <http://www.w3.org/TR/rdf-syntax-grammar/>
  
- ◆ Turtle - Terse RDF Triple Language
  - <http://www.dajobe.org/2004/01/turtle/>  
(for tools, editors, queries etc. writing down explaining RDF)

We start with the XML syntax, more on turtle later!

# RDF/XML:

- ❖ RDF written down as Triples or graph notation cannot be integrated in a webpage in a machine readable way...
- ❖ machine-readable exchange format is necessary: RDF/XML
- ❖ Example for RDF/XML Syntax:



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

  <rdf:Description rdf:about = "http://www.polleres.net/page.html">
    <dc:creator>Axel Polleres</dc:creator>
  </rdf:Description>

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

# RDF/XML Structure

## XML-Namespaces:

- references a web-resource with unambiguous vocabulary
- external term definitions (ontologies like here Dublin Core) can be referenced

Head  
Body  
(RDF statements)  
End

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

  <rdf:Description rdf:about="http://www.Batman.org/Robin/">
    <mySchema:employedBy rdf:resource="#Batman" />
  </rdf:Description>

  <rdf:Description rdf:id="Batman">
    <mySchema:Name>Bruce Wayne</mySchema:Name>
    <mySchema:Email rdf:resource="mailto:boss@batman.org" />
  </rdf:Description>

</rdf:RDF>
```

described  
Resource

Reference to  
Identifier

# RDF/XML – several statements:

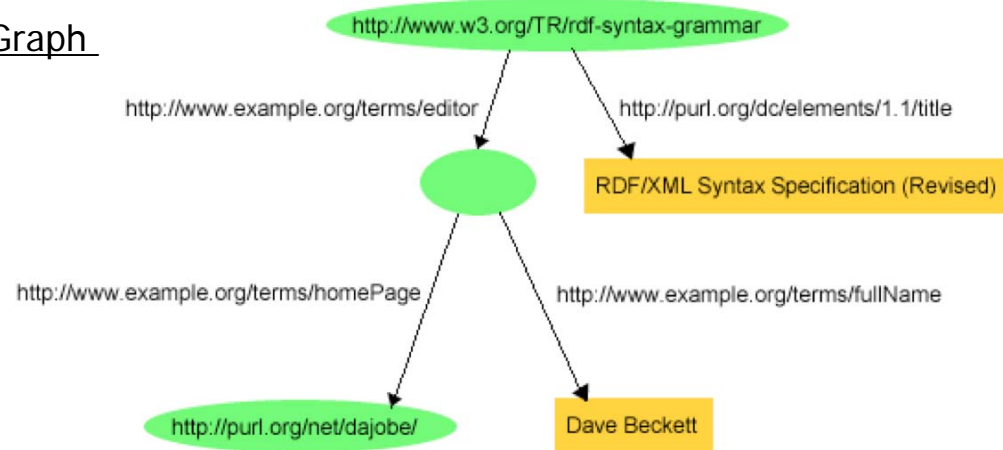
Several statements on the same subject can be written within a single `<rdf:Description>` :

```
<?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.polleres.net/index.html">
      <exterms:creationDate>April 1, 2005</exterms:creation-date>
      <dc:language>en</dc:language>
      <dc:creator rdf:resource="http://www.polleres.net/foaf.rdf#me" />
    </rdf:Description>
    ...
  </rdf:RDF>
```

# RDF/XML Syntax – Blank Nodes

## RDF Graph



## RDF/XML Syntax

```
<?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:externs="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>
      <externs:editor rdf:nodeID="x" />
    </rdf:Description>
    <rdf:Description rdf:nodeID="x">
      <externs:fullName>Dave Beckett</externs:fullName>
      <externs:homePage rdf:resource="http://purl.org/net/dajobe/" />
    </rdf:Description>
  </rdf:RDF>
```

These so-called **nodeIDs** are references only valid in the scope of one RDF/XML documents, but which don't have a unique URI (cf. the scope of an existential variable in a formula!)



# Some more features of RDF:

- ◆ Typed nodes
- ◆ `rdf:IDs`
- ◆ Containers
- ◆ Collections
- ◆ Reification

# RDF/XML Syntax – typed nodes:

RDF has a special property for is-a relations: `rdf:type`

RDF triple Notation...

```
http://www.polleres.net/foaf.rdf#me rdf:type ex:Person.
```

...in RDF/XML Syntax:

```
<?xml version="1.0"?>
  <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
          xmlns:foaf="http://xmlns.com/foaf/0.1/">

    <rdf:Description rdf:about="http://www.polleres.net/foaf.rdf#me">
      <rdf:type rdf:resource="http://www.example.org/Person"/>
      ... other predicates for axel ...
    </rdf:Description>
  </rdf:RDF>
```

There is an abbreviated notion for this in RDF/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/"
          xmlns:ex="http://www.example.org/">

    <ex:Person rdf:about="http://www.example.org/staffid/85740">
      ... other predicates for 85740 ...
    </ex:Person>

  </rdf:RDF>
```

# RDF/XML Syntax – Literals with Datatypes

RDF triple notation...

```
ex:index.html exterms:creation-date "1999-08-16"^^xsd:date .
```

...in RDF/XML Syntax:

```
<?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:creationdate rdf:datatype="http://www.w3.org/2001/XMLSchema#date">
        1999-08-16
      </exterms:creation-date>
    </rdf:Description>

  </rdf:RDF>
```

**Note:** `http://www.w3.org/2001/XMLSchema#` can not directly be referred via a namespace prefix here because it is inside the attribute value, but you could use a DTD entity for abbreviation... cf. slide 27

# RDF/XML syntax - IDs

```
<?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:externs="http://www.example.com/terms/"
          xml:base="http://www.example.com/2002/04/products">

    <rdf:Description rdf:ID="item10245">
      <rdf:type rdf:resource="http://www.example.com/terms/Mountainbike"/>
      <externs:model rdf:datatype="&xsd:string">Rockclimber</externs:model>
      <externs:weight rdf:datatype="&xsd:decimal">9.4</externs:weight>
      <externs:packedSize rdf:datatype="&xsd:integer">784</externs:packedSize>
    </rdf:Description>

    ...other product descriptions...
  </rdf:RDF>
```

An rdf:ID can be referenced in another document relative to base document (similar to IDs in HTML, XML):

```
<rdf:Description rdf:about="http://www.polleres.net/foaf.rdf#me">
  <blabla:owns rdf:resource="http://www.example.com/2002/04/products#item10245">
</rdf:Description>
```

# RDF Containers

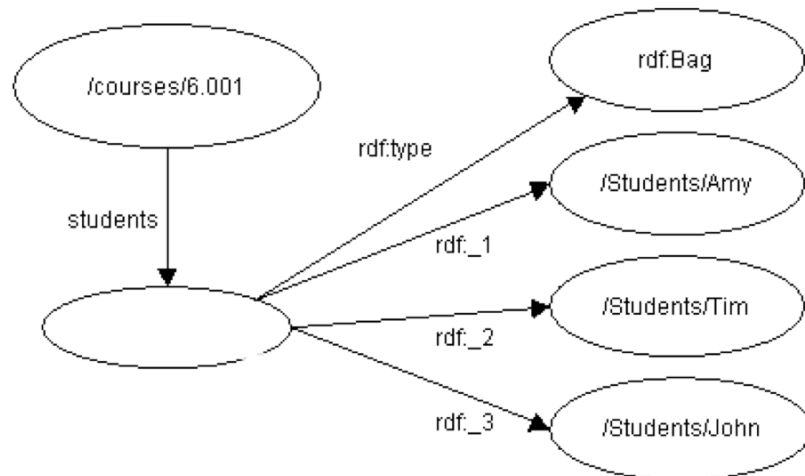
- ◆ If you want to give a set as attribute value, RDF provides 3 types of **Containers**:

<u><a href="#">rdf:Bag</a></u>	Unordered list of resources or literals as multiple values of a Property.
<u><a href="#">rdf:Sequence</a></u>	Sequence, ordered list of resources or literals as multiple values of a Property.
<u><a href="#">rdf:Alt</a></u>	Alternative, list of resources or literals that are alternatives for the (single) value of a Property.

