State of the Semantic Web

Ivan Herman, W3C

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> So where are we with the Semantic Web?

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> We have the basic technologies

- Stable specifications for the basics since 2004: RDF, OWL
- Work is being done to properly incorporate rules
- We have a standard for query since 2008: SPARQL
- We have some additional technologies to access/create RDF data: GRDDL, RDFa, POWDER, …
- Some fundamental vocabularies became pervasive (FOAF, Dublin Core,…)

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> Lots of Tools (*not* an exhaustive list!)

- **Triple Stores**
  - RDFStore, AllegroGraph, Tucana
  - RDF Gateway, Mulgara, SPASQL
  - Jena's SDB, D2R Server, SOR
  - Virtuoso, Oracle11g
  - Sesame, OWLIM, Tallis Platform
  - …
- **Reasoners**
  - Pellet, RacerPro, KAON2, FaCT++
  - Ontobroker, Ontotext
  - SHER, Oracle 11g, AllegroGraph
  - …
- **Converters**
  - flickurl, TopBraid Composer
  - GRDDL, Triplr, jpeg2rdf
  - …
- **Search Engines**
  - Falcon, Sindice, Swoogle
  - …
- **Middleware**
  - IODT, Open Anzo, DartGrid
  - Ontology Works, Ontoprise
  - Profium Semantic Information Router
  - Software AG's EII, Thetus Publisher, Asio, SDS
  - …
- **Semantic Web Browsers**
  - Disco, Tabulator, Zitgist, OpenLink Viewer
  - …
- **Development Tools**
  - SemanticWorks, Protégé
  - Jena, Redland, RDFLib, RAP
  - Sesame, SWI-Prolog
  - TopBraid Composer, DOME
  - …
- **Semantic Wiki and CMS systems**
  - Semantic Media Wiki, Platypus
  - Visual knowledge
  - Drupal 7

Inspired by "Enterprise Semantic Web in Practice", Jeff Pollock, Oracle. See also W3C's Wiki Site.

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> Lots of tools (cont.)

- Significant speed, store capacity, etc; improvements are reported every day
- Some of the tools are open source, some are not; some are very mature, some are not: *it is the usual picture of software tools*, nothing special any more!
- *Anybody can start developing RDF-based applications today*

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> There is a great community

- There are *lots* of tutorials, overviews, and books around
  - again, some of them good, some of them bad, just as with any other areas…
- Active developers' communities
  - blogs, IRC channels, mailing lists, various fora: more than what one person can oversee…
- Some measures claim that there are over 10^7 Semantic Web documents on the Web

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> Some deployment communities

- Major communities pick the technology up: digital libraries, defense, eGovernment, energy sector, financial services, health care, oil and gas industry, life sciences …
- Semantic Web also appears in the “Web 2.0/Web 3.0” world (whatever that means)
  - exchange of social data
  - personal “space” applications
  - multimedia asset management (video, photos, audio, …)
  - etc

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> So what *is* the Semantic Web?

- There is a growing number of application patterns referring to the Semantic Web:
  - data integration using RDF, SKOS, OWL, …
  - knowledge engineering with complex ontologies
  - better data management, archiving, cataloging, digital libraries, …
  - managing, coordinating, combining Web services
  - intelligent software agents
  - improving search (usually using domain specific vocabularies…)
  - etc
  - and, of course, mixtures of these…
- But: what binds these all together?

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> Is this where we are?

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> So what *is* the Semantic Web? (cont.)

- Maybe, but being an elephant is not necessary bad!
  - it shows that the Semantic Web is a mature technology
  - that there is lots of interest, applications
  - various application areas pick what they need…
    - e.g., some need sophisticated knowledge management, so they go for complex ontologies…
    - some concentrate on semantically simpler vocabularies but large volume of data
  - …and that is fine, there is room for many!

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> So what *is* the Semantic Web? (cont.)

- But it is good to (re-)emphasize some principles
- The Semantic Web:
  - a unique way of specifying data and data *relationships*
  - extend principles of the Web from documents to data; create a *Web of data*
  - it is the Semantic *Web*, and not only Semantics
    - data, ontologies, vocabularies, etc, should be shared, reused, potentially on Web scale
    - e.g., one can use the Web infrastructure to denote "things"…
      - Eg: **`http://www.ivan-herman/me`** denotes, well, *me* (not my home page, not my foaf file, but *me*!)
    - … and add relationships for those, too!

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> A few words about “newer” technologies

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> Querying RDF: SPARQL

- Querying RDF graphs is essential (can you imagine Relational Databases without SQL?)
- SPARQL is
  - a query language based on graph patterns
  - a protocol layer to use SPARQL over, eg, HTTP
  - an XML return format for the query results
- Numerous implementations are already available (eg, built in triple stores)

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> SPARQL (cont.)

- There are also SPARQL "endpoints" on the Web:
  - send a query and a reference to data over HTTP GET, receive the result in XML or JSON
    - some of those can be easily installed on any machine
  - big datasets often offer "SPARQL endpoints" to their local data
  - *applications may not need any direct RDF programming any more, just use a SPARQL processor*
- SPARQL can also be used to *construct* graphs!

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> The power of CONSTRUCT

```
CONSTRUCT {
    <http://dbpedia.org/resource/Amitav_Ghosh> ?p1 ?o1.
    ?s2 ?p2 <http://dbpedia.org/resource/Amitav_Ghosh>.
}
WHERE {
    <http://dbpedia.org/resource/Amitav_Ghosh> ?p1 ?o1.
    ?s2 ?p2 <http://dbpedia.org/resource/Amitav_Ghosh>.
}
```



```
SELECT *
FROM <http://dbpedia.org/sparql/?query=CONSTRUCT+%7B++...>
WHERE {
  ?author_of dbpedia:author res:Amitav_Ghosh.
  res:Amitav_Ghosh  dbpedia:reference ?homepage;
                    rdf:type          ?type;
                    foaf:name         ?foaf_name.
  FILTER regex(str(?type),"foaf")
}
```

- SPARQL endpoint
- returns RDF/XML

- Data reused in a query elsewhere…

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> A word of warning on SPARQL…

- Some features are missing
  - control and/or description on the entailment regimes of the triple store (RDFS? OWL-DL? OWL-Lite? …)
  - modify the triple store
  - querying collections or containers may be complicated
  - no functions for sum, average, min, max, …
  - ways of aggregating queries
  - …
- Delayed for a next version…

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> But: how do you get the data on the SW?

