Short introduction to the Semantic Web

$Date: 2006/11/25 13:37:30 $

Ivan Herman, W3C

Towards a Semantic Web

- The current Web represents information using
  - *natural language (English, Hungarian, Chinese,…)*
  - *graphics, multimedia, page layout structure*
  - *etc*
- Humans can process this easily
  - *can deduce facts from partial information*
  - *can create mental associations*
  - *are used to various sensory information*
    - (well, sort of… people with disabilities may have serious problems on the Web with rich media!)

Towards a Semantic Web

- Tasks often require to *combine* data on the Web:
  - *hotel and travel information may come from different sites*
  - *searches in different digital libraries*
  - *etc.*
- Again, humans combine these information easily
  - *even if different terminologies are used!*

However…

- However: machines are ignorant!
  - *partial information is unusable*
  - *difficult to make sense from, e.g., an image*
  - *drawing analogies automatically is difficult*
  - *difficult to combine information automatically*
    - is `<foo:creator>` same as `<bar:author>`?
    - how to combine different XML hierarchies?
  - *…*

Example: Searching

- The best-known example…
  - *Google et al. are great, but there are too many false or missing hits*
    - e.g., if you search in for “yacht racing”, the America’s Cup will *not* be found
  - *adding (maybe application specific) descriptions to resources should improve this*

