Questions (and Answers) on the Semantic

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- Usually, one gives an introduction to SW...
  ...and then, questions are asked
- But this audience already knows the introduction...
  ...so let us move to questions right away!

So...

Questions?

Well, Let Me Help You...

- Some questions come up regularly, so I collected them ;-)
  1. Is the Semantic Web AI on the Web?
  2. Where is the "Web" in SW?
  3. Isn't the RDF Model way too complex?
  4. Why should I use RDF?
  5. With *huge* ontologies on the Web, does this scale?
  6. Isn't This Research Only?
  7. Does SW Replace Web Services?
  8. Are we done?
  9. What can I read to understand?
- I can answer these if you want...

Is the Semantic Web AI on the Web?

NO!!!

- RDF and OWL are very simple things (compared to AI, that is...)
- They offer:
  - a simple way to express and store metadata
  - a way to "structure" and characterize the terms

and that is it!

RDF (Resource Description Framework)

- RDF is a set of *statements*
- Statements can be modeled (mathematically) with:
  - Resources: an element, a URI, a literal, ...
  - Properties: *directed* relations between *two* resources
  - Statements: "triples" of two resources bound by a property
    - usual terminology: (s,p,o) for subject, property, object
- *RDF* is a general model for such statements

OWL (Web Ontology Language)

- OWL refines the usage of RDF by:
  - defining the terminology used in a specific context (ontologies)
  - imposing constraints on properties
    - e.g., cardinality constraints
  - characterizing the logical characteristics of properties
    - e.g., transitivity, funcionality
  - defining the equivalence of terms across ontologies
  - etc.

(to be precise: these are done by RDFS+OWL)

OWL and Logic

- OWL expresses a *small subset* of First Order Logic
  - it has a "structure" (class hierarchies, properties, datatypes...), and "axioms" can be stated within that structure only
  - i.e., OWL uses FOL to describe "traditional" ontology concepts... ...but it is *not* a general logic system per se!
- Inference based on OWL is *within this framework only*
  - it seems modest, but has proven to be remarkably useful...

And what about AI?

- AI requires much more complicated logical inferences
- There are *lots* of things RDF/OWL cannot express, eg:
  - the "uncle" relationship:

    $\forall x,z: ((\exists y: (y \text{ parent } x) \wedge (y \text{ brother } z)) \Rightarrow (z \text{ uncle } x))$
  - temporal and spatial reasoning
  - fuzzy logic
  - ...
- AI can be built by using OWL *and many other things*...
  ... but that is true for about everyting in IT 😉

Where is the "Web" in SW?

The "Web" is in the URI-s!

- On the SW, resources are identified by URI-s, e.g.:
  - URL-s
    - http://www.ivan-herman.net
    - ftp://ftp.cwi.nl
  - URN-s
    - urn:ISBN:0-395-36341-1
    - urn:lsid:ensembl.org:homosapiens_gene:ensg00000002016
- Anybody can create metadata on any resource on the Web
- It becomes easy to merge metadata
- *URI-s ground RDF into the Web*

Related Question...

- Q: People have misused HTML's `meta` elements... Why would that be different?
- A: The `meta` elements are *in the HTML source*
  - i.e., only the authors can set them
  - on the SW, *anybody* can define metadata
  - so one can get around misuse...

Isn't the RDF Model way too complex?

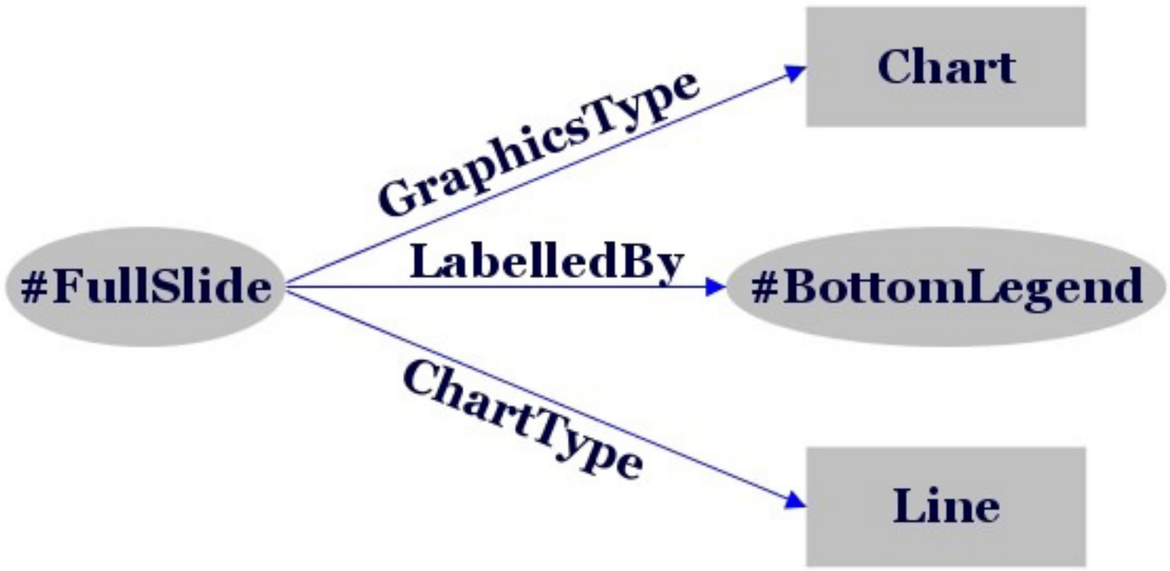
(look how complex RDF/XML is 😟)

RDF is a graph!