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> Public datasets are accumulating

- IgentaConnect bibliographic metadata storage: over 200 million triplets
- RDFS/OWL Representation of WordNet: also downloadable as 150MB of RDF/XML
- "Département/canton/commune" structure of France published by the French Statistical Institute
- Geonames Ontology and Data: 6 million (and growing) geographical features
- RDF Book Mashup: book data from, eg, Amazon,
- "dbpedia": infobox data of Wikipedia into RDF
- Note the "Billion Triple Challenge 2008"!

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> How to get RDF data?

- Of course, one could create RDF data manually…
- … but that is unrealistic on a large scale
- Goal is to generate RDF data automatically (when possible) and "fill in" by hand only when necessary
- Different data formats should be considered
  - databases (relational or otherwise)
  - data in XML, HTML, in pictures, videos,
  - etc
- Details of the process is still subject of very active R&D!

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> Bridge to relational databases

- Huge amount of data are stored in (relational) databases
  - "RDFying" them is impossible
- "Bridges" are being defined:
  - a layer between RDF and the relational data
    - RDB tables are "mapped" to RDF graphs, possibly on the fly
  - systems can now be used as relational database as well as triple stores (eg, Oracle, OpenLink, …)
- Work for a survey on mapping techniques has just started at W3C
- SPARQL is becoming the tool of choice to query the data (via "SPARQL Endpoints")

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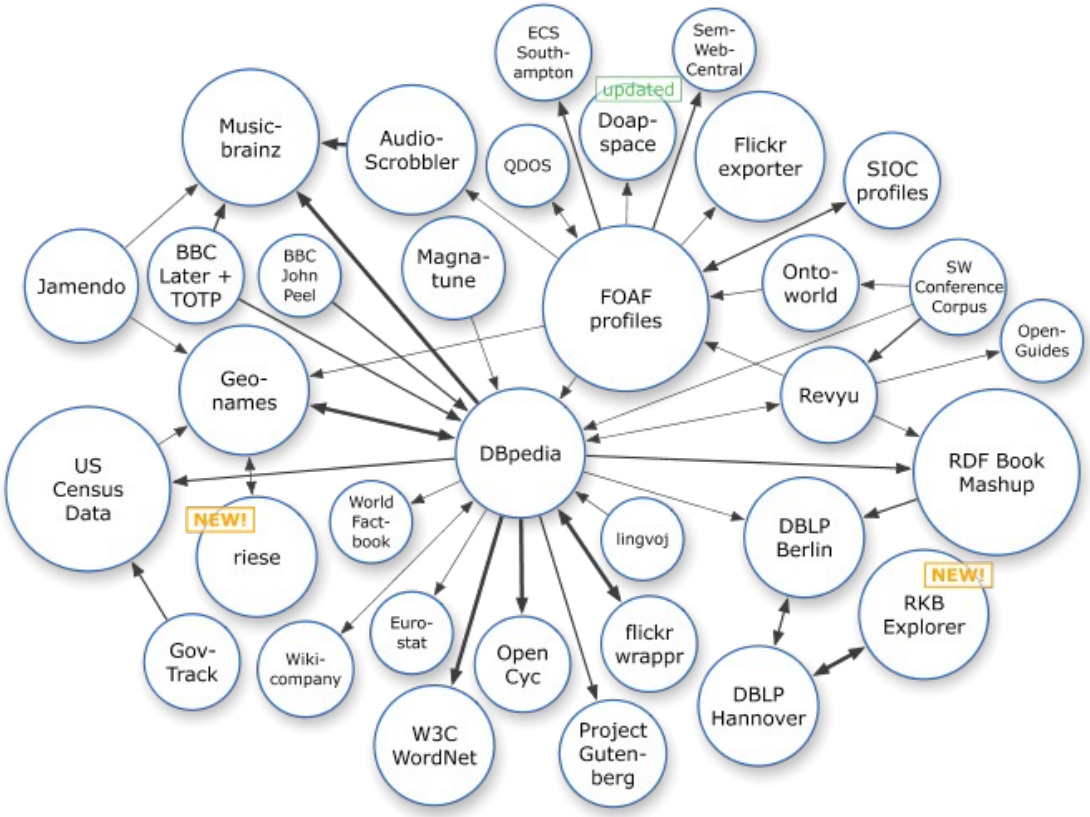
> Linking Open Data Project

- Goal: “expose” open datasets in RDF
- *Set RDF links among the data items* from different datasets
- Set up SPARQL endpoints to query the data, too



- billions of triples
- millions of “links”

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> Example data source: DBpedia

- DBpedia is a community effort to
  - extract structured (“infobox”) information from Wikipedia
  - provide a SPARQL endpoint to the dataset
  - interlink the DBpedia dataset with other datasets on the Web

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> Structured data from Wikipedia

```
http://en.wikipedia.org/wiki/San_Jose
%2C_California
```

```
<http://dbpedia.org/resource/San_Jose
%2C_California>
  dbpedia:areaTotalSqMi "178.2"^^xsd:double;
  dbpedia:areaTotalKm "461.5"^^xsd:double;
  dbpedia:populationTotal "929936"^^xsd:double;
  dpbedia:leaderName
       dbpedia:Chuck_Reed, "Debra Figone";
 ...
```

City of San Jose

Flag

Government		
- Type	charter city, mayor-council	
- Mayor	Chuck Reed	
- Vice Mayor	Dave Cortese	
- City Manager	Debra Figone	
- Senate	List of Senators	[show]
- Assembly	Assembly List	[show]
Area [1]		
- City	178.2 sq mi (461.5 km²)	
- Land	174.9 sq mi (452.9 km²)	
- Water	3.3 sq mi (8.6 km²)	
- Urban	260.11 sq mi (673.68 km²)	
- Metro	2,694.7 sq mi (6,979.4 km²)	
Elevation [2]	85 ft (26 m)	
Population (2006)[3][4][5]		
- City	929,936 (10th)	
- Density	5,216.3/sq mi (2,014.4/km²)	
- Urban	1,611,000	
- Metro	7,264,887	
- Demonym	San Josean	