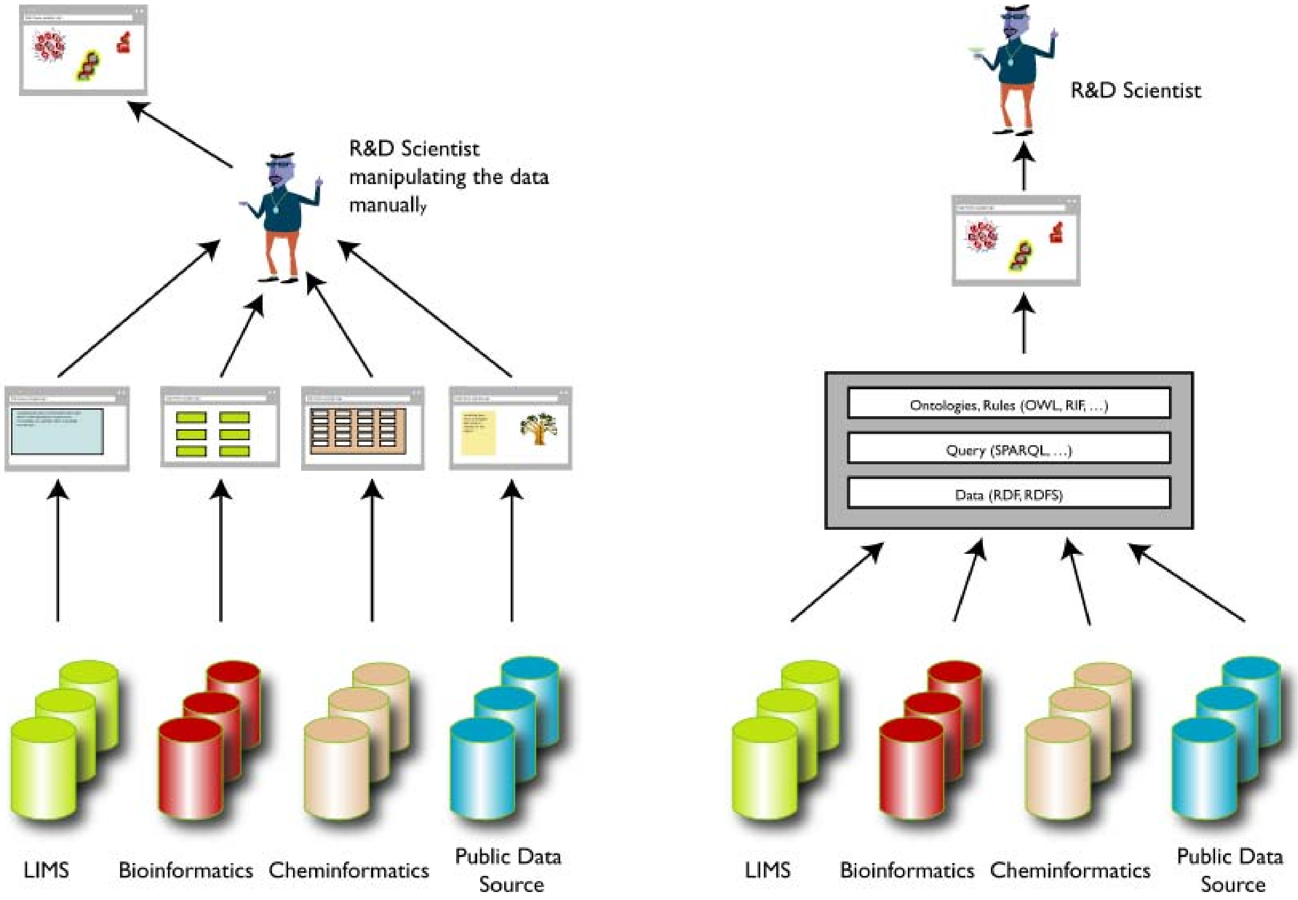
Example: Automatic Airline Reservation

- Your automatic airline reservation
  - *knows about your preferences*
  - *builds up knowledge base using your past*
  - *can combine the local knowledge with remote services:*
    - airline preferences
    - dietary requirements
    - calendaring
    - etc
- It communicates with *remote* information (i.e., on the Web!)
- (M. Dertouzos: The Unfinished Revolution)