- An (s,p,o) triple can be viewed as a labelled edge in a graph
  - i.e., a set of RDF statements is a *directed, labelled graph*
    - both "objects" and "subjects" are the graph nodes
    - "properties" are the edges
  - the formal semantics of RDF is also described using graphs
- One should "think" in terms of graphs, and...

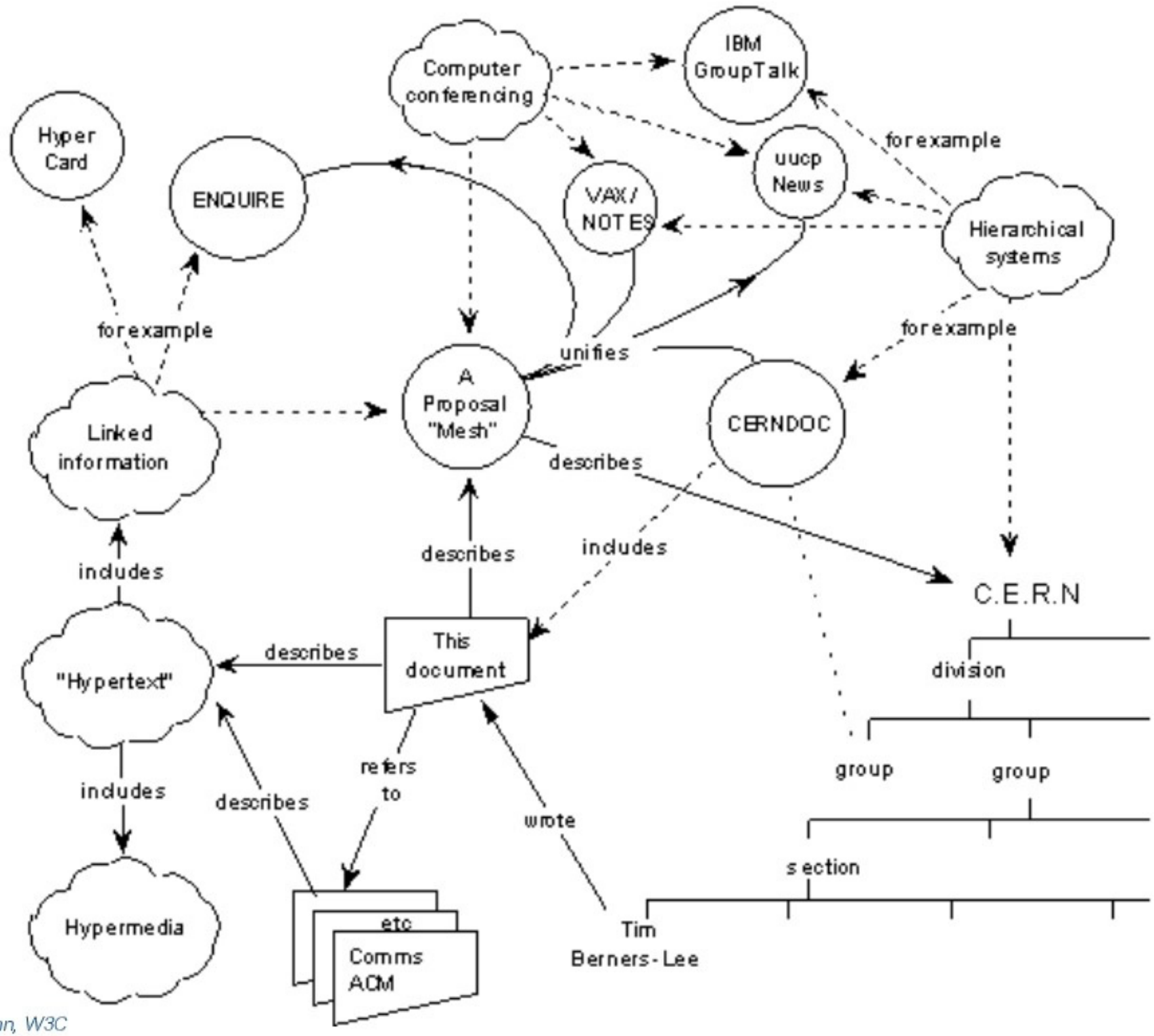
  ...RDF/XML is only a tool for practical usage!
- RDF authoring tools often work with graphs, too (XML is done "behind the scenes")
- If one thinks in graphs, things become simple!

