
# State of the Semantic Web

Karl Dubost and Ivan Herman, W3C

INTAP Semantic Web Conference, Tokyo, Japan, March 7, 2008

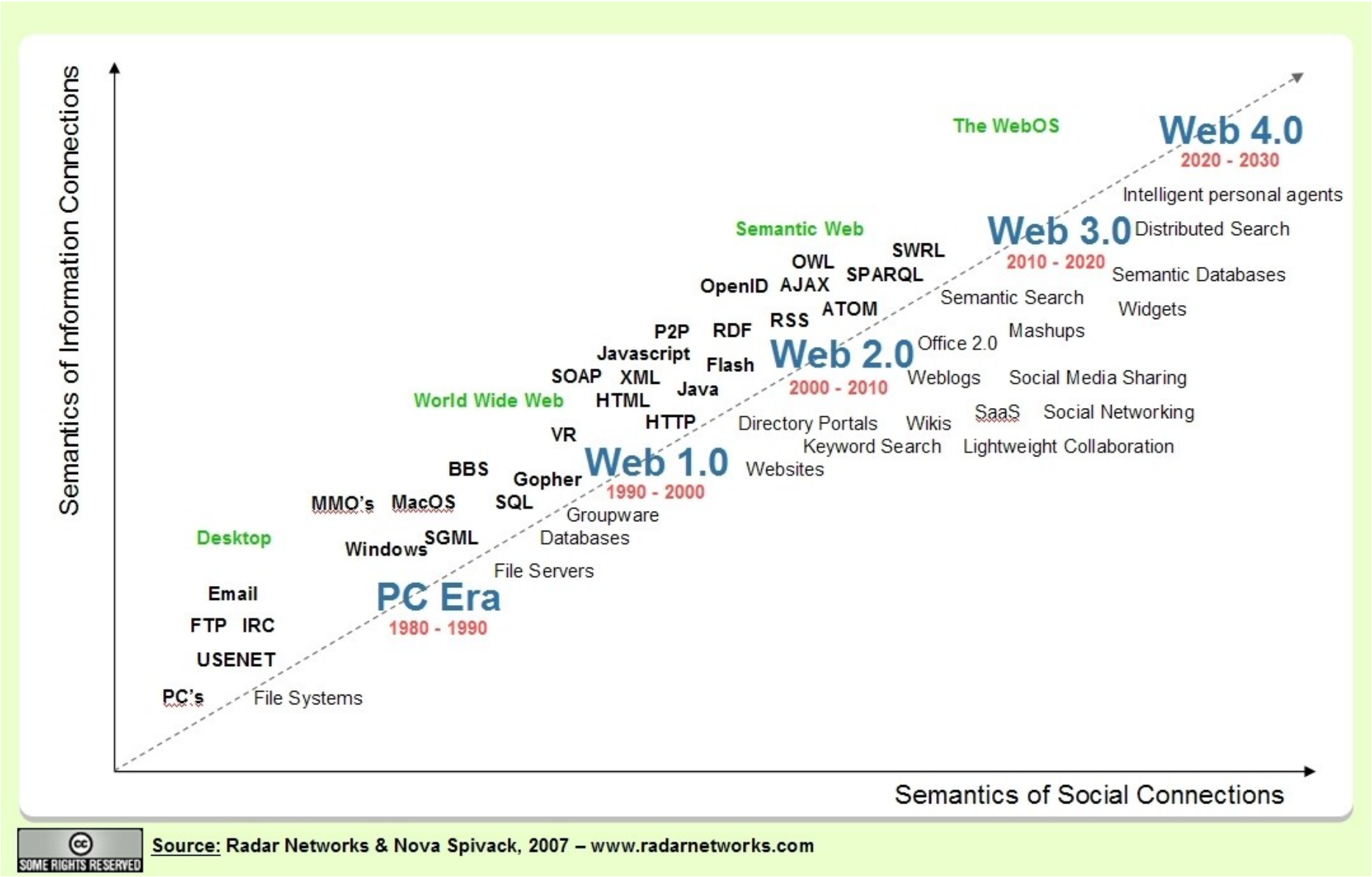
# > Significant buzz…

- There is quite a buzz around “Semantics”, “Semantic Technologies”, “Semantic Web”, “Web 3.0”, “Data Web”, etc, these days
- New applications, companies, tools, etc, come to the fore frequently
- It is, of course, not always clear what these terms all mean:
  - “Semantic Web” is a way to specify data and data relationships; it is also a collection of specific technologies (RDF, OWL, GRDDL, SPARQL, …)
  - “Semantic Technologies”, “Web 3.0” often mean more, including intelligent agents, usage of complex logical procedures, etc

# > Significant buzz… (cont.)

- Predicting the exact evolution in terms of Web 3.0, Web 4.0, etc, is a bit as looking into a crystal ball
- But the *Semantic Web technologies are already here, are used and deployed*
- They are at the basis of further evolution

# > A vision on the evolution…




SOME RIGHTS RESERVED Source: Radar Networks & Nova Spivack, 2007 – www.radarnetworks.com

(this Web 3.0 is *not* identical to the "journalistic" Web3.0; merely timing)

# > The 2007 Gartner predictions

During the next 10 years, Web-based technologies will improve the ability to embed semantic structures [… it] will occur in multiple evolutionary steps…

By 2017, we expect the vision of the Semantic Web […] to coalesce […] and the majority of Web pages are decorated with some form of semantic hypertext.

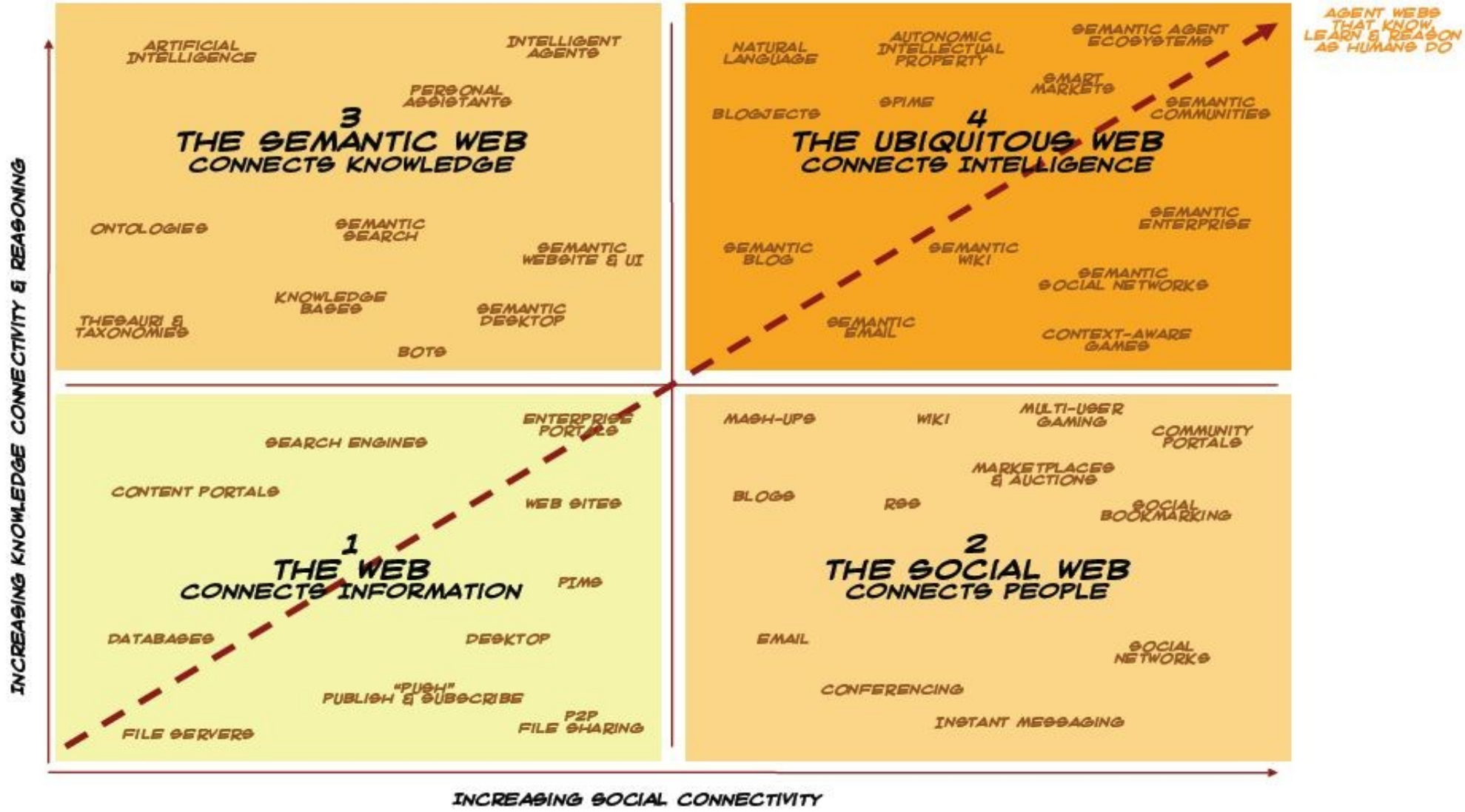
By 2012, 80% of public Web sites will use some level of semantic hypertext to create SW documents […] 15% of public Web sites will use more extensive Semantic Web-based ontologies to create semantic databases

(note: "semantic hypertext" refers to, eg, RDFa, microformats with possible GRDDL, etc.)

*Source: "Finding and Exploiting Value in Semantic Web Technologies on the Web", Gartner Research Report, May 2007*

# > Another longer term vision…

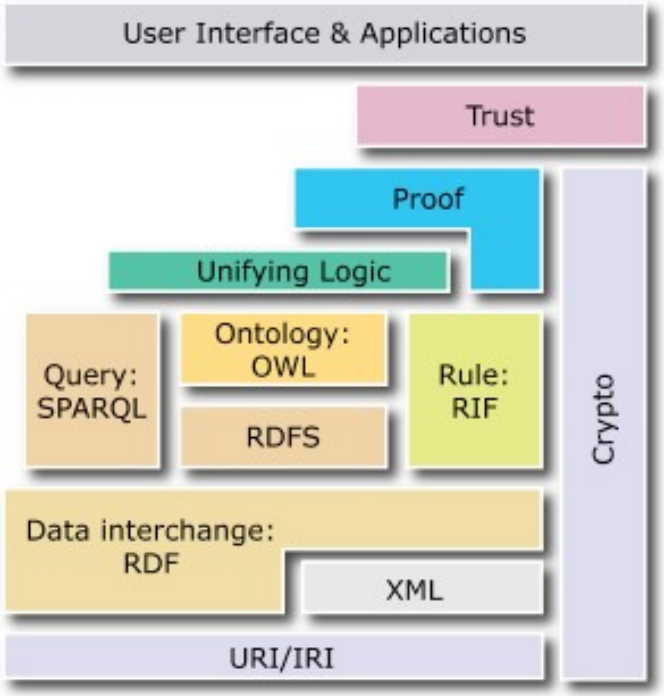
(from the “Semantic Wave 2008” report, from Project10X)




*Courtesy of Mills Davis, Project10X; source: Nova Spivack, Radar Networks and John Breslin, DERI*

# > Let us keep to the Semantic Web for now…

- In what follows we will restrict ourselves to the *Semantic Web*
  - a way to specify data and data relationships
  - allows data to be shared and reused across application, enterprise, and community boundaries
  - a collection of fundamental technologies (RDF/S, OWL, GRDDL, SPARQL, …)



# > The “corporate” landscape is moving

- Major companies offer (or will offer) Semantic Web tools or systems using Semantic Web: Adobe, Oracle, IBM, HP, Software AG, GE, Northrop Gruman, Altova, Microsoft, Dow Jones, …
- Others are using it (or consider using it) as part of their own operations: Novartis, Boeing, Pfizer, Telefónica, …
- Some of the names of active participants in W3C SW related groups: ILOG, HP, Agfa, SRI International, Fair Isaac Corp., Oracle, Boeing, IBM, Chevron, Siemens, Nokia, Pfizer, Sun, Eli Lilly, …

# > Some SW Tools (*not* and 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 systems**
  - Semantic Media Wiki, Platypus
  - Visual knowledge

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

# > Some SW 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!
- We still need more “middleware” tools to properly *combine* what is already available…
- *Anybody can start developing RDF-based applications today*

*Let us look at the technical state of the SW first*

# > 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
- Is a W3C Standard (since January 2008)
- Numerous implementations are already available (eg, built in triple stores)

# > Some new technologies at W3C

- SPARQL
- GRDDL
- RDFa
- SKOS
- OWL 1.1
- RIF (Rules)

# > SPARQL (cont.)

- There are also SPARQL “endpoints” services on the Web:
  - send a query and a reference to data over HTTP GET, receive the result in XML or JSON
  - big datasets often offer “SPARQL endpoints” to query 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!

# > 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…

# > 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…

# > Bridge to relational databases

- Most of the data on the Web are stored in relational databases
  - "RDFying" them is an impossible
  - relational databases are here to stay…
- "Bridges" are being defined:
  - a layer between RDF and the relational data
    - RDB tables are "mapped" to RDF graphs, possibly on the fly
    - different mapping languages/approaches are being used
  - a number of systems can now be used as relational database as well as triple stores (eg, Oracle, OpenLink, …)
- Work for a survey on mapping techniques benchmarks may start soon at W3C
- SPARQL is becoming the tool of choice to query the data
  - ie, "SPARQL endpoints" are defined to query the databases



# > 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
- We have already seen the work relating to "traditional" databases
- But there are also other types of data out there, too…

# > 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

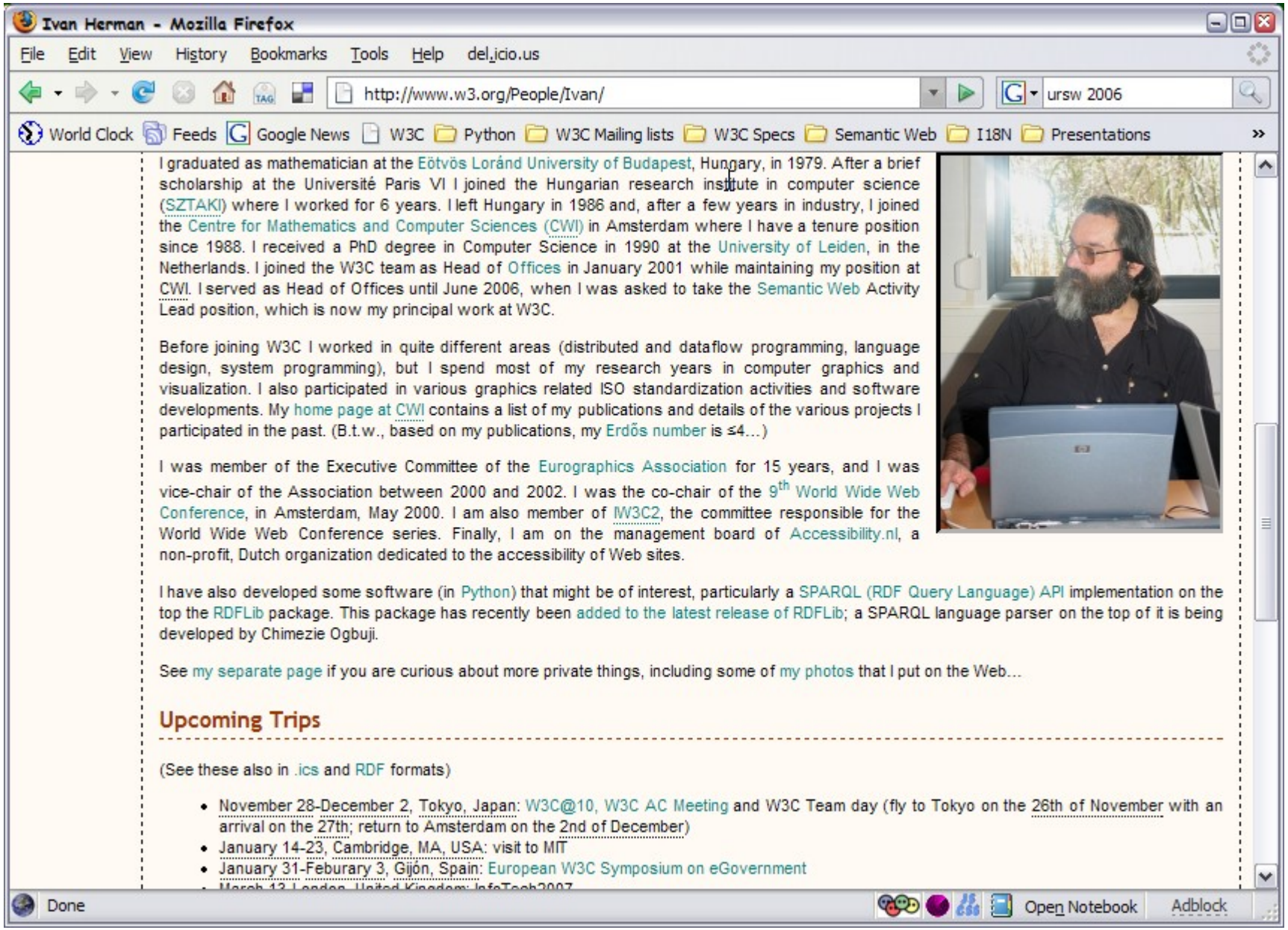
# > Getting structured data to RDF: GRDDL

- 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
    - script is usually XSLT but not necessarily
    - has a variant for XHTML
  - 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

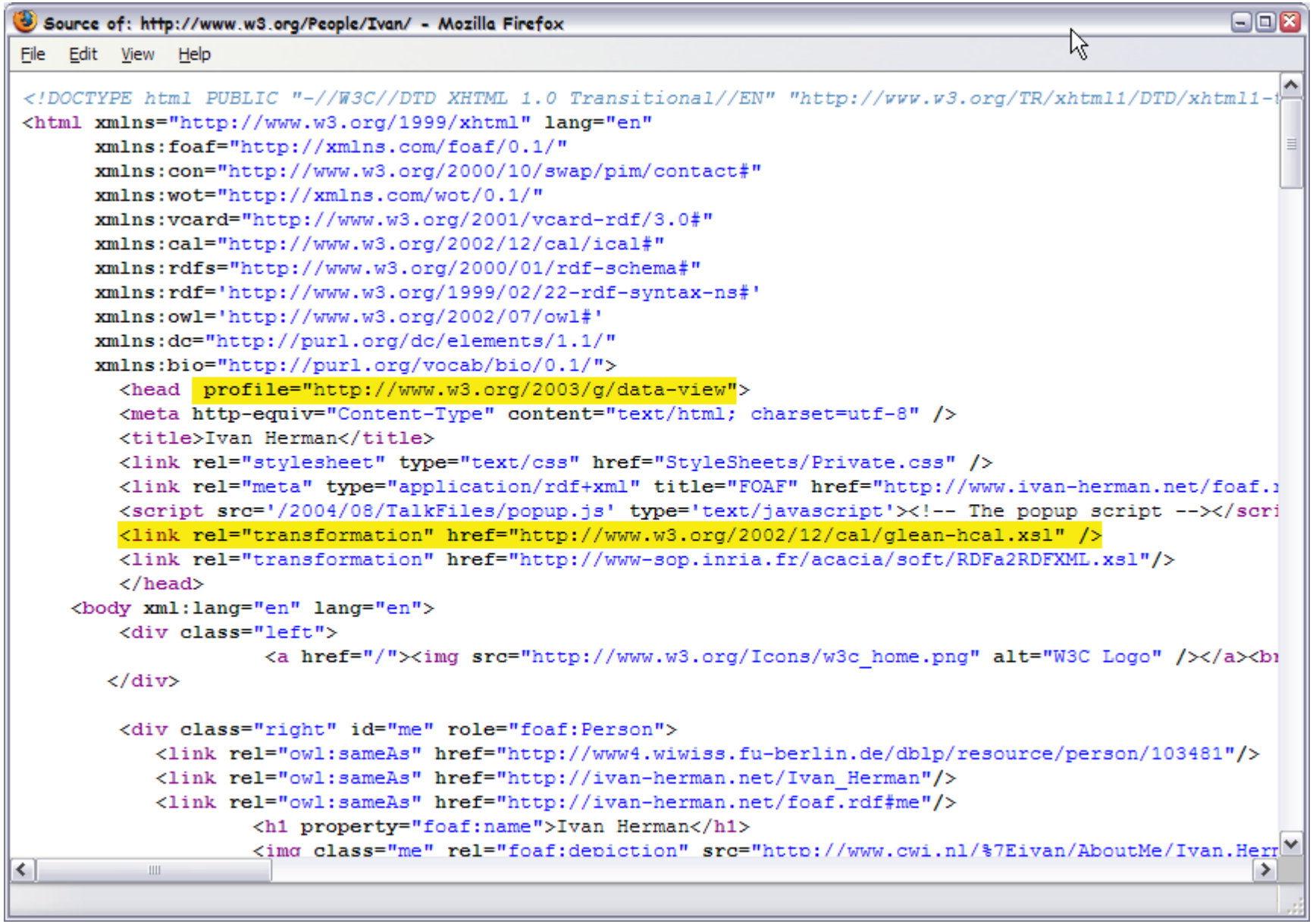
# > Getting structured data to RDF: RDFa

- 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
- It can also be used with GRDDL
  - but: no need to implement a separate transformation per vocabulary