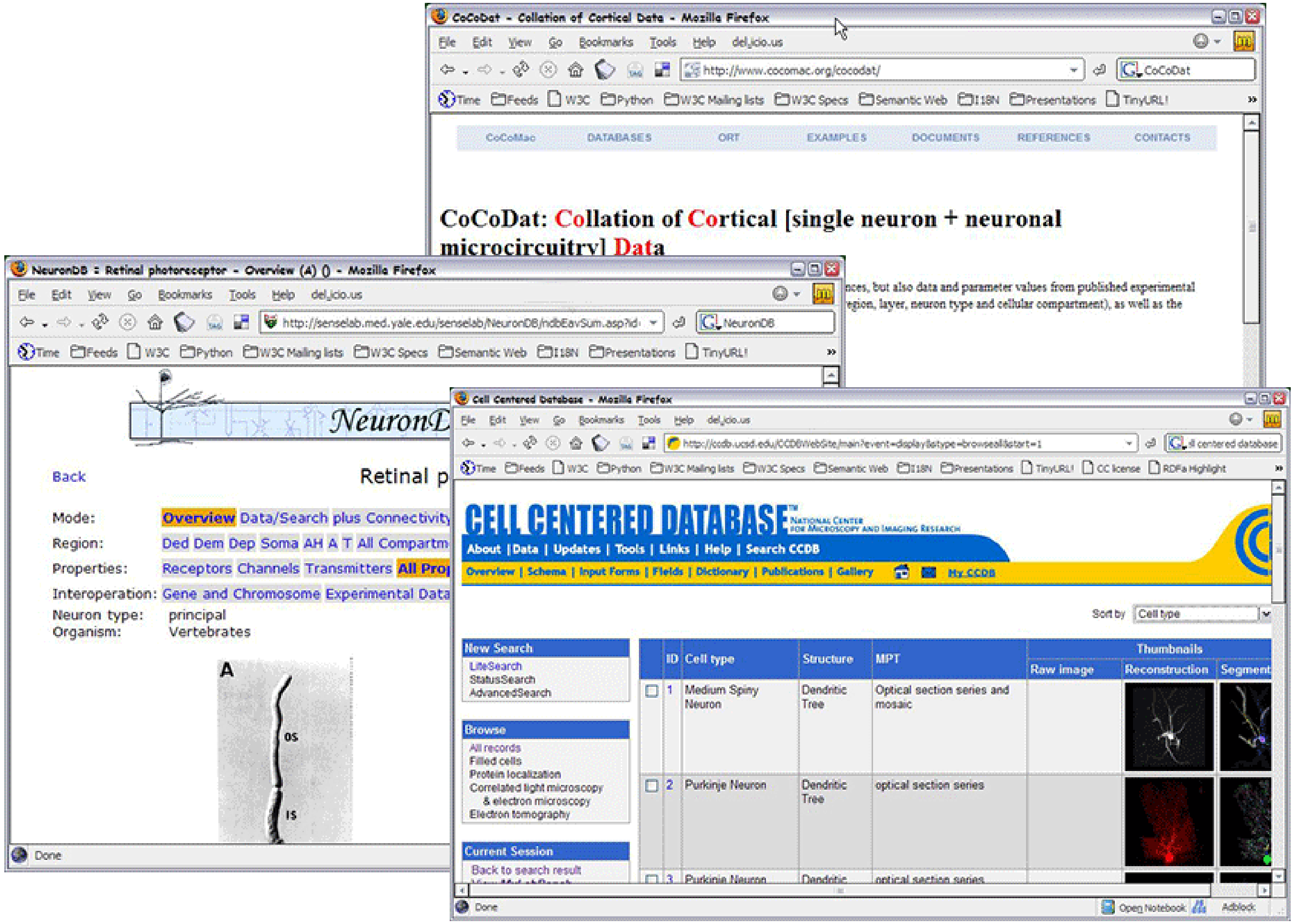
Example: Data(base) Integration

- Databases are very different in structure, in content
- Lots of applications require managing *several* databases
  - *after company mergers*
  - *combination of administrative data for e-Government*
  - *biochemical, genetic, pharmaceutical research*
  - *etc.*
- Most of these data are accessible from the Web (though not necessarily public yet)

Example: data integration in life sciences



And the problem *is* real


CoCoDat - Collation of Cortical Data - Mozilla Firefox
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NeuronDB : Retinal photoreceptor - Overview (A) () - Mozilla Firefox
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http://ccdb.ucsd.edu/CCDBWebSite/main?event=display&type=browseall&start=1
ll centered database
CC license RDFa Highlight
CELL CENTERED DATABASE™ National Center for Microscopy and Imaging Research
About | Data | Updates | Tools | Links | Help | Search CCDB
Overview | Schema | Input Forms | Fields | Dictionary | Publications | Gallery
My CCDB
Open Notebook
Adblock

CoCoDat: Collation of Cortical [single neuron + neuronal microcircuitry] Data

nces, but also data and parameter values from published experimental
egion, layer, neuron type and cellular compartment), as well as the

NeuronD

Back

Retinal p

Mode: Overview Data/Search plus Connectivity

Region: Ded Dem Dep Soma AH A T All Compartm

Properties: Receptors Channels Transmitters All Prop

Interoperation: Gene and Chromosome Experimental Data

Neuron type: principal

Organism: Vertebrates

Sort by Cell type

New Search
LiteSearch
StatusSearch
AdvancedSearch

Browse
All records
Filled cells
Protein localization
Correlated light microscopy
& electron microscopy
Electron tomography

Current Session
Back to search result

	ID	Cell type	Structure	MPT	Thumbnails		
					Raw image	Reconstruction	Segment
□	1	Medium Spiny Neuron	Dendritic Tree	Optical section series and mosaic			
□	2	Purkinje Neuron	Dendritic Tree	optical section series			
□	3	Purkinje Neuron	Dendritic	optical section series			

Example: Digital Libraries

- It is a bit like the search example
- It means catalogs on the Web
  - *librarians have known how to do that for centuries*
  - *goal is to have this on the Web, World-wide*
  - *extend it to multimedia data, too*
- But it is more: software agents should also be librarians!
  - *help you in finding the right publications*

Example: Semantics of Web Services

- Web services technology is great
- But if services are ubiquitous, searching issue comes up, for example:
  - *“find me the best differential equation solver”*
  - *“check if it can be combined with the XYZ plotter service”*
- It is necessary to characterize the service
  - *not only in terms of input and output parameters…*
  - *…but also in terms of its semantics*

What Is Needed?

- (Some) data should be available for machines for further processing
- Data should be possibly combined, merged on a Web scale
- Sometimes, data may describe other data (like the library example, using metadata)…
- … but sometimes the data is to be exchanged by itself, like my calendar or my travel preferences
- Machines may also need to *reason* about that data

What Is Needed (Technically)?