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> Automatic links among open datasets

Linking DBPedia and the US Census data:

```
<http://dbpedia.org.../San_Jose%2C_California>
  owl.sameAs
     <http://.../usgov/geo/.../santa_clara_county/san_jose>;
 ...
```

```
<http://.../usgov/geo/.../santa_clara_county/san_jose>
  owl:sameAs <http://DBpedia.org/.../San_Jose%2C_California>
  census:households "559949"^^xsd:integer;
  wgspos:lat "37.318892"^^xsd:double;
 ...
```

Processors can switch automatically from one to the other…

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> Linking Open Data Project (cont)

- This is a *major* community project
  - anybody can participate; to subscribe to the list:
    - http://lists.w3.org/Archives/public/public-lod/
  - or look at the project site:
    - http://esw.w3.org/topic/SweoIG/TaskForces/CommunityProjects/LinkingOpenData
  - if you know of open data sets: contact the project to incorporate it with the rest!
- Applications using this set of data in real-life setting should come to the fore soon

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> Data may be around already…

- Part of the (meta)data 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 web data would be easy!
- "SW-aware" tools are around (even if you do not know it…), though more would be good:
  - Photoshop CS stores metadata in RDF in, say, jpg files (using XMP)
  - …

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> Data may be extracted (a.k.a. “scraped”)

- Different tools, services, etc, come around:
  - get RDF data associated with images, for example:
    - service to get RDF from flickr images
    - service to get RDF from XMP
  - scripts to convert spreadsheets to RDF
  - etc
- Many of these tools are still individual “hacks”, but show a general tendency
- Hopefully more tools will emerge
  - there is a separate wiki page collecting references to existing ones

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> Getting structured data to RDF: GRDDL

- GRDDL is a way to access structured data in XML/ XHTML and turn it into RDF:
  - defines XML attributes to bind a suitable script to transform (part of) the data into RDF
  - a “GRDDL Processor” runs the script and produces RDF on–the–fly
- A way to access existing structured data and “bring” it to RDF
  - eg, a possible link to microformats
  - exposing data from large XML use bases, like XBRL

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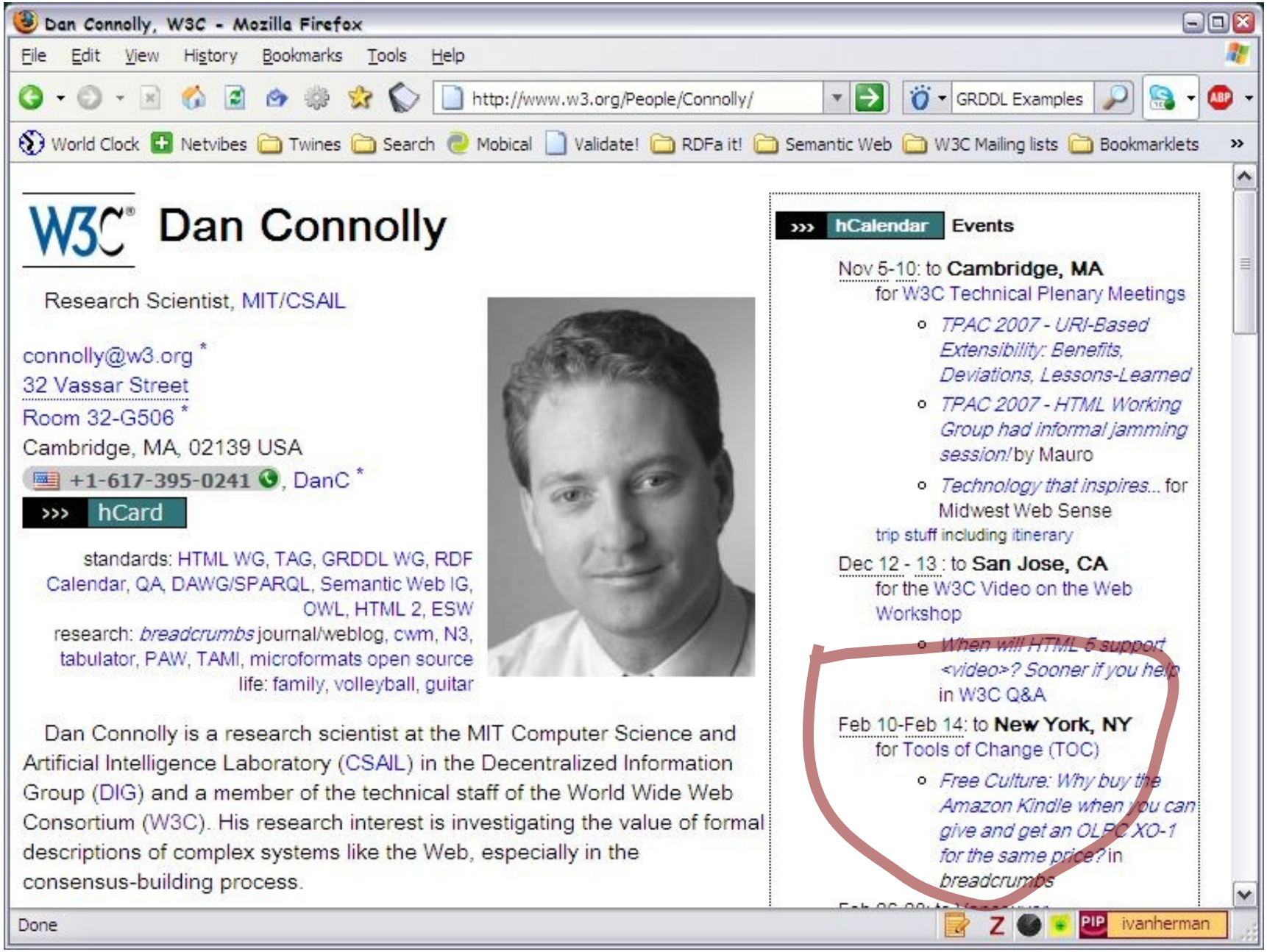
> GRDDL example: Dan's homepage…