- ◆ **Beispiel (rdf:Bag) :**

Die Studenten im Kurs 6.001 sind Amy, Tim, and John. \*

## RDF Model



## RDF/XML Syntax

```
<rdf:RDF>
<rdf:Description
    about="http://.../courses/6.001">
  <s:students>
    <rdf:Bag>
      <rdf:li resource="http://.../students/Amy"/>
      <rdf:li resource="http://.../students/Tim"/>
      <rdf:li resource="http://.../students/John"/>
    </rdf:Bag>
  </s:students>
</rdf:Description>
</rdf:RDF>
```

\*: **Beispiel von: REC-rdf-syntax-19990222**

<http://www.w3.org/TR/1999/REC-rdf-syntax-19990222/#containers>

# RDF Collection

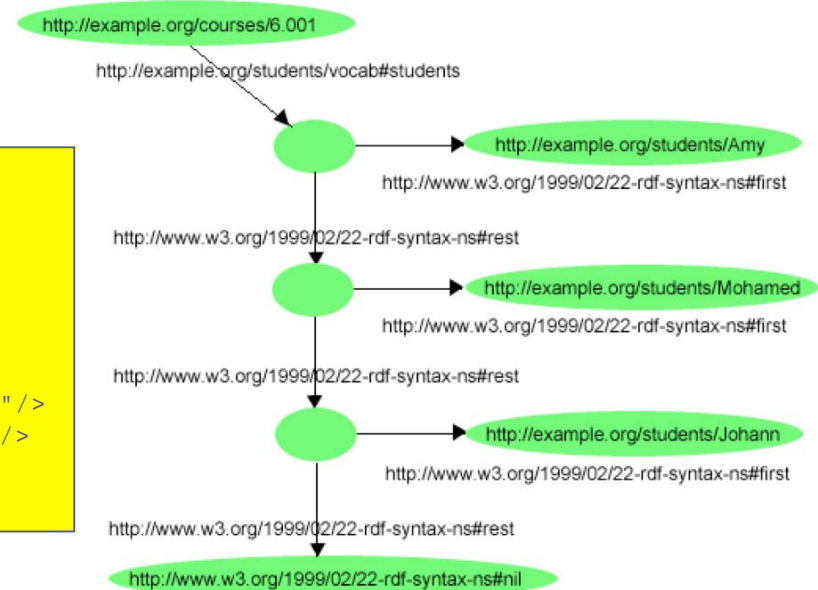
Similar to RDF containers, but resolves collection in LISP-style lists:

## RDF/XML Syntax

```
<?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/Mohamed" />
      <rdf:Description rdf:about="http://example.org/students/Johann" />
    </s:students> </rdf:Description>
  </rdf:RDF>
```

## RDF Model



# Reification

- ◆ In RDF you can make statements about statements, e.g. you might want to express when a certain statement has been made, who made it, etc.

RDF Graph:

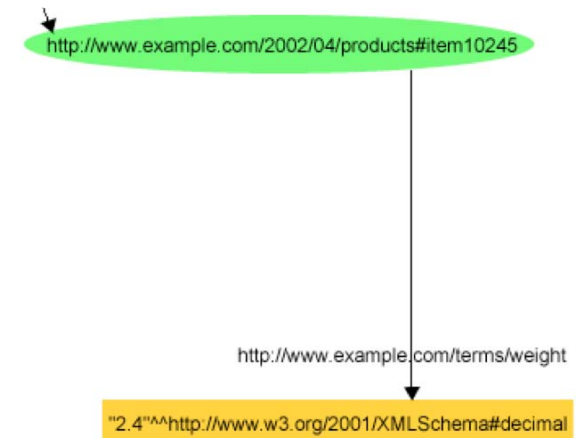
## RDF/XML Syntax

```
<?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:dc="http://purl.org/dc/elements/1.1/"
  xmlns:exterm="http://www.example.com/terms/"
  xml:base="http://www.example.com/2002/04/products">

  <rdf:Description rdf:ID="item10245">
    <exterm:weight rdf:datatype="&xsd;decimal">2.4</exterm:weight>
  </rdf:Description>

</rdf:RDF>
```

*Remark: Here we use the abbreviated notation from slide 26*



# Alternative: Use of rdf:ID for Reification

In an rdf:Description one can give an ID for triples...

```
<rdf:Description rdf:ID="item10245">
  <externs:weight rdf:ID="triple12345" rdf:datatype="&xsd;decimal">
    2.4</externs:weight>
</rdf:Description>

<rdf:Description rdf:about="#triple12345">
  <dc:creator rdf:resource="http://www.example.com/staffid/85740"/>
</rdf:Description>
```

... which can be reused in other meta-statements later on!



Break!

# Overview:

## Part I

- ◆ What is the „Semantic Web“?
- ◆ What is the „Semantic Web“ not?
- ◆ Why XML/XPath/XSLT is not enough
- ◆ RDF

## Part II

- ◆ **SPARQL - Querying RDF**
- ◆ RDFS and Ontologies

## Part III

- ◆ Where is the „Semantic Web“?
- ◆ Concrete applications

## 2 RDF syntaxes:

- ◆ A machine readable XML exchange syntax
  - <http://www.w3.org/TR/rdf-syntax-grammar/>

Before we talk about SPARQL, we will briefly talk about another syntax:

- ◆ **Turtle - Terse RDF Triple Language**
  - <http://www.dajobe.org/2004/01/turtle/>  
(for tools, editors, etc. writing down explaining RDF)

# We continue here on Turtle & SPARQL:

Lecture material by Jos de Bruijn

◆ Turtle & Basic SPARQL

<http://www.inf.unibz.it/~jdebruijn/teaching/swt/#le3>

# Overview:

## Part I

- ◆ What is the „Semantic Web“?
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- ◆ **RDFS and Ontologies**

## Part III

- ◆ Where is the „Semantic Web“?
- ◆ Concrete applications

# Meta-meta data: RDFS & Ontologies

# RDF, what's missing?

- ◆ We now know (almost) all about RDF:
  - Standardised model for describing meta-data in a simple, flexible manner in a machin-readable format
- ◆ How do we describe the meaning of triples?
- ◆ I.e., how do we describe meta-meta-level information such as

→ RDFS, OWL



# RDFS – a simple Ontology language

- ◆ With **rdf:type** we could already express in RDF, what is the Type of a resource.
- ◆ **RDF Schema** (RDFS) describes relations between the used Types and properties in RDF
- ◆ RDFS thus is a “Meta-Meta-description language” for describing the structure of knowledge, i.e. with RDFS we can describe the used **Vocabulary: Classes and Properties**
- ◆ Uses and extends RDF:

The most important RDFS constructs:





# RDFS

## ◆ classes

- 'Types' of resources are called classes in RDFS
- **rdfs:Resource** is the most general class: 'things, which can be described by a URI' are classes
- **rdfs:Class**, all resources, which are classes
- **rdfs:Literal**, the class of literal values (strings, numbers, XML fragments), können Typen haben
- **rdfs:Datatype**, the class of (literal) data types
- **rdf:XMLLiteral**, the class of XML literals
- **rdf:Property**, the class of RDF Properties

## ◆ properties

- Properties describe relations between Subject- and Object-resources
- **rdfs:domain**: resources, which use a certain property are members of a particular class (same as domain of a function in mathematics)
- **rdfs:range**: object values of a property are instances of a certain class (range in a function in mathematics)
- **rdf:type** is used to assign in instance to a class („is-a“ relation, class membership)
- **rdfs:subClassOf** (Sub-)relation between classes
- **rdfs:subPropertyOf** (Sub-)relation between properties
- **rdfs:label** human readable label for a resource
- **rdfs:comment** human readable comment

# RDFS Examples:

Usage of `rdf:type`, `rdfs:subClassOf`, `rdfs:subPropertyOf`, `rdfs:domain`, `rdfs:range`:

„Axel Polleres is a researcher“

`<http://www.polleres.net/foaf.rdf#me> rdf:type ex1:Researcher.`

„People who are experts in Semantic Web, are experts in RDF.“

`ex1:SemanticWebExpert rdfs:subClassOf ex1:RDFExpert.`

„Professors are employees of the university.“

`urjc:prof rdfs:subClassOf urjc:employee.`

„If A is the father of B, then A is also a parent of B.“

`ex1:fatherOf rdfs:subPropertyOf ex:parentOf.`

„If A is a parent of B, then A is a Person.“

`ex1:parentOf rdfs:domain foaf:Person.`

„If A is parent of B , then B is a Person.“

`ex1:parentOf rdfs:range foaf:Person.`

We used Turtle here, the XML notation for RDFS is analogous to „normal“ RDF:

All RDFS statements are again RDF statement!

Difference: With additional RDFS information you can **derive** new information!!!

# Inferring new Information from Meta-Data in RDF+RDFS:

Axel Polleres is a researcher

- ◆ `<http://www.polleres.net/foaf.rdf#me> rdf:type ex1:researcher.`
- ◆ `<http://www.polleres.net/foaf.rdf#me> ex1:worksFor <http://www.deri.org/deri>.`

Axel Polleres works for DERI

... Let's assume DERI defines a new class `deri:researcher` in their corporate RDF Schema:

- ◆ `<http://www.polleres.net/foaf.rdf#me> rdf:type deri:researcher`

Persons who know about Semantic Web technologies, know about RDF.

We have additional RDFS information:

- ◆ `deri:researcher rdfs:subClassOf ex1:SemanticWebExpert`
- ◆ `ex1:SemanticWebExpert rdfs:subClassOf ex1:RDFExpert.`

All researchers at DERI are Semantic Web experts.