A Simple RDF Example




```
<rdf:Description rdf:about="#FullSlide">
   <axsvg:GraphicsType>Chart</axsvg:GraphicsType>
   <axsvg:LabelledBy rdf:resource="#BottomLegend"/>
   <axsvg:ChartType>Line</axsvg:ChartType>
</rdf:Description>
```

Things Are Not That New...



RDF/XML has its Problems

- RDF/XML was developed in the "prehistory" of XML
  - e.g., even namespaces did not exist!
- Coordination was not perfect, leading to problems
  - the syntax cannot be checked with XML DTD-s
  - XML schemas are also a problem
  - encoding is verbose and complex
    - (e.g., simplifications lead to confusions)

  but there is too much legacy code 😟
- Don't be influenced (and set back...) by the XML format
  - the important point is the *model*, XML is just syntax
  - other "serialization" methods may come to the fore

Other Encodings Examples...

- Turtle, n3, N-triples (variants of one another):

```
:object :pred [
  :pred2 :val1;
  :pred3 :val2;
]
```

- RXR (Regular XML RDF):

```
<triple>
    <subject uri="..."/>
    <predicate uri="..."/>
    <object>A Literal</object>
</triple>
```

- OWL "Abstract Syntax":

```
Class(animate)
Class(animateMotion)
Class(animationEntity complete
    unionOf(animate animateMotion ...)
)
```

- Again: these are all just syntactic sugar!

Why should I use RDF?

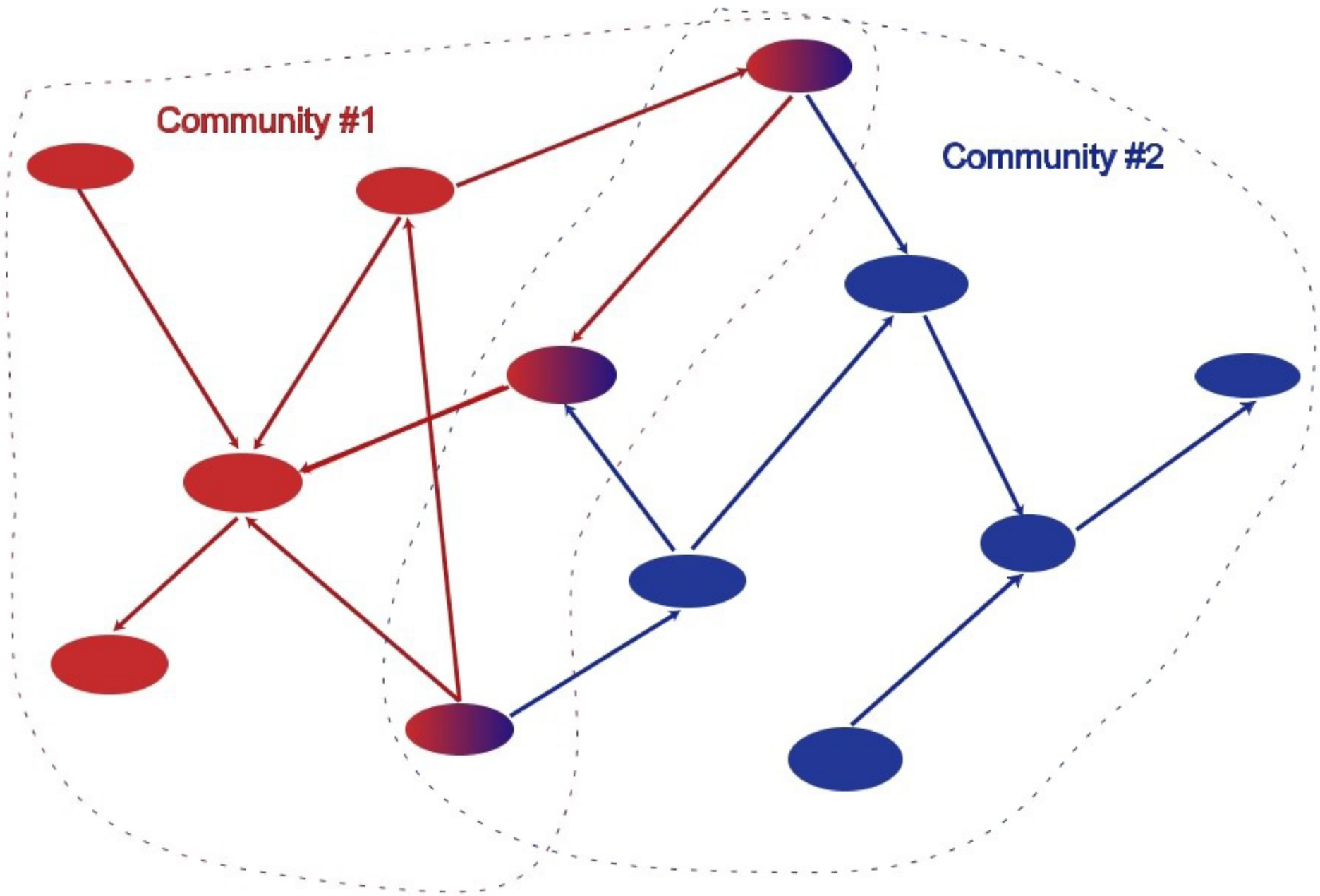
(Couldn't I simply use XML with XML Schema instead?)