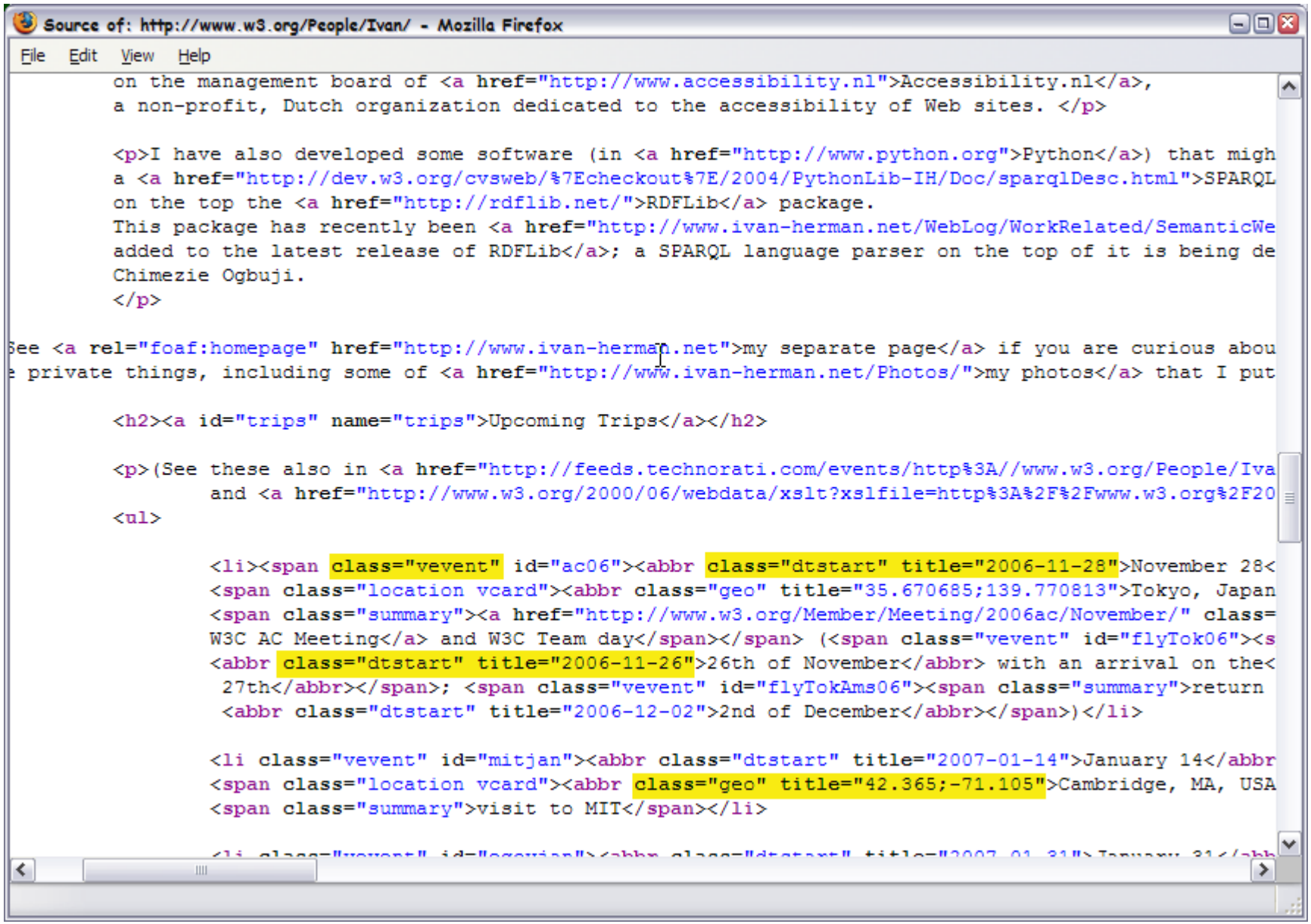
# > GRDDL & RDFa: Ivan' home page…



# > …marked up with GRDDL headers…



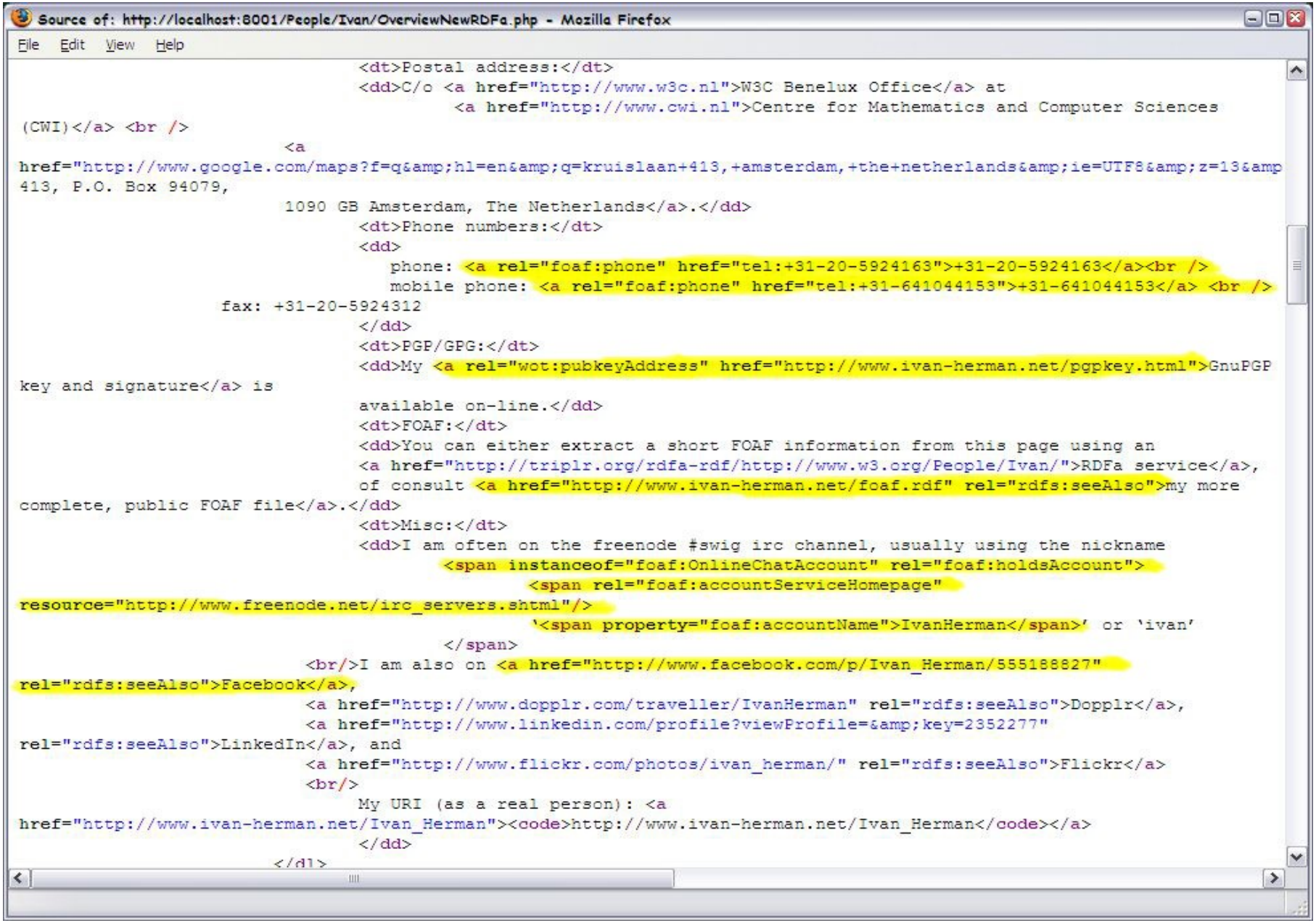
# > …and hCard microformat tags…



# > …yielding; …

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xml:base="http://www.w3.org/People/Ivan/">
 <c:Vcalendar xmlns:r="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
                 xmlns:ical=… >
  <c:component>
   <c:Vevent r:about="#ac06">
    <ical:summary>W3C@10, W3C AC Meeting and W3C Team day</ical:summary>
    <ical:dtstart>2006-11-28</ical:dtstart>
    <ical:dtend>2006-12-03</ical:dtend>
    <ical:url
       r:resource="http://www.w3.org/Member/Meeting/2006ac/November/"/>
    <loc:location xml:lang="en">Tokyo, Japan</location>
    <geo:geo r:parseType="Resource">
      <r:first>35.670685</r:first>
      <r:rest r:parseType="Resource">
        …
       </r:rest>
    </geo:geo>
…
```

# > …marked up with RDFa tags…




```
                                <dt>Postal address:</dt>
                                <dd>C/o <a href="http://www.w3c.nl">W3C Benelux Office</a> at
                                        <a href="http://www.cwi.nl">Centre for Mathematics and Computer Sciences
(CWI)</a> <br />
                        <a
href="http://www.google.com/maps?f=q&amp;hl=en&amp;q=kruislaan+413,+amsterdam,+the+netherlands&amp;ie=UTF8&amp;z=13&amp
413, P.O. Box 94079,
                        1090 GB Amsterdam, The Netherlands</a>.</dd>
                                <dt>Phone numbers:</dt>
                                <dd>
                                   phone: <a rel="foaf:phone" href="tel:+31-20-5924163">+31-20-5924163</a><br />
                                   mobile phone: <a rel="foaf:phone" href="tel:+31-641044153">+31-641044153</a> <br />
                fax: +31-20-5924312
                                </dd>
                                <dt>PGP/GPG:</dt>
                                <dd>My <a rel="wot:pubkeyAddress" href="http://www.ivan-herman.net/pgpkey.html">GnuPGP
key and signature</a> is
                                available on-line.</dd>
                                <dt>FOAF:</dt>
                                <dd>You can either extract a short FOAF information from this page using an
                                <a href="http://triplr.org/rdfa-rdf/http://www.w3.org/People/Ivan/">RDFa service</a>,
                                of consult <a href="http://www.ivan-herman.net/foaf.rdf" rel="rdfs:seeAlso">my more
complete, public FOAF file</a>.</dd>
                                <dt>Misc:</dt>
                                <dd>I am often on the freenode #swig irc channel, usually using the nickname
                                        <span instanceof="foaf:OnlineChatAccount" rel="foaf:holdsAccount">
                                                <span rel="foaf:accountServiceHomepage"
resource="http://www.freenode.net/irc_servers.shtml"/>
                                                '<span property="foaf:accountName">IvanHerman</span>' or 'ivan'
                                        </span>
                        <br/>I am also on <a href="http://www.facebook.com/p/Ivan_Herman/555188827"
rel="rdfs:seeAlso">Facebook</a>,
                        <a href="http://www.dopplr.com/traveller/IvanHerman" rel="rdfs:seeAlso">Dopplr</a>,
                        <a href="http://www.linkedin.com/profile?viewProfile=&amp;key=2352277"
rel="rdfs:seeAlso">LinkedIn</a>, and
                        <a href="http://www.flickr.com/photos/ivan_herman/" rel="rdfs:seeAlso">Flickr</a>
                        <br/>
                                My URI (as a real person): <a
href="http://www.ivan-herman.net/Ivan_Herman"><code>http://www.ivan-herman.net/Ivan_Herman</code></a>
                                </dd>
                        </dl>
```

# > … yielding

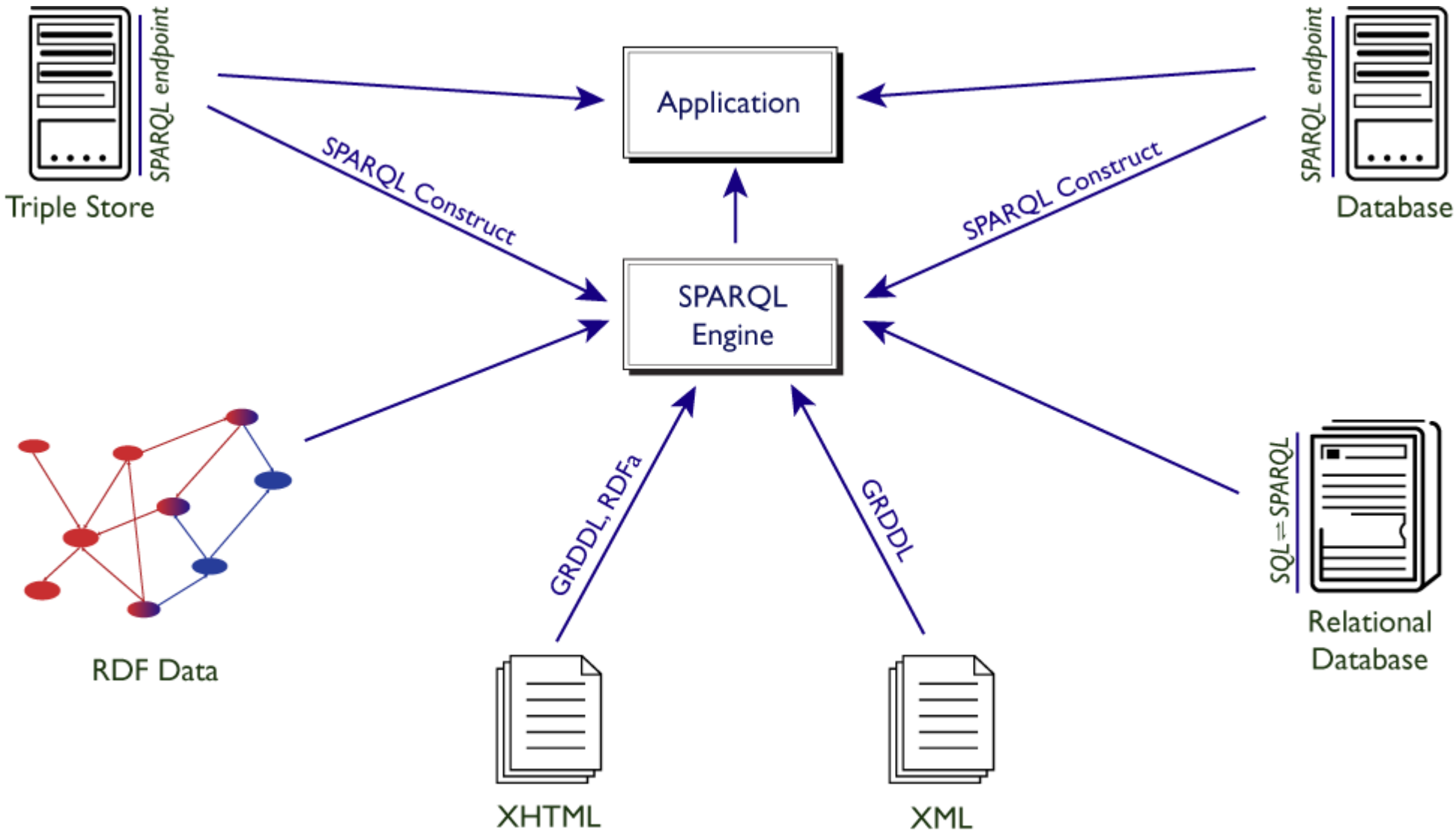
```
@prefix foaf: <http://xmlns.com/foaf/0.1/>
@prefix wot: <http://xmlns.com/wot/0.1/>
...
@base <http://www.w3.org/People/Ivan/>

<#me>
  foaf:phone <tel:+31-20-5924163>;
  foaf:phone <tel:+31-641044153>;
  wot:pubkeyAddress <http://www.ivan-herman.net/pgpkey.html>;
  rdfs:seeAlso <http://www.ivan-herman.net/foaf.rdf>;
  foaf:holdsAccount
    [ a foaf:OnlineChatAccount;
      foaf:accountServiceHomepage
        <http://www.freenode.net/irc_servers.html>;
      foaf:accountName "IvanHerman";
    ];
  rdfs:seeAlso <http://www.facebook.com/p/Ivan_Herman/555188824>;
  ...
```

# > 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.
}
```

# > SPARQL as a unifying point!



# > Simple Knowledge Organization System

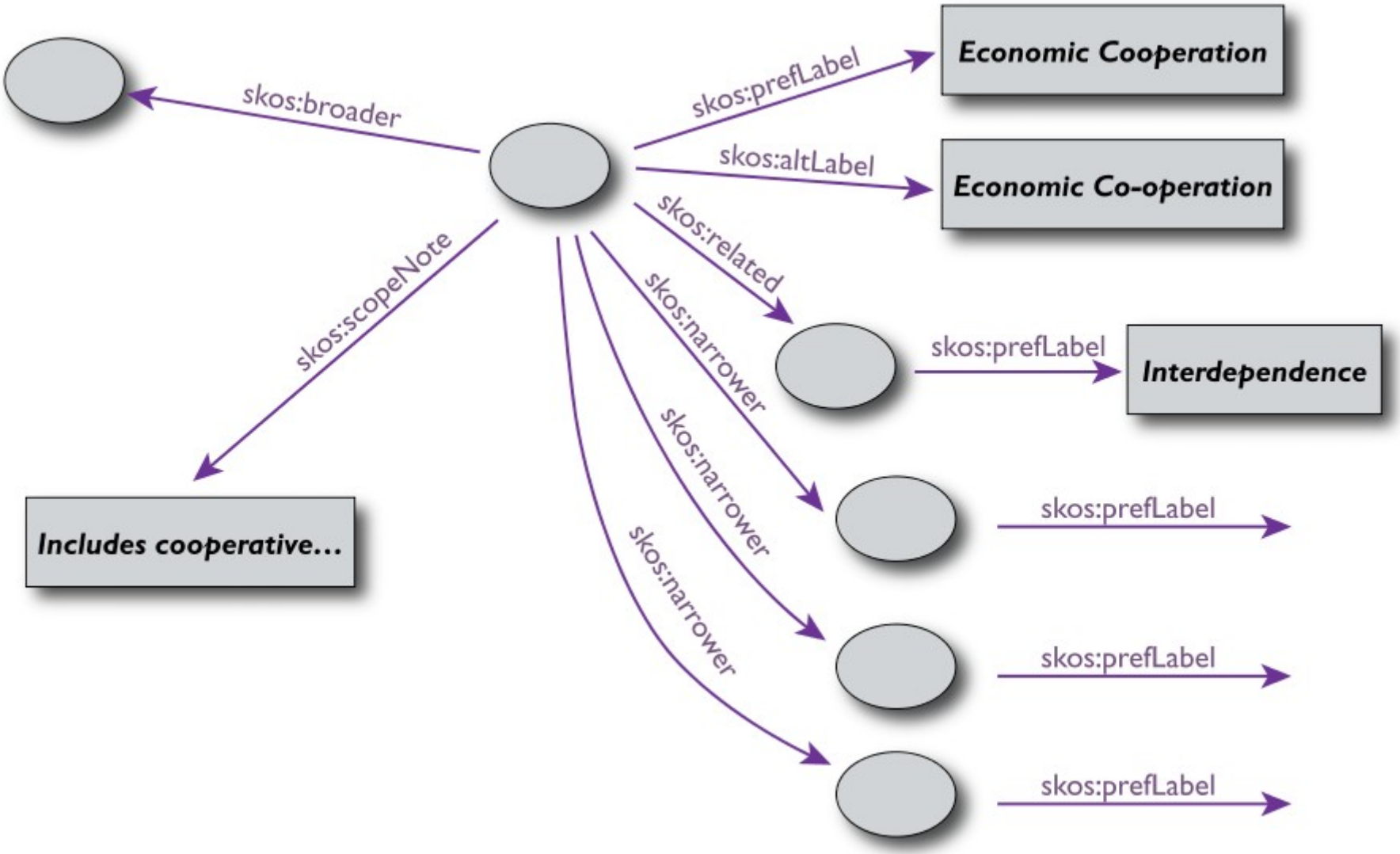
- Goal: representing and sharing classifications, glossaries, thesauri, etc, as developed in the “Print World”. For example:
  - Dewey Decimal Classification, Art and Architecture Thesaurus, ACM classification of keywords and terms…
  - DMOZ categories (a.k.a. Open Directory Project)
- The system must be simple to allow for a quick port of traditional data (done by non-experts in, say, Semantic Web)
- This is where *SKOS* comes in: define classes, properties, where those structures can be added

# > Example: thesaurus

**Term**
Economic cooperation
**Used For**
Economic co-operation
**Broader terms**
Economic policy
**Narrower terms**
Economic integration, European economic cooperation, …
**Related terms**
Interdependence
**Scope Note**
Includes cooperative measures in banking, trade, …

(from the UK Archival Thesaurus)

# > Example: thesaurus in SKOS



# > SKOS and digital libraries

- SKOS plays an important role in “bridging” to digital libraries
- A huge community out there with its own traditions, style…
- … but huge amount of data to be “linked” to the Semantic Web!
- Major library metadata standards are being re-defined in terms of RDF (and SKOS),
  - eg, “Resource Description and Access” (RDA)
    - a major cataloging rule set for librarians
    - potentially, all major library catalogs around the globe could be translated into RDF and, eg, linked as an Open Linked Data…

# > Ontologies

- Large ontologies are being developed (converted from other formats or defined in OWL). For example:
  - eClassOwl: eBusiness ontology for products and services, 75,000 classes and 5,500 properties
  - National Cancer Institute's ontology: about 58,000 classes
  - Open Biomedical Ontologies Foundry: a collection of ontologies, including the Gene Ontology, to describe gene and gene product attributes; or UniProt for protein sequence and annotation terminology and data
  - BioPAX: for biological pathway data
  - ISO 15926: "Integration of life-cycle data for process plants including oil and gas production facilities"

# > OWL in applications

- An increasing number of applications rely on OWL (Pfizer, Nasa, Eli Lilly, Elsevier, FAO, …)
  - see some more example at the end of the talk
- Not all use complex reasoning; in many cases a small fraction of OWL is used

# > New OWL Working Group

- A new Working Group just started on the revision of OWL
- The goal of the group:
  1. add a few extensions to current OWL that are useful, and is known to be implementable
     - many things happened in research since 2004
     - features should (if possible) be valid both in the DL and OWL Full world
  2. define fragments, ie, “profiles” of OWL that are:
     - smaller, easier to implement and deploy
     - cover important application areas and are easily understandable to non-expert users

# > “OWL 1.1”: new proposed features

- “Qualified cardinality restrictions” (eg, “class instance must have two black cats”)
- Disjoint, reflexive, irreflexive properties; disjoint union of classes
- Property chains (eg, the uncle example: “if y is father x of y and y is brother of z, then z is uncle of x”)
- Own datatype constructs instead of complex XML Schema datatypes
  - eg, to express restrictions like number intervals easily

# > “OWL 1.1”: new proposed features (cont)

- Metamodeling (a.k.a. “punning”): the same symbol may be used both as, e.g., a Class and an Instance, or for a datatype and an object property
  - this is not a problem in OWL Full, but is a significant restriction in OWL DL
  - in the DL there would still be some restrictions on how that can be used (eg, not all “natural” inferences can be drawn)

# > “OWL 1.1”: small fragments

- For a number of applications RDFS is not enough, but even OWL Lite is too much (and too complex to implement)
- There is a need for (very) “light” versions of OWL: just a few extra possibilities added to RDFS
- Some can be as simple as having only (on top of RDFS):

```
equivalentClass
equivalentProperty
sameAs
```

```
inverseOf
TransitiveProperty
SymmetricProperty
FunctionalProperty
InverseFunctionalProperty
```

# > “OWL 1.1”: small fragments (cont.)

- There are a number of proposals, papers, prototypes (and implementations!). Eg:
  - EL++, DLP: all DL dialects (e.g., EL++ is already in use by the health care community for medical ontologies)
  - pD*, OWLPrime: OWL Full dialects, that can be implemented with rule engines on top of, say, database engines
- It may be possible to create a (or more) dialect that may have both a DL and an OWL Full semantics (eg, OWLPrime~DLP)
- The Working Group will have to settle on the final list and structure

# > Rules

- There is a long history of rule languages and rule-based systems
  - eg: logic programming (Prolog), production rules
- Lots of small and large rule systems (from mail filters to expert systems)
- Hundreds of niche markets

# > Why rules on the Semantic Web?

- There are conditions that ontologies (ie, OWL) cannot express (or only with difficulties)
  - a well known examples is Horn rules: $(P1 \wedge P2 \wedge \ldots) \rightarrow C$
- There are conditions that are complicated in rules and ontologies are better (eg, complex classification of terms)
- Simple rule engines might be easier to implement (eg, on top of database engines)
- A different way of thinking — people may feel more familiar in one or the other

# > Things you may want to express

- An example:
  - “if two Persons have the same name and the same email, or the same name and the same home page, then they are identical”
- Something like (with an ad-hoc syntax):

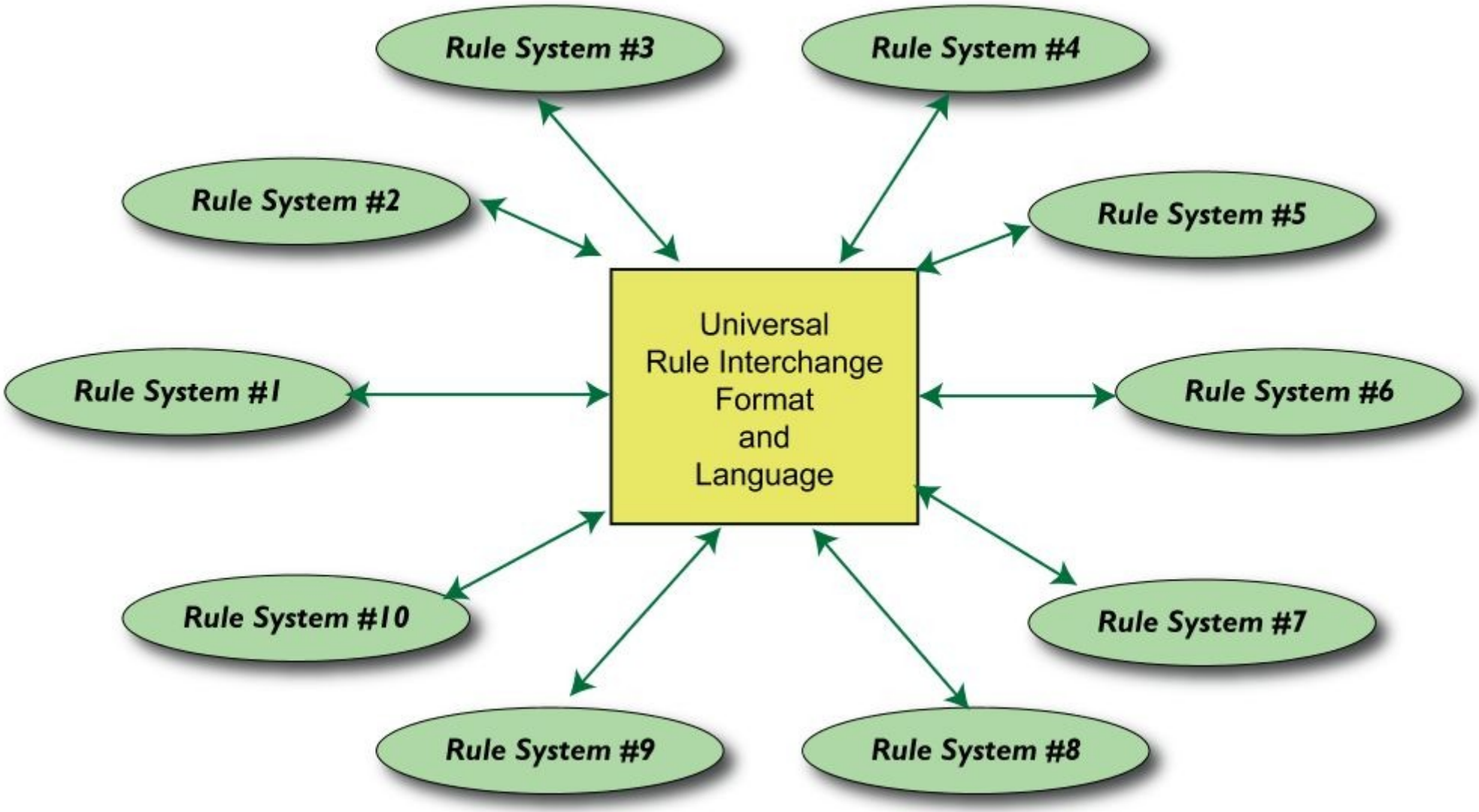
```
If { ?x rdf:type foaf:Person.
     ?y rdf:type foaf:Person.
     ?x foaf:name ?n.
     ?x foaf:homepage ?h.
     ?y foaf:name ?n.
     ?y foaf:homepage ?h. }
then { ?x = ?y }

If { ?x rdf:type foaf:Person.
     ?y rdf:type foaf:Person.
     ?x foaf:name ?n.
     ?x foaf:mailbox ?h.
     ?y foaf:name ?n.
     ?y foaf:mailbox ?m. }
then { ?x = ?y }
```

# > A new requirement: *exchange* of rules

- Applications may want to *exchange* their rules:
  - negotiate eBusiness contracts across platforms: supply vendor-neutral representation of your business rules so that others may find you
  - describe privacy requirements and policies, and let clients "merge" those (e.g., when paying with a credit card)
- Hence the name of the working group: *Rule Interchange Format*
  - a language that
    - expresses the rules a bit like a rule language with, eg, RDF
    - can be used to exchange rules among engines