- To make data machine processable, we need:
  - *unambiguous names for resources (that may also bind data to real world objects): URI-s*
  - *a common data model to interchange, connect, describe the resources: RDF*
  - *access to that data: SPARQL*
  - *define common vocabularies: RDFS, OWL, SKOS*
  - *reasoning logics: OWL, Rules*
- *The "Semantic Web" is an extension of the current Web, providing an infrastructure for the integration of data on the Web*

RDF Triples

- We said “connecting” data…
- But a simple connection is not enough… it should be named somehow
  - *a connection from “me” to my calendar is not the same as the connection from “me” to my CV (even if all of these are on the Web)*
  - *the first connection should somehow say “myCalendar”', the second “myCV”*
- Hence the RDF Triples: a *labelled connection between two resources*

RDF Triples (cont.)

- An RDF Triple (s,p,o) is such that:
  - *“s”, “p” are URI-s, ie, resources on the Web; “o” is a URI or a literal*
  - *conceptually: “p” connects, or relates the “s” and ”o”*
  - *note that we use URI-s for naming: i.e., we can use* **`http://www.example.org/myCalendar`**
  - *here is the complete triple:*

```
(http://www.ivan-herman.net, http://…/myCalendar, http://…/calendar)
```

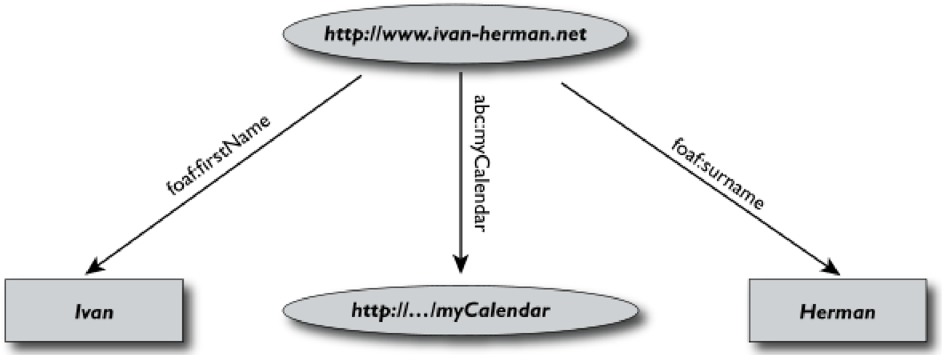
- *RDF*

  is a general model for such triples (with machine readable formats like RDF/XML, Turtle, n3, RXR, …)
- … *and that’s it!* (simple, isn't it? ☺)

RDF Triples (cont.)

- RDF Triples are also referred to as *“triplets”*, or *“statement”*
- The s, p, o resources are also referred to as *“subject”*, *“predicate”*, *”object”*, or *“subject”*, *”property”*, *”object”*
- Resources can use *any* URI; i.e., it can denote an element *within* an XML file on the Web, not only a “full” resource, e.g.:
  - ***`http://www.example.org/file.xml#xpointer(id('calendar'))`***
  - ***`http://www.example.org/file.html#calendar`***

A Simple RDF Example



```
<rdf:Description rdf:about="http://www.ivan-herman.net">
    <foaf:name>Ivan</foaf:name>
    <abc:myCalendar rdf:resource="http://…/myCalendar"/>
    <foaf:surname>Herman</foaf:surname>
</rdf:Description>
```