It Depends...

- XML's model is
  - a tree, i.e., a strong hierarchy
  - applications may rely on hierarchy position (e.g., `li` in HTML)
  - relatively simple syntax and structure
  - not easy to *combine* trees
- RDF's model is
  - a *loose* collections of relations
  - applications may do "database"-like search
  - not easy to recover hierarchy
  - easy to combine relations in one big collection
    - great for the integration of heterogeneous information

Merge Shown as a Graph...

(note the power of the graph notation...)



"Joint" Community #1 and #2

Extra Bonus: OWL

- You may not use OWL reasoning yet...
- ...but you may in future, RDF leaves the door open!

Finding New Relationships

- RDF (possibly with OWL) helps in finding *new* relationships
  - e.g., in Life Sciences:
    - most of the drug experiments are unsuccessful
    - but the information from *each* experiment may be valuable
    - by "binding" this information new insights can be gained

  (currently, life sciences are *very* excited by the prospects of the Semantic Web!)
- Sharing and aggregation of data becomes easier
  - may be determinant for future R&D, for example
  - great tool for general community building

With *huge* ontologies on the Web, does this scale?

It May Be a Problem, But...

- Yes, reasoning over *huge* ontologies may be a problem
  - combination of ontologies may lead to this
  - DL systems shown to work for ≈100k concepts already
    - albeit with a simple structure
  - there are already applications with large ontologies (see later)
  - lots of R&D is happening here...

    but it is indeed still a challenge
- But: "a little semantics can take you far" (Jim Hendler)
  - i.e., small OWL ontologies may lead to useful applications
  - applications may use ontology "islands", and loosely bind them
    - OWL gives you tools for that

Where does the metadata come from?

(should we really expect the author to type in all this metadata?)

Not Necessarily

- Part of the metadata information is present in tools...

  ...but thrown away at output 😔
  - e.g., a business chart can be generated by a tool...

    ...it "knows" the structure, the classification, etc. of the chart

    ...but, usually, this information is lost

    ...storing it in metadata would be easy!
- "SW-aware" authoring tools will be of a great help
- Tools can also extract some metadata from HTML files (with little help)
- Ontologies also exist already
  - albeit mostly in propriatery formats
  - but conversion tools exist!

Isn't This Research Only?

(or: does this have *any* industrial relevance whatsoever?)

Not Any More...

- SW has indeed a strong foundation in research results...
- ...but we see more and more companies embracing it!
- Remember:
  1. the Web was born at CERN...
  2. ...was first picked up by high energy physicists...
  3. ...then by academia at large...
  4. ...then by small businesses and start-ups...
  5. "big business" came only later!

  network effect kicked in early...
- Semantic Web is now at #4, and moving to #5!

Lots of Tools

- (Graphical) Editors:
  - IsaViz (Xerox Research/W3C), RDFAuthor (Univ. of Bristol), Protege 2000 (Stanford Univ.), SWOOP (Univ. of Maryland) Orient (IBM)
- Programming Environments:
  - Jena (for Java, includes OWL reasoning), RDFLib (for Python), Redland (in C, with interfaces to Tcl, Java, PHP, Perl,...), SWI-Prolog, IBM's Semantic Toolkit, ...
- Triple based database systems:
  - Kowari, Tucana, Sesame
- RDF and OWL validators:
  - http://www.w3.org/RDF/Validator/ , http://owl.bbn.com/validator/
- Ontology converter (to OWL):
  - http://www.mindswap.org/2002/owl.html
- The list gets longer every day! You can always start with:
  - http://www.w3.org/RDF/#developers