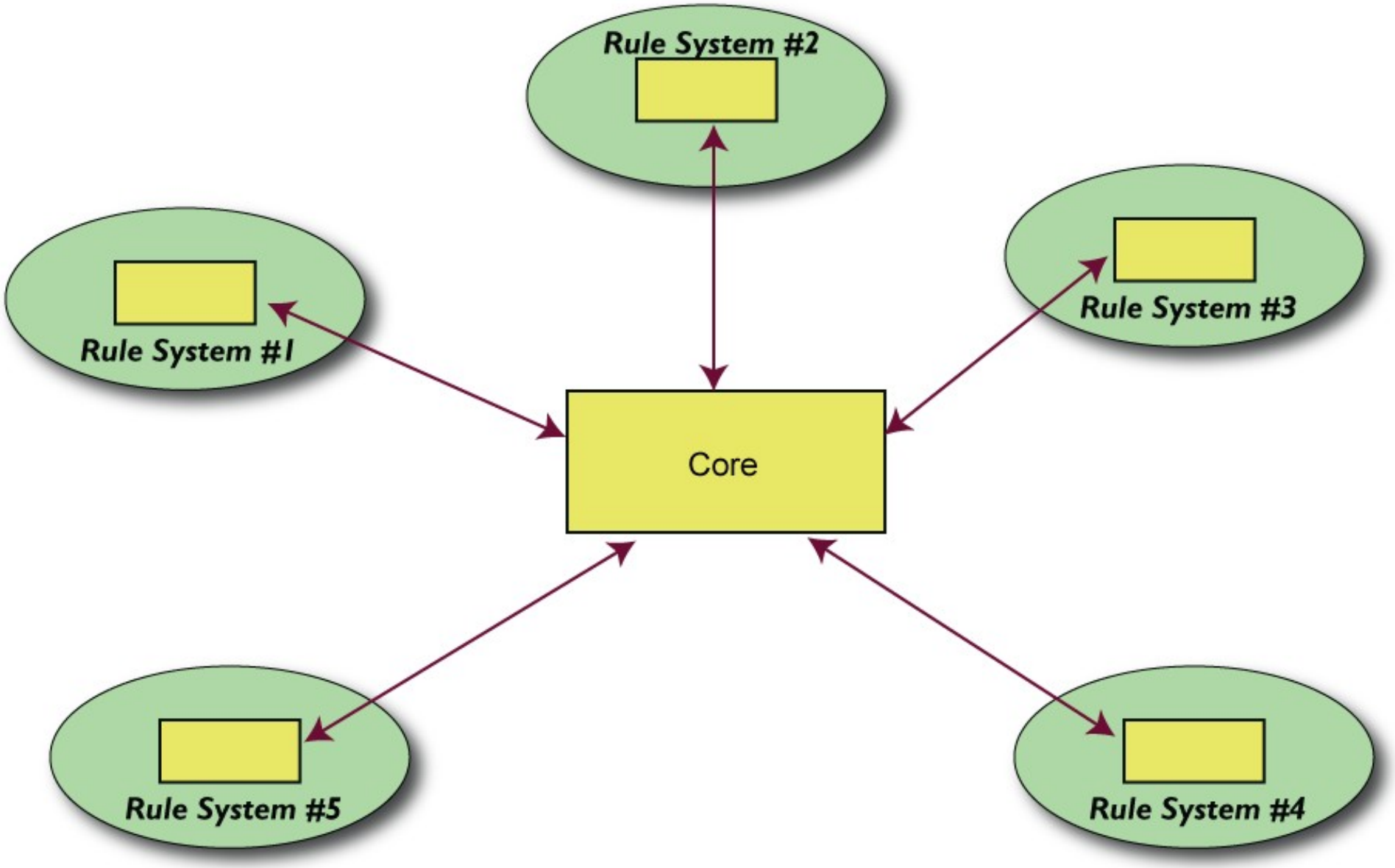
# > In an ideal World



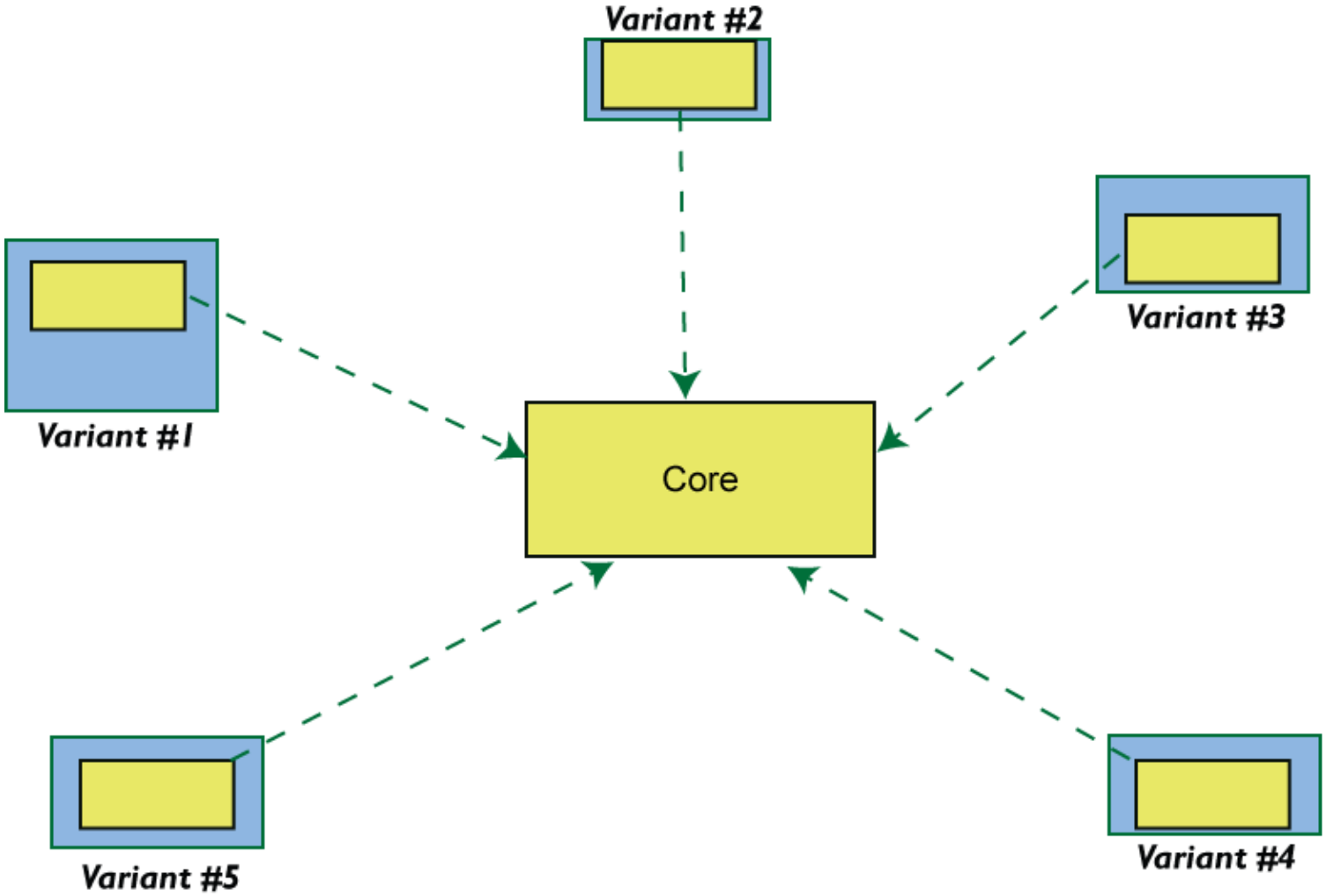
# > In the real World…

- Rule based systems can be very different
  - different rule semantics (based on various type of model theories, on proof systems, etc)
  - production rule systems, with procedural references, state transitions, etc
- Such universal exchange format is not feasible
- The idea is to define “cores” for a family of languages with “variants”

# > RIF “core”: only partial interchange

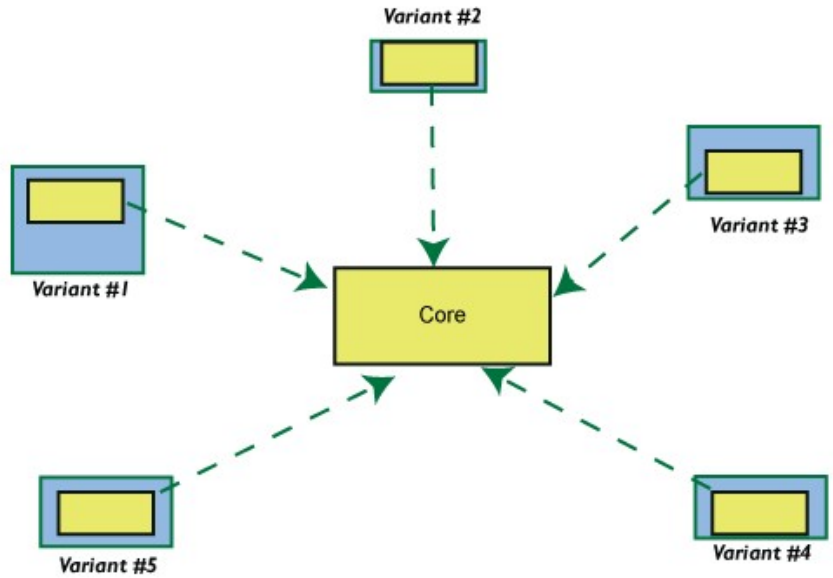


# > RIF “variants”

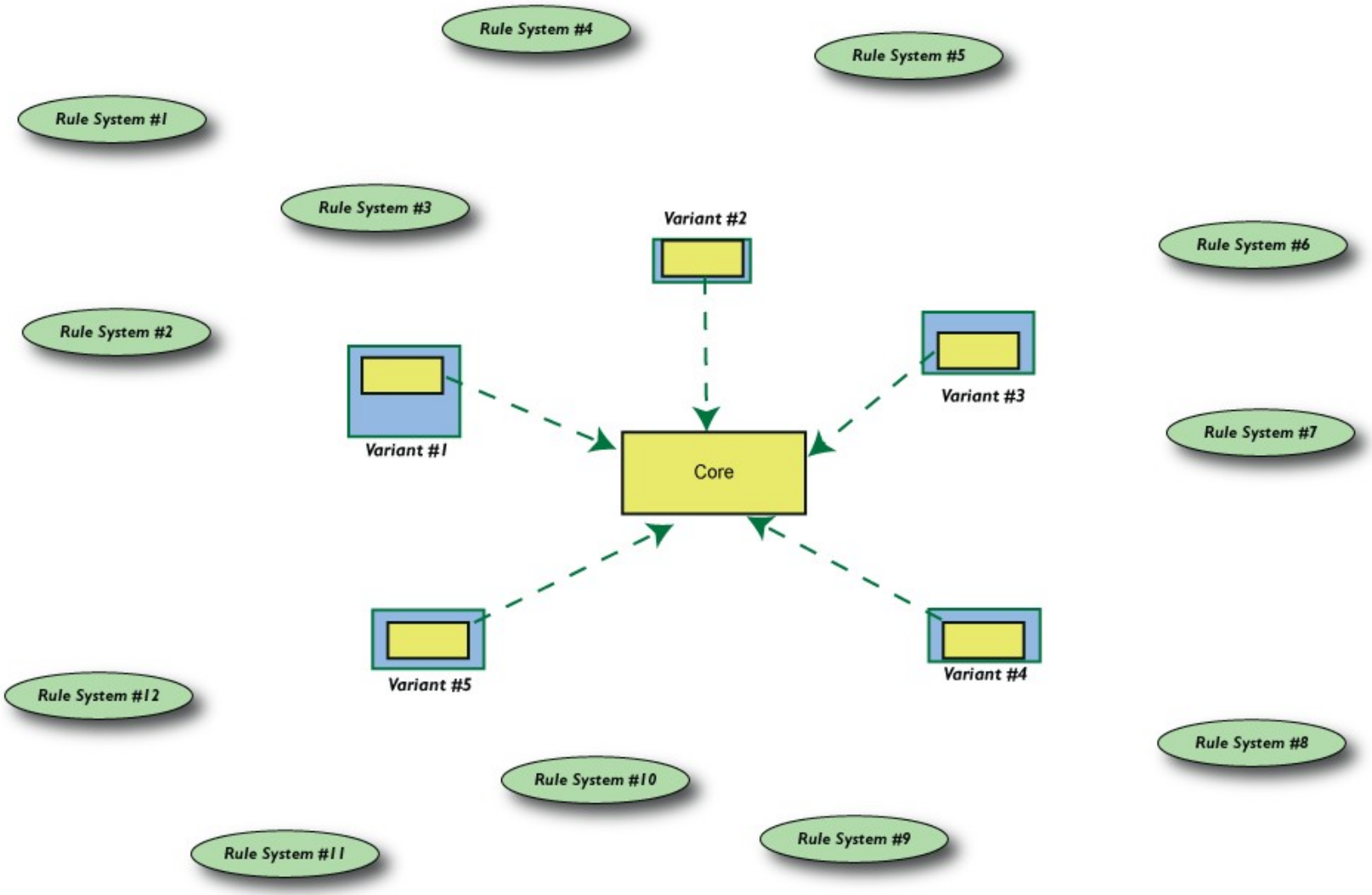



- Possible variants: F-logic, production rules, fuzzy logic systems, …; none of these have been finalized yet

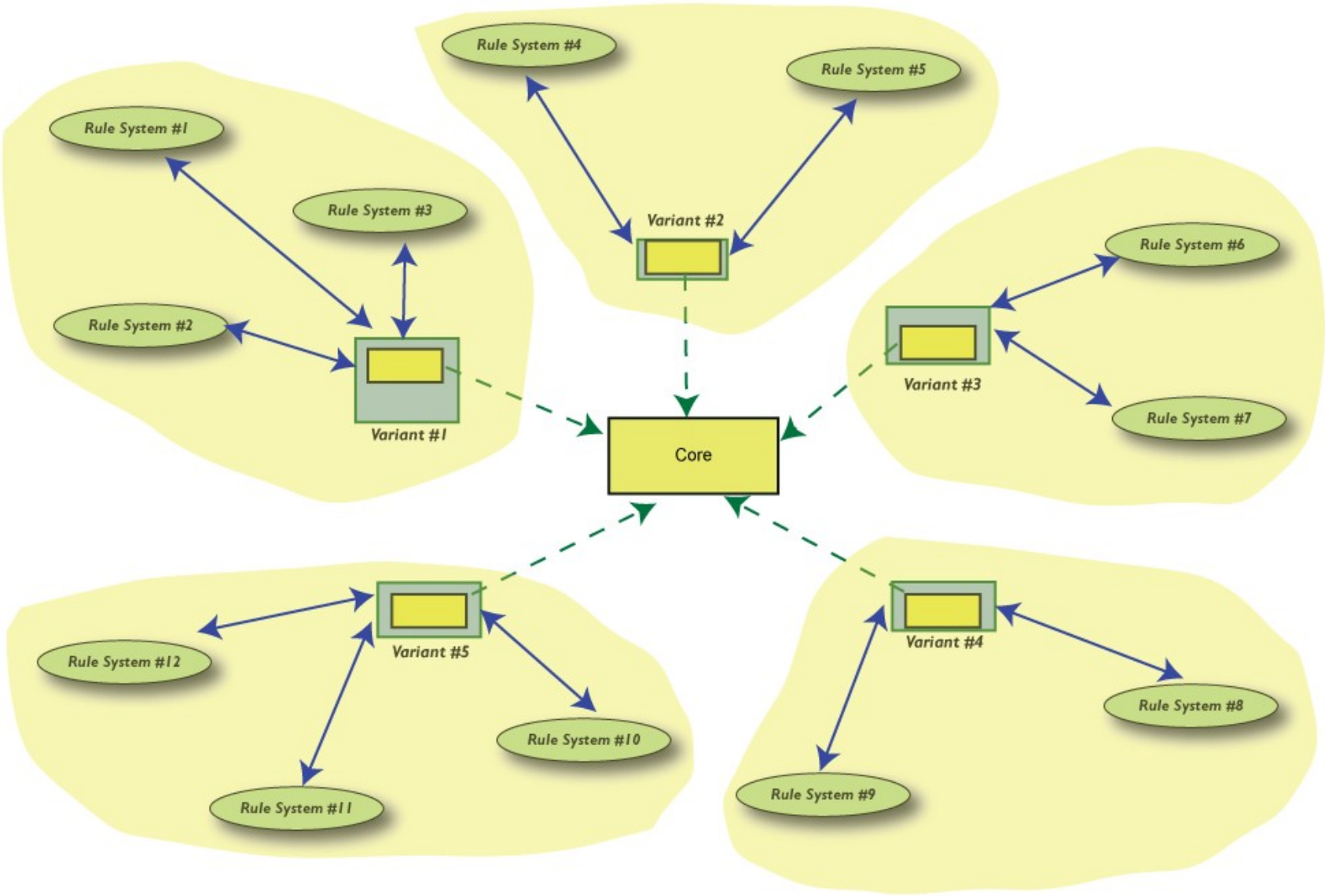
# > Role of variants



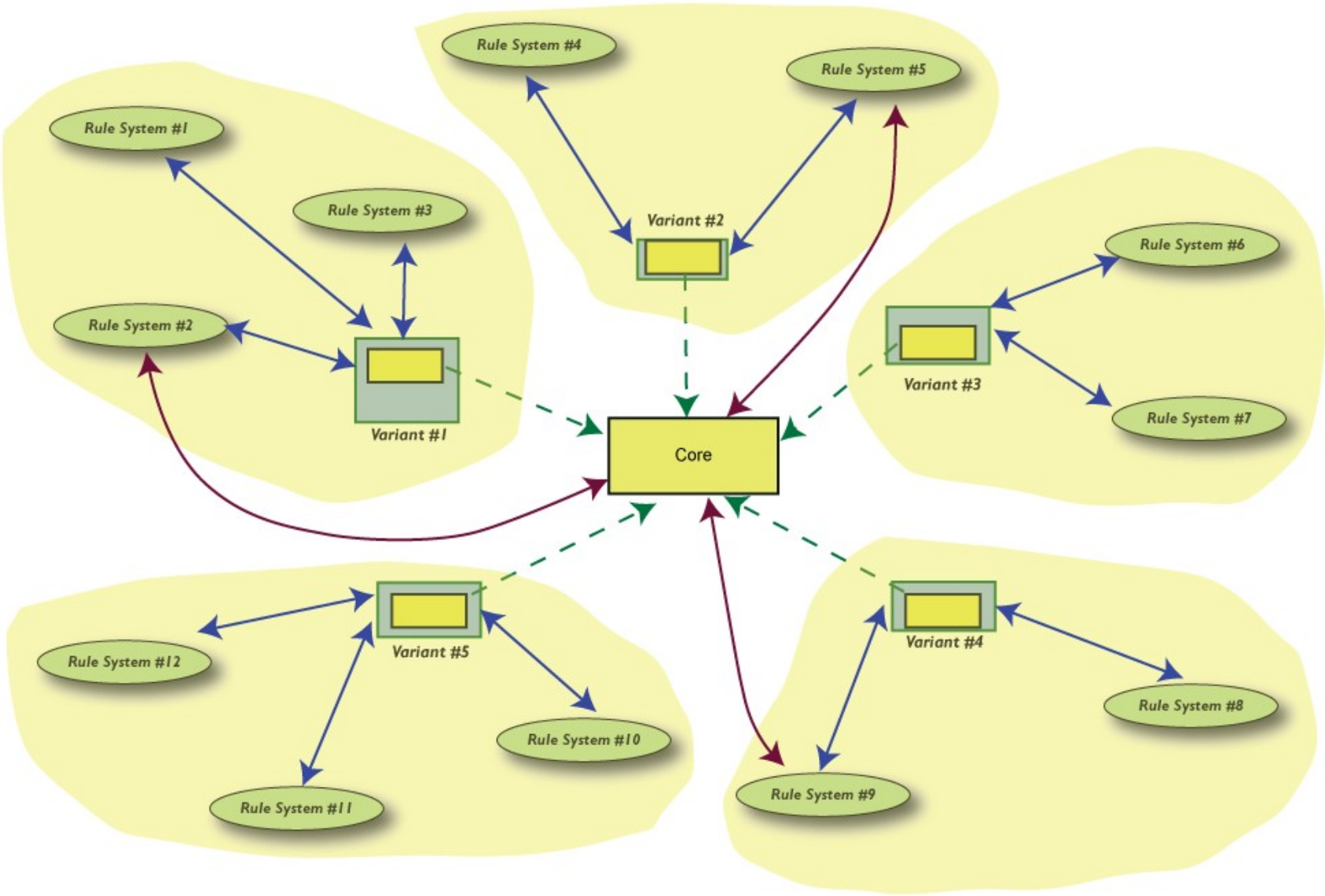
# > Role of variants



# > Role of variants



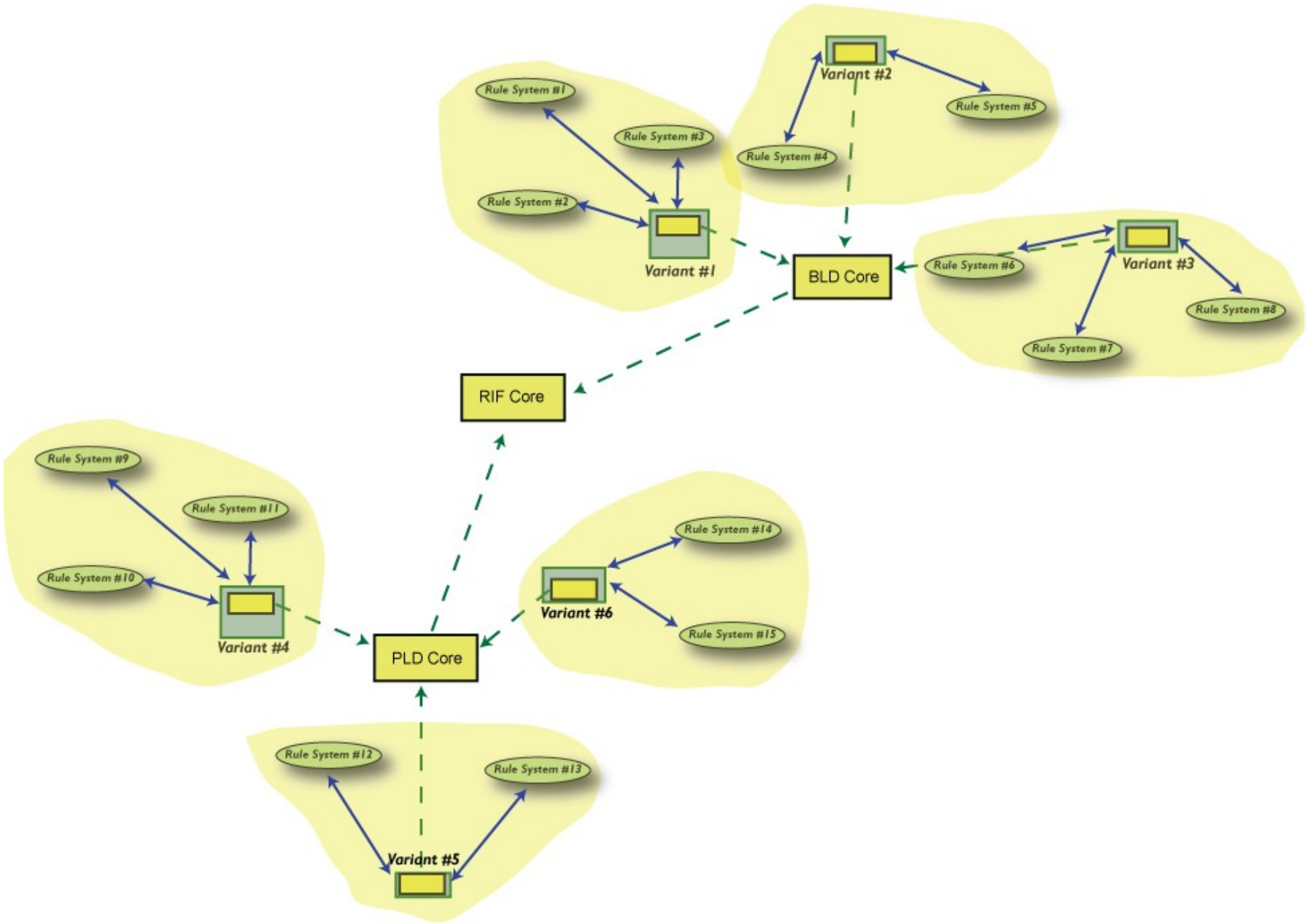
# > Role of variants



# > However…

- Even this model does not completely work ☹
- The gap between production rules and “traditional” logic systems seems to be large
- A hierarchy of cores may be necessary:
  - a *Basic Logic Dialect* and *Production Rule Dialect* as “cores” for families of languages
  - a common *RIF Core* binding these two

# > Hierarchy of cores



# > Current status

- There is a draft for the BLD
  - it defines a “positive Horn” language
  - it is a logic based general rule language
  - the language can be used
    - with or without RDF data and/or OWL
    - as a rule *language* or a rule *interchange format*
- The plan is to have BLD as a recommendation in 2008
- The work on the PLD Core has also begun