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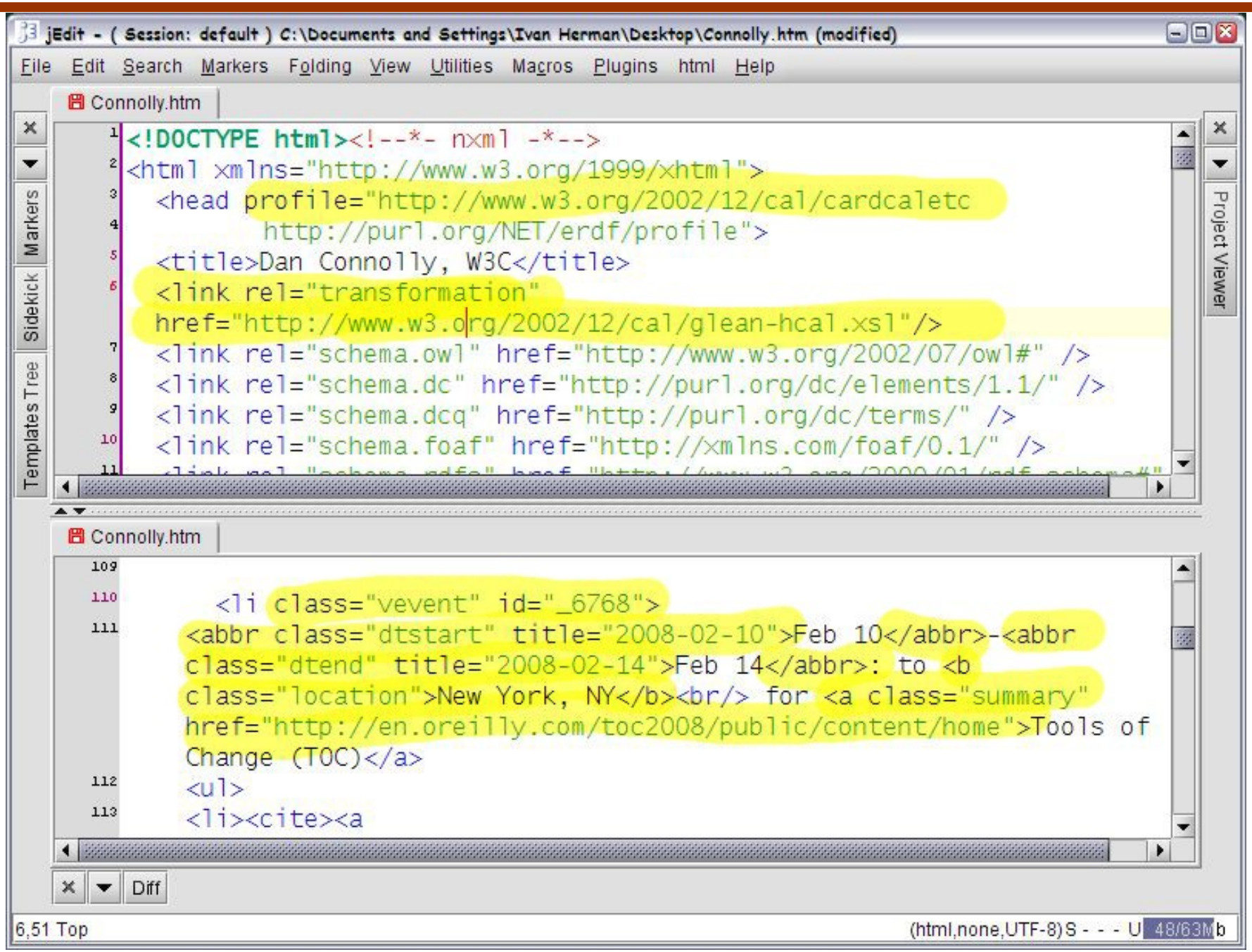
> … behind the scenes …



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>…yielding, through the GRDDL transform

```
<http://www.w3.org/People/Connolly/#_6768>
    a <http://www.w3.org/2002/12/cal/icaltzd#Vevent>;
    <http://www.w3.org/2002/12/cal/icaltzd#organizer>
          <http://www.w3.org/People/Connolly/#me>;
    <http://www.w3.org/2002/12/cal/icaltzd#summary>
          "Tools of Change (TOC)";
    <http://www.w3.org/2002/12/cal/icaltzd#dtstart>
          "2008-02-10"^^<http://www.w3.org/2001/XMLSchema#date>;
    <http://www.w3.org/2002/12/cal/icaltzd#dtend>
          "2008-02-14"^^<http://www.w3.org/2001/XMLSchema#date>;
    <http://www.w3.org/2002/12/cal/icaltzd#url>
          <http://www.w3.org/People/Connolly/#_6768>;
    <http://www.w3.org/2002/12/cal/icaltzd#location>
          "New York, NY" .
```


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> Getting structured data to RDF: RDFa

- RDFa extends XHTML with a set of attributes to include structured data into XHTML
- Makes it easy to “bring” existing RDF vocabularies into XHTML
  - uses namespaces for an easy mix of terminologies