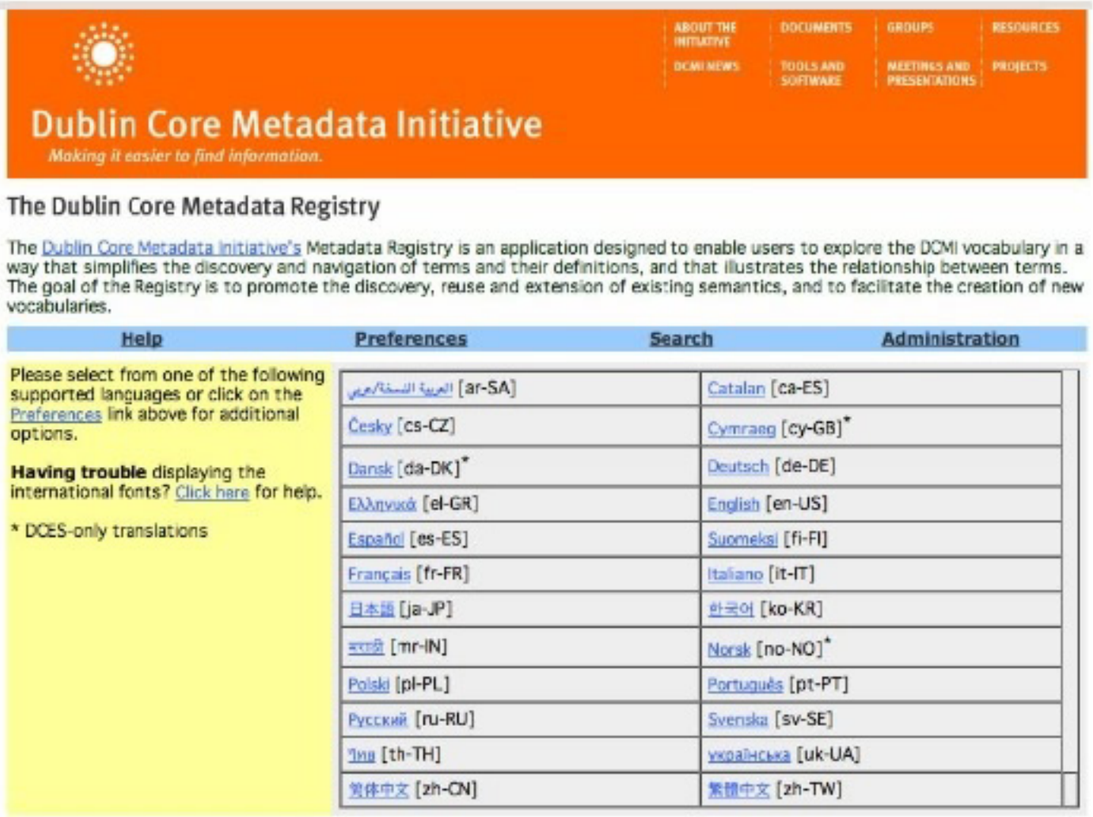
SW Applications

- Large number of applications emerge
  - some applications use RDF only
  - others use ontologies, too
    - huge number of ontologies exist, using proprietary formats
    - converting them to RDF/OWL will be a major task
      (but there are converters)
    - but it will be worth it!
- SWAD-Europe survey:
  - URI: http://www.w3.org/2003/11/SWApplSurvey
  - lists more than 50 applications in 12 categories...
  - and is already more than a years old!

SW Application Examples

Dublin Core

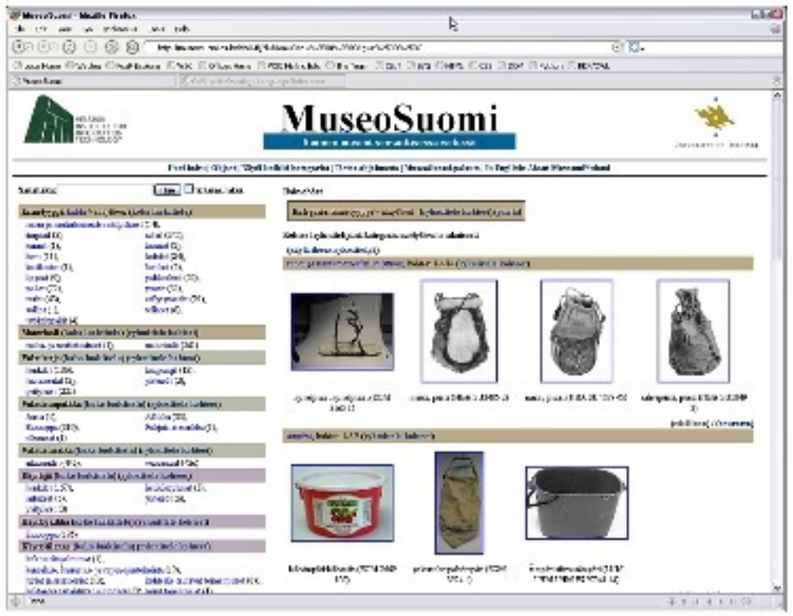
- vocabularies for distributed Digital Libraries
- one of the first metadata vocabularies in RDF
- URI: http://www.dublincore.org
- extensions exist, eg, PRISM that includes digital right tracking



SW Application Examples (cont)

Data integration

- achieve semantic integration of corporate resources or different databases
- RDF/RDFS/OWL based vocabularies as an "interlingua" among system components
- Boeing example: http://www.cs.rutgers.edu/~shklar/www11/final_submissions/paper3.pdf
- similar approaches: Artiste project, MITRE Corp., MuseoSuomi, ...
- there are companies specializing in the area



SW Application Examples (cont)