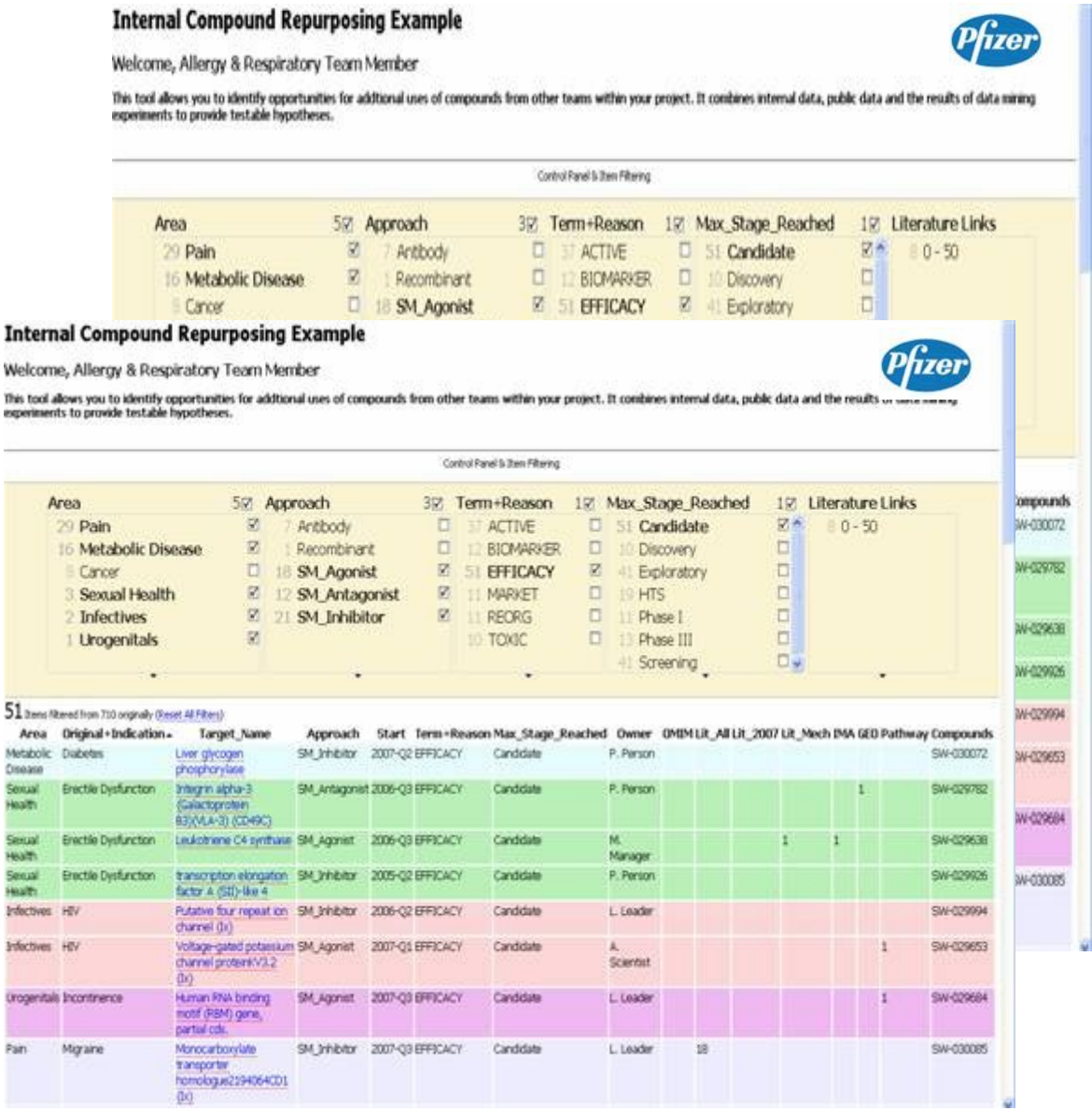
*How do applications look like?*

# > Application patterns

- It is fairly difficult to “categorize” applications (there are always overlaps)
- With this caveat, some of the application patterns:
  - data integration (ie, integrating data from major databases)
  - intelligent (specialized) portals (with improved local search based on vocabularies and ontologies)
  - content and knowledge organization
  - knowledge representation, decision support
  - X2X integration (often combined with Web Services)
  - data registries, repositories
  - collaboration tools (eg, social network applications)

# > Applications can be very simple

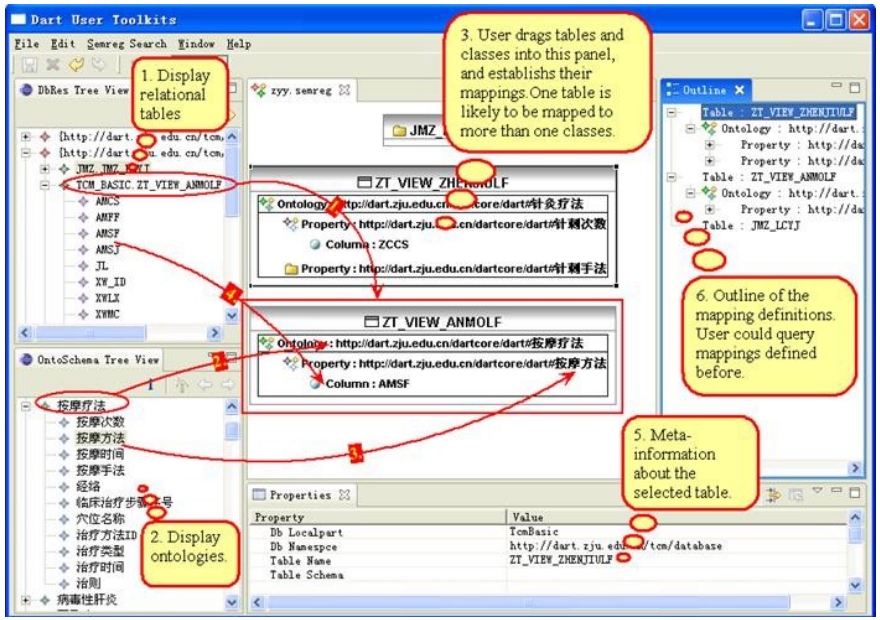
- Goal: reuse of older experimental data
- Keep data in databases or XML, just export key "fact" as RDF
- Use a faceted browser to visualize and interact with the result

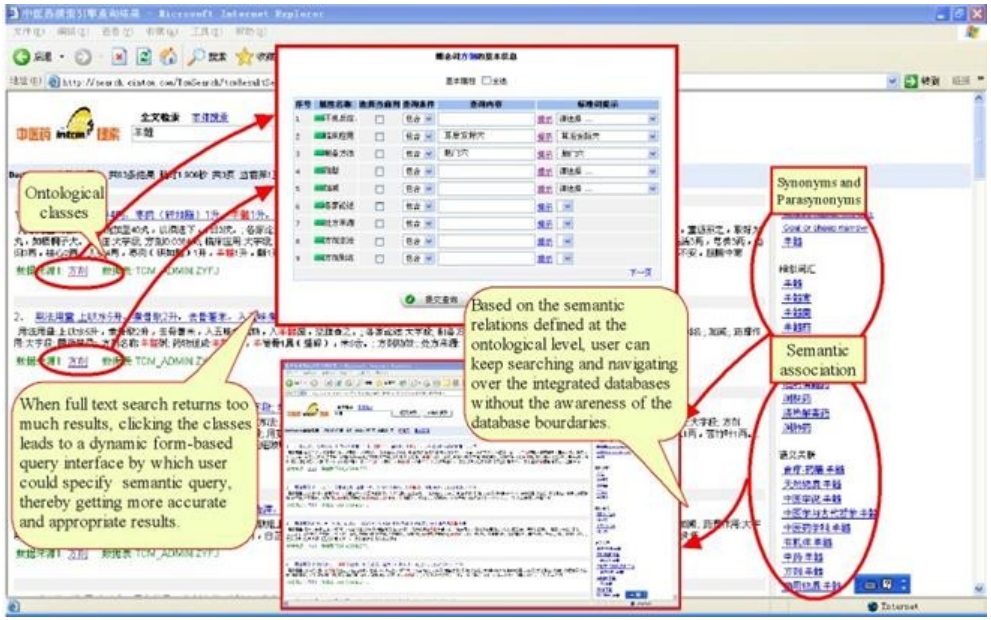



*Courtesy of Nigel Wilkinson, Lee Harland, Pfizer Ltd, Melliyal Annamalai, Oracle (SWEO Case Study)*

# > Integrate knowledge for Chinese Medicine

- Integration of a large number of relational databases (on traditional Chinese medicine) using a Semantic Layer
  - around 80 databases, around 200,000 records each
- A visual tool to map databases to the semantic layer using a specialized ontology
- Form based query interface for end users

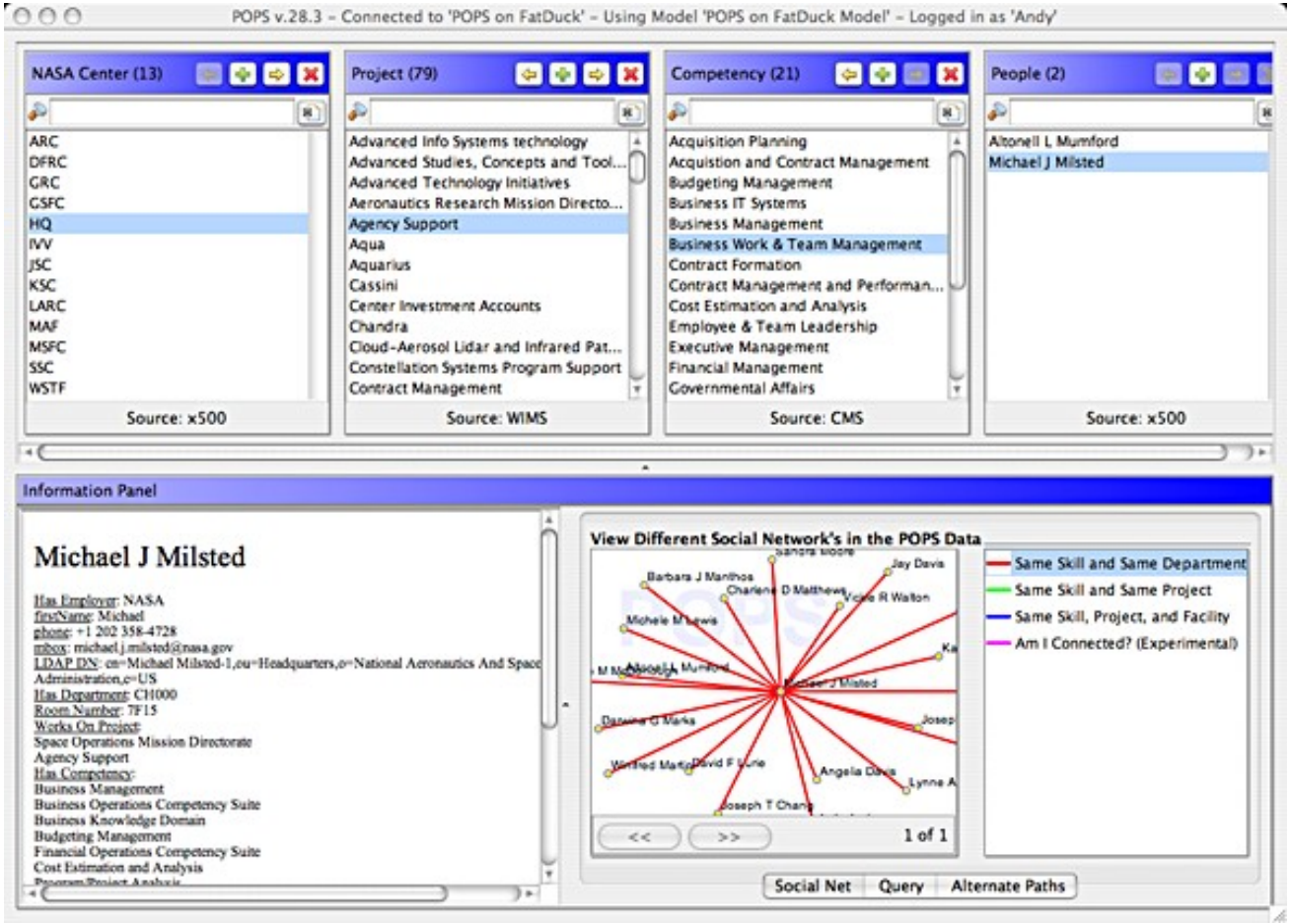



*Courtesy of Huajun Chen, Zhejiang University, (SWEO Case Study)*

# > Find the right experts at NASA

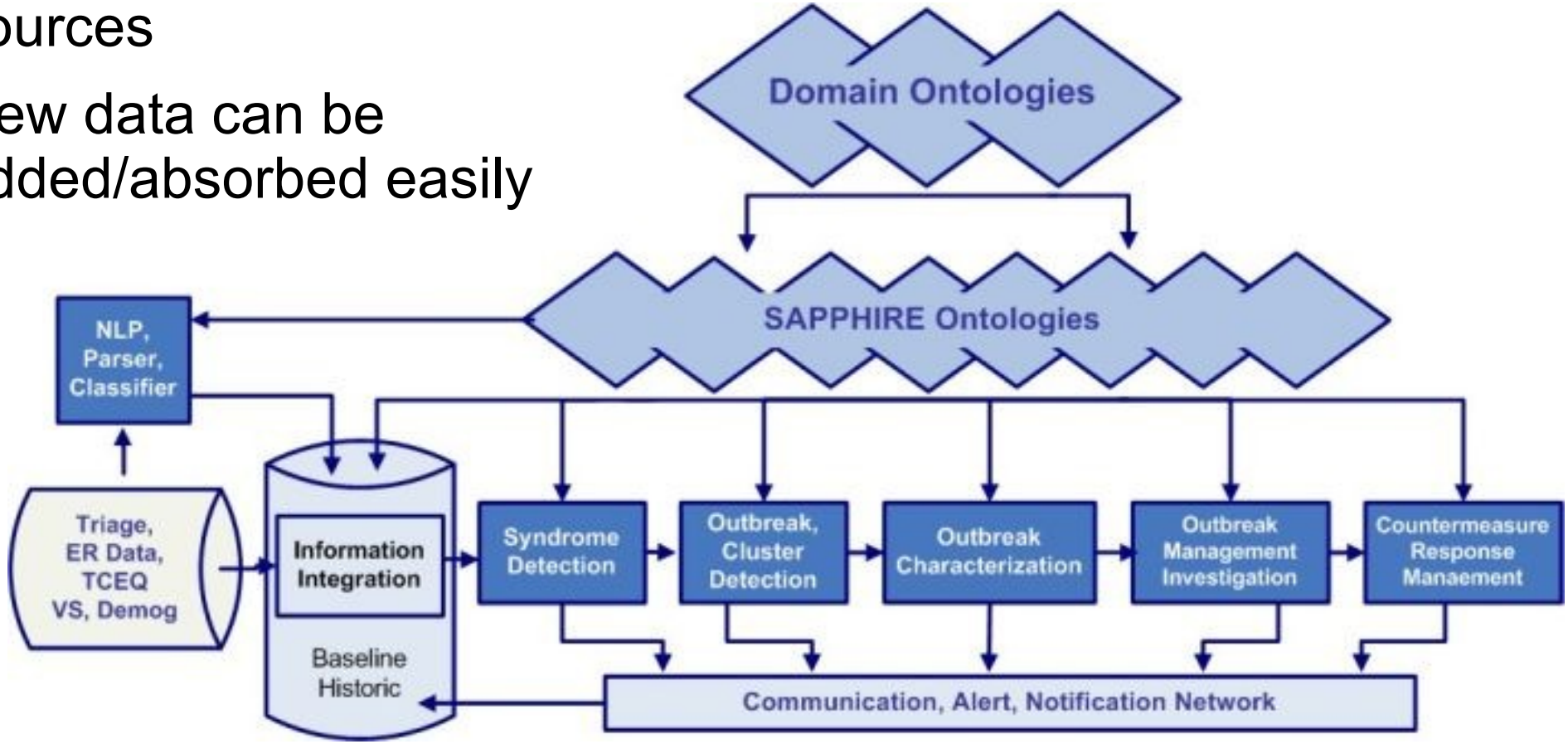
- Expertise locater for nearly 20,000 NASA civil servants using RDF integration techniques over 6 or 7 geographically distributed databases, data sources, and web services…




*Courtesy of Kendall Clark, Clark & Parsia, LLC*

# > Public health surveillance (Sapphire)

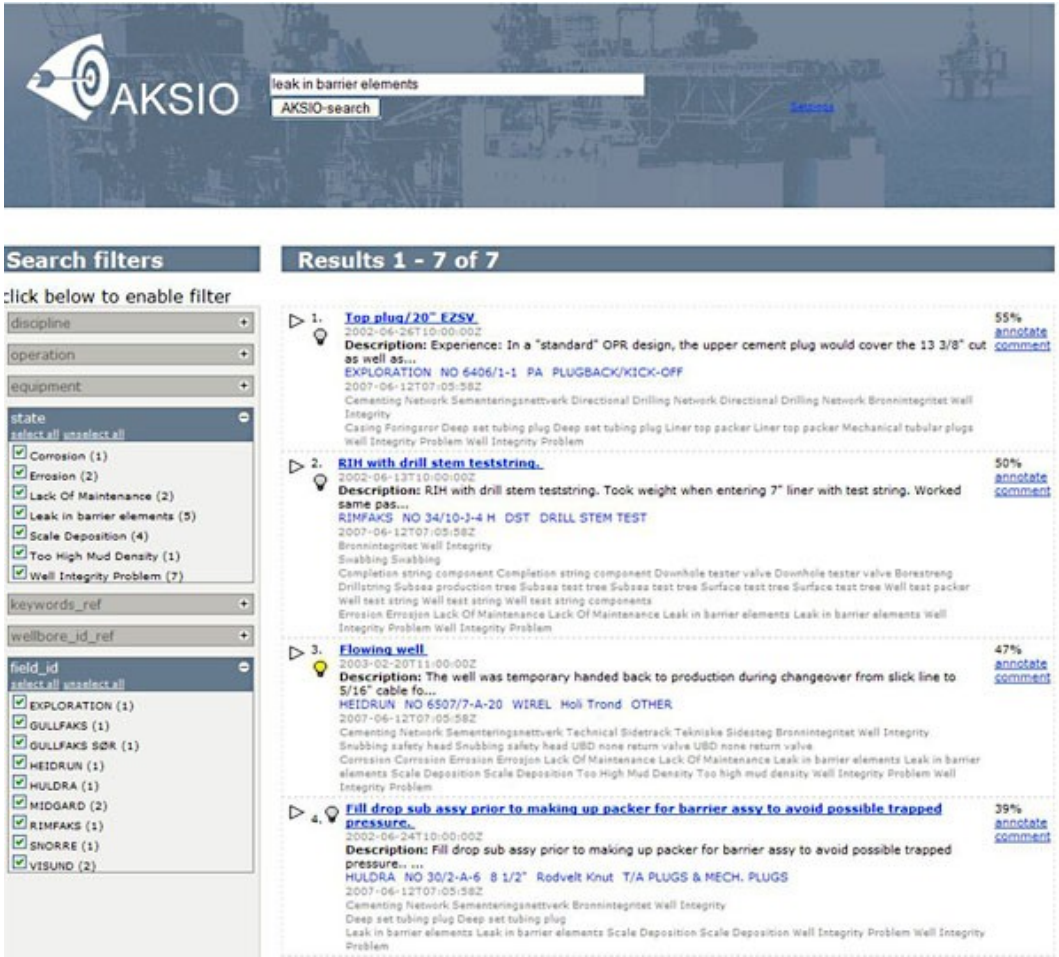
- Integrated biosurveillance system (biohazards, bioterrorism, disease control, etc)
- Integrates from multiple data sources
- New data can be added/absorbed easily




*Courtesy of Parsa Mirhaji, School of Health Information Sciences, University of Texas (SWEO Case Study)*

# > Help for deep sea drilling operations

- Integration of experience and data in the planning and operation of deep sea drilling processes
- Discover relevant experiences that could affect current or planned drilling operations
  - uses an ontology backed search engine




*Courtesy of David Norheim and Roar Fjellheim, Computas AS (SWEO Use Case)*

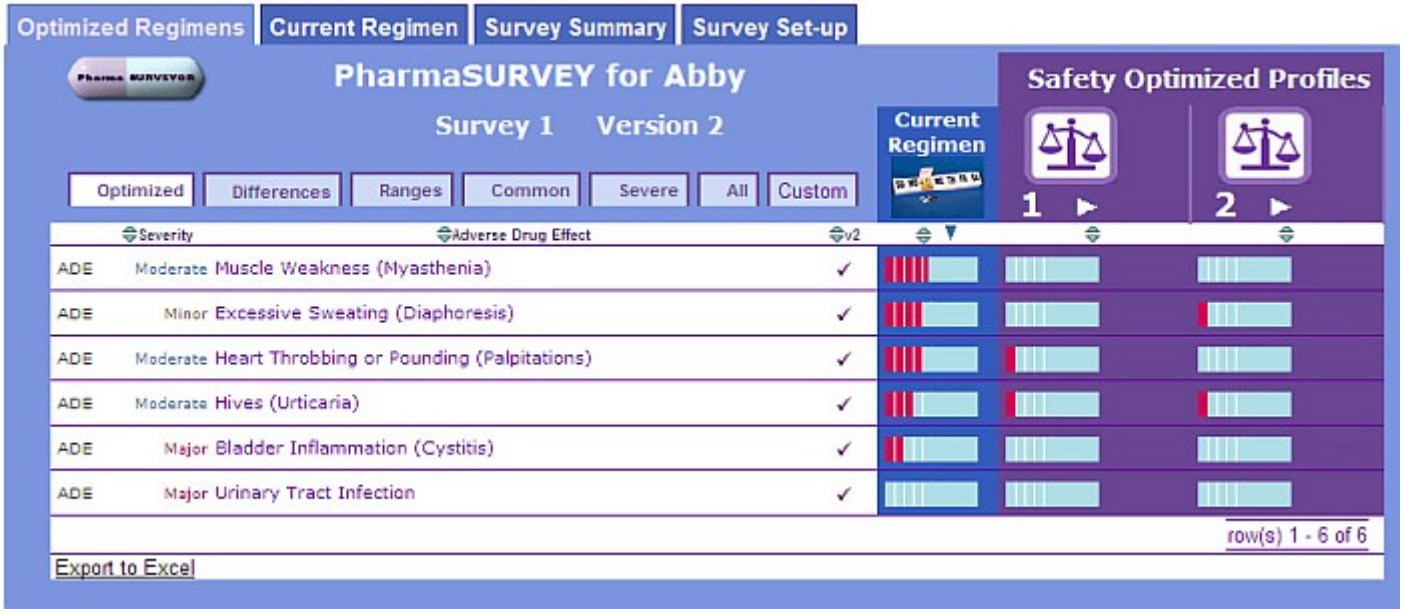
# > Vodafone live!