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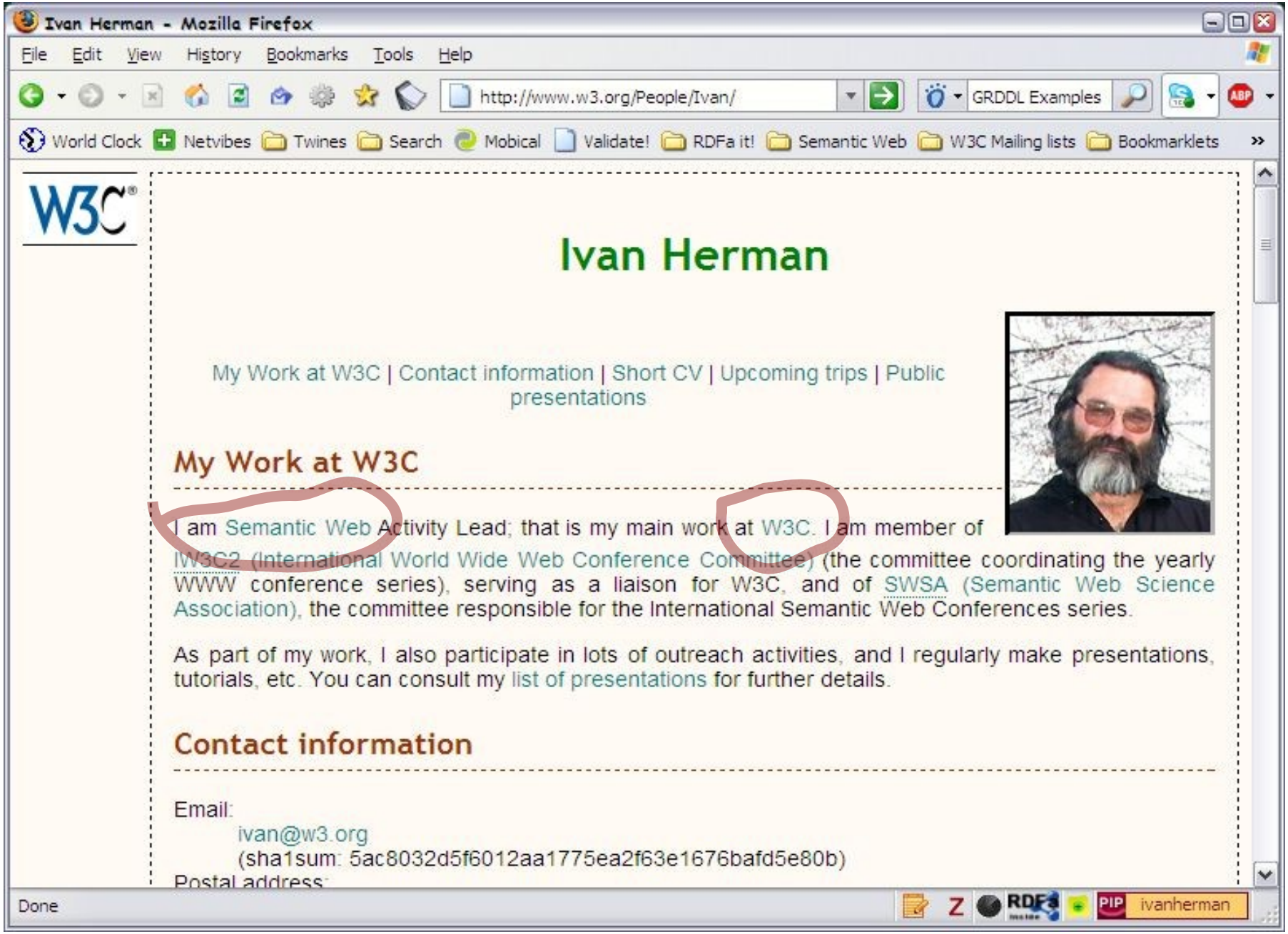
> RDFa example: Ivan's homepage...



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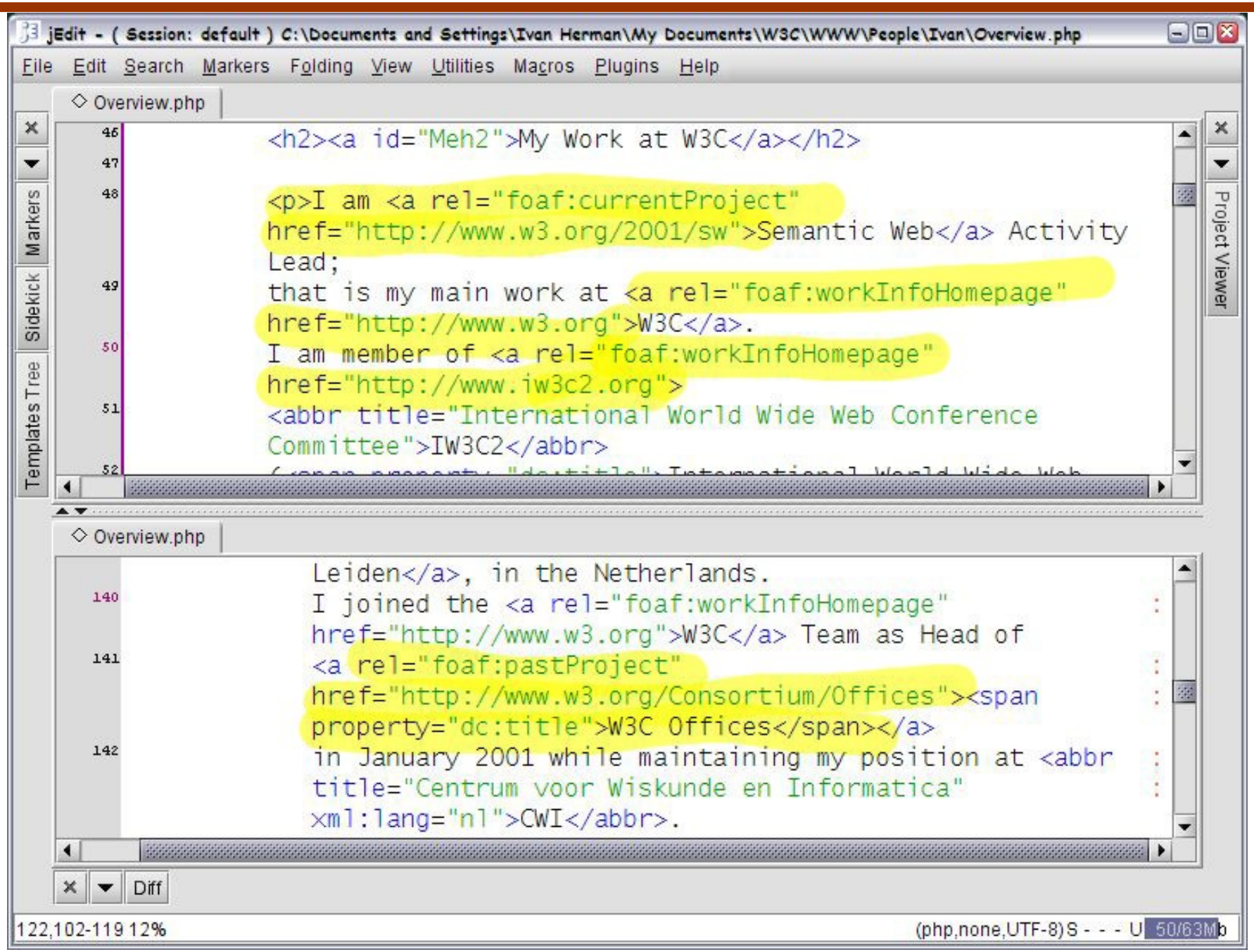
> … behind the scenes …