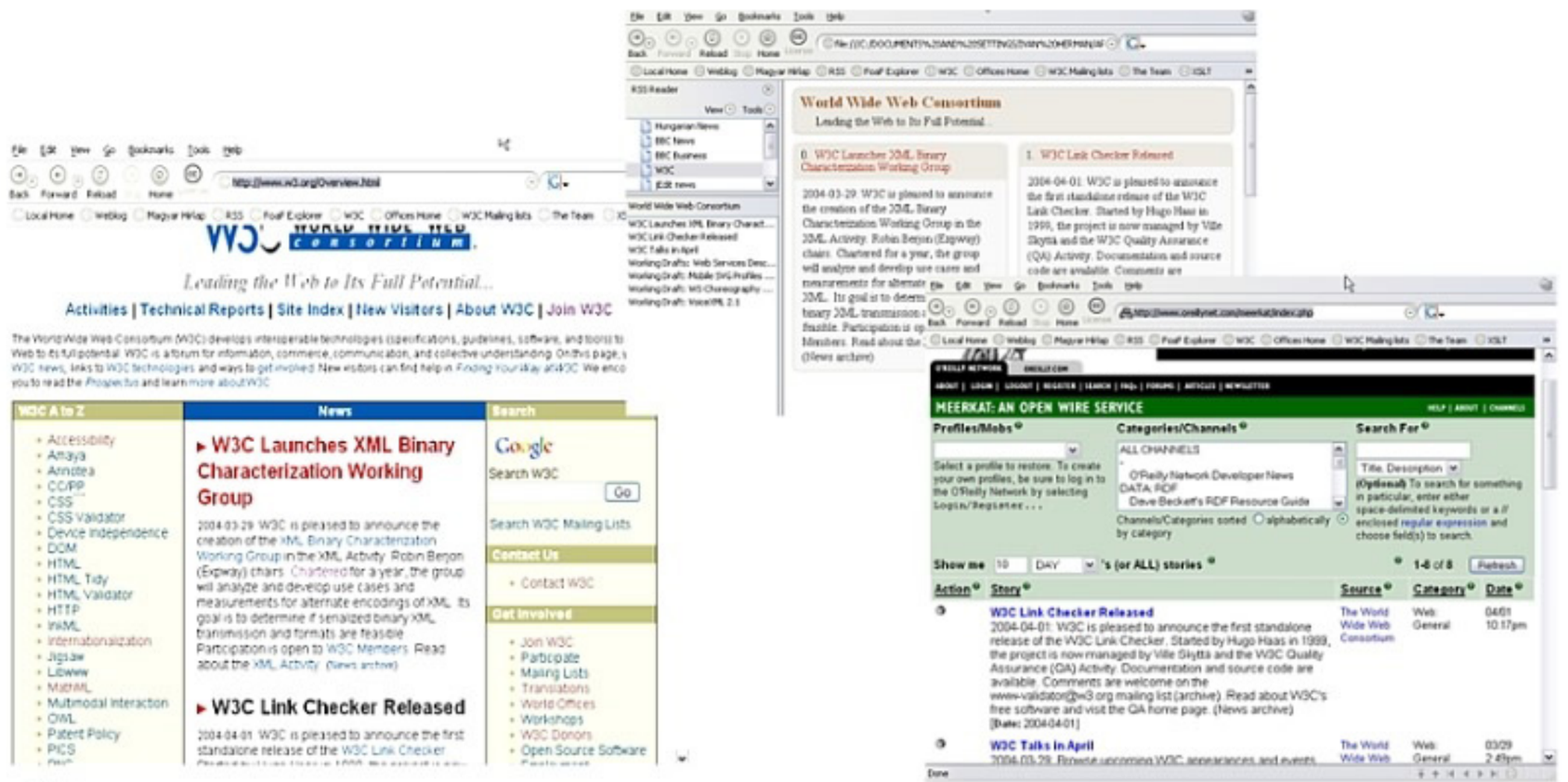
Sun's SwordFish

- Sun provides assisted support for its products, handbooks, etc
- Public queries go through an internal RDF engine for, eg:
  - Sun's White Papers collection
    (http://www.sun.com/servers/wp.html/)
  - Sun's System Handbooks collection
    (http://sunsolve.sun.com/handbook_pub/)

SW Application Examples (cont)

Web Content Syndication (RSS)