- Integrate various vendors' product descriptions via RDF
  - ring tones, games, wallpapers
  - manage complexity of handsets, binary formats
- A portal is created to offer appropriate content
- Significant increase in content download after the introduction


*Courtesy of Kevin Smith, Vodafone Group R&D* *(SWEO Case Study)*

# > Help in choosing the right drug regimen

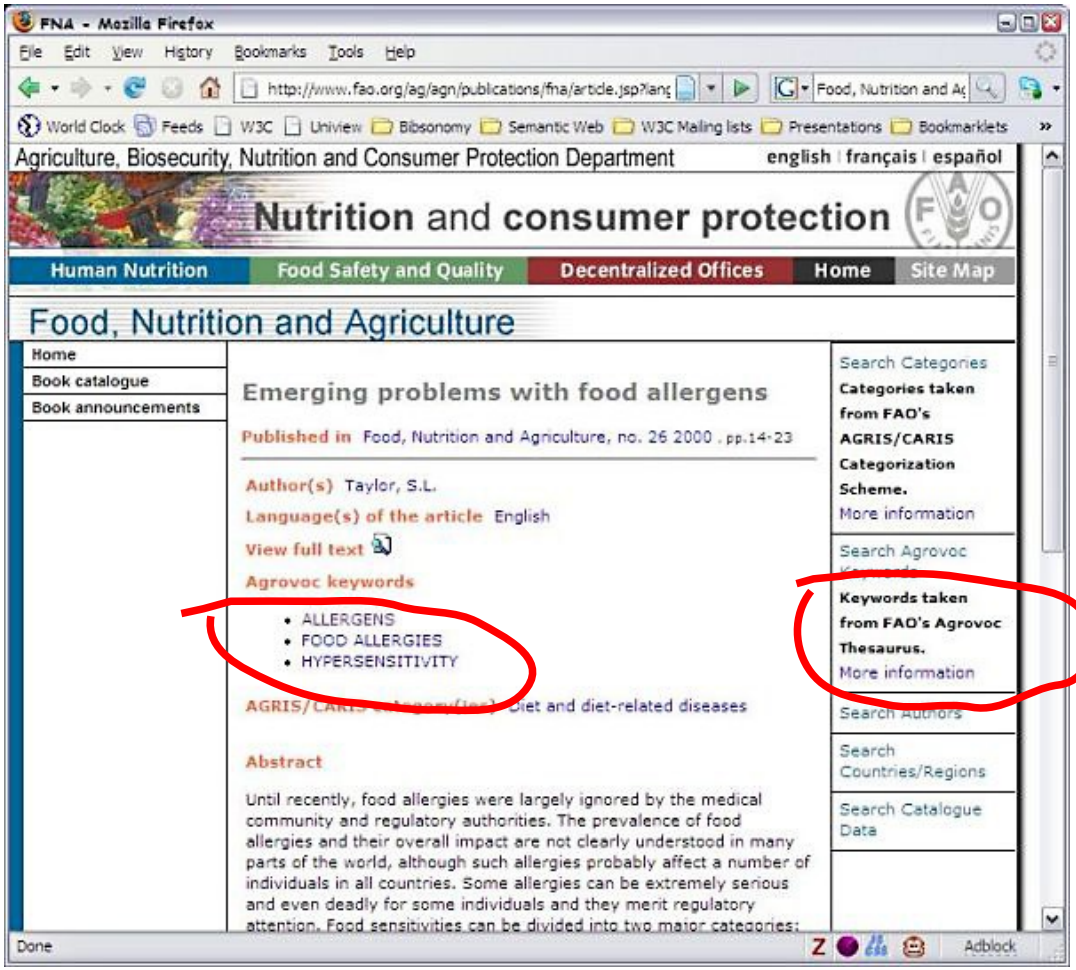
- Help in finding the best drug regimen for a specific case
  - find the best trade-off for a patient
- Integrate data from various sources (patients, physicians, Pharma, researchers, ontologies, etc)
- Data (eg, regulation, drugs) change often, but the tool is much more resistant against change




*Courtesy of Erick Von Schweber, PharmaSURVEYOR Inc., (SWEO Use Case)*

# > FAO Journal portal

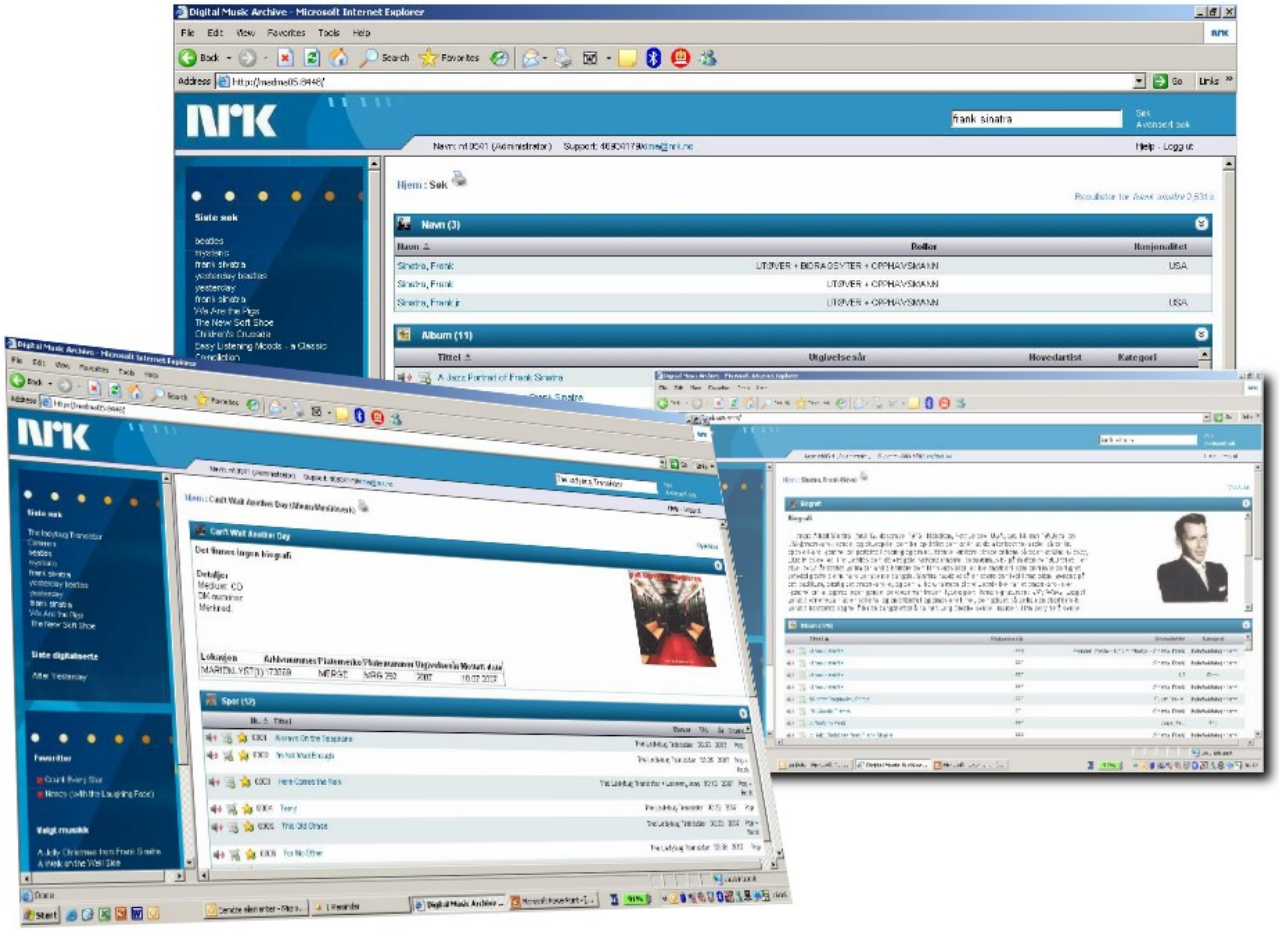
- Improved search on journal content based on an agricultural ontology and thesaurus (AGROVOC)




*Courtesy of Gauri Salokhe, Margherita Sini, and Johannes Keizer, FAO, (SWEO Case Study)*

# > Digital music asset portal at NRK

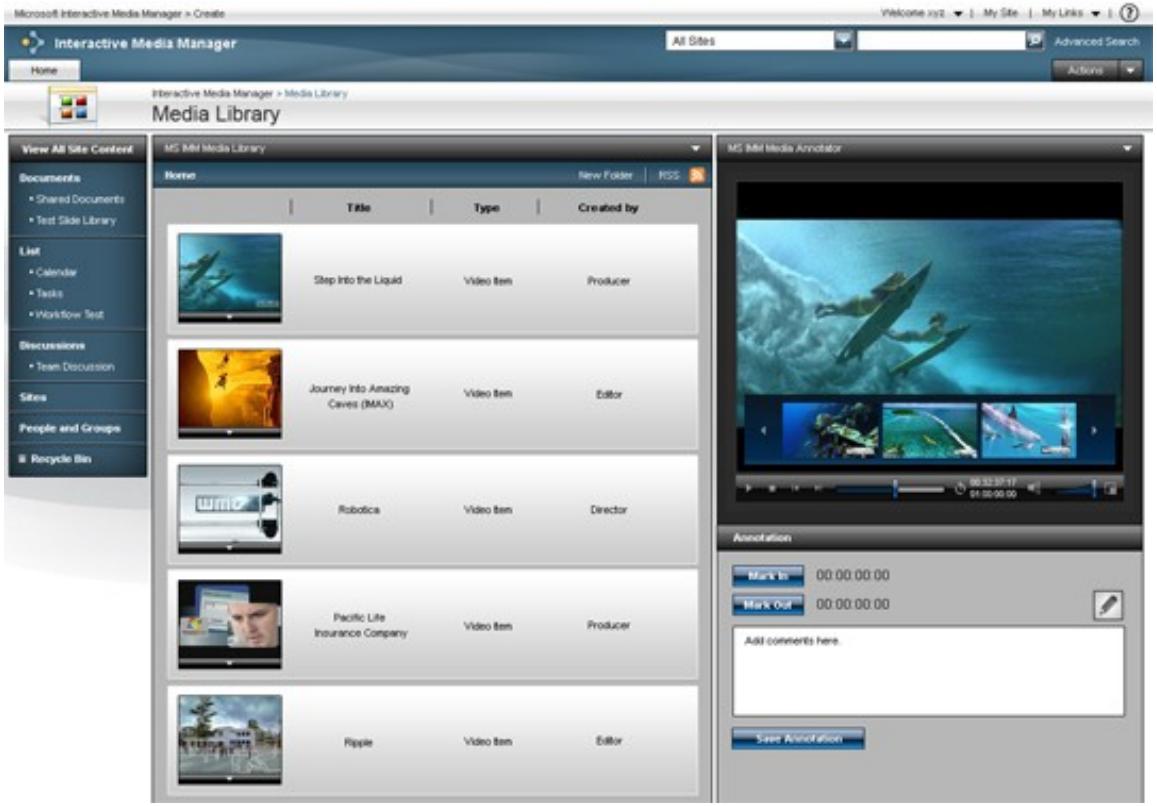
- Used by program production to find the right music in the archive for a specific show




*Courtesy of Robert Engels, ESIS, and Jon Roar Tønnesen, NRK (SWEO Case Study)*

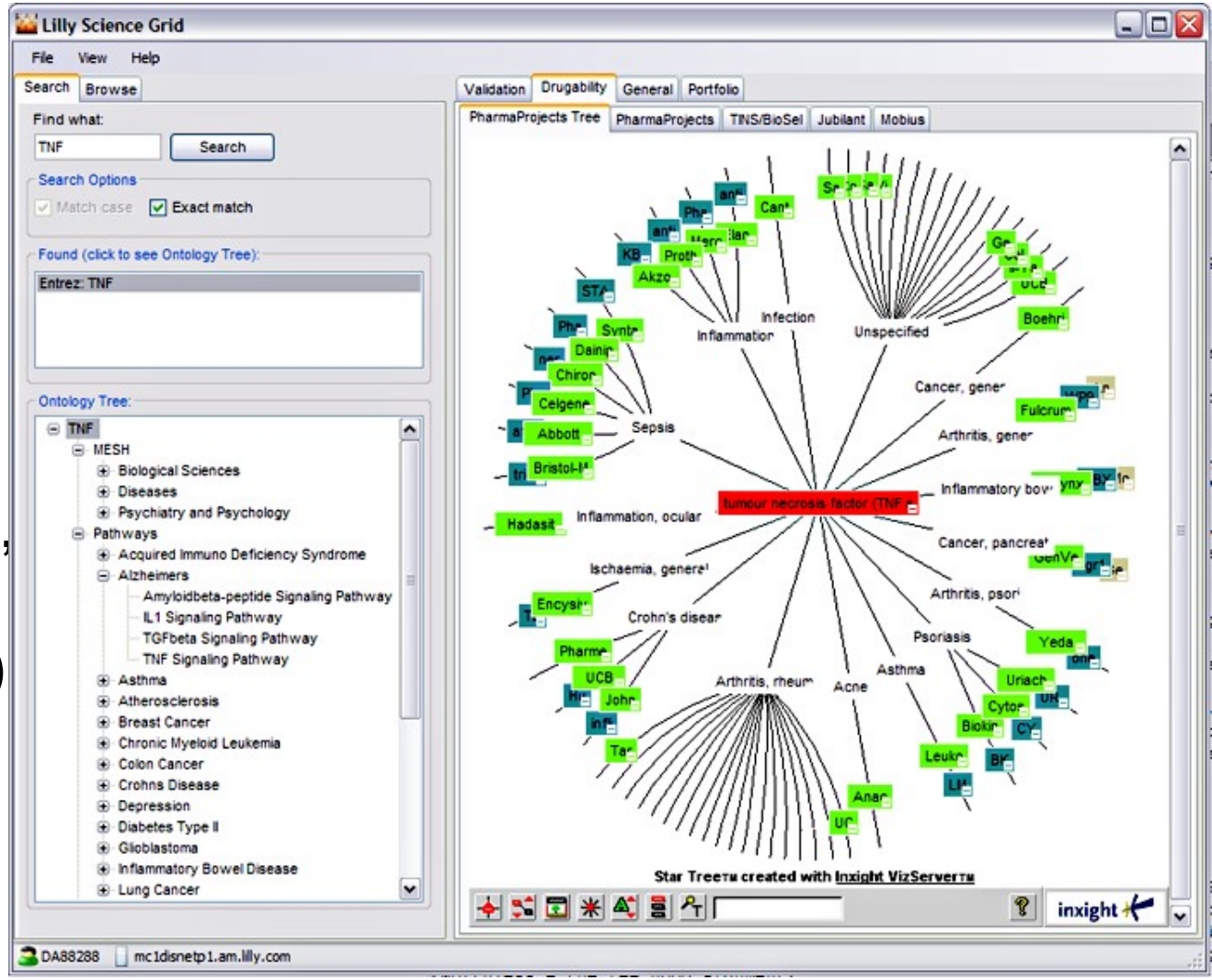
# > Microsoft Vista's Interactive Media Manager

- Uses an RDF/SPARQL/OWL based metadata framework
  - eg, for a better control over relationships among media assets and categories
- Custom OWL ontologies can be created and imported



# > Eli Lilly's Target Assessment Tool

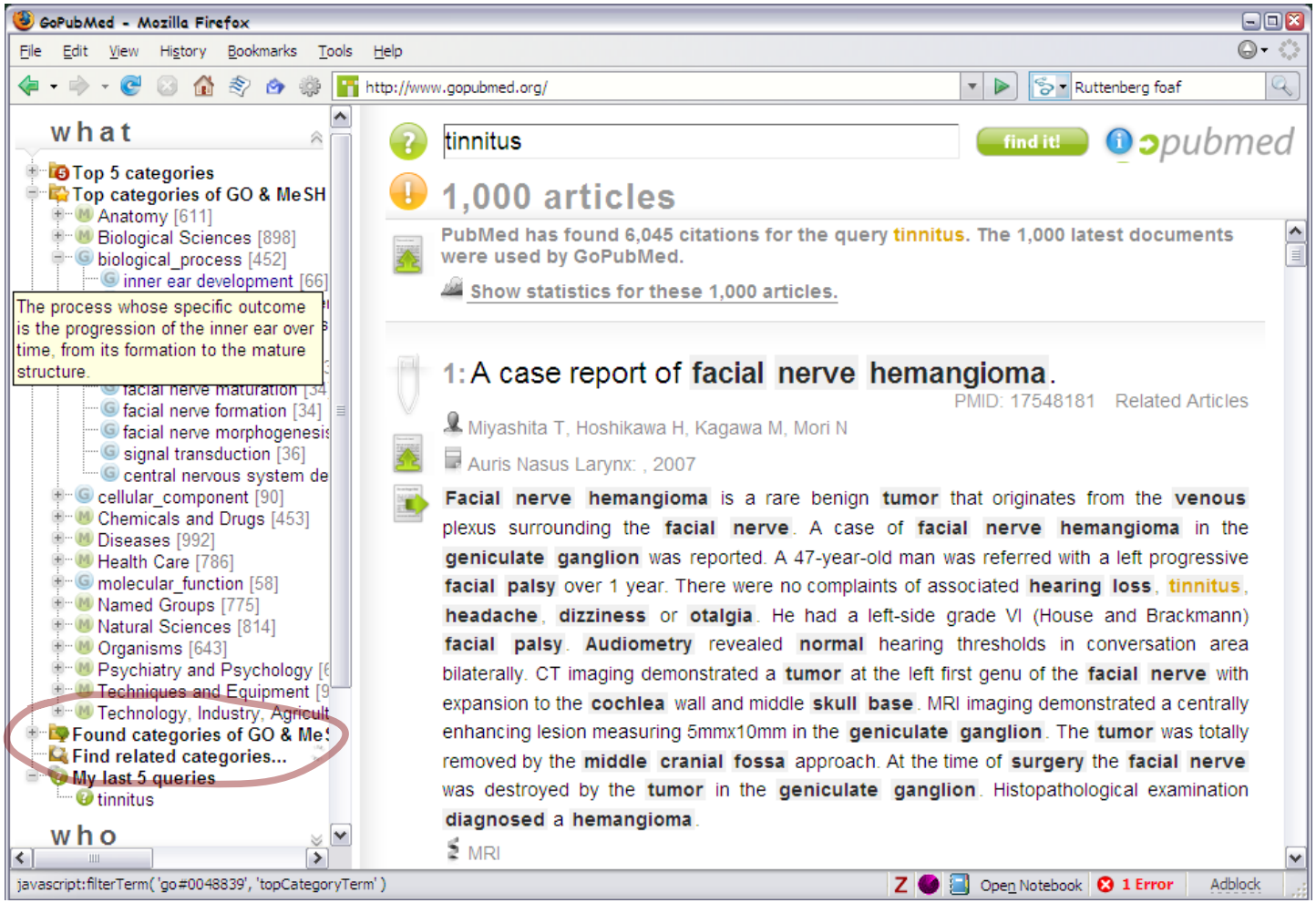
- Better prioritization of possible drug target, integrating data from different sources and formats
- Integration, search, etc, via ontologies (proprietary and public)




*Courtesy of Susie Stephens, Eli Lilly (SWEO Case Study)*

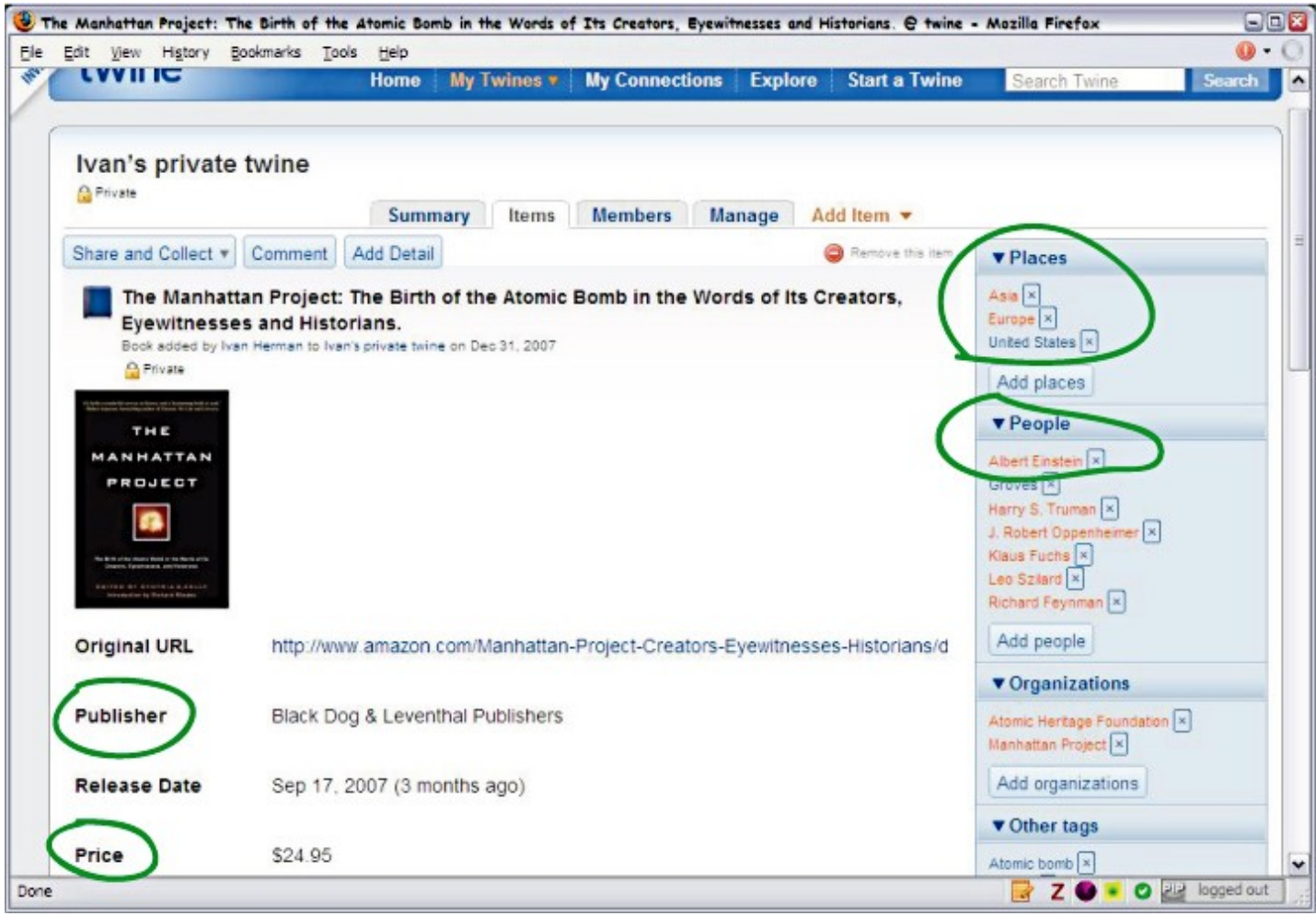
# > Improved Search via Ontology: GoPubMed

- Improved search on top of pubmed.org
  - search results are ranked using ontologies
  - related terms are highlighted, usable for further search



# > Radar Network's Twine

- "Social bookmarking on steroids"
- Item relationships are based on ontologies
  - evolving over time
  - possibly enriched by users
- Internals in RDF, will be available via APIs and SPARQL



# > Other application areas come to the fore

- Content management
- Business intelligence
- Collaborative user interfaces
- Sensor-based services
- Linking virtual communities
- Grid infrastructure
- Multimedia data management
- Etc

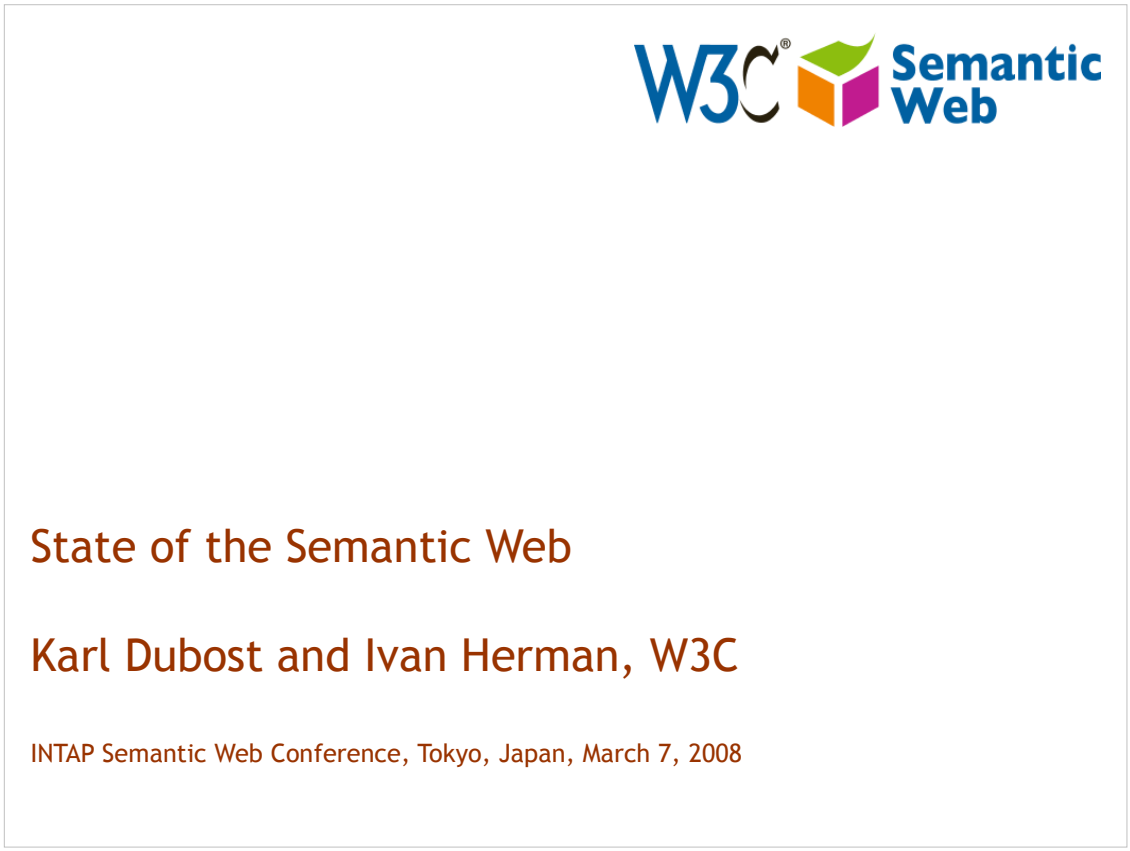
# > Thank you for your attention!