Now the following **inference rules** are valid in RDFS:

- ◆ If **A** `rdfs:subClassOf B`. and **B** `rdfs:subClassOf C`. then also **A** `rdfs:subClassOf C`.
- ◆ If **R** `rdf:type A`. and **A** `rdfs:subClassOf B`. then also **R** `rdf:type B`

**An RDFS aware application can infer from this:**

- ◆ `<http://www.polleres.net/foaf.rdf#me> rdf:type ex1:RDFExpert.`
- ◆ Thus: „Axel Polleres is an expert for RDF “

We need someone who knows about RDF for a lecture at URJC

# RDFS vs logical inference

- ◆ This looked a lot like logics, didn't it?
- ◆ Most of the RDFS inference rules can be written down as Prolog style rules!

- ◆ If  $A$  `rdfs:subClassOf`  $B$ . and  $B$  `rdfs:subClassOf`  $C$ . then also  $A$  `rdfs:subClassOf`  $C$ .

```
triple(A,rdfs:subClassOf,C) :- triple(A,rdfs:subClassOf,B),
                                triple(B,rdfs:subClassOf,C).
```

- ◆ If  $R$  `rdf:type`  $A$ . and  $A$  `rdfs:subClassOf`  $B$ . then also  $R$  `rdf:type`  $B$

```
triple(R,rdf:type,B) :- triple(R,rdf:type,A),
                        triple(A,rdfs:subClassOf,B).
```

- ◆ However, the logics of RDF/RDFS is not very expressive...

- ◆ A list of RDFS inference rules can be found in the RDF semantics document:

[http://www.w3.org/TR/rdf-mt/ Sections 3.1 and 4.1](http://www.w3.org/TR/rdf-mt/Sections%203.1%20and%204.1)

## A large part of RDF and RDFS semantics is expressible in PROLOG style rules:

```
triple(P,rdf:type,rdf:Property) :- triple(S,P,0).
triple(S,rdf:type,rdfs:Resource) :- triple(S,P,0).
triple(0,rdf:type,rdfs:Resource) :- triple(S,P,0).
triple(S,rdf:type,C) :- triple(S,P,0), triple(P,rdfs:domain,C).
triple(0,rdf:type,C) :- triple(S,P,0), triple(P,rdfs:range,C).
triple(C,rdfs:subClassOf,rdfs:Resource) :- triple(C,rdf:type,rdfs:Class).
triple(C1,rdfs:subClassOf,C3) :- triple(C1,rdfs:subClassOf,C2),
                                triple(C2,rdfs:subClassOf,C3).
triple(S,rdf:type,C2)           :- triple(S,rdf:type,C1),
                                triple(C1,rdfs:subClassOf,C2).
triple(C,rdf:type,rdfs:Class) :- triple(S,rdf:type,C).
triple(C,rdfs:subClassOf,C)    :- triple(C,rdf:type,rdfs:Class).
triple(P1,rdfs:subPropertyOf,P3) :- triple(P1,rdfs:subPropertyOf,P2),
                                    triple(P2,rdfs:subPropertyOf,P3).
triple(S,P2,0)                 :- triple(S,P1,0),
                                    triple(P1,rdfs:subPropertyOf,P2).
triple(P,rdfs:subPropertyOf,P) :- triple(P,rdf:type,rdf:Property).
```

### ◆ Why not all? Blank nodes are nasty!

$\exists j . \text{knows}(\text{axel},j) \wedge \text{name}(j, \text{"Jos de Bruijn"})$

recall: This is not Horn ... As we learnt last semester: skolemization helps in some cases.

# By the way: Why URIs?

## ◆ Why are URIs used identifiers for resources?

- URIs belong to somebody! `$ whois polleres.net`
- A person in control of a URI can control what a URI means (e.g. by providing a file with RDF/RDFS information defining the resource at that URI:  
<http://www.polleres.net/foaf.rdf#me> is my ID

## ◆ It is simple to merge RDF graphs talking about the same things, if you agree upon the URIs, e.g in <http://www.polleres.net/foaf.rdf> you find triples:

`<http://www.polleres.net/foaf.rdf#me> foaf:knows <http://sw.deri.org/~haller/foaf.rdf#ah> .`

And I can find more triples using the URI `<http://sw.deri.org/~haller/foaf.rdf#ah>` in Armin Haller's personal RDF file.

## ◆ One can define links and connections, similar to links in the „normal “ Web!

`<http://sw.deri.org/~haller/foaf.rdf#ah> rdfs:seeAlso <http://sw.deri.org/~haller/foaf.rdf> .`


`rdfs:seeAlso` : says that there is more information about this resource at that URI.

# What's missing in RDFS?

- ◆ Some things cannot be expressed in RDFS e.g. in the example before:

`http://www.polleres.net/foaf.rdf#me rdf:type ex1:researcher.`

`http://www.polleres.net/foaf.rdf#me ex1:worksFor http://www.deri.org/deri.`



All researchers at  
DERI are Semantic  
Web experts.

Here we did a trick and „invented“ a new class.

The Web Ontology Language **OWL** allows to say more about classes and properties, e.g. one can define classes not only by subclass relationships, but also by their attribute Values...

```
<owl:Class>
  <owl:intersectionOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="#worksFor" />
      <owl:hasValue rdf:resource="http://www.deri.org/deri" />
    </owl:Restriction>
    <owl:Class rdf:about="#Researcher" />
  </owl:intersectionOf>
  <owl:subclassOf rdf:about="" rdf:resource="#SemanticWebExpert"/>
</owl:Class>
```

# Web Ontology Language - OWL

- ◆ RDFS is useful, but doesn't solve all problems
- ◆ Complex applications need more expressivity:
  - More complex inferences by Terms:
    - ◆ z.B. transitive Properties can not be described in RDFS: "if «A» is ancestor of «B» and «B» is ancestor of «C», then «A» is ancestor of «C»?"  
ex:ancestorOf rdf:type owl:TransitiveProperty .
  - Equivalences of individuals and classes  
<http://www.polleres.net/> owl:sameAs <http://platon.escet.urjc.es/~axel/> .
  - *Build classes from other classes, describe them by union, intersection, attribute values, cardinality of attributes, etc.*
- ◆ OWL (Web Ontology Language) addresses these and other problems.
  
- ◆ ... and OWL ist not the end of the story!  
Further extensions of OWL/RDFS such as complex rules languages are currently under development in the W3C.



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- ◆ RDF

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## Part III

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- ◆ Concrete applications

# Where is the Semantic Web today?

- ◆ Predefined vocabularies in RDFS are beginning to be adopted:

## Examples:

- Dublin Core
- FOAF
- RSS

# Dublin Core Metadata Set

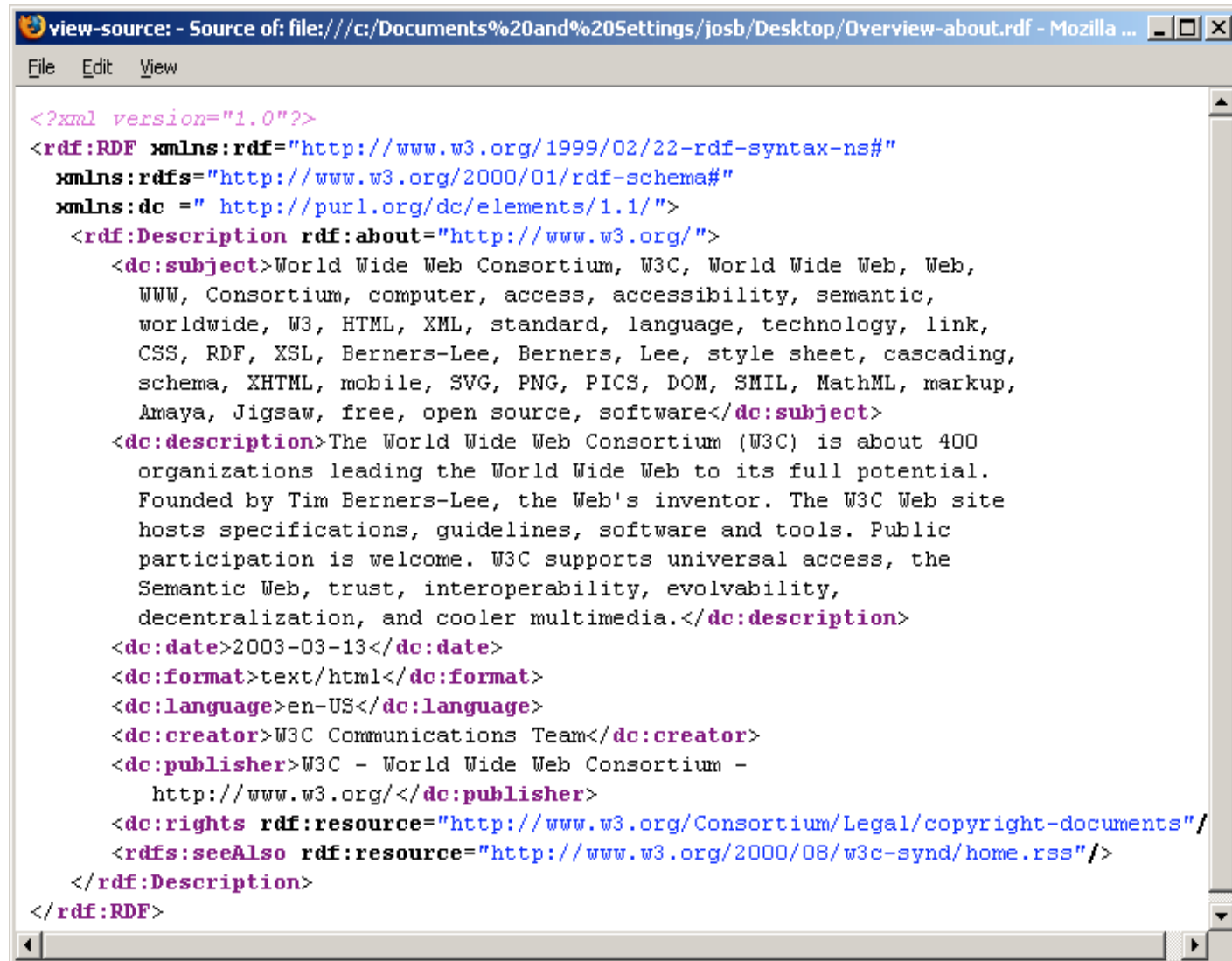
*The Dublin Core Metadata Initiative (DCMI) is an organization dedicated to promoting the widespread adoption of interoperable metadata standards and developing specialized metadata vocabularies for describing resources that enable more intelligent information discovery systems.*