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> …yielding, by extracting RDF

```
<Overview.html#me> a foaf:Person;
    foaf:currentProject <http://www.w3.org/2001/sw>;
    foaf:workInfoHomepage
         <http://www.iw3c2.org>,
         <http://www.w3.org>;
    foaf:pastProject
         <http://www.w3.org/Consortium/Offices>;
      ...

<http://www.w3.org/Consortium/Offices> dc:title "W3C Offices".
```


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> Such data can be SPARQL-ed

```
SELECT DISTINCT ?name ?home ?orgRole ?orgName ?orgHome
# Get RDFa from my home page:
FROM <http://www.w3.org/People/Ivan/>
# GRDDL-ing http://www.w3.org/Member/Mail:
FROM <http://www.w3.org/Member/Mail/>
WHERE {
?foafPerson   foaf:mbox ?mail;
              foaf:homepage ?home.
?individual   contact:mailbox ?mail;
              contact:fullName ?name.
?orgUnit ?orgRole ?individual;
          org:name ?orgName;
          contact:homePage ?orgHome.
}
```


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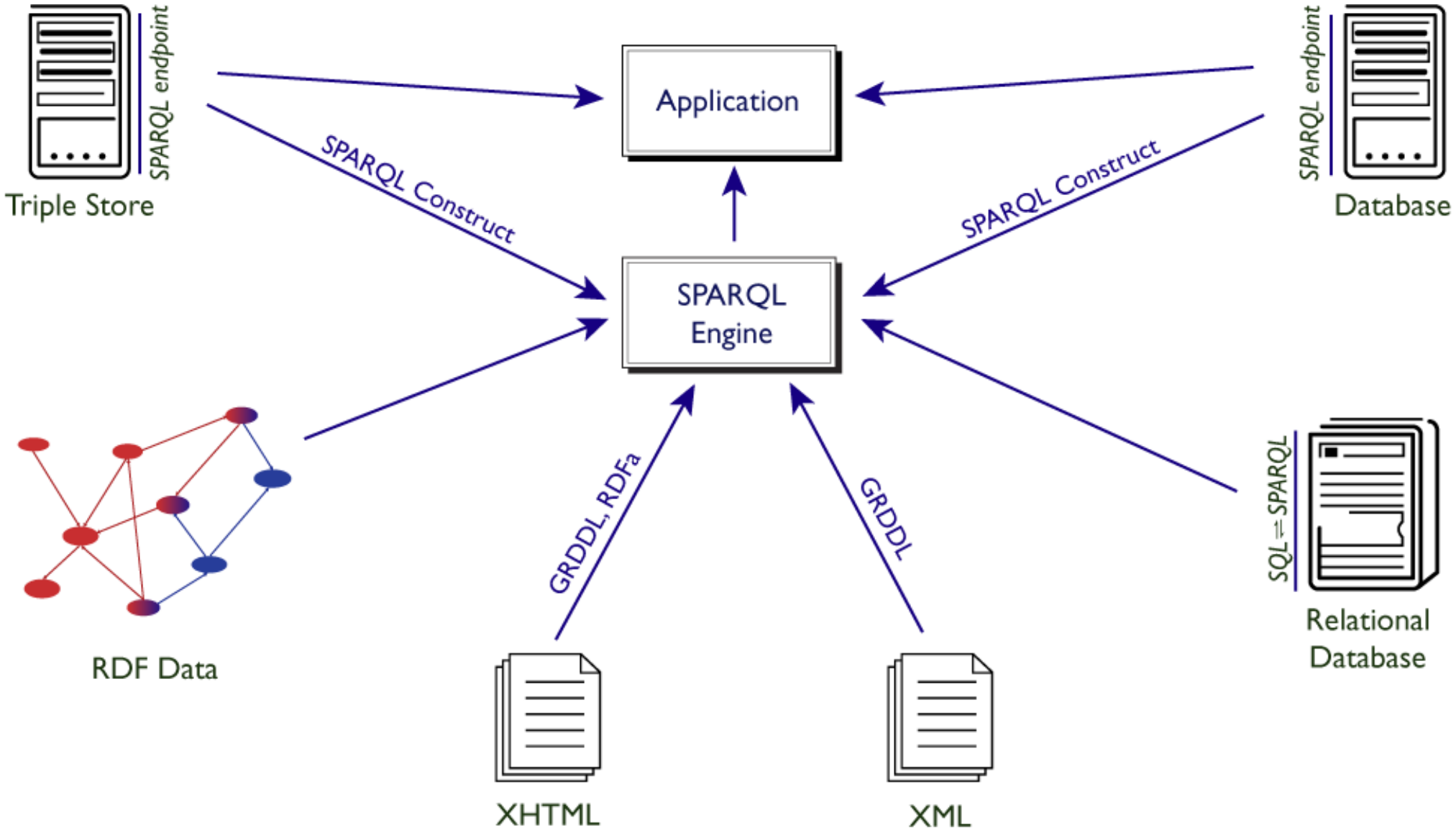
> SPARQL as a unifying point!



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> How to “assign” RDF data to resources?

- Some examples:
  - copyright information for your photographs
  - is a Web page usable on a mobile phone and how?
  - bibliographical data for a publication
  - annotation of the data resulting from a scientific experiment
  - etc
- The issue: if I have the URI of the resource (photograph, publication, etc), how do I find the relevant RDF data?