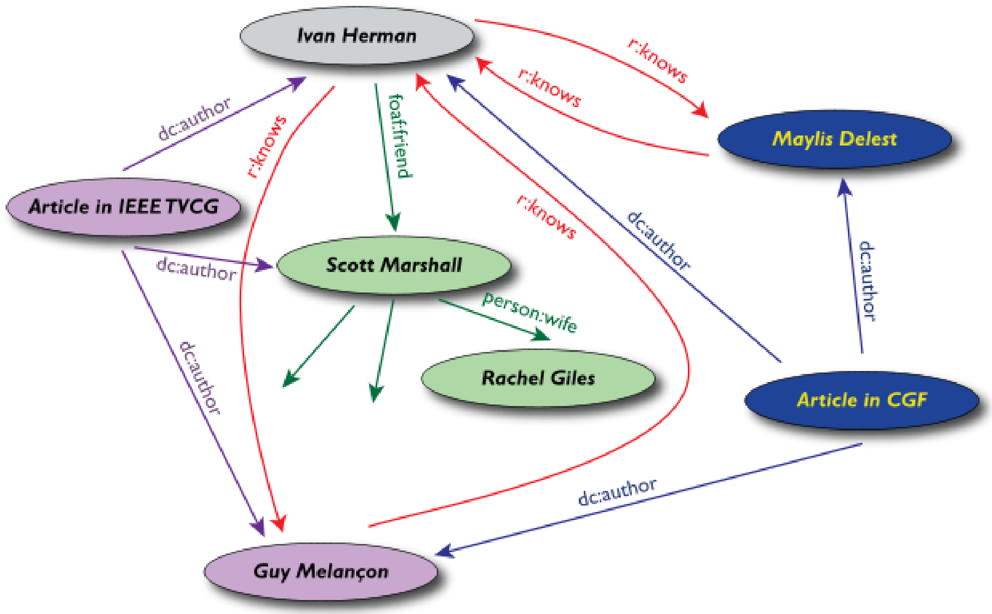
URI-s Play a Fundamental Role

- *Anybody* can create (meta)data on *any* resource on the Web
  - *e.g., the same SVG or XHTML file could be annotated through other terms*
  - *semantics is added to existing Web resources via URI-s*
  - *URI-s make it possible to link (via properties) data with one another*
- *URI-s ground RDF into the Web*
  - *information can be retrieved using existing tools*
  - *this makes the "Semantic Web", well… "Semantic Web"*

URI-s: Merging

- It becomes easy to *merge* data
  - *e.g., applications may merge annotations*
- Merge can be done because statements refer to the *same* URI-s
  - *nodes with identical URI-s are considered identical*
- Merging is a *very* powerful feature of RDF
  - *data linkage, metadata, etc, may be defined by several (independent) parties…*
  - *…and combined by an application*
  - *one of the areas where RDF is much handier than pure XML in many applications*

What Merge Can Do...



Need for a Query Language

- Each data model needs its own “query language” to access large amount of data
  - *relational databases have SQL, XML has XQuery…*
- SPARQL is the query language for RDF
  - *queries are expressed in forms of RDF triples with unknown variables*
  - *the query returns a list possible resources (i.e., URI-s or literal values) or full set of triples (depending on the query type)*
- SPARQL is emerging as *the* primary way to access RDF data

How to Get to RDF Data?

- The simplest aproach: write your own RDF data in your preferred syntax
- Using URI-s in RDF binds you automatically to the real resources
- You may add RDF to XML directly (in its own namespace)
  - *e.g., in SVG:*

```
<svg ...>
  ...
  <metadata>
    <rdf:RDF xmlns:rdf="http://../rdf-syntax-ns#">
      ...
    </rdf:RDF>
  </metadata>
    ...
</svg>
```

- Works in some cases, but not satisfactory for a real deployement!