[\(http://dublincore.org/\)](http://dublincore.org/)

# Dublin Core

- ◆ The Dublin Core Metadata Set [DublinCore] is a standard vocabulary for describing resources (such as web resources, pictures, etc.) in RDF syntax, with keywords such as:
  - title
  - description
  - author
  - creator
  - format
  - date
  - type
  - relation
  - ...

# Dublin Core Example: the W3C



```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:dc="http://purl.org/dc/elements/1.1/">
  <rdf:Description rdf:about="http://www.w3.org/">
    <dc:subject>World Wide Web Consortium, W3C, World Wide Web, Web,
      WWW, Consortium, computer, access, accessibility, semantic,
      worldwide, W3, HTML, XML, standard, language, technology, link,
      CSS, RDF, XSL, Berners-Lee, Berners, Lee, style sheet, cascading,
      schema, XHTML, mobile, SVG, PNG, PICS, DOM, SMIL, MathML, markup,
      Amaya, Jigsaw, free, open source, software</dc:subject>
    <dc:description>The World Wide Web Consortium (W3C) is about 400
      organizations leading the World Wide Web to its full potential.
      Founded by Tim Berners-Lee, the Web's inventor. The W3C Web site
      hosts specifications, guidelines, software and tools. Public
      participation is welcome. W3C supports universal access, the
      Semantic Web, trust, interoperability, evolvability,
      decentralization, and cooler multimedia.</dc:description>
    <dc:date>2003-03-13</dc:date>
    <dc:format>text/html</dc:format>
    <dc:language>en-US</dc:language>
    <dc:creator>W3C Communications Team</dc:creator>
    <dc:publisher>W3C - World Wide Web Consortium -
      http://www.w3.org/</dc:publisher>
    <dc:rights rdf:resource="http://www.w3.org/Consortium/Legal/copyright-documents"/>
    <rdfs:seeAlso rdf:resource="http://www.w3.org/2000/08/w3c-synd/home.rss"/>
  </rdf:Description>
</rdf:RDF>
```

# Dublin Core another example:

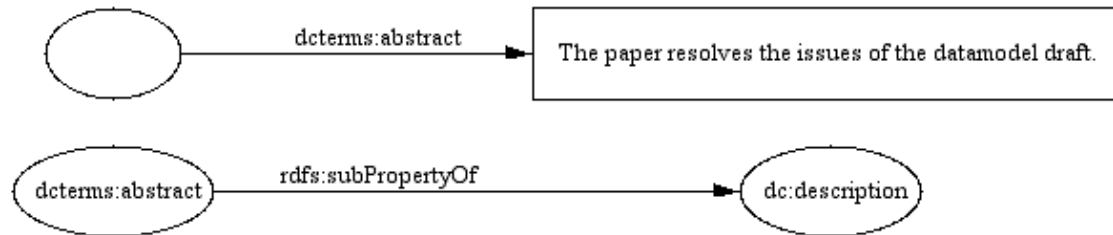
◆ Axel's homepage: <http://www.polleres.net/metadata.rdf>

```
<?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:dt="http://purl.org/dc/terms/">
- <rdf:Description rdf:about="http://homepage.uibk.ac.at/~c703262/">
  <dc:title>Axel Polleres' Personal Web Page</dc:title>
  <dc:creator rdf:resource="http://homepage.uibk.ac.at/~c703262/" />
  <dc:description>This is the homepage of Axel Polleres. I currently work for DERI (Digital enterprise Research
  Institute) Innsbruck, the former Next Web Generation research group, at the Institute for Computer Science
  at the University of Innsbruck in Austria.</dc:description>
  <dc:date>2003-10-08</dc:date>
  <dc:type>Text</dc:type>
  <dc:format>text/html</dc:format>
  <dc:language>en</dc:language>
  <dc:relation rdf:resource="http://www.deri.at/" />
  <dc:relation rdf:resource="http://www.deri.org/" />
  <dc:relation rdf:resource="http://informatik.uibk.ac.at/" />
  <dc:relation rdf:resource="http://www.uibk.ac.at/" />
</rdf:Description>
</rdf:RDF>
```

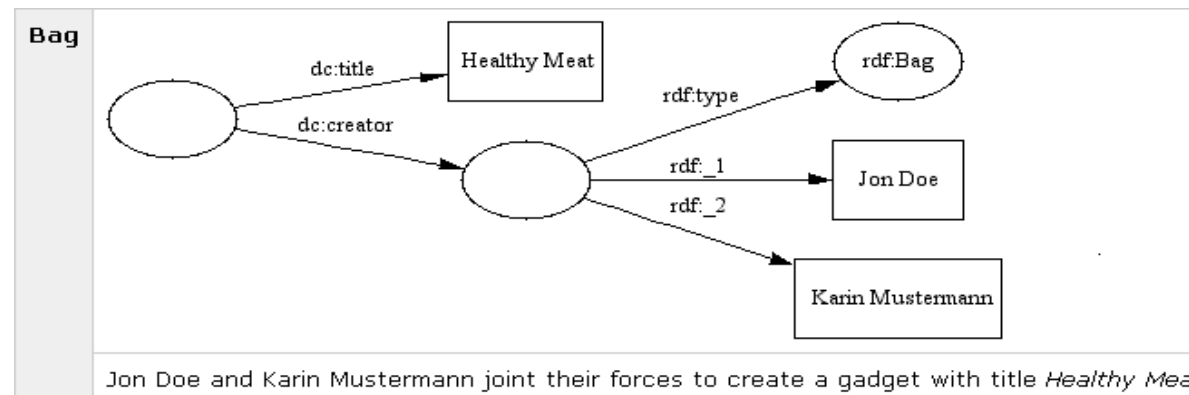
All DC vocabulary, see: <http://dublincore.org/documents/dcmi-terms/>

# DC as a RDFS taxonomy of properties:

- ◆ DC properties are organized in a taxonomy using RDFS, e.g.



- ◆ all properties can be declared several times or using RDF Bag, Seq, etc. (e.g. Sequence for describing several authors in a particular sequences)



More details how to express qualified dublin core in RDF:  
<http://www.dublincore.org/documents/dcq-rdf-xml/>

# DC Summary:

- ◆ Provides a core meta-data vocabulary to describe documents...
- ◆ For a detailed description of the vocabulary suggested by DC, check:  
<http://dublincore.org/>

What is it used for:

- ◆ annotating (Web) Resources, Documents,
- ◆ also for Pictures, etc.



# FOAF: Friend of a friend

*"The Friend of a Friend (FOAF) project is about creating a Web of machine-readable homepages describing people, the links between them and the things they create and do." (<http://www.foaf-project.org/>)*

- ◆ Annotation vocabulary for linking semantic information about people to achieve a social network
- ◆ Everybody can provide/link his/her own FoaF file on his/her own webpage.
- ◆ Related to the success of "social networks": friendster, orkut, ryze, LinkedIn etc.  
But: these use disclosed applications/databases/portals instead whereas FOAF is intended to work decentralized and based on RDF.