- These slides are publicly available on:

`http://www.w3.org/2008/Talks/0307-Tokyo-IH/`

- There is also a collection of use cases at:

`http://www.w3.org/2001/sw/sweo/public/UseCases/`




This is just a generic slide set. Should be adapted, reviewed, possibly with slides removed, for a specific event. Rule of thumb: on the average, a slide is a minute…

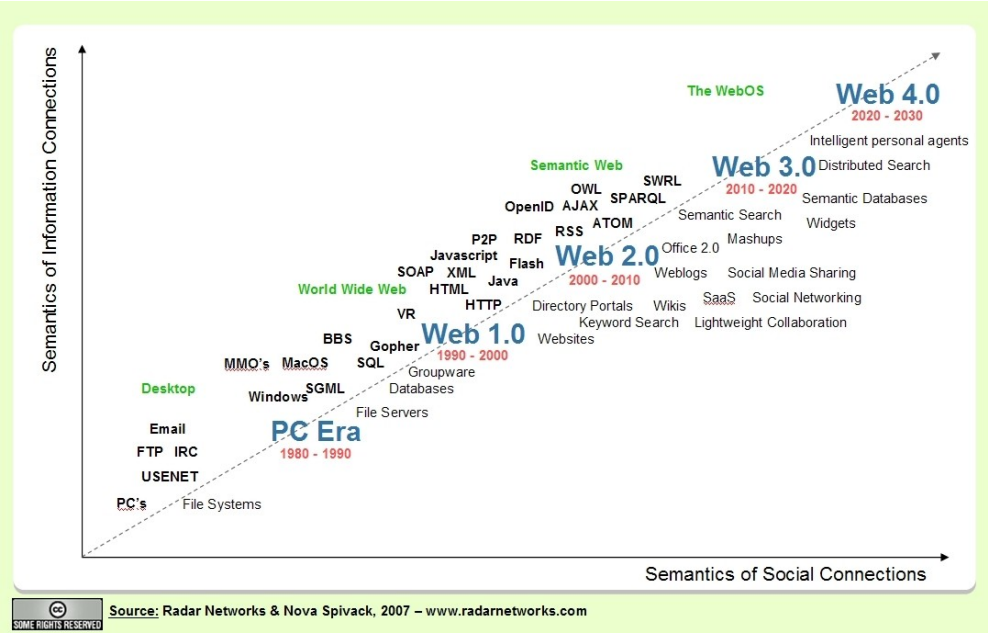
## > Significant buzz…

- There is quite a buzz around “Semantics”, “Semantic Technologies”, “Semantic Web”, “Web 3.0”, “Data Web”, etc, these days
- New applications, companies, tools, etc, come to the fore frequently
- It is, of course, not always clear what these terms all mean:
  - “Semantic Web” is a way to specify data and data relationships; it is also a collection of specific technologies (RDF, OWL, GRDDL, SPARQL, …)
  - “Semantic Technologies”, “Web 3.0” often mean more, including intelligent agents, usage of complex logical procedures, etc

## > Significant buzz… (cont.)

- Predicting the exact evolution in terms of Web 3.0, Web 4.0, etc, is a bit as looking into a crystal ball
- But the *Semantic Web technologies are already here, are used and deployed*
- They are at the basis of further evolution

## > A vision on the evolution…




(this Web 3.0 is *not* identical to the "journalistic" Web3.0; merely timing)



This Web 3.0 is not the 'usual' Web 3.0. It is simply an evolutionary, well, versioning step, whereas, often, W3b 3.0 has an emphasis on the role of Artificial intelligence...

## > The 2007 Gartner predictions

During the next 10 years, Web-based technologies will improve the ability to embed semantic structures [… it] will occur in multiple evolutionary steps…

By 2017, we expect the vision of the Semantic Web […] to coalesce […] and the majority of Web pages are decorated with some form of semantic hypertext.

By 2012, 80% of public Web sites will use some level of semantic hypertext to create SW documents […] 15% of public Web sites will use more extensive Semantic Web-based ontologies to create semantic databases

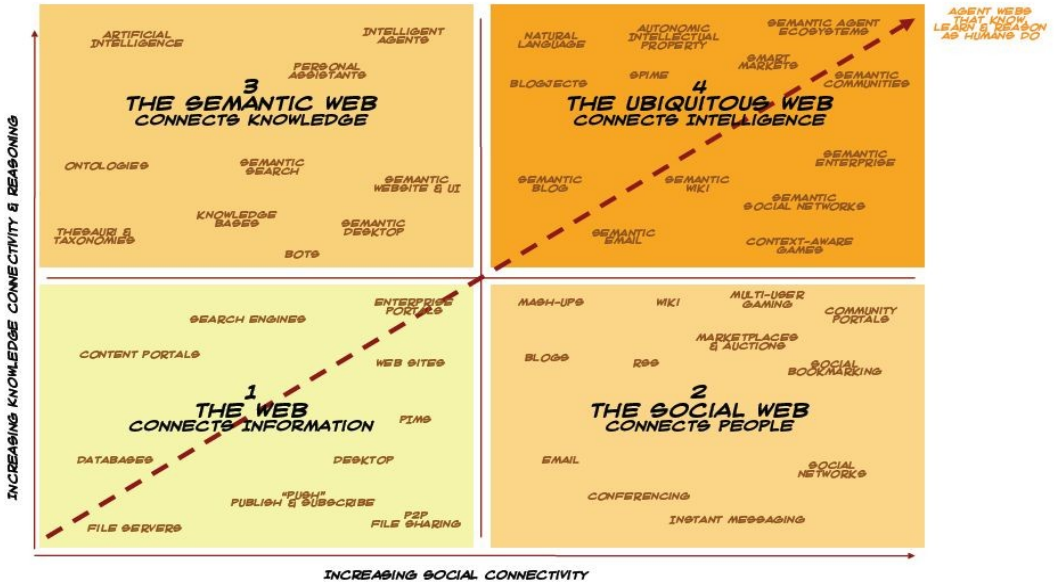
(note: “semantic hypertext” refers to, eg, RDFa, microformats with possible GRDDL, etc.)

*Source: “Finding and Exploiting Value in Semantic Web Technologies on the Web”, Gartner Research Report, May 2007*



## > Another longer term vision…

(from the “Semantic Wave 2008” report, from Project10X)



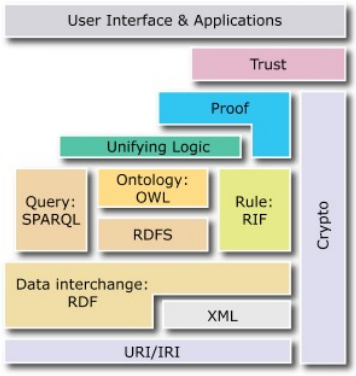

*Courtesy of Mills Davis, Project10X; source: Nova Spivack, Radar Networks and John Breslin, DERI*



The W3C's terminology is more to say that the SW 'connects data' rather than the (much more vague) term of connecting knowledge, but that is a minor issue. The upper right hand corner is certainly one grand vision for these analysts.

# > Let us keep to the Semantic Web for now…

- In what follows we will restrict ourselves to the *Semantic Web*
  - a way to specify data and data relationships
  - allows data to be shared and reused across application, enterprise, and community boundaries
  - a collection of fundamental technologies (RDF/S, OWL, GRDDL, SPARQL, …)



## > The “corporate” landscape is moving

- Major companies offer (or will offer) Semantic Web tools or systems using Semantic Web: Adobe, Oracle, IBM, HP, Software AG, GE, Northrop Gruman, Altova, Microsoft, Dow Jones, …
- Others are using it (or consider using it) as part of their own operations: Novartis, Boeing, Pfizer, Telefónica, …
- Some of the names of active participants in W3C SW related groups: ILOG, HP, Agfa, SRI International, Fair Isaac Corp., Oracle, Boeing, IBM, Chevron, Siemens, Nokia, Pfizer, Sun, Eli Lilly, …

## > Some SW Tools (*not* and 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 systems**
  - Semantic Media Wiki, Platypus
  - Visual knowledge

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



Not an exhaustive list of tools. Some of the tools are open source (eg, Jena), some of them are products (Ontotext). Some of them are from big, established companies (Oracle), some of them are from smaller, specialized companies (AllegroGraph from Franc Inc), etc. *It is the usual picture of the Web industry*; in this sense, nothing special any more...

## > Some SW 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!
- We still need more "middleware" tools to properly *combine* what is already available…
- *Anybody can start developing RDF-based applications today*



The last point is important. Some years ago the problem was that application developers had to start from scratch because (almost) only the specifications were around plus some initial, mostly not-well-tested open source project results (or academic work output). Since about 2 years (rough estimate) this is not true any more.

*Let us look at the technical state of the SW first*

## > 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
- Is a W3C Standard (since January 2008)
- Numerous implementations are already available (eg, built in triple stores)



The fact that SPARQL is not only a query language, but a full protocol over the Web is important to emphasize. *This* makes it deployable on the Web.

## > Some new technologies at W3C

- SPARQL
- GRDDL
- RDFa
- SKOS
- OWL 1.1
- RIF (Rules)

## > SPARQL (cont.)

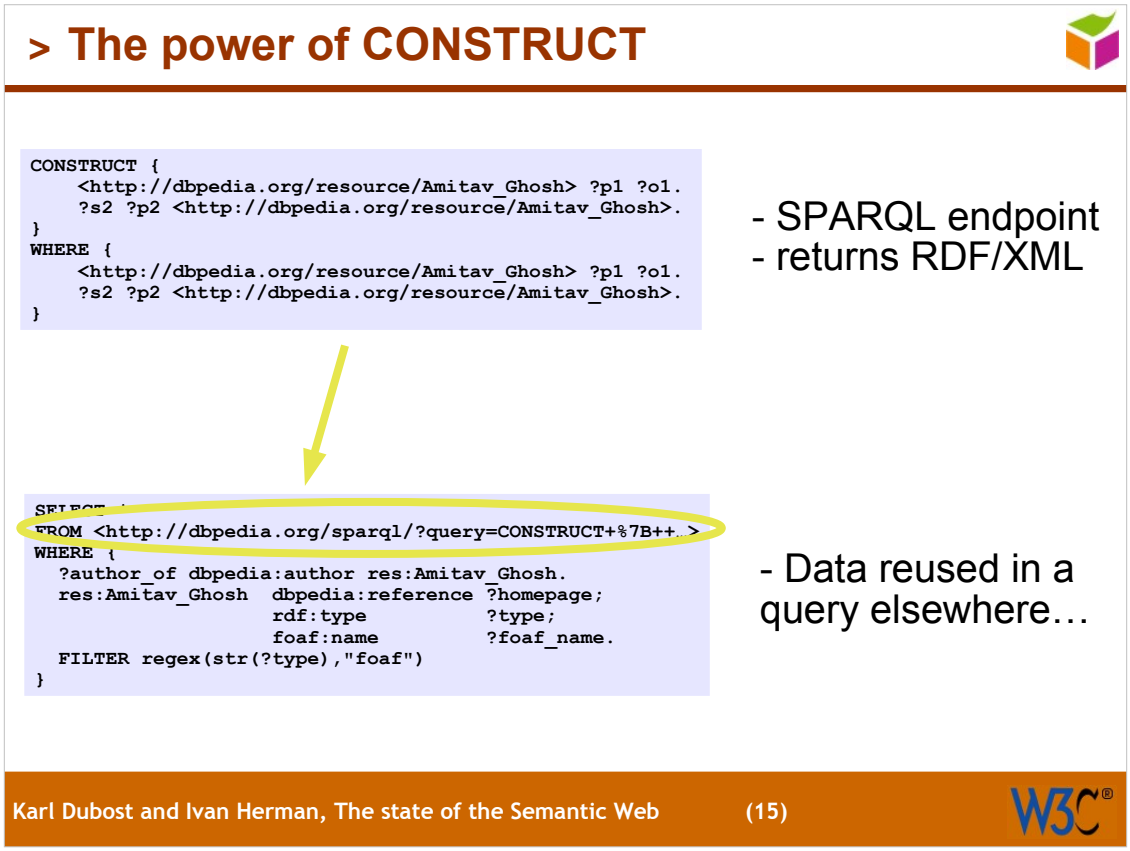
- There are also SPARQL “endpoints” services on the Web:
  - send a query and a reference to data over HTTP GET, receive the result in XML or JSON
  - big datasets often offer “SPARQL endpoints” to query local data
  - *applications may not need any direct RDF programming any more, just use a SPARQL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



“service” means that these are running SPARQL processors that people can simply use by sending RDF reference data URI-s and the query, and they do the query for you. For some of these public services the RDF data can be anywhere on the web, not necessarily on the same site. Ie, these services make it possible to query RDF data anywhere in the world. Of course, these services usually have limitations in size, so one cannot do very serious applications, but it is good for simpler ones. Also: it is very easy to install some of these services locally on one's own machine. Typical example: Jena's sparql service, or Virtuoso's free version.

The last bulleted item is important: for many applications, one can rely on the query language only and it is not necessary to know about the details of how RDF environment store and manage triples, what programming language they use, etc. SPARQL makes it much easier to develop applications that mash up RDF data.

The last point is showed more in details in the next few slides. It is an essential, but not very well known feature of SPARQL, good to show for an already RDF aware audience




This means: one can have a URI that refers to a specific graph as returned by a SPARQL query somewhere on the WEB. This URI can then be incorporated into the query of *another* SPARQL processor. Another way of putting it is that SPARQL queries can be, sort of, "chained" together.

## > 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…



Note: W3C is in the process of setting up an appropriate mechanism to gather feedbacks and will, probably, start work for a "SPARQL2" (*provisional* name) within 1-2 years. Undecided, though.

## > Bridge to relational databases

- Most of the data on the Web are stored in relational databases
  - "RDFying" them is an impossible
  - relational databases are here to stay…
- "Bridges" are being defined:
  - a layer between RDF and the relational data
    - RDB tables are "mapped" to RDF graphs, possibly on the fly
    - different mapping languages/approaches are being used
  - a number of systems can now be used as relational database as well as triple stores (eg, Oracle, OpenLink, …)
- Work for a survey on mapping techniques benchmarks may start soon at W3C
- SPARQL is becoming the tool of choice to query the data
  - ie, "SPARQL endpoints" are defined to query the databases



On the work coming up: we are in discussion for two XG-s on those issues. It is not yet 100% sure they will happen, there is currently a bigger probability for the mapping one to come and the other is still unclear. Of course, members interested in this work would be welcome!

# > 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
- We have already seen the work relating to "traditional" databases
- But there are also other types of data out there, too…

## > 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

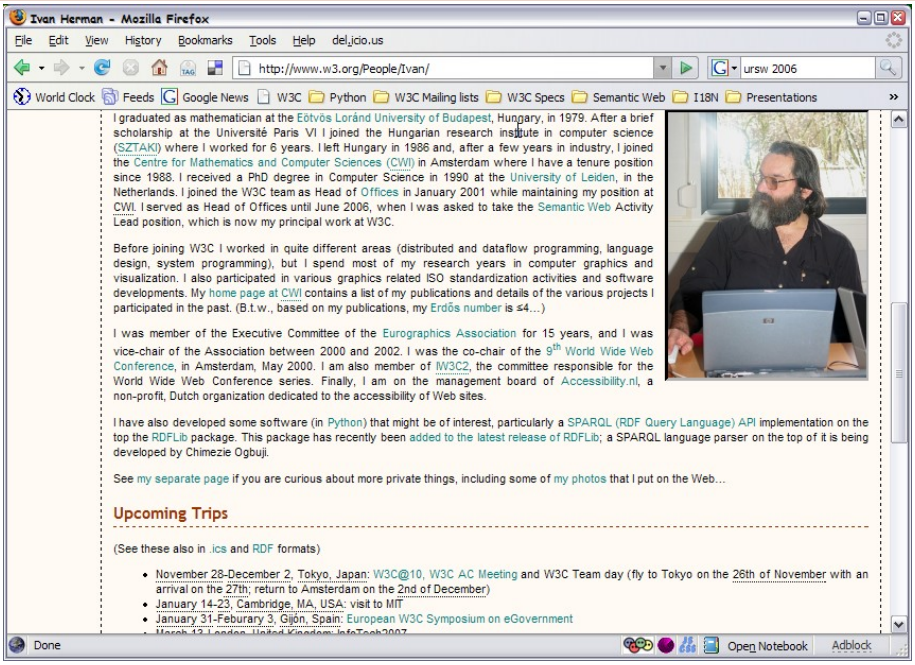
## > Getting structured data to RDF: GRDDL

- 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
    - script is usually XSLT but not necessarily
    - has a variant for XHTML
  - 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

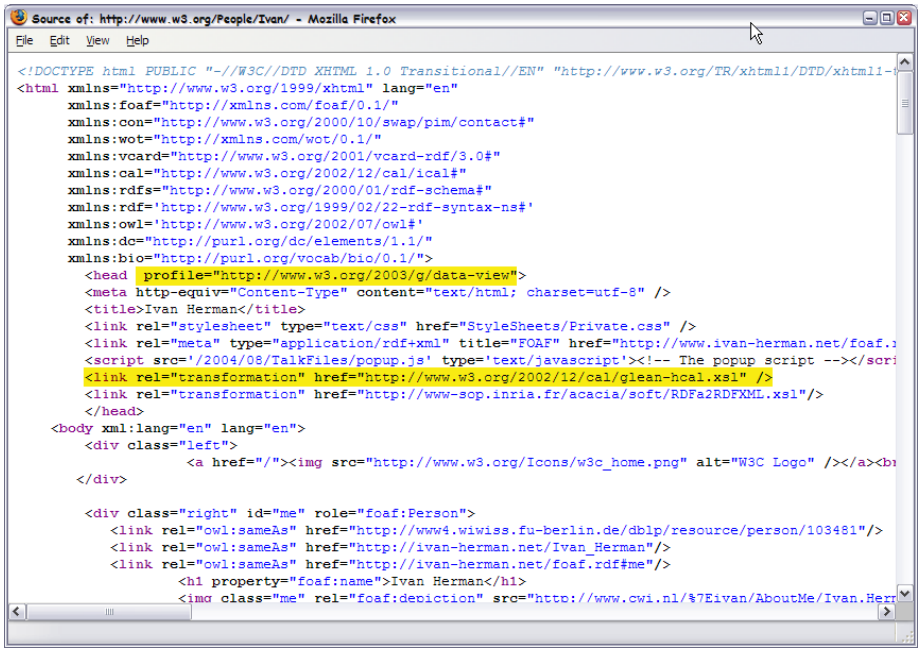
## > Getting structured data to RDF: RDFa

- 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
- It can also be used with GRDDL
  - but: no need to implement a separate transformation per vocabulary

# > GRDDL & RDFa: Ivan' home page…



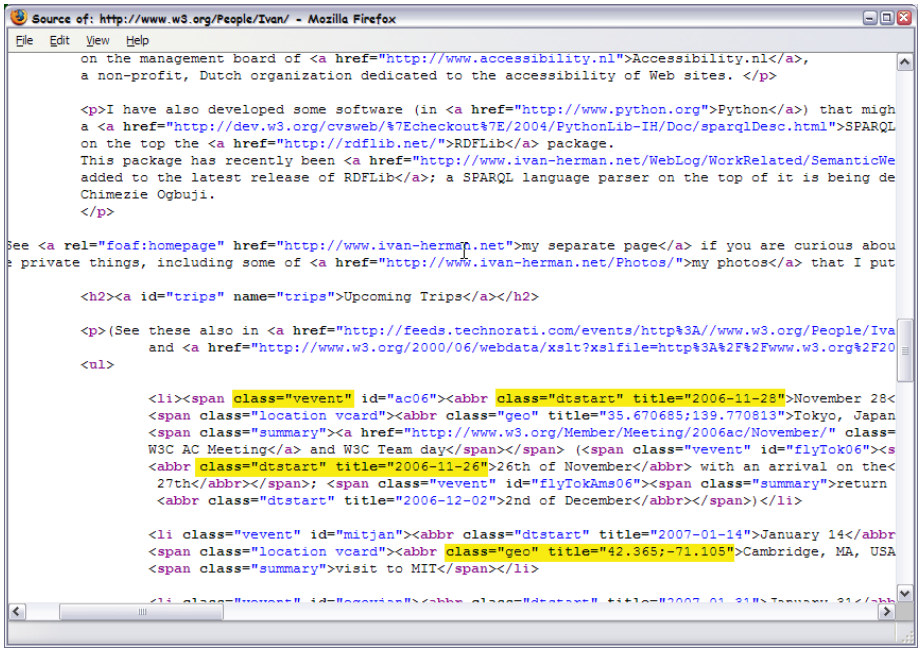
## > …marked up with GRDDL headers…






The two highlighted lines make it GRDDL aware: set the profile and set the transformation.

## > …and hCard microformat tags…





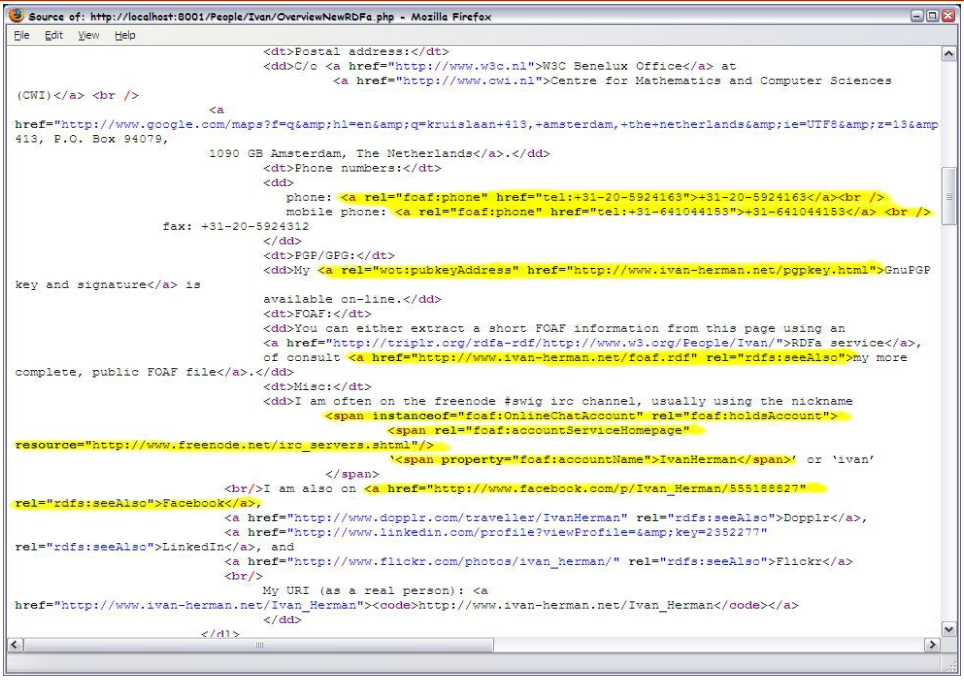

The microformat is not defined by W3C...

# > …yielding; …

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xml:base="http://www.w3.org/People/Ivan/">
 <c:Vcalendar xmlns:r="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
              xmlns:ical=… >
  <c:component>
   <c:Vevent r:about="#ac06">
    <ical:summary>W3C@10, W3C AC Meeting and W3C Team day</ical:summary>
    <ical:dtstart>2006-11-28</ical:dtstart>
    <ical:dtend>2006-12-03</ical:dtend>
    <ical:url
       r:resource="http://www.w3.org/Member/Meeting/2006ac/November/"/>
    <loc:location xml:lang="en">Tokyo, Japan</location>
    <geo:geo r:parseType="Resource">
      <r:first>35.670685</r:first>
      <r:rest r:parseType="Resource">
        …
       </r:rest>
    </geo:geo>
…
```



# > …marked up with RDFa tags…




```
                                <dt>Postal address:</dt>
                                <dd>C/o <a href="http://www.w3c.nl">W3C Benelux Office</a> at
                                        <a href="http://www.cwi.nl">Centre for Mathematics and Computer Sciences
(CWI)</a> <br />
                        <a
href="http://www.google.com/maps?f=q&amp;hl=en&amp;q=kruislaan+413,+amsterdam,+the+netherlands&amp;ie=UTF8&amp;z=13&amp
413, P.O. Box 94079,
                        1090 GB Amsterdam, The Netherlands</a>.</dd>
                                <dt>Phone numbers:</dt>
                                <dd>
                                   phone: <a rel="foaf:phone" href="tel:+31-20-5924163">+31-20-5924163</a><br />
                                   mobile phone: <a rel="foaf:phone" href="tel:+31-641044153">+31-641044153</a> <br />
                    fax: +31-20-5924312
                                </dd>
                                <dt>PGP/GPG:</dt>
                                <dd>My <a rel="wot:pubkeyAddress" href="http://www.ivan-herman.net/pgpkey.html">GnuPGP
key and signature</a> is
                                available on-line.</dd>
                                <dt>FOAF:</dt>
                                <dd>You can either extract a short FOAF information from this page using an
                                <a href="http://triplr.org/rdfa-rdf/http://www.w3.org/People/Ivan/">RDFa service</a>,
                                of consult <a href="http://www.ivan-herman.net/foaf.rdf" rel="rdfs:seeAlso">my more
complete, public FOAF file</a>.</dd>
                                <dt>Misc:</dt>
                                <dd>I am often on the freenode #swig irc channel, usually using the nickname
                                        <span instanceof="foaf:OnlineChatAccount" rel="foaf:holdsAccount">
                                                <span rel="foaf:accountServiceHomepage"
resource="http://www.freenode.net/irc_servers.shtml"/>
                                                'span property="foaf:accountName">IvanHerman</span>' or 'ivan'
                                        </span>
                                <br/>I am also on <a href="http://www.facebook.com/p/Ivan_Herman/555188827"
rel="rdfs:seeAlso">Facebook</a>,
                                <a href="http://www.dopplr.com/traveller/IvanHerman" rel="rdfs:seeAlso">Dopplr</a>,
                                <a href="http://www.linkedin.com/profile?viewProfile=&amp;key=2352277"
rel="rdfs:seeAlso">LinkedIn</a>, and
                                <a href="http://www.flickr.com/photos/ivan_herman/" rel="rdfs:seeAlso">Flickr</a>
                                <br/>
                                    My URI (as a real person): <a
href="http://www.ivan-herman.net/Ivan_Herman"><code>http://www.ivan-herman.net/Ivan_Herman</code></a>
                                </dd>
                        </dl>
```

# > … yielding

```
@prefix foaf: <http://xmlns.com/foaf/0.1/>
@prefix wot: <http://xmlns.com/wot/0.1/>
...
@base <http://www.w3.org/People/Ivan/>