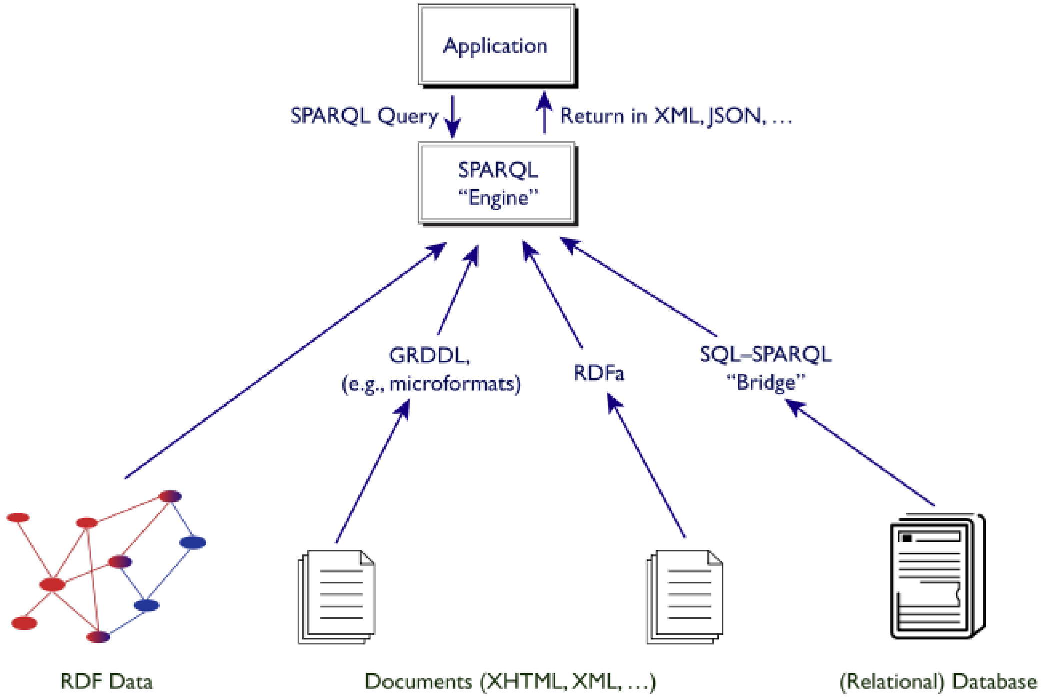
RDF Can Also Be Extracted/Generated

- Use intelligent “scrapers” or “wrappers” to extract a structure (hence RDF) from a Web page…
  - *using conventions in, e.g., class names or header conventions like* **`meta`** *elements*
- … and then *generate* RDF automatically (e.g., via an XSLT script)
- This is what the “microformats” are doing
  - *they may not extract RDF but use the data directly instead, but that depends on the application*
  - *other applications may extract it to yield RDF (e.g., RSS1.0)*

Bridge to Relational Databases

- Most of the data are stored in relational databases
- “RDFying” them is an impossible task
- “Bridges” are being defined:
  - *a layer between RDF and the database*
  - *RDB tables are “mapped” to RDF graphs on the fly*
  - *in some cases the mapping is generic (columns represent properties, etc…)*
  - *… in other cases separate mapping files define the details*
- This is a *very* important source of RDF data

SPARQL As a Unifying Force



RDF is not Enough…

- Creating data and using it from a program works, provided the program *knows* what terms to use!
- We used terms like:
  - ***`foaf:name`***, ***`abc:myCalendar`***, ***`foaf:surname`***, …
  - *etc*
- Are they all known? Are they all correct? (it is a bit like defining record types for a database)

Possible Issues to Handle

- What are the possible terms?
  - *“is the set of data terms known to the program?”*
- Are the properties used correctly?
  - *“do they make sense for the resources?”*
- Can a program *reason* about some terms? Eg:
  - *“if «A» is left of «B» and «B» is left of «C», is «A» left of «C»?”*
  - *obviously true for humans, not obvious for a program …*
  - *… programs should be able to deduce such statements*
- If somebody else defines a set of terms: are they the same?
  - *clearly an issue in an international context*

Ontologies

- The Semantic Web needs a support of *ontologies*:

“defines the concepts and relationships used to describe and represent an area of knowledge”

- We need a *Web Ontologies Language* to define:
  - *the terminology used in a specific context*
  - *possible constraints on properties*
  - *the logical characteristics of properties*
  - *the equivalence of terms across ontologies*
  - *etc*
- This is done by RDFS (RDF Schemas) and OWL (Web Ontology Language)