# FOAF Vocabulary:

## FOAF Basics

- [Agent](#)
- [Person](#)
- [name](#)
- [nick](#)
- [title](#)
- [homepage](#)
- [mbox](#)
- [mbox\\_sha1sum](#)
- [img](#)
- [depiction](#) (depicts)
- [surname](#)
- [family\\_name](#)
- [givenname](#)
- [firstName](#)

## Personal Info

- [weblog](#)
- [knows](#)
- [interest](#)
- [currentProject](#)
- [pastProject](#)
- [plan](#)
- [based\\_near](#)
- [workplaceHomepage](#)
- [workInfoHomepage](#)
- [schoolHomepage](#)
- [topic\\_interest](#)
- [publications](#)
- [geekcode](#)
- [myersBriggs](#)
- [dnaChecksum](#)

## Online Accounts / IM

- [OnlineAccount](#)
- [OnlineChatAccount](#)
- [OnlineEcommerceAccount](#)
- [OnlineGamingAccount](#)
- [holdsAccount](#)
- [accountServiceHomepage](#)
- [accountName](#)
- [icqChatID](#)
- [msnChatID](#)
- [aimChatID](#)
- [jabberID](#)
- [yahooChatID](#)

## Projects and Groups

- [Project](#)
- [Organization](#)
- [Group](#)
- [member](#)
- [membershipClass](#)
- [fundedBy](#)
- [theme](#)

## Documents and Images

- [Document](#)
- [Image](#)
- [PersonalProfileDocument](#)
- [topic](#) (page)
- [primaryTopic](#)
- [tipjar](#)
- [sha1](#)
- [made](#) (maker)
- [thumbnail](#)
- [logo](#)

See details at  
<http://xmlns.com/foaf/0.1/>

# FOAF example:

◆ Axel's homepage: <http://www.polleres.net/foaf.rdf>

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Austria

Curriculum Vitae | Research | Publications | Teaching | Links

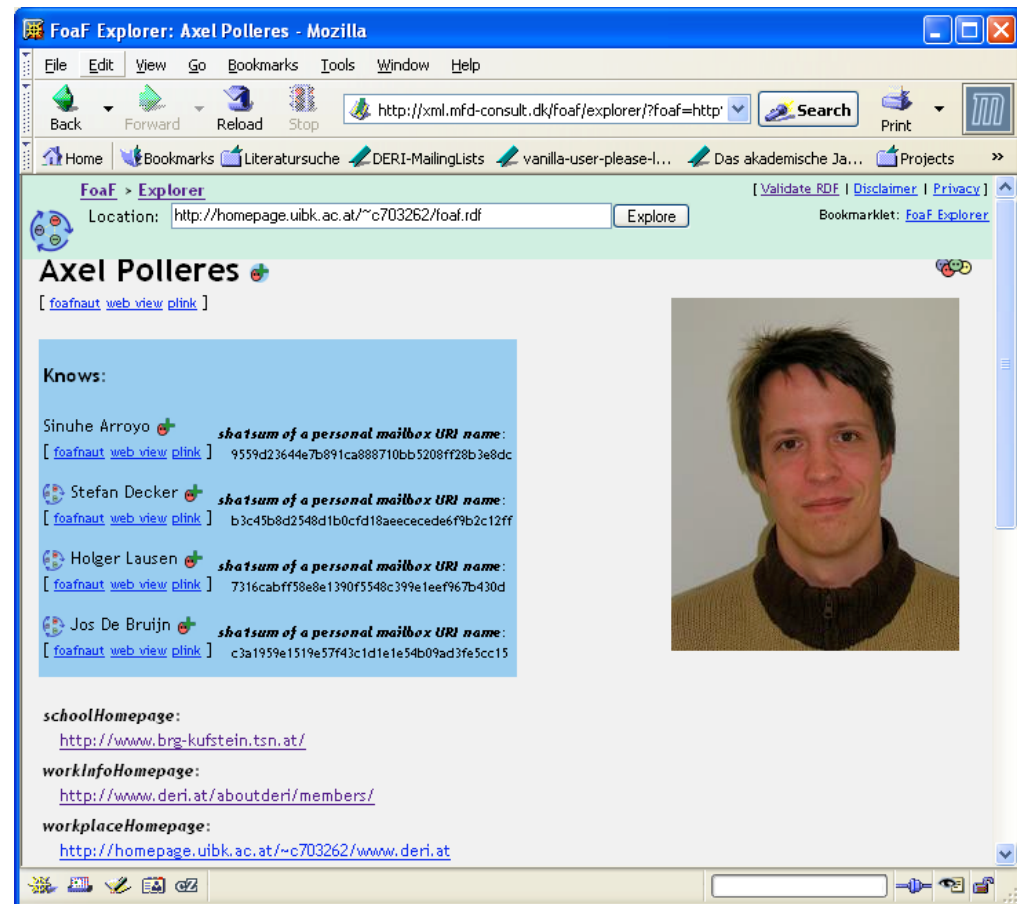
W3C XHTML 1.0 RDF Metadata

<http://www.uibk.ac.at/~c703262/images/axel1.jpg>

```
<?xml version="1.0" encoding="UTF-8" ?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns:rdfs="http://www.w3.org/2000/01/rdf-
schema#" xmlns:foaf="http://xmlns.com/foaf/0.1/" xmlns:admin="http://webns.net/mvcb/">
- <foaf:Person>
  <foaf:name>Axel Polleres</foaf:name>
  <foaf:title>Dr</foaf:title>
  <foaf:firstName>Axel</foaf:firstName>
  <foaf:surname>Polleres</foaf:surname>
  <foaf:nick>drexel</foaf:nick>
  <foaf:nick>xel</foaf:nick>
  <foaf:nick>xl</foaf:nick>
  <foaf:mbox_sha1sum>b0d2466b988a6ea89c26a31505f31748525ac9fa</foaf:mbox_sha1sum>
  <foaf:homepage rdf:resource="http://www.uibk.ac.at/~c703262/" />
  <foaf:depiction rdf:resource="http://www.uibk.ac.at/~c703262/images/axel.jpg" />
  <foaf:phone rdf:resource="tel:+435125076486" />
  <foaf:phone rdf:type="http://skype.com/" rdf:resource="callto://drexel" />
  <foaf:workplaceHomepage rdf:resource="http://www.deri.org/" />
  <foaf:schoolHomepage rdf:resource="http://www.brg-kufstein.tsn.at/" />
- <foaf:knows>
  - <foaf:Person>
    <foaf:name>Jos De Bruijn</foaf:name>
    <foaf:mbox_sha1sum>c3a1959e1519e57f43c1d1e1e54b09ad3fe5cc15</foaf:mbox_sha1sum>
    <rdfs:seeAlso rdf:resource="http://homepage.uibk.ac.at/~c703239/foaf.rdf" />
  </foaf:Person>
  </foaf:knows>
- <foaf:knows>
  - <foaf:Person>
    <foaf:name>Anna V. Zhdanova</foaf:name>
    <foaf:mbox_sha1sum>63069939f878323e2e66ec68942a3ec06034d6ac</foaf:mbox_sha1sum>
    <rdfs:seeAlso rdf:resource="http://homepage.uibk.ac.at/~c703261/foaf.rdf" />
  </foaf:Person>
  </foaf:knows>
- <foaf:knows>
  - <foaf:Person>
    <foaf:name>Holger Lausen</foaf:name>
    <foaf:mbox_sha1sum>32d59b1dc86b5134914d9aa574cf3d05ac670781</foaf:mbox_sha1sum>
    <rdfs:seeAlso rdf:resource="http://homepage.uibk.ac.at/~c703240/foaf.rdf" />
  </foaf:Person>
  </foaf:knows>
- <foaf:knows>
  - <foaf:Person>
    <foaf:name>Stefan Decker</foaf:name>
    <rdfs:seeAlso rdf:resource="http://www.isi.edu/~stefan/foaf.rdf" />
  </foaf:Person>
  </foaf:knows>
</foaf:Person>
</rdf:RDF>
```

# Tools for FOAF:

- ◆ FoaF-Explorer (<http://xml.mfd-consult.dk/foaf/explorer/>) a Foaf Browser
- ◆ FoaF-a-Matic (<http://www.ldodds.com/foaf/foaf-a-matic.html>) a Foaf generator



# FOAF Conclusions

- ◆ Vocabulary for machine-processable personal homepages
- ◆ some preliminary tools available
- ◆ not yet as successful as social networks such as friendster, which use proprietary central data
- ◆ But: sites such as **LIVEJOURNAL™** start to export FOAF !!
- ◆ advantage of FOAF: decentralized, could serve as exchange format between those existing networks and exists on its own

# RSS

- ◆ **RDF Site Summary** (sometimes called **Really Simple Syndication**) ...
- ◆ Web content syndication format
- ◆ However... the only RDF is the header,
- ◆ more an XML application. RSS files conform to XML 1.0 specification
- ◆ Confusion about versions, however, widely used:
  - Version 0.9 by netscape,
  - Version 1.0 by RSS-Dev Group
  - Version 2.0 released 7/15/03 through Harvard under a Creative Commons license
- ◆ Provides **vocabulary for describing lists of news** items (feed) to be processed by RSS compliant newsreaders

# RSS



## ◆ Required channel elements

- Title (The name of the channel. It's how people refer to your service e.g. GoUpstate.com News Headlines)
- Link (The URL to the HTML website corresponding to the channel e.g. <http://www.goupstate.com/>)
- Description (Phrase or sentence describing the channel e.g. The latest news from GoUpstate.com, a Spartanburg Herald-Journal Web site)