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> The data might be embedded

- Some data formats allow the direct inclusion of (RDF) metadata:
  - SVG (Scalable Vector Graphics)
  - XHTML+RDFa
  - microformats+GRDDL
  - JPG files using the comment area and, eg, Adobe's XMP technology
- That can include all the information, or link to further data

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> POWDER

- POWDER (Protocol for Web Description Resources) provides for more elaborate scenarios
- With POWDER:
  1. define a *set* of resources by constraints on the URIs; eg
     - URIs must begin with **`http://www.example.com/bla/`**
     - the port number in the URI-s should be **`XYZW`**
  2. define description resources, binding each resource in the set to additional information
     - this *must* be attributed and may be open to authentication
  3. get such description resources, eg, via a link statements, via HTTP, via SPARQL from a depository, …
- A technology under development at W3C

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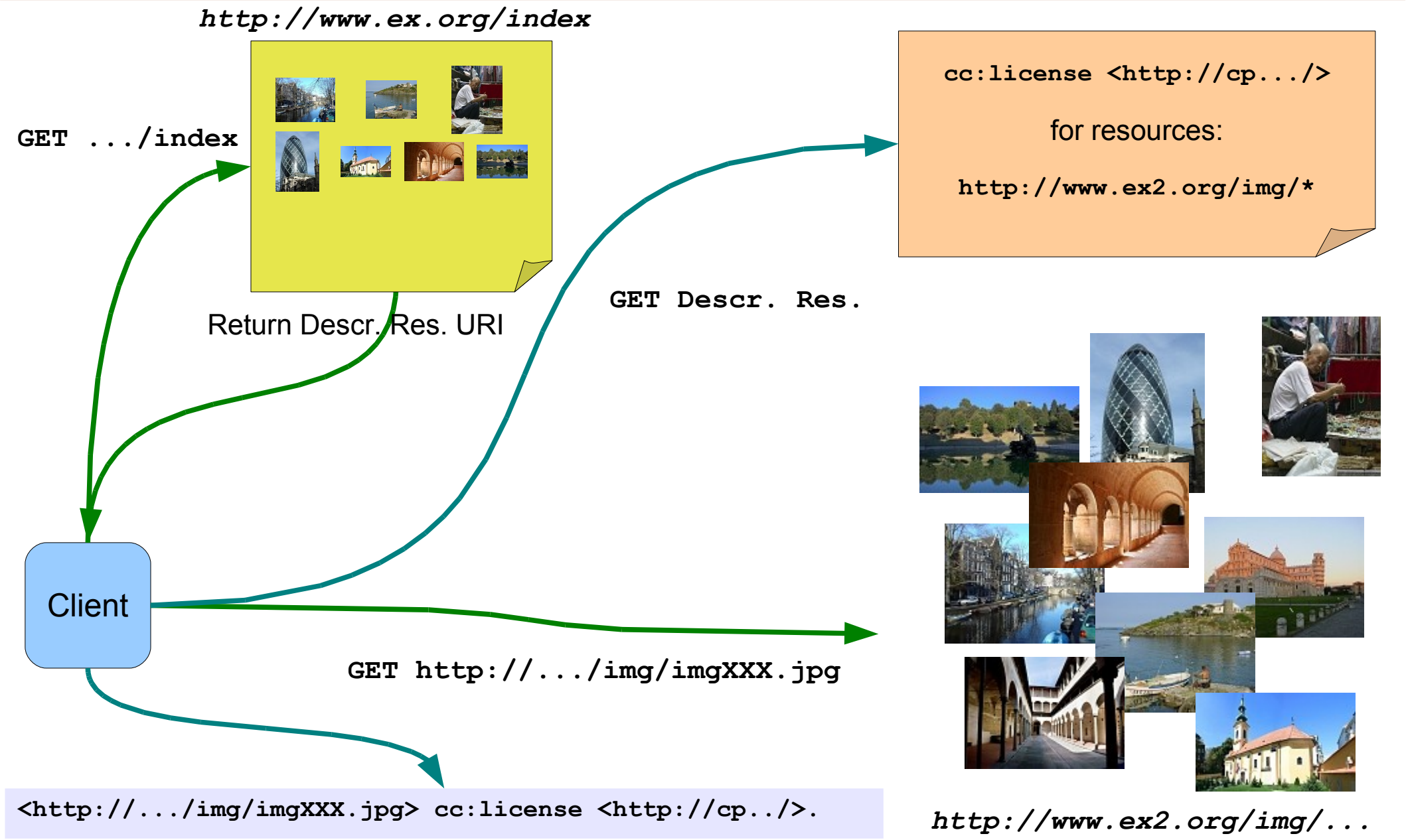
> A POWDER scenario: copyrights



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> Everything has not been solved…

- Integration of rules and Semantic Web
  - subject of the RIF Working Group at W3C
- Updating OWL
  - in a renewed OWL Working group at W3C:
    - add new features that practice has shown to be important
    - define better “profiles” to adapt to various user communities

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> Everything has not been solved…

- A number of open issues, problems
  - open technical issues
  - misconceptions, messaging problems
  - need for more applications, deployment, acceptance
  - etc

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> Some open technical issues

- Security, trust, provenance
  - combining cryptographic techniques with the RDF model, sign a portion of the graph, etc
  - trust models
- Ontology merging, alignment, term equivalences, versioning, development, …
- Uncertainty (fuzzy and/or probabilistic relations, reasoning, …)
- etc

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> Other items: naming

- The SW infrastructure relies on unique naming of “things” via URI-s
- Lots of discussions are happening that also touch upon general Web architecture:
  - HTTP URI-s or other URN-s?
    - using non-HTTP unnecessarily complicates the general infrastructure
  - URI-s for “informational resources” and “non informational resources”
  - how to ensure that URI-s used on the SW are dereferencable
  - what inferences can be drawn upon an HTTP session?
  - etc

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> Other items: naming (cont)

- A different aspect of naming: *what* is the URI for a specific resource
  - what is the unique URI for, eg, Bach's Well-Tempered Clavier?
    - obviously important for, eg, music ontologies and data
    - who has the authority or the means to define and maintain such URI-s?
    - the traditional library community may be of a big help in this area
  - what is the URI of time-dependent entity (e.g., a specific point *within* a video)?