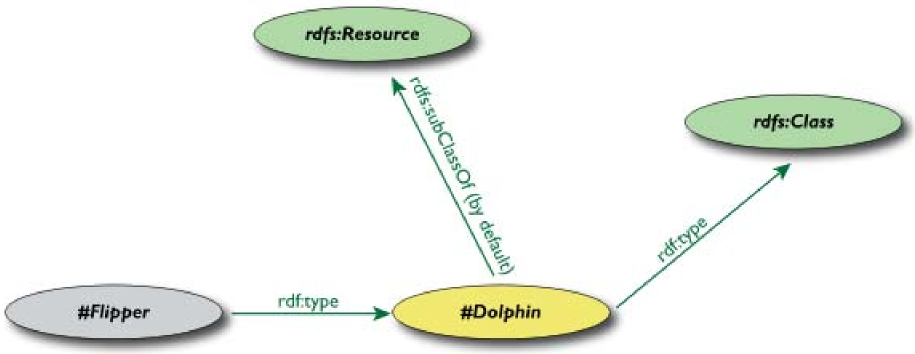
Classes, Resources, …

- Think of well known in traditional ontologies:
  - *use the term "mammal"*
  - *"every dolphin is a mammal"*
  - *"Flipper is a dolphin"*
  - *etc.*
- RDFS defines *resources* and *classes*:
  - *everything in RDF is a "resource"*
  - *"classes" are also resources, but…*
  - *they are also a collection of possible resources (i.e., "individuals")*
    - ○ "mammal", "dolphin", …

Classes, Resources, … (cont.)

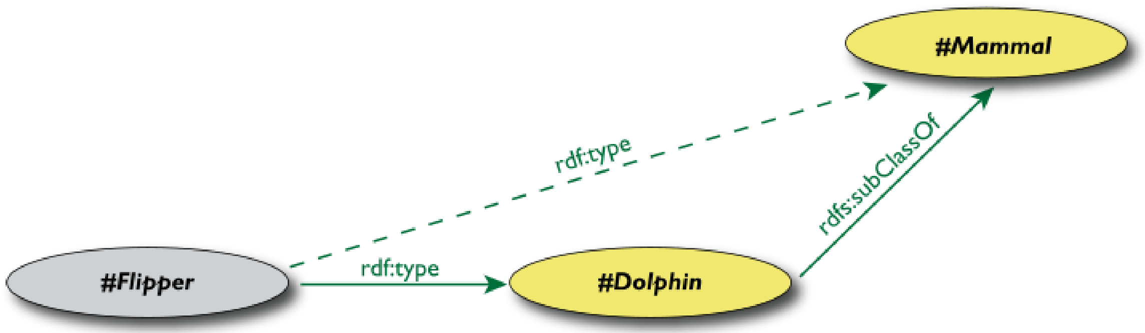
- Relationships are defined among classes/resources:
  - *“typing”: an individual belongs to a specific class (“Flipper is a dolphin”)*
  - *“subclassing”: instance of one is also the instance of the other (“every dolphin is a mammal”)*
- *RDFS formalizes these notions in RDF*

Classes, Resources in RDF(S)



- RDFS defines **`rdfs:Resource`**, **`rdfs:Class`** as nodes; **`rdf:type`**, **`rdfs:subClassOf`** as properties
  - *(these are all special URI-s, we just use the namespace abbreviation)*

Inferred Properties



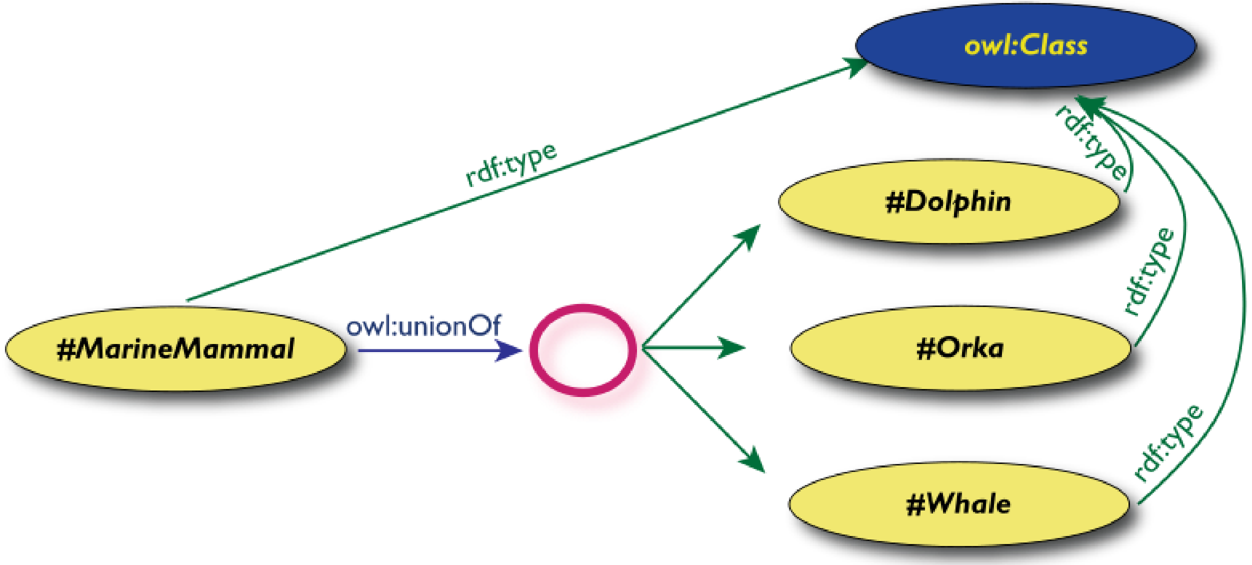
- • ***(#Flipper rdf:type #Mammal)***
- is *not* in the original RDF data…
- …but can be *inferred* from the RDFS rules
- Better RDF environments return that triplet, too