## ◆ Optional channel elements

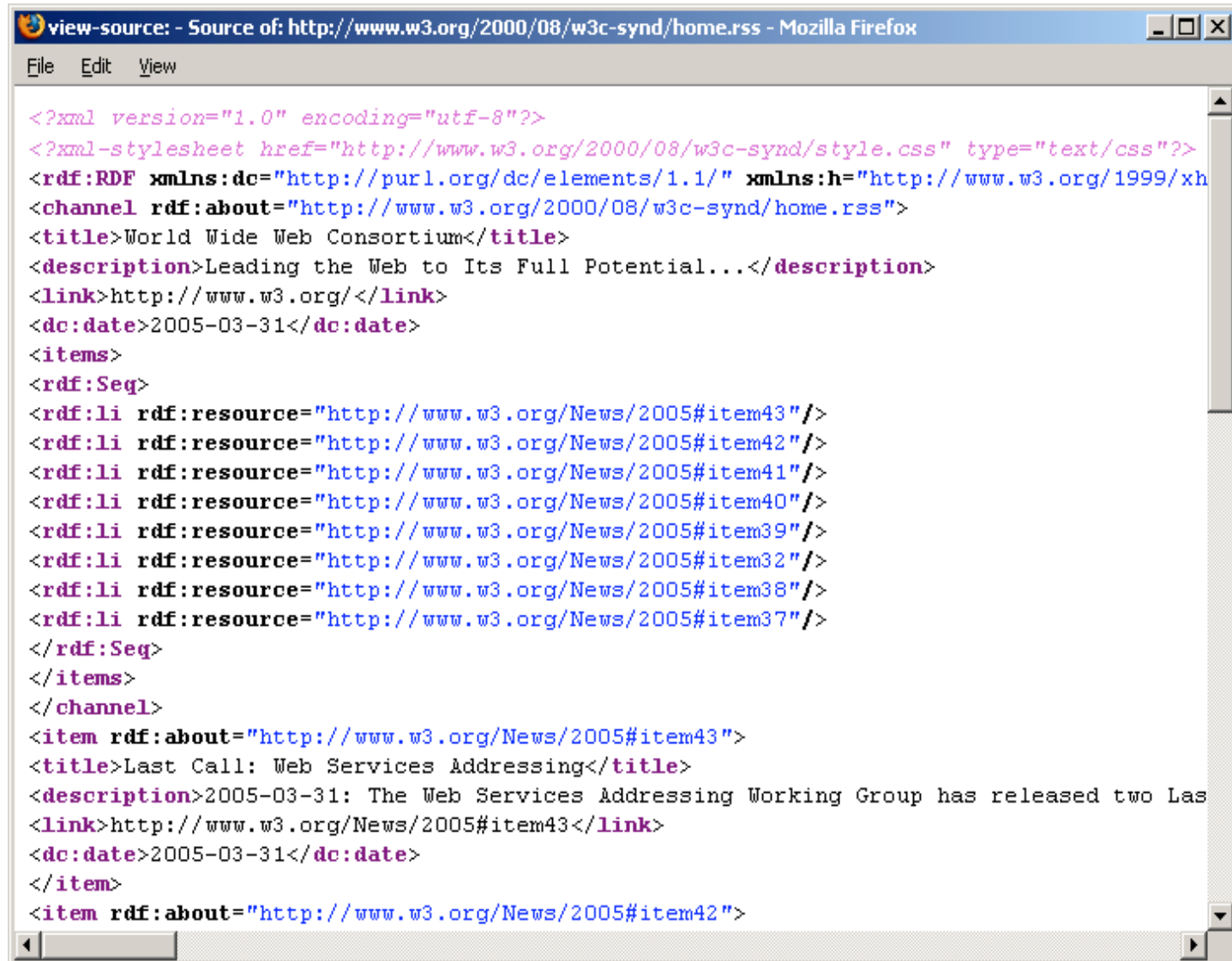
- Language
- Copyright
- pubDate
- Category
- Rating
- ...

# RSS (Cont'd)

- ◆ RSS 1.0 is RDF-based
  - Module mechanism for extension; a number of modules is standardized (e.g. Dublin Core)
  - Allows integration with other RDF-based vocabularies
  - Allows structured content
  - Allows reuse of RDF vocabulary
- ◆ RSS 2.0 is XML-based
  - Extension via namespaces
  - Limited reuse of vocabulary
  - More convenient to write
  
- ◆ So actually, we are talking about 2 standards here, one being a XML grammar, the other one being an RDF vocabulary.



# RSS 1.0 Example



```
<?xml version="1.0" encoding="utf-8"?>
<?xml-stylesheet href="http://www.w3.org/2000/08/w3c-synd/style.css" type="text/css"?>
<rdf:RDF xmlns:dc="http://purl.org/dc/elements/1.1/" xmlns:h="http://www.w3.org/1999/xhtml"
<channel rdf:about="http://www.w3.org/2000/08/w3c-synd/home.rss">
<title>World Wide Web Consortium</title>
<description>Leading the Web to Its Full Potential...</description>
<link>http://www.w3.org/</link>
<dc:date>2005-03-31</dc:date>
<items>
<rdf:Seq>
<rdf:li rdf:resource="http://www.w3.org/News/2005#item43"/>
<rdf:li rdf:resource="http://www.w3.org/News/2005#item42"/>
<rdf:li rdf:resource="http://www.w3.org/News/2005#item41"/>
<rdf:li rdf:resource="http://www.w3.org/News/2005#item40"/>
<rdf:li rdf:resource="http://www.w3.org/News/2005#item39"/>
<rdf:li rdf:resource="http://www.w3.org/News/2005#item32"/>
<rdf:li rdf:resource="http://www.w3.org/News/2005#item38"/>
<rdf:li rdf:resource="http://www.w3.org/News/2005#item37"/>
</rdf:Seq>
</items>
</channel>
<item rdf:about="http://www.w3.org/News/2005#item43">
<title>Last Call: Web Services Addressing</title>
<description>2005-03-31: The Web Services Addressing Working Group has released two Las
<link>http://www.w3.org/News/2005#item43</link>
<dc:date>2005-03-31</dc:date>
</item>
<item rdf:about="http://www.w3.org/News/2005#item42">
```

# RSS 2.0 example: Telegraph UK News

```
- <rss version="2.0">
- <channel>
  <title>Telegraph Sport</title>
  <link>http://sport.telegraph.co.uk</link>
  <description>UK Sport news from telegraph.co.uk</description>
  <language>en-uk</language>
- <copyright>
  Copyright of Telegraph Group Limited 2004. Please refer to the Terms and Conditions of Use at http://www.telegraph.co.uk/rss
</copyright>
<webMaster>rss@telegraph.co.uk</webMaster>
<pubDate>Mon, 10 May 2004 00:05:00 GMT</pubDate>
<lastBuildDate>Tue, 11 May 2004 00:28:00 GMT</lastBuildDate>
<ttl>60</ttl>
- <image>
  <title>Telegraph Sport</title>
  <width>124</width>
  <height>18</height>
  <link>http://sport.telegraph.co.uk</link>
- <url>
  http://www.telegraph.co.uk/newsfeed/rss/tcuk_main.gif
</url>
</image>
- <item>
  <title>Sacked rebels set to sue ZCU</title>
- <link>
  http://sport.telegraph.co.uk/sport/main.jhtml?xml=/sport/2004/05/11/sczimb11.xml
</link>
- <guid isPermaLink="true">
  http://sport.telegraph.co.uk/sport/main.jhtml?xml=/sport/2004/05/11/sczimb11.xml
</guid>
<pubDate>Tue, 11 May 2004 00:01:00 GMT</pubDate>
- <description>
  Zimbabwe Cricket Union terminate contracts of 15 white "rebel" cricketers. By Simon Briggs and Peta Thornycroft.
</description>
</item>
```

# RSS

- ◆ RSS allows Web Sites and users to subscribe to headline feeds from news sites, with links to complete stories
- ◆ Feeds can be read by aggregators, that aggregate headlines from a large number of sources

*However: Remark: Actually this isn't a complete success story of RDF so far... since the RDF dialect didn't really become accepted so far and more sites use the XML version... but it is straightforward to get RDF out of RSS2.0 as well.*

# Who provides RSS feeds?

- ◆ Very successful and widely used!
  - BBC
  - CNET News.Com
  - iTunes
  - Telegraph (UK)
  - New York Times
  - Yahoo! News
  - W3C
  - ...
  
- ◆ Widely used in the permanently growing BLOGGING community!