<#me>
  foaf:phone <tel:+31-20-5924163>;
  foaf:phone <tel:+31-641044153>;
  wot:pubkeyAddress <http://www.ivan-herman.net/pgpkey.html>;
  rdfs:seeAlso <http://www.ivan-herman.net/foaf.rdf>;
  foaf:holdsAccount
    [ a foaf:OnlineChatAccount;
      foaf:accountServiceHomepage
        <http://www.freenode.net/irc_servers.html>;
      foaf:accountName "IvanHerman";
    ];
  rdfs:seeAlso <http://www.facebook.com/p/Ivan_Herman/555188824>;
  ...
```

## > Such data can be SPARQL-ed

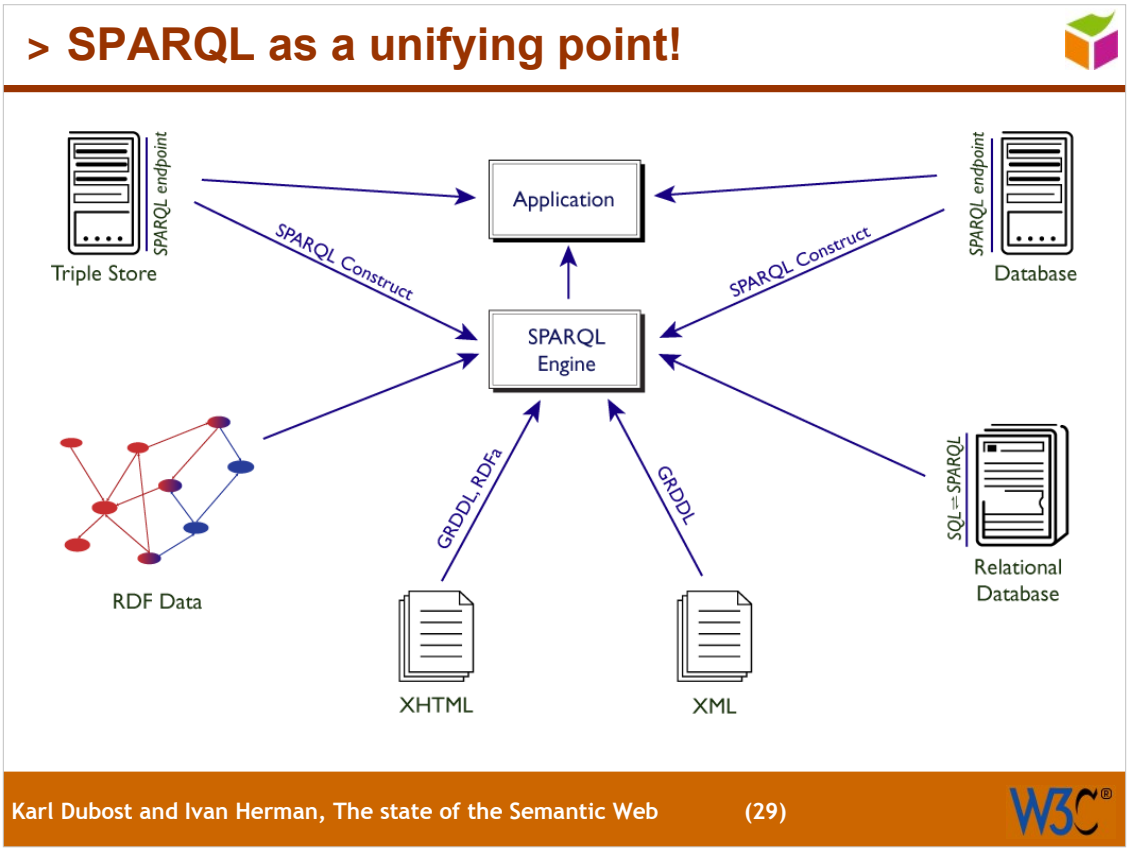
```
SELECT DISTINCT ?name ?home ?orgRole ?orgName ?orgHome
# Get RDFa from my home page:
FROM <http://www.w3.org/People/Ivan/>
# GRDDL-ing http://www.w3.org/Member/Mail:
FROM <http://www.w3.org/Member/Mail/>
WHERE {
?foafPerson  foaf:mbox ?mail;
             foaf:homepage ?home.
?individual  contact:mailbox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



Note that the SPARQL query:

- uses the same URI for the page and the RDF data (some processors, like Virtuoso or Tabulator) are capable of running the converters (well, Tabulator does not do it for RDFa yet)

- the query shows the data coming from different sources, (colour coded) with the ?mail term, sort of, 'binding' the data coming from different places. .Ie, the SPARQL query does the 'mash up' on the query level, regardless of the exact format the data is stored in...




This binds back to an earlier remark on SPARQL. For many applications, SPARQL is the only interface to the Semantic Web data, everything else is done under the hood via GRDDL/RDFa, other SPARQL endpoints to data, etc.

## > Simple Knowledge Organization System

- Goal: representing and sharing classifications, glossaries, thesauri, etc, as developed in the “Print World”. For example:
  - Dewey Decimal Classification, Art and Architecture Thesaurus, ACM classification of keywords and terms…
  - DMOZ categories (a.k.a. Open Directory Project)
- The system must be simple to allow for a quick port of traditional data (done by non-experts in, say, Semantic Web)
- This is where *SKOS* comes in: define classes, properties, where those structures can be added



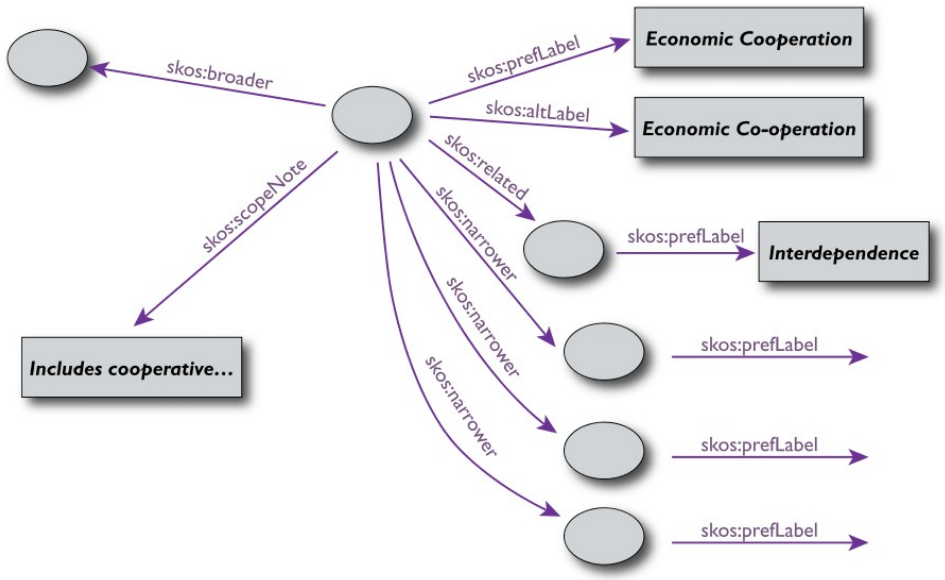
This is a very important spec in accessing to, eg, the (digital) library world, to various thesauri and taxonomies around the globe!

## > Example: thesaurus

**Term**
Economic cooperation
**Used For**
Economic co-operation
**Broader terms**
Economic policy
**Narrower terms**
Economic integration, European economic cooperation, …
**Related terms**
Interdependence
**Scope Note**
Includes cooperative measures in banking, trade, …

(from the UK Archival Thesaurus)

# > Example: thesaurus in SKOS



# > SKOS and digital libraries

- SKOS plays an important role in “bridging” to digital libraries
- A huge community out there with its own traditions, style…
- … but huge amount of data to be “linked” to the Semantic Web!
- Major library metadata standards are being re-defined in terms of RDF (and SKOS),
  - eg, “Resource Description and Access” (RDA)
    - a major cataloging rule set for librarians
    - potentially, all major library catalogs around the globe could be translated into RDF and, eg, linked as an Open Linked Data…

# > Ontologies

- Large ontologies are being developed (converted from other formats or defined in OWL). For example:
  - eClassOwl: eBusiness ontology for products and services, 75,000 classes and 5,500 properties
  - National Cancer Institute's ontology: about 58,000 classes
  - Open Biomedical Ontologies Foundry: a collection of ontologies, including the Gene Ontology, to describe gene and gene product attributes; or UniProt for protein sequence and annotation terminology and data
  - BioPAX: for biological pathway data
  - ISO 15926: "Integration of life-cycle data for process plants including oil and gas production facilities"

## > OWL in applications

- An increasing number of applications rely on OWL (Pfizer, Nasa, Eli Lilly, Elsevier, FAO, …)
  - see some more example at the end of the talk
- Not all use complex reasoning; in many cases a small fraction of OWL is used

## > New OWL Working Group

- A new Working Group just started on the revision of OWL
- The goal of the group:
  1. add a few extensions to current OWL that are useful, and is known to be implementable
     - many things happened in research since 2004
     - features should (if possible) be valid both in the DL and OWL Full world
  2. define fragments, ie, “profiles” of OWL that are:
     - smaller, easier to implement and deploy
     - cover important application areas and are easily understandable to non-expert users



The work is based on the input of an “ad-hoc” group that looked at the issue in the past 1.5-2 years

## > “OWL 1.1”: new proposed features

- “Qualified cardinality restrictions” (eg, “class instance must have two black cats”)
- Disjoint, reflexive, irreflexive properties; disjoint union of classes
- Property chains (eg, the uncle example: “if y is father x of y and y is brother of z, then z is uncle of x”)
- Own datatype constructs instead of complex XML Schema datatypes
  - eg, to express restrictions like number intervals easily

## > “OWL 1.1”: new proposed features (cont)

- Metamodeling (a.k.a. “punning”): the same symbol may be used both as, e.g., a Class and an Instance, or for a datatype and an object property
  - this is not a problem in OWL Full, but is a significant restriction in OWL DL
  - in the DL there would still be some restrictions on how that can be used (eg, not all “natural” inferences can be drawn)

## > “OWL 1.1”: small fragments

- For a number of applications RDFS is not enough, but even OWL Lite is too much (and too complex to implement)
- There is a need for (very) “light” versions of OWL: just a few extra possibilities added to RDFS
- Some can be as simple as having only (on top of RDFS):

```
equivalentClass
equivalentProperty
sameAs
```

```
inverseOf
TransitiveProperty
SymmetricProperty
FunctionalProperty
InverseFunctionalProperty
```



Worth noting: the small example is very close to OWLPrime, that Oracle implemented in their newest version (11g) that came out a few months ago

## > “OWL 1.1”: small fragments (cont.)

- There are a number of proposals, papers, prototypes (and implementations!). Eg:
  - EL++, DLP: all DL dialects (e.g., EL++ is already in use by the health care community for medical ontologies)
  - pD*, OWLPrime: OWL Full dialects, that can be implemented with rule engines on top of, say, database engines
- It may be possible to create a (or more) dialect that may have both a DL and an OWL Full semantics (eg, OWLPrime~DLP)
- The Working Group will have to settle on the final list and structure

## > Rules

- There is a long history of rule languages and rule-based systems
  - eg: logic programming (Prolog), production rules
- Lots of small and large rule systems (from mail filters to expert systems)
- Hundreds of niche markets

## > Why rules on the Semantic Web?

- There are conditions that ontologies (ie, OWL) cannot express (or only with difficulties)
  - a well known examples is Horn rules: (P1 ∧ P2 ∧ …) → C
- There are conditions that are complicated in rules and ontologies are better (eg, complex classification of terms)
- Simple rule engines might be easier to implement (eg, on top of database engines)
- A different way of thinking — people may feel more familiar in one or the other

# > Things you may want to express

- An example:
  - "if two Persons have the same name and the same email, or the same name and the same home page, then they are identical"
- Something like (with an ad-hoc syntax):

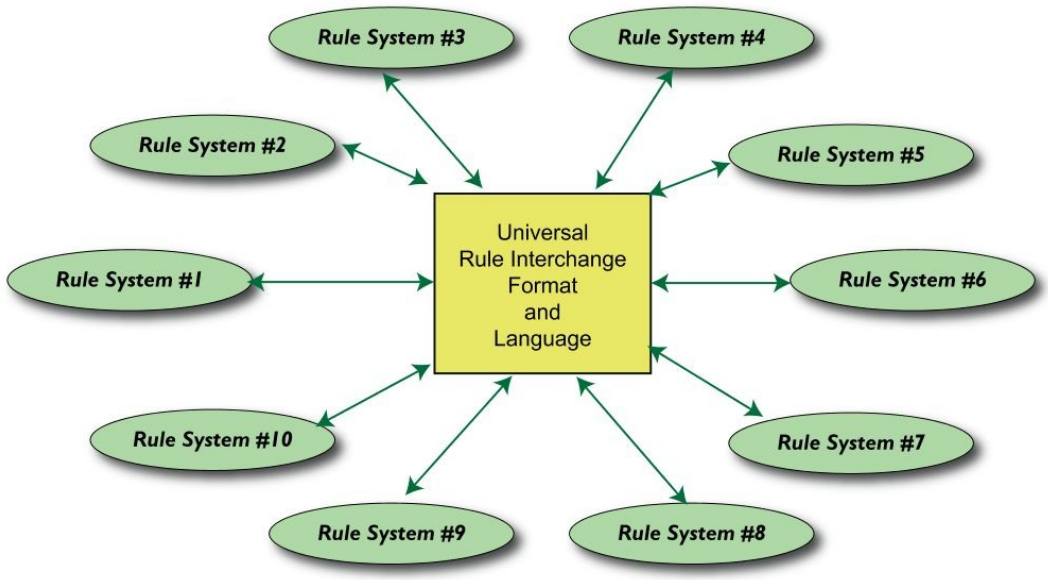
```
If { ?x rdf:type foaf:Person.
     ?y rdf:type foaf:Person.
     ?x foaf:name ?n.
     ?x foaf:homepage ?h.
     ?y foaf:name ?n.
     ?y foaf:homepage ?h. }
then { ?x = ?y }

If { ?x rdf:type foaf:Person.
     ?y rdf:type foaf:Person.
     ?x foaf:name ?n.
     ?x foaf:mailbox ?h.
     ?y foaf:name ?n.
     ?y foaf:mailbox ?m. }
then { ?x = ?y }
```

## > A new requirement: *exchange* of rules

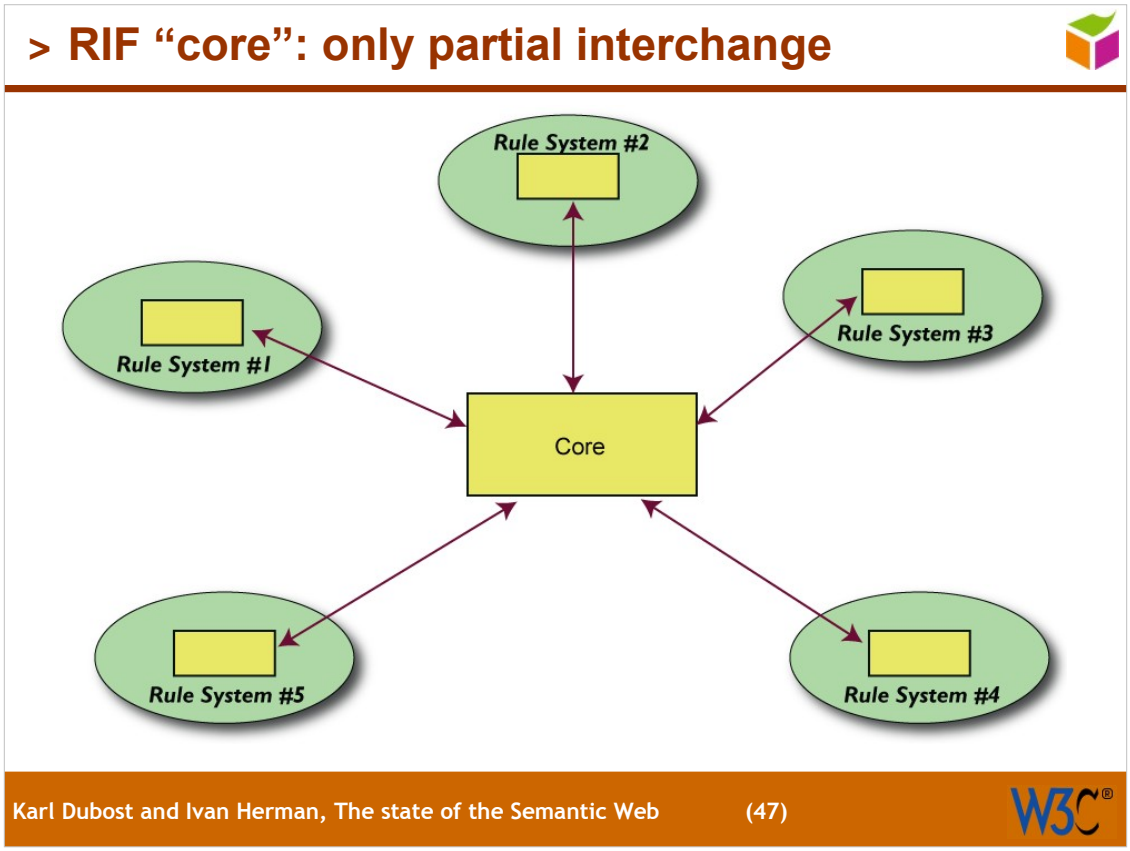
- Applications may want to *exchange* their rules:
  - negotiate eBusiness contracts across platforms: supply vendor-neutral representation of your business rules so that others may find you
  - describe privacy requirements and policies, and let clients "merge" those (e.g., when paying with a credit card)
- Hence the name of the working group: *Rule Interchange Format*
  - a language that
    - expresses the rules a bit like a rule language with, eg, RDF
    - can be used to exchange rules among engines

# > In an ideal World



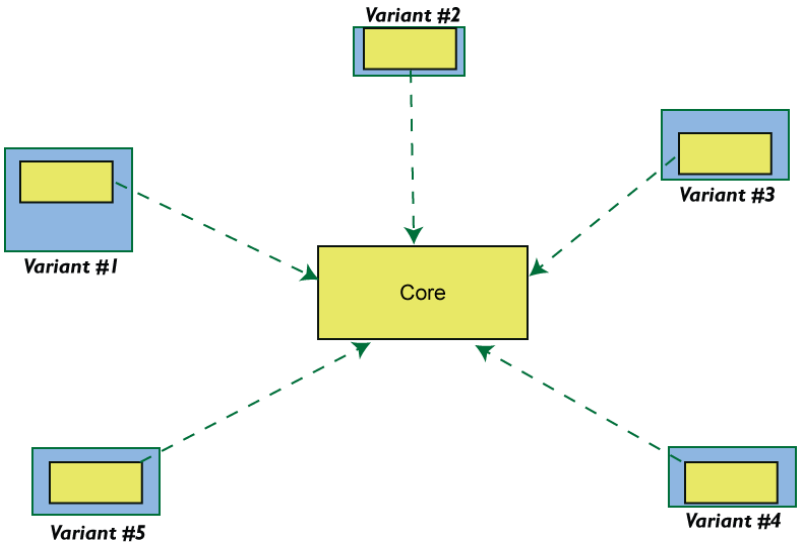
## > In the real World…

- Rule based systems can be very different
  - different rule semantics (based on various type of model theories, on proof systems, etc)
  - production rule systems, with procedural references, state transitions, etc
- Such universal exchange format is not feasible
- The idea is to define “cores” for a family of languages with “variants”




Ie, only those aspects of, say, Rule System #1 can be exchanged with Rule system #4 that are in the core

## > RIF “variants”

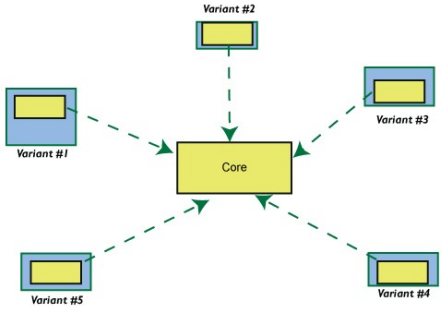



- Possible variants: F-logic, production rules, fuzzy logic systems, …; none of these have been finalized yet

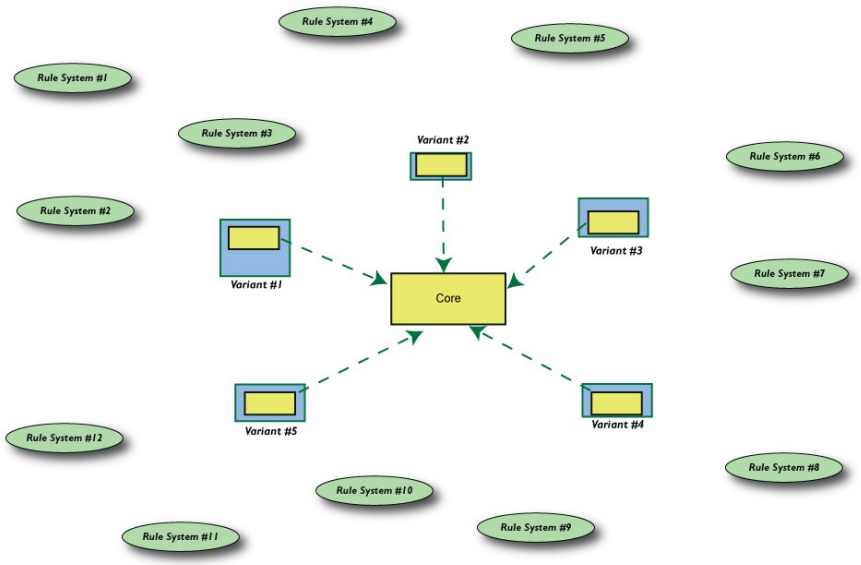


Variants are, in fact, an extension mechanism to the core...

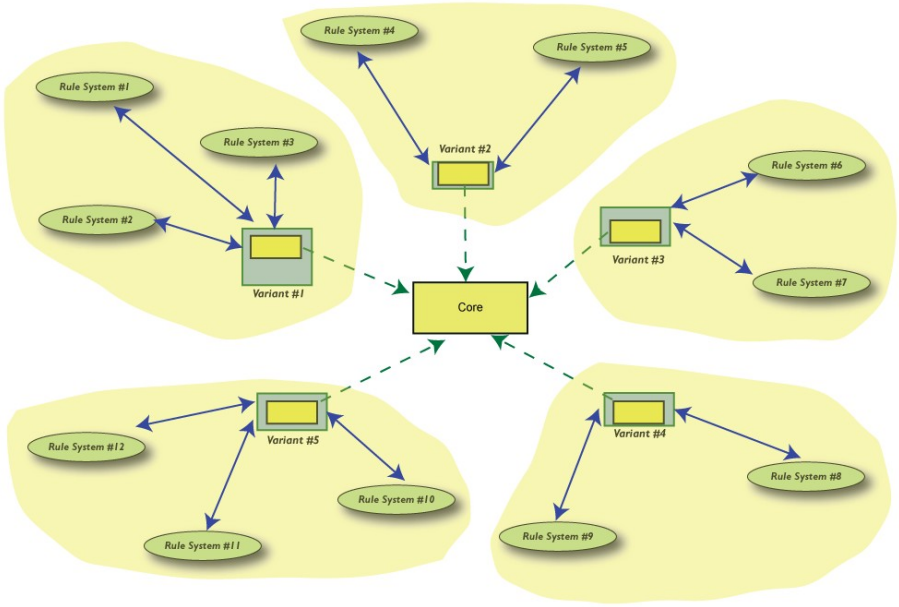
# > Role of variants



# > Role of variants



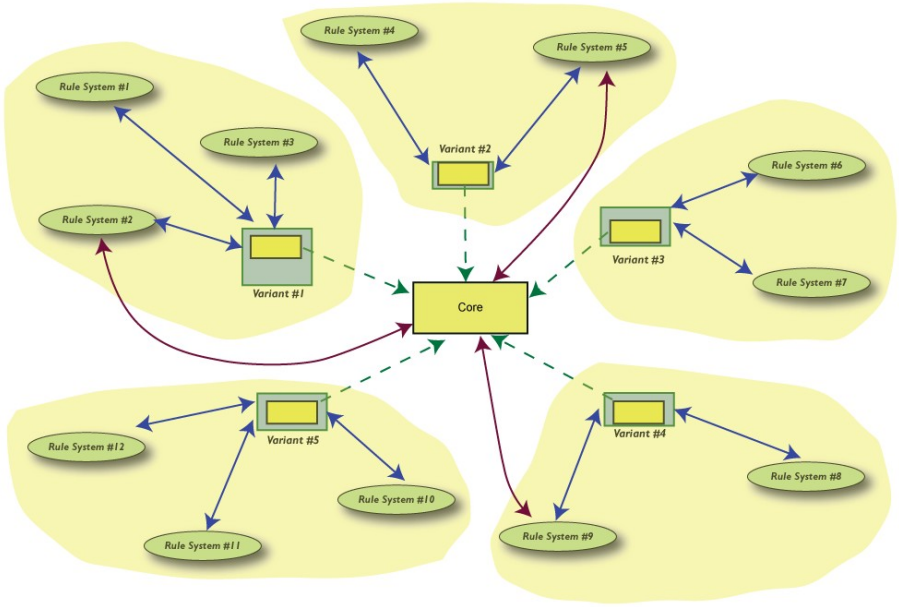
## > Role of variants






Ie: variants can play the role of an exchange 'core' within a family of rule systems, but for exchange among families, only the basic core can be applied.

## > Role of variants






Ie: variants can play the role of an exchange 'core' within a family of rule systems, but for exchange among families, only the basic core can be applied.