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> A major problem: messaging

- Some of the messaging on Semantic Web has gone terribly wrong over the years
- This has created lots of (unnecessary) controversies

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> Some of the usual misconceptions…

- The Semantic Web is simply Artificial Intelligence on the Web
- It is just an ugly application of XML
- One has to add metadata to all Web pages, convert all databases and XML data to use the Semantic Web
  - which is obviously unrealistic…
- One has to learn formal logic, knowledge representation techniques, etc, to use it (ie, it has nothing to do with the Web)

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> … and some more …

- It relies on a centrally controlled super-ontology for "meaning"
  - and this is impossible, because people will never agree on all terms
  - as opposed to a democratic, bottom-up control of terms
  - we do not need Semantic Web, Web 2.0 approaches solve all our needs…
- It is, essentially, an academic project, of no interest to industry and the real World

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> Just to pick some of these…

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> SW Ontologies ≠ a central, big ontology!

- The “ethos” of the Semantic Web is on sharing, ie, sharing ontologies (small or large)
- A huge, central ontology would be unmanageable
- The practice:
  - SW applications using ontologies always mix large number of ontologies and vocabularies (FOAF, DC, and others)
  - the real advantage comes from this mix: that is also how new relationships may be discovered
  - applications in an area can agree on their vocabularies: and that is enough; a global consistency may not be necessary

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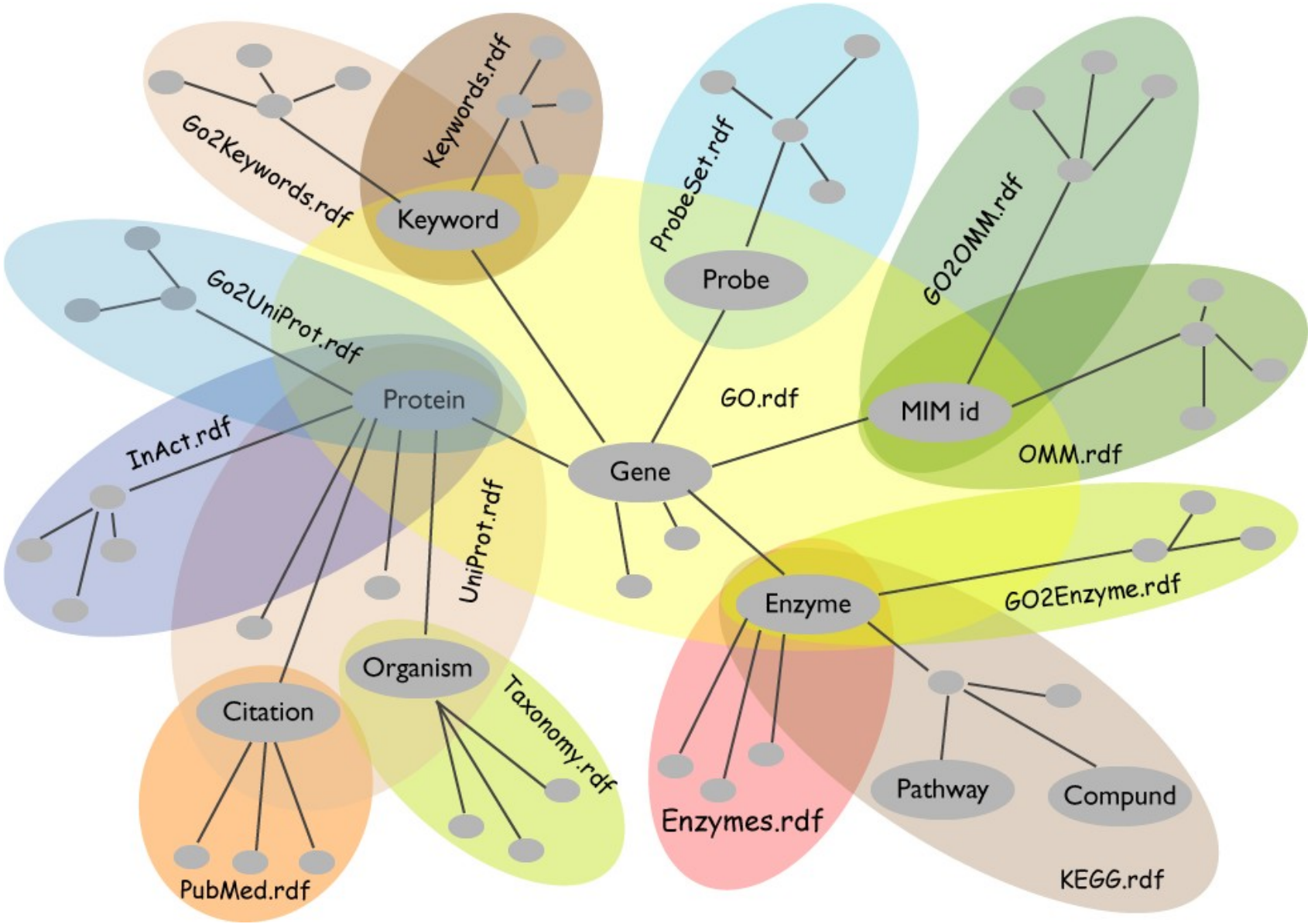
> A good example…



Courtesy of Susie Stephens, Eli Lilly

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> Web 2.0 and SW are no enemies…

- Web 2.0 recognized the importance of data to be processed, mashed-up, mixed
  - this is at the heart of the Semantic Web
  - SW provides a set of consistent tools and definitions to help that
- Sometimes the simplicity (eg, in tagging, microformats) pays off; sometimes more rigor is necessary
  - GRDDL is a good example for a “bridge”
  - SPARQL can be used for more complex mash-ups
- Let us forget about a turf/ego war; it is unnecessary and counterproductive

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> Semantic Web ≠ academic research only

- SW has indeed a strong foundation in research results
- But a large number of applications are now available
- See the collection at W3C: **`http://www.w3.org/2001/sw/sweo/public/UseCases`**
- But, mainly: *look at this conference and enjoy the variety!*

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> Thank you for your attention!

- These slides are publicly available on:

http://www.w3.org/2008/Talks/0518-SanJose-IH/

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