# RSS aggregators & validators

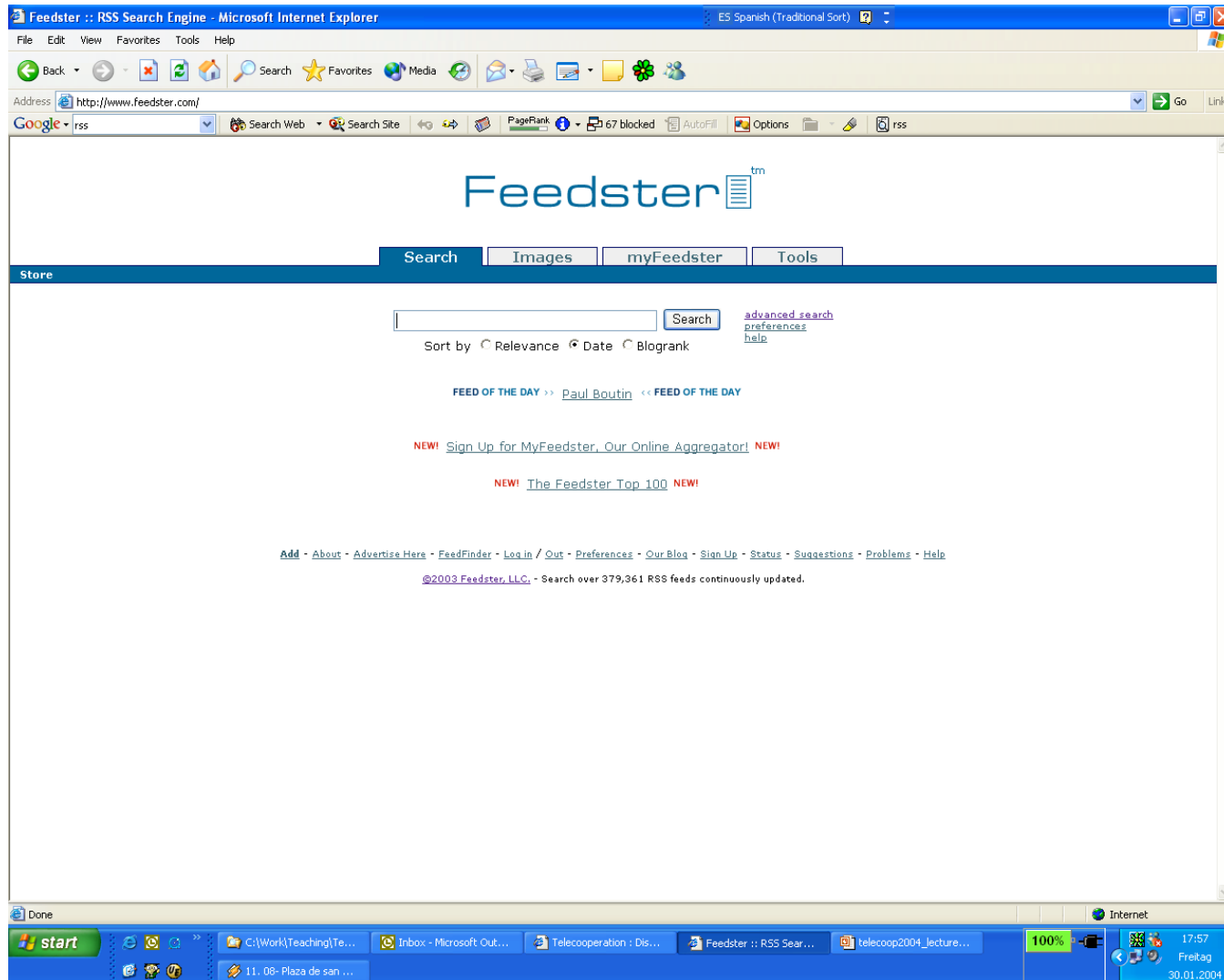
(this list is probably outdated...)

- ◆ RSS aggregators: aggregate RSS content from different sources (see details at <http://blogs.law.harvard.edu/tech/directory/5/aggregators>)
  - Aggie (.NET)
  - AmphetaDesk (Windows, Macintosh, Linux)
  - BlogLines (Server-based)
  - BottomFeeder (Windows, Macintosh, Unix)
  - EffNews RSS Reader (Windows)
  - FeedDemon (Windows)
  - FeedReader (Windows)
  - NetNewsWire (Macintosh)
  - NewsDesk (.NET)
  - NewsGator (.NET)
  - NewsIsFree (Server-based)
  - NewsMonster (Mozilla)
  - ...
  
- ◆ RSS validators (see details at <http://blogs.law.harvard.edu/tech/directory/5/validators>)
  - Feed validator
  - UserLand.Com


# Tools

- ◆ Tools that generate RSS 2.0 feeds (see more details at <http://blogs.law.harvard.edu/tech/directory/5/tools>)
  - Blogger
  - Manila
  - Movable Type
  - Nucleus CMS
  - Radio UserLand
  - Feedster (RSS tailored search engine)

# Search engines



# RSS Conclusions

- ◆ RSS A serialization convention with two standards:
  - RSS 2.0 is an XML Application (in its current version no RDF syntax, but could be easily provided)
  - RSS 1.0 is an RDF vocabulary
  
- ◆ RSS 2.0 only uses XML tags
  - Not an explicit ontology!
  
- ◆ Tool support (mainly for RSS 2.0), browsers support it natively nowadays!  BTW, side remark: Mozilla uses a lot of RDF inside...
  
- ◆ It is a success story of a commonly and successfully used shared vocabulary on the Web, which is the basic idea of sharing vocabularies and ontologies!



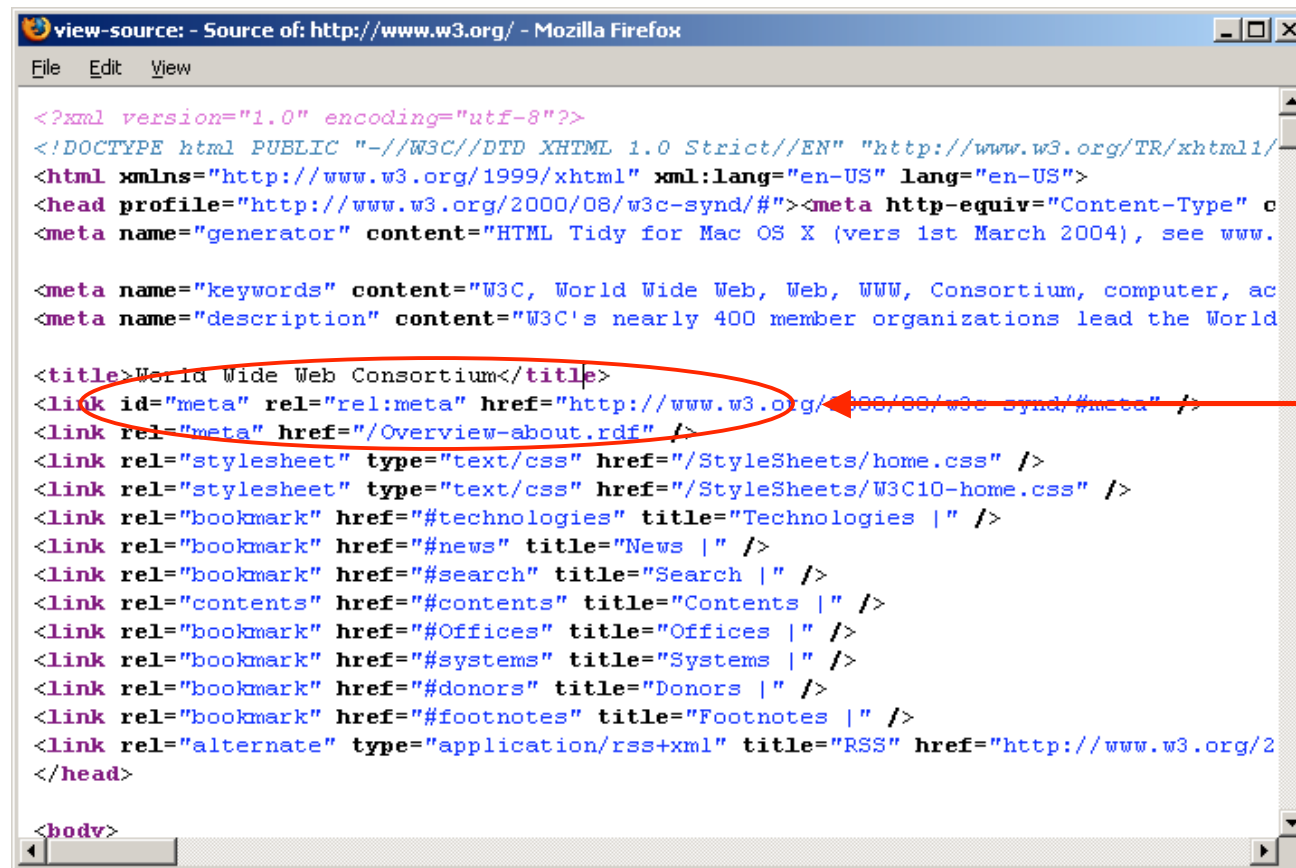
# Summary: RDF Vocabularies

- ◆ The general recommendation is: Whenever you annotate data with RDF use an existing widely used RDFS or OWL vocabulary wherever possible!
- ◆ Each of these vocabularies can be combined arbitrarily in one RDF graph/file (with other RDF data, with RDFS and OWL statements)
- ◆ *For making the semantic web happen, the reuse of such common vocabularies is essential !*