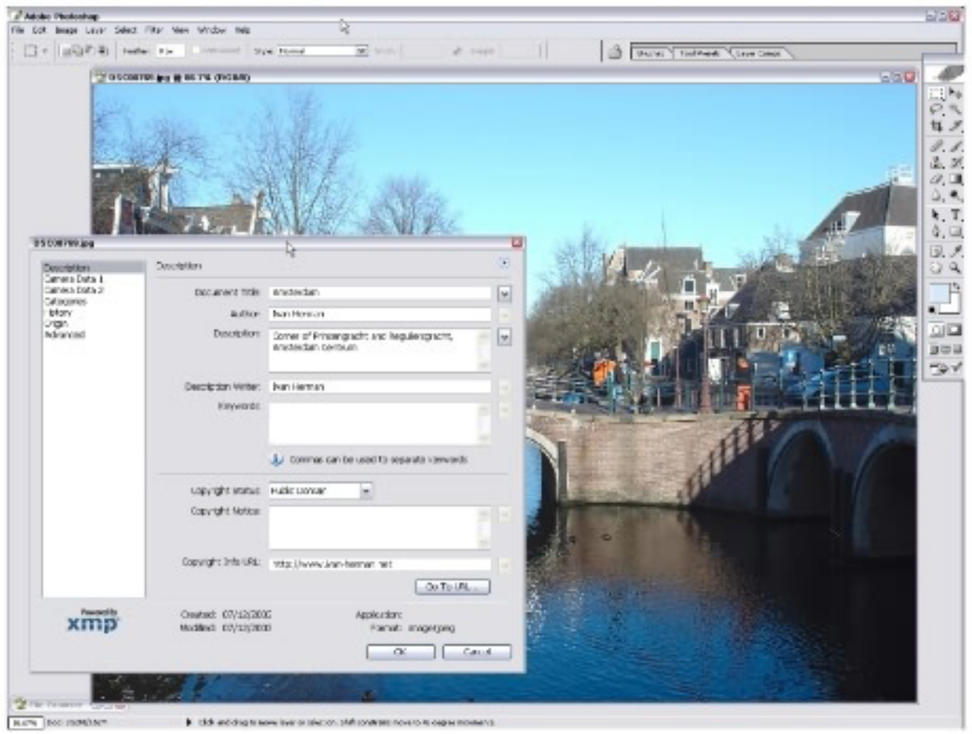
- can be used to specify the *important* content of a page
- there is a Yahoo discussion group and (non-W3C) working group
- URI: http://purl.org/rss/
- widely used in the weblog world!
- example: W3C home page syndicated



SW Application Examples (cont)

XMP

- Adobe's tool to add RDF-based metadata to *all* their file formats
  - eg, Photoshop in Creative Suite
  - millions of people use RDF without knowing it...
- the tool is available for all!
- URI: http://www.adobe.com/products/xmp/main.html



SW Application Examples (cont)

Mozilla

- internal data are stored in RDF (eg, bookmarks, conf. files)

Brandsoft

- entreprise Web Management
- all business models are stored in RDF
- easy to set up internal rules

Creative Commons

- an environment to express rights of digital content on the Web
  - legal constraints referred to in RDF, added to pages
- there are specialized browsers, browser plugins
- more than 1,000,000 users worldwide(!)
  - without knowing that they use RDF...

Does the SW Replace Web Services?

SW and WS are Complementary

- Two facets of machine-to-machine communication
  - service based ("Web of applications")
  - metadata based ("Web of data")
- *A widely deployed Web Services infrastructure may be the most compelling business case for the Semantic Web*
- *The synergy of Semantic Web and Web Service will hugely benefit for the wide deployement of both!*

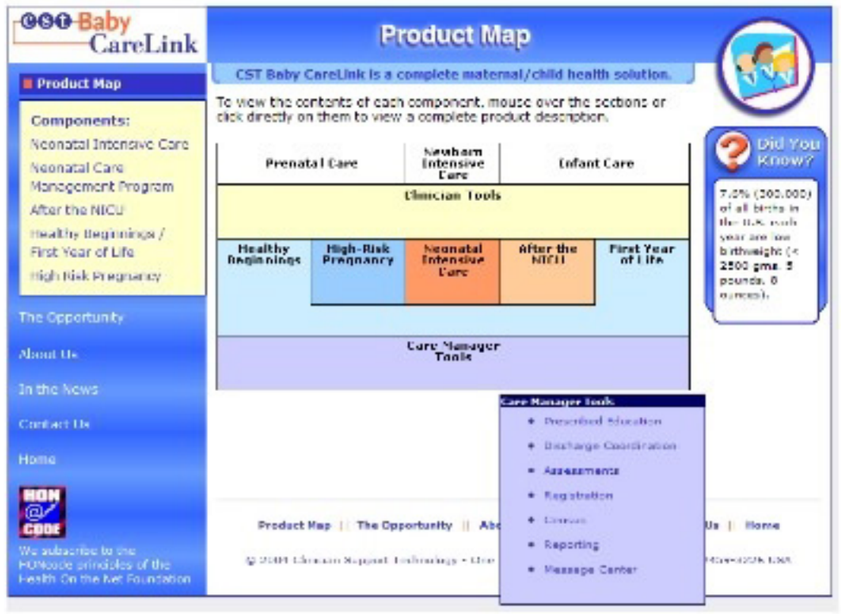
Examples for Potential Synergies

- Semantic Web based search engines for Web Services
  - search based on complex constraints
    - e.g., "find the most elegant Schrödinger equation solver"
- Ontology services
  - "provide a Web Service to make logical deductions on my behalf" (e.g., on complex metadata with an ontology)
    - find and manage equivalences
    - make logical deduction of terms
    - check SW description for validity
    - etc

SW-WS Synergy Example

Baby CareLink

- centre of information for the treatment of premature babies
- provides an OWL service *as a Web Service*
  - combines disparate vocabularies like medical, insurance, etc
  - remember: ontology is hard!
  - users can add new entries to ontologies
  - complex questions can be asked through the service



Convergence (at W3C)

- *Both areas are represented at W3C*
- The Groups on Web Services work on convergence, too
  - mapping of WSDL1.2 to RDF
  - Web Choreography development in terms of RDF
    - initiatives already exist, e.g., OWL-S (formerly DAML-S)
  - cooperation with the RDF Interest Group
  - there is a "Semantic Web Services" Interest Group
- The SW activity regards WS as one of its test cases

Are we done?