RDFS and OWL

- RDFS defines the basic principles
- OWL adds more complicated features to RDFS like:
  - *constructions of classes using existing ones*
  - *characterize relationships (e.g., whether they are transitive, symmetric, functional, etc)*

Union of Classes

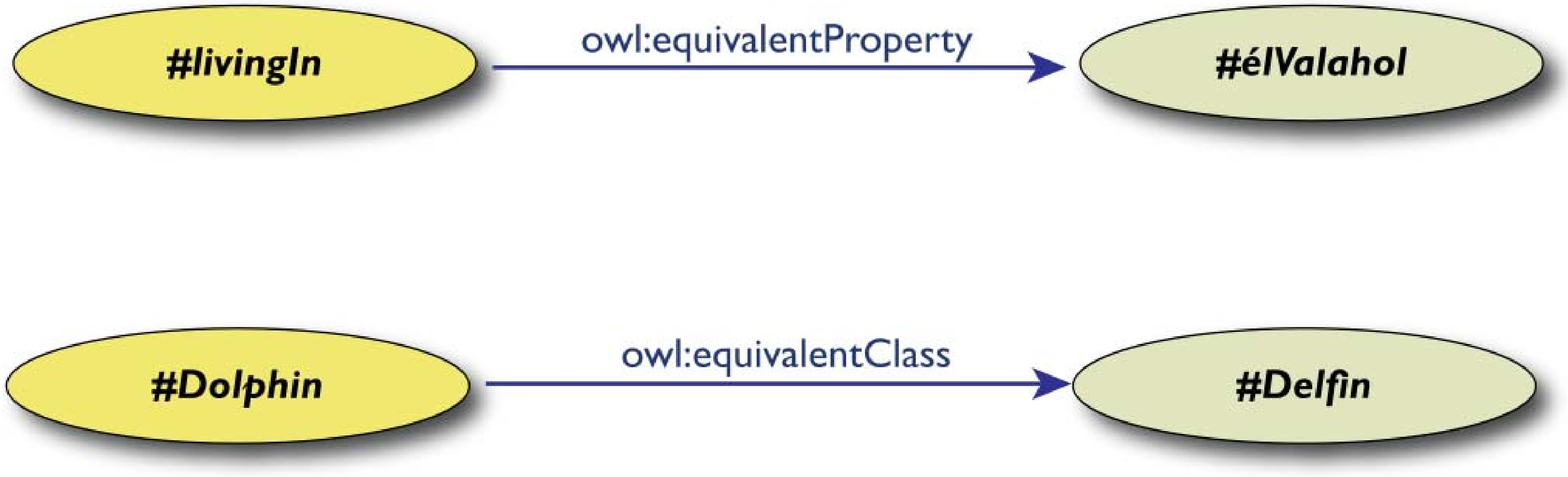
- Essentially, like a set-theoretical union:



OWL: Additional Features