# Linking metadata to HTML:

- ❖ Currently no standard method for linking meta-data “inline” in an HTML documents.
- ❖ 3 Alternatives:
  - **Mix** HTML with own XML tags or with RDF:  
*Problem: This is neither HTML nor valid RDF*
  - RDF inline in HTML **Comments** `<!-- -->`  
*Problem: comments have no meaning and should be ignored by tools.*
  - **Link to an external (rdf) Document**, with `<link>` tag:  
`<link rel="meta" type="application/rdf+xml" href="metadata.rdf"/>`  
`<link rel="meta" type="application/rdf+xml" title="FOAF" href="foaf.rdf" />`
- ❖ **But:**
  - In RDFa (currently W3C working draft) RDF and XHTML will come closer! <http://www.w3.org/TR/xhtml-rdfa-primer/>
  - In the Gleaning Resource Descriptions from Dialects of Languages (GRDDL) working group, people work on defining standards on how to extract RDF from XML (by typically linking an XSLT) <http://www.w3.org/2001/sw/grddl-wg/>

# Linking Web and Semantic Web



```
view-source: - Source of: http://www.w3.org/ - Mozilla Firefox
File Edit View

<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN" "http://www.w3.org/TR/xhtml1/
<html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en-US" lang="en-US">
<head profile="http://www.w3.org/2000/08/w3c-synd/#"><meta http-equiv="Content-Type" c
<meta name="generator" content="HTML Tidy for Mac OS X (vers 1st March 2004), see www.

<meta name="keywords" content="W3C, World Wide Web, Web, WWW, Consortium, computer, ac
<meta name="description" content="W3C's nearly 400 member organizations lead the World

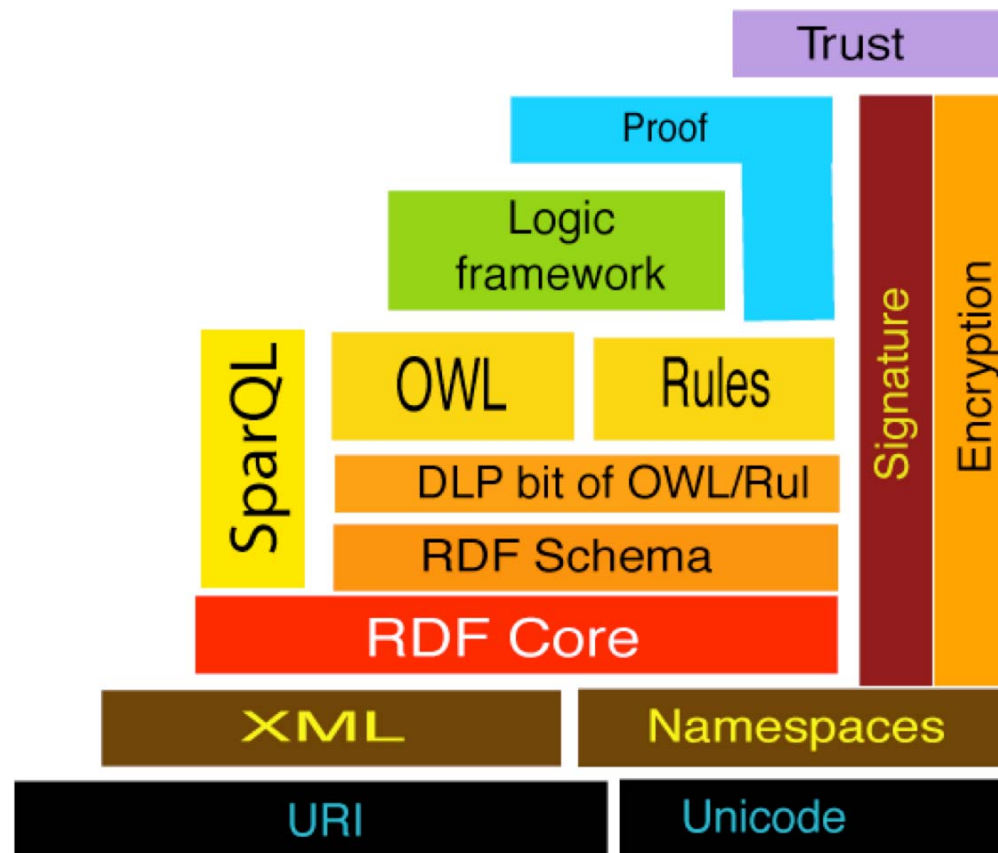
<title>World Wide Web Consortium</title>
<link id="meta" rel="rel:meta" href="http://www.w3.org/2000/08/w3c-synd/#meta" />
<link rel="meta" href="/Overview-about.rdf" />
<link rel="stylesheet" type="text/css" href="/StyleSheets/home.css" />
<link rel="stylesheet" type="text/css" href="/StyleSheets/W3C10-home.css" />
<link rel="bookmark" href="#technologies" title="Technologies |" />
<link rel="bookmark" href="#news" title="News |" />
<link rel="bookmark" href="#search" title="Search |" />
<link rel="contents" href="#contents" title="Contents |" />
<link rel="bookmark" href="#Offices" title="Offices |" />
<link rel="bookmark" href="#systems" title="Systems |" />
<link rel="bookmark" href="#donors" title="Donors |" />
<link rel="bookmark" href="#footnotes" title="Footnotes |" />
<link rel="alternate" type="application/rss+xml" title="RSS" href="http://www.w3.org/2
</head>

<body>
```

# Trust: What's after OWL and RDF?

- ◆ Can I trust Meta-Data on the Web?
  - Is the author the one he/she pretends to be? Where can I check trust/authentication?
  - Can I trust inferred knowledge? Inference is just as good as the source data. And how can I trust the knowledge without knowing HOW it was inferred?
  - etc.
- ◆ Some building blocks are already there (e.G., Signature/Encryption) , others not:
  - How do I give a name to an RDF Graph
  - "Canonical" (i.e. unique) form for graphs (necessary, to compare graphs, check signatures)
  - How can we express „trust“? (e.g. trust in a particular context)
  - ...
- ◆ The SW community is working on it...

# The semantic Web Architecture:



From: <http://www.w3.org/2005/Talks/1110-iswc-tbl/>

Keynote of Tim Berners-Lee @ ISWC 2005, Galway, Ireland

# Semantic Web: Application scenarios (1/4)

## ◆ Example: Websearch

### ◆ The best-known example...

- Google et al. are of great help, but too many false „hits“
- Meta-data can improve this!

## Semantic Web: Application scenarios (2/4)

### ◆ **Example: Automatic Assistant**

#### ◆ Your PDA (Personal digital Assistant knows:

- Your preferences
- Can record past events and store them as meta-data information
- Can combine local knowledge with online knowledge:
  - ◆ Hotel reservations, preferences for particular airlines
  - ◆ Personal diet plan
  - ◆ Medical appointments, medicine prescriptions
  - ◆ calendar,
  - ◆ etc

#### ◆ **Keyword: Context-Sensitivity!**

(M. Dertouzos: The Unfinished Revolution)

## Semantic Web: Application scenarios (3/4)

- ◆ **Example: Data(base) integration**
- ◆ Databases have different format, structure and content, possibly overlapping.
- ◆ Many modern applications use several databses
  - company mergers
  - merging administrative data in eGovernment
  - E-Science
  - etc.
- ◆ A lot of this data is already on the Web!
- ◆ The *Semantics* of the data should be accessible via Web interfaces just as the data itself. --> RDFS, OWL



# Semantic Web: Application scenarios (4/4)

- ◆ **Example: Digital Libraries**
- ◆ A bit between the Web search example and the Database integration example
- ◆ Library catalogs are available on the Web, but also apart from that a strong claim for unified formats in this area!
  - librarians have known how to do that for centuries
  - goal is to have this on the Web, World-wide
  - extend it to multimedia data, too
- ◆ But it is more: Software agents should also be librarians!
  - Help us in finding the right publications
- ◆ Librarians of the future are information managers, not only for publications, but also experimental data, etc., new possibilities for e-Science!

Slides translated from German to English by Ivan Herman, W3C

# References and Links:

- ◆ “RDF Primer”:
  - <http://www.w3.org/TR/rdf-primer>
- ◆ Turtle - Terse RDF Triple Language
  - <http://www.dajobe.org/2004/01/turtle/>
- ◆ “OWL Guide”:
  - <http://www.w3.org/TR/owl-guide/>
- ◆ SPARQL specification, Sections 1-8
  - <http://www.w3.org/TR/rdf-sparql-query/>

W3C RDF Validator:

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

Test SPARQL queries online:

<http://xmlarmyknife.org/api/rdf/sparql/query>

<http://con.fusion.at/dlvhex/sparql-query-evaluation.php> (under development)