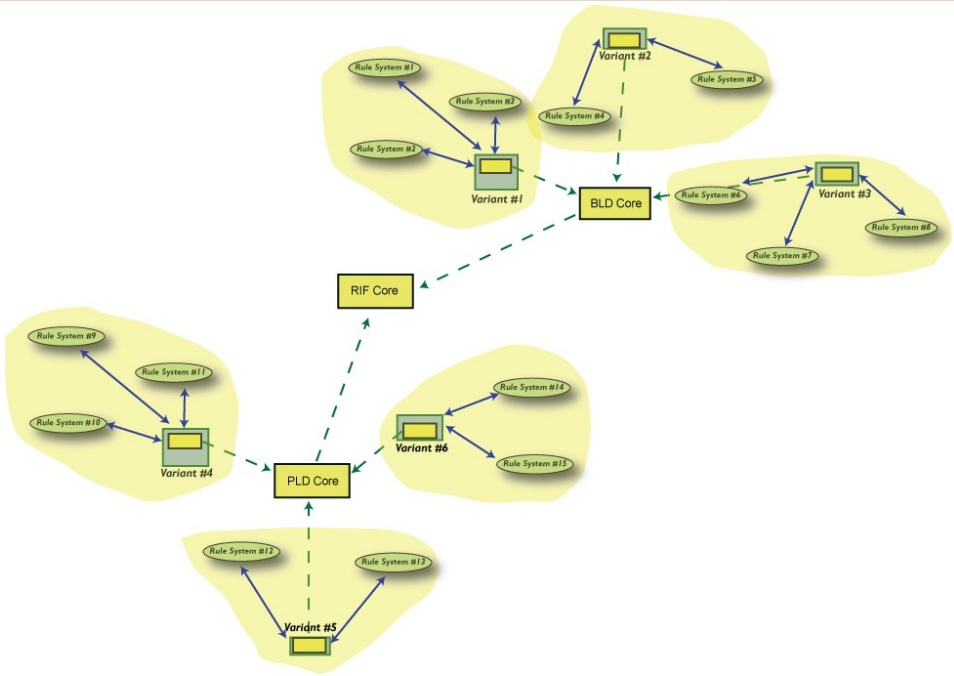
## > However…

- Even this model does not completely work
- The gap between production rules and “traditional” logic systems seems to be large
- A hierarchy of cores may be necessary:
  - a *Basic Logic Dialect* and *Production Rule Dialect* as “cores” for families of languages
  - a common *RIF Core* binding these two



The caveat: the model on previous pages was dominating the discussion in the group until around early autumn 2007, but it did not prove to be 100% feasible:-(

## > Hierarchy of cores






It is the same model as before but with one more level in the exchange hierarchy. Whether the central core will become feasible is still an open issue at this moment.

## > Current status

- There is a draft for the BLD
  - it defines a “positive Horn” language
  - it is a logic based general rule language
  - the language can be used
    - with or without RDF data and/or OWL
    - as a rule *language* or a rule *interchange format*
- The plan is to have BLD as a recommendation in 2008
- The work on the PLD Core has also begun



The publication of the more complete BLD draft is imminant (February 2008)

*How do applications look like?*

## > Application patterns

- It is fairly difficult to “categorize” applications (there are always overlaps)
- With this caveat, some of the application patterns:
  - data integration (ie, integrating data from major databases)
  - intelligent (specialized) portals (with improved local search based on vocabularies and ontologies)
  - content and knowledge organization
  - knowledge representation, decision support
  - X2X integration (often combined with Web Services)
  - data registries, repositories
  - collaboration tools (eg, social network applications)

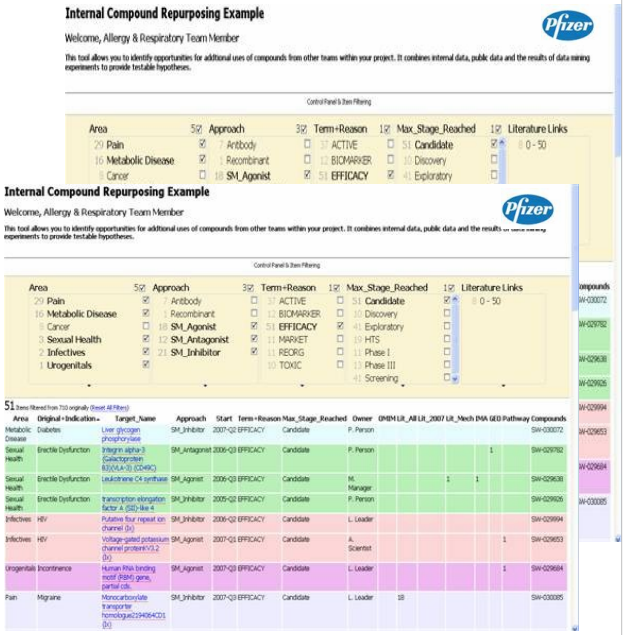


X2X means here all the different buzzwords: B2B, B2C, etc...

## > Applications can be very simple



- Goal: reuse of older experimental data
- Keep data in databases or XML, just export key "fact" as RDF
- Use a faceted browser to visualize and interact with the result




*Courtesy of Nigel Wilkinson, Lee Harland, Pfizer Ltd, Melliyal Annamalai, Oracle (SWEO Case Study)*

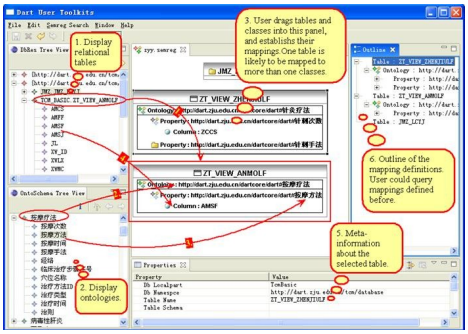


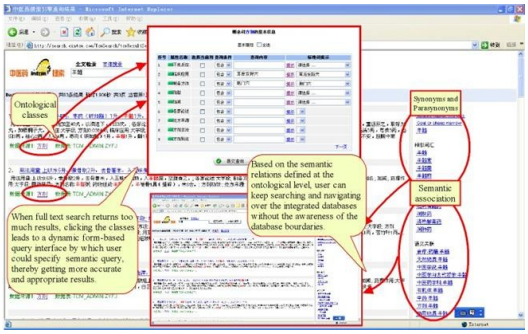
Various types of databases are accessed having an RDF transformation of (part of the data) on the fly. Some of the data may be simple tables, some are the result of continuous background processing analysing the literature (not directly related to the Semantic Web per se).

The integration of the data is done on the RDF level, and is viewed via an off-the-shelf (though experimental) faceted browser (Exhibit). Ie, the Semantic Web portion is very simple but allows for a very quick integration of the data on the screen.

## > Integrate knowledge for Chinese Medicine

- Integration of a large number of relational databases (on traditional Chinese medicine) using a Semantic Layer
  - around 80 databases, around 200,000 records each
- A visual tool to map databases to the semantic layer using a specialized ontology
- Form based query interface for end users




*Courtesy of Huajun Chen, Zhejiang University, (SWEO Case Study)*

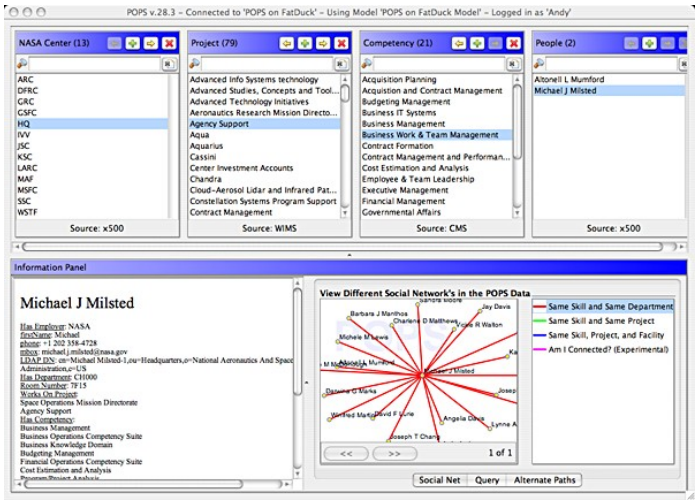


The various databases around the country are handled by independent bodies. A visual query generator creates a SPARQL query, this is then decomposed to access the individual databases, on-the-fly transformed into SQL queries, the result are in RDF and recombined for the answer. The system  is uses in the Chinese Academy of Sciences' Research institute on traditional Chinese medicine.

The university is also working on a nation-wide ontology on traditional Chinese Medicine that can be combined with the search to improve it. Still in development. That ontology might be bound to western medical ontologies, too (eventually).

## > Find the right experts at NASA

- Expertise locater for nearly 20,000 NASA civil servants using RDF integration techniques over 6 or 7 geographically distributed databases, data sources, and web services…



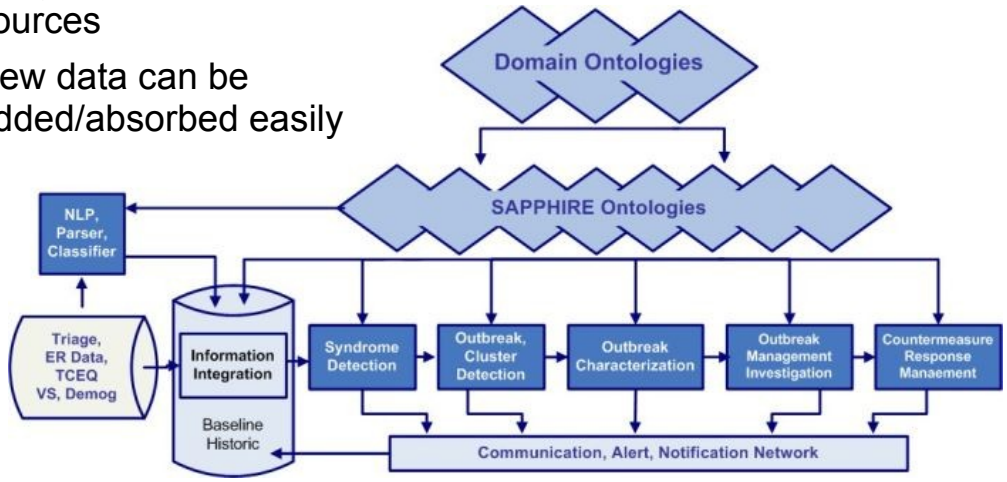

*Courtesy of Kendall Clark, Clark & Parsia, LLC*



The use internal ontologies/vocabularies to describe the knowledge areas, and a combination of the RDF data and that ontology to search through the (integrated) databases for a specific knowledge expertise. The dump is from a faceted browser developed by the company to view result data.

## > Public health surveillance (Sapphire)

- Integrated biosurveillance system (biohazards, bioterrorism, disease control, etc)
- Integrates from multiple data sources
- New data can be added/absorbed easily




*Courtesy of Parsa Mirhaji, School of Health Information Sciences, University of Texas (SWEO Case Study)*



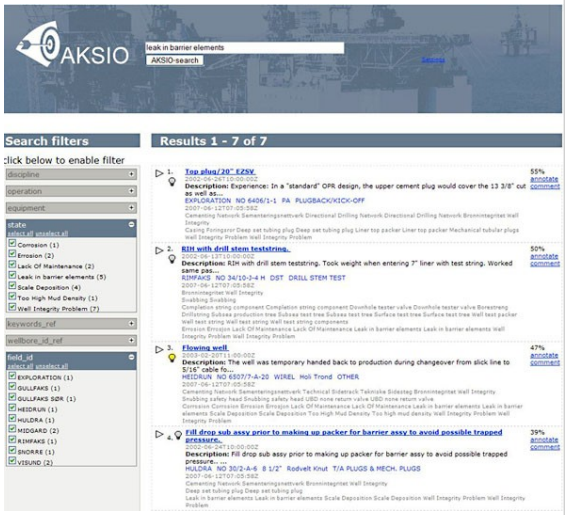
She University of Texas Health Science Center (UTHSC) has used Semantic Web technologies to build a prototype system for context-aware interpretation and integration of clinical data, environmental readings, and patient interviews. The system integrates a wide range of health and epidemiological data from local healthcare providers, hospitals and pharmacies. SAPPHIRE constructs a collaborative and distributed system to analyze, detect, and respond to public health matters.

Every ten minutes, SAPPHIRE receives electronic health records, triage data, patients' complaints, and clinician's notes from eight hospitals spanning four counties and covering more than 30% of all Houston-area emergency-room visits. Using unstructured text analysis and Semantic Web technologies, this information is mined and integrated into a single view of current health conditions across the city.

The flexibility of Semantic Web technologies allows SAPPHIRE to operate equally effectively in other contexts. At Hurricane Katrina. Within eight hours of the opening of the shelters, UTHSC configured SAPPHIRE to respond to the needs of the disaster.

## > Help for deep sea drilling operations

- Integration of experience and data in the planning and operation of deep sea drilling processes
- Discover relevant experiences that could affect current or planned drilling operations
  - uses an ontology backed search engine




*Courtesy of David Norheim and Roar Fjellheim, Computas AS (SWEO Use Case)*



The system has been developed and tested for Statoil, which is the largest oil company on the Norwegian Continental Shelf, and covers experiences with over 2,500 drilling operations since the early 90s.

The objective of the reuse improvements is to discover relevant experiences that could affect current or planned drilling operations. The shared domain ontology is used for semantic annotation, and for retrieval of information. It is developed collaboratively by the discipline advisors, and covers operations, equipment, events and failure states in drilling operations. It also includes relations between these concepts, for example, to indicate that a particular event may result in a failure state.

# > Vodafone live!

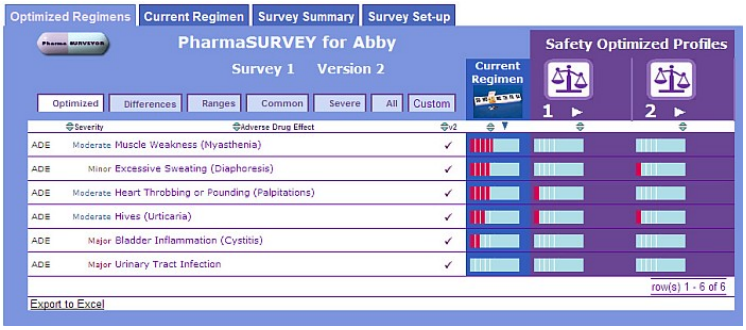


- Integrate various vendors' product descriptions via RDF
  - ring tones, games, wallpapers
  - manage complexity of handsets, binary formats
- A portal is created to offer appropriate content
- Significant increase in content download after the introduction


*Courtesy of Kevin Smith, Vodafone Group R&D* *(SWEO Case Study)*

## > Help in choosing the right drug regimen

- Help in finding the best drug regimen for a specific case
  - find the best trade-off for a patient
- Integrate data from various sources (patients, physicians, Pharma, researchers, ontologies, etc)
- Data (eg, regulation, drugs) change often, but the tool is much more resistant against change




*Courtesy of Erick Von Schweber, PharmaSURVEYOR Inc., (SWEO Use Case)*



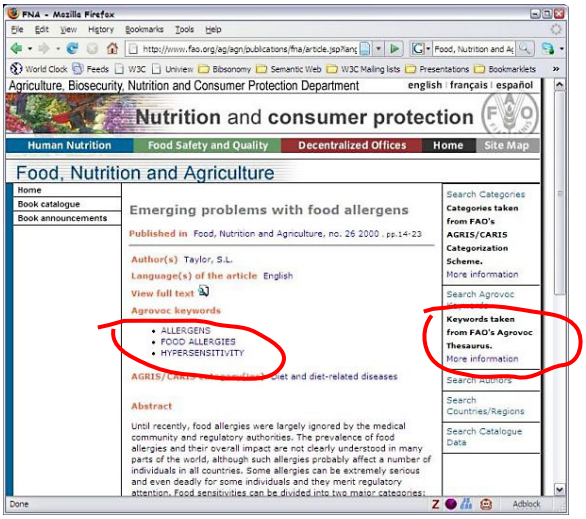
Tool to find the best drug usage adapted to an individual patient. The navigator tool combines various databases, ontologies to provide a better tool.

The flexibility of the interface is important: the structure of the underlying data (eg, databases, regulation) change often, but by localizing the change on the database-to-RDF mapping, the rest of the system is protected against change; one of the main reasons why this approach was chosen

## > FAO Journal portal



- Improved search on journal content based on an agricultural ontology and thesaurus (AGROVOC)




*Courtesy of Gauri Salokhe, Margherita Sini, and Johannes Keizer, FAO, (SWEO Case Study)*

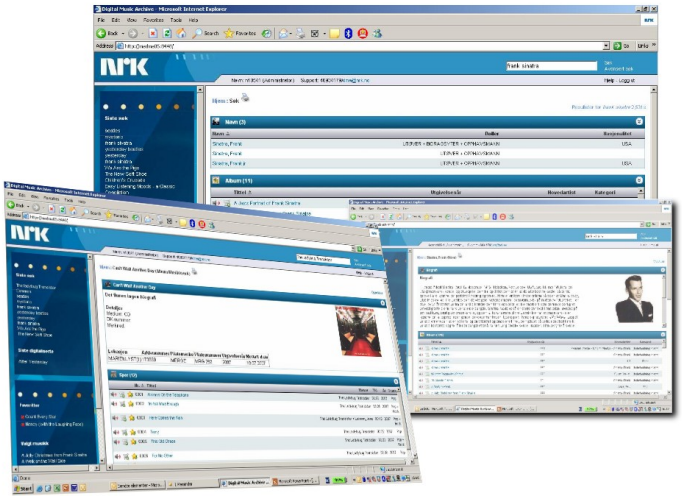


The articles in the Food, Nutrition and Agriculture (FNA) Journal cover topics such as community nutrition, food quality and safety, nutrition assessment, nutrient requirements, food security and rural development. The full-text articles may be in English, French or Spanish.

Metadata about each article in the FNA Journal was available in different formats. Work has been undertaken to combine the metadata and to convert it to a single RDF(S) format, using some ontologies developed internally. A search application was created on top of the ontology and the instance data. A user is guided through the navigation of data by following the links that connect the different metadata elements, such as articles within a specific issue, authors, languages, or keyword.

## > Digital music asset portal at NRK

- Used by program production to find the right music in the archive for a specific show



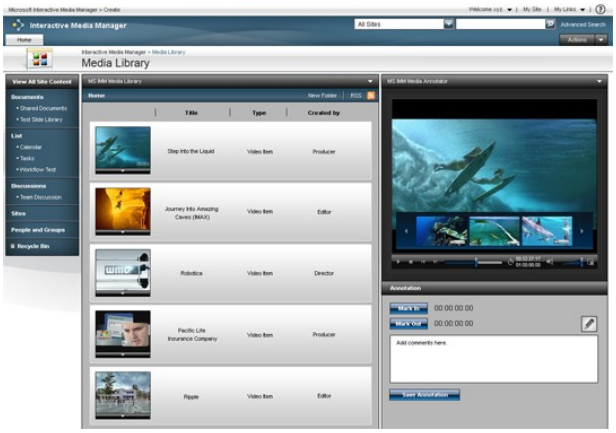
*Courtesy of Robert Engels, ESIS, and Jon Roar Tønnesen, NRK (SWEO Case Study)*



NRK is the Norwegian National TV; currently 1.2 million tracks are digitized and only 45,000 are used in practice when, for example, a new program is planned and a music track is to be found to accompany it. Via the metadata, vocabulary, and associated search a much better environment is provided to find appropriate music track. “Hidden assets” could be found much more easily that way. The user interface also provides a much easier and quicker access to data.

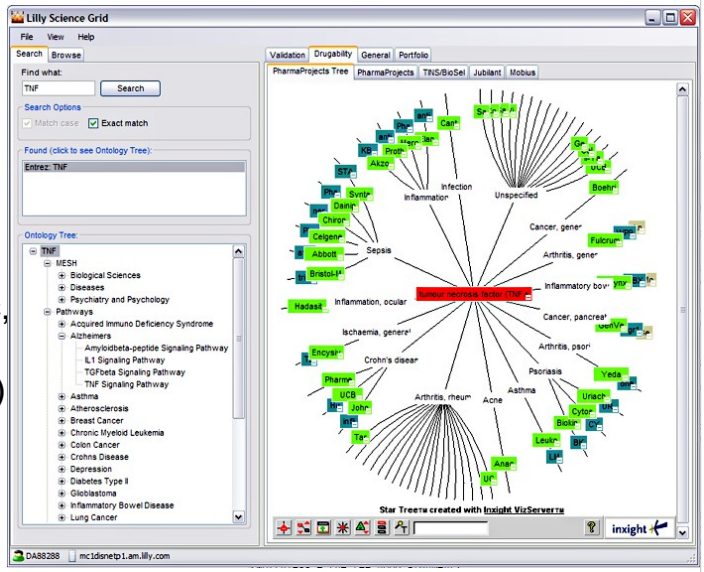
# > Microsoft Vista's Interactive Media Manager

- Uses an RDF/SPARQL/OWL based metadata framework
  - eg, for a better control over relationships among media assets and categories
- Custom OWL ontologies can be created and imported



## > Eli Lilly's Target Assessment Tool

- Better prioritization of possible drug target, integrating data from different sources and formats
- Integration, search, etc, via ontologies (proprietary and public)




*Courtesy of Susie Stephens, Eli Lilly (SWEO Case Study)*

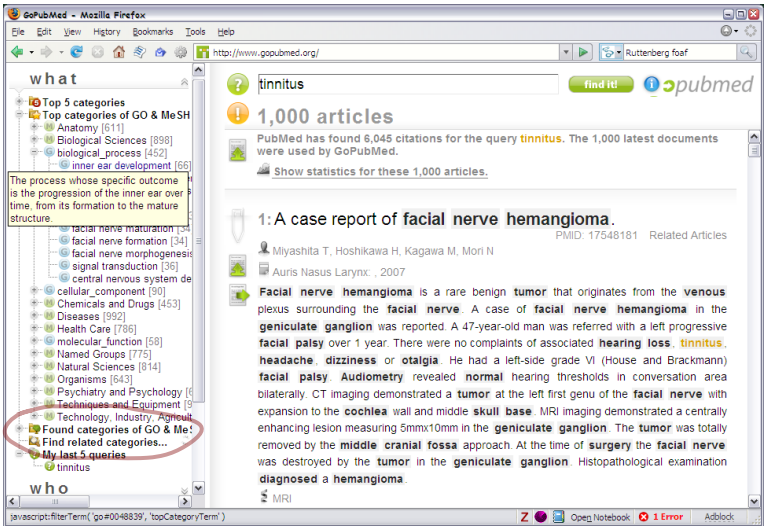


The important point is that the (subsequent) search is not simply done on a (key)word level, like for a traditional search engine, but through the tree of all related terms, where those relations are determined via internal and public ontologies and vocabularies.

The screen snapshot illustrates the user interface of the Target Assessment Tool within Lilly Science Grid. The panels to the left of the screen snapshot show that it is possible to directly search for a term or to navigate the ontology to identify a term of interest. The panel to the right of the screen snapshot demonstrates a graph view of data within the data as it relates to the search term.

# > Improved Search via Ontology: GoPubMed

- Improved search on top of pubmed.org
  - search results are ranked using ontologies
  - related terms are highlighted, usable for further search



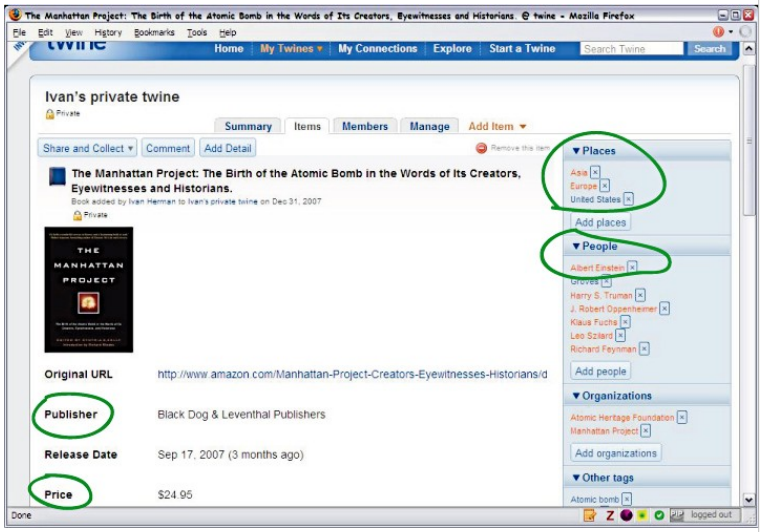



Pubmed.org is the 'google' of the medical profession. The result of a search is re-ranked, a better interface is provided, and related terms are also shown based on public medical ontologies. The left hand side refers to the Gene Ontology and Mesh ontologies; actually (red highlight on the screen) and the user is able to follow up related terms, too.

Produced by a German company (transinight)

# > Radar Network's Twine

- "Social bookmarking on steroids"
- Item relationships are based on ontologies
  - evolving over time
  - possibly enriched by users
- Internals in RDF, will be available via APIs and SPARQL



## > Other application areas come to the fore

- Content management
- Business intelligence
- Collaborative user interfaces
- Sensor-based services
- Linking virtual communities
- Grid infrastructure
- Multimedia data management
- Etc

## > Thank you for your attention!

- These slides are publicly available on:

`http://www.w3.org/2008/Talks/0307-Tokyo-IH/`

- There is also a collection of use cases at:

`http://www.w3.org/2001/sw/sweo/public/UseCases/`