Semantic Web Activity Phase 2

- First phase (completed): core infrastructure
- Second phase: promotion and implementation needs
  - relevant working groups
  - outreach to user communities
    - life sciences
    - geospatial information systems
    - libraries and digital repositories
    - ...
  - intersection of SW with other technologies
    - Semantic Web Services
    - privacy policies
    - ...

"Best Practices" Work

- "Semantic Web Best Practices and Deployment"
  - recommendations for practical deployment
  - engineering guidelines
  - ontology/vocabulary development practices
  - educational material
  - effective demonstrations
  - information on applications
  - etc.
- Goal is to increase awareness on SW
- W3C started work in this area recently
  - some initial drafts are already available

RDF Data Access (a.k.a. Queries)

- In Python, for example, one uses:

```
# do something with (p,o) pairs
for (p,o) in triples.predicate_objects(subject) :
    do_something(p,o)
```

  "predicate_objects" returns a *subgraph*

- Applications may want more
  - i.e., return complex subgraph with parts missing
- Very important for large and *distributed* RDF depositories
- There are more than 20 RDF Query languages

Data Access Example

- One may want something like:

```
SELECT (a,b)
  WHERE [?x 'parent' a] and [b 'brother' ?x]
```

(i.e., 'b is the uncle of a')

- W3C started a standardization work in this area recently
  - precise relationships to XML Query has to be defined
  - concentrates also on *protocols* to extract subgraphs
    - e.g., using SOAP
- Such facilities already implemented in Jena, RAP,...

Rules

- OWL can be used for simple inferences
- Applications may require more, e.g., Horn clauses:
  - (ant-1 ∧ ant-2 ∧ ...) ⇒ (cons-1 ∧ cons-2 ∧ ...)
  - e.g.:
    - for *any* «X», «Y» and «Z»:

      "if «Y» is a parent of «X», and «Z» is a brother of «Y»

      then «Z» is the uncle of «X»"
    - using a logic formalism:

      $\forall x,z: ((\exists y: (y \text{ parent } x) \wedge (y \text{ brother } z)) \Rightarrow (z \text{ uncle } x))$
- Lots of research is happening to extend RDF/OWL (RuleML, SWRL, cwm, ...)
- W3C *may* initiate a standardization work in this area, too
  - question is whether results are "ripe" for standardization
  - and whether the necessary manpower is available

Trust

- Can I trust a metadata on the Web?
  - is the author the one who claims he/she is?
  - can I check the credentials?
  - can I trust the inference engine?
  - what about IPR of the metadata?
  - etc.
- Some of the basic building blocks are available:
  - XML Signature/Encryption
  - XML based Key Management is in preparation
- Much is missing, e.g.:
  - a "canonical" form of RDF/XML
    - necessary for unambiguous signatures
  - exhaustive tests for inference engines
  - protocols to check, for example, a signature
- It is on the "future" stack of W3C...

What can I read to understand?

Some Books

- M. Dertouzos: The Unfinished Revolution (1995)
  - an early "vision" book (not only on the Semantic Web)
- T. Berners-Lee: Weaving the Web (1999)
  - another "vision" book
- J. Davies, D. Fensel, F. van Harmelen: Towards the Semantic Web (2002)
- S. Powers: Practical RDF (2003)
- D. Fensel, J. Hendler: Spinning the Semantic Web (2003)
- G. Antoniu, F. van Harmelen: Semantic Web Primer (2004)
- ...

Further Information

- Bristol University
  - http://www.ilrt.bristol.ac.uk/discovery/rdf/resources/
  - huge list of documents, publications
- Semantic Web Community Portal
  - http://www.semanticweb.org/
  - "Business model IG" (part of the portal)
  - huge set of links to documents, software, …
- SemWeb Central
  - http://semwebcentral.org
  - Open Source development archive
- W3C team public presentations:
  - http://www.w3.org/2001/sw/EO/talks
- W3C's Semantic Web home page:
  - http://www.w3.org/2001/sw/

W3C Primers and Test Cases

RDF Primer

URI: http://www.w3.org/TR/rdf-primer

OWL Guide

URI: http://www.w3.org/TR/owl-guide/

RDF Test Cases

URI: http://www.w3.org/TR/rdf-testcases/

OWL Test Cases

URI: http://www.w3.org/TR/owl-test/

Public Fora at W3C

Semantic Web Interest Group

a forum for discussions on applications

URI: http://www.w3.org/RDF/Interest

RDF Logic

public (archived) mailing list for technical discussions

URI: http://lists.w3.org/Archives/Public/www-rdf-logic/

Further Information

These slides (with links)

http://www.w3.org/2004/Talks/3108-Stockholm-IH

W3C Office in Sweden:

http://www.w3c.se

Mail me:

ivan@w3.org

Now For Real...

Other Questions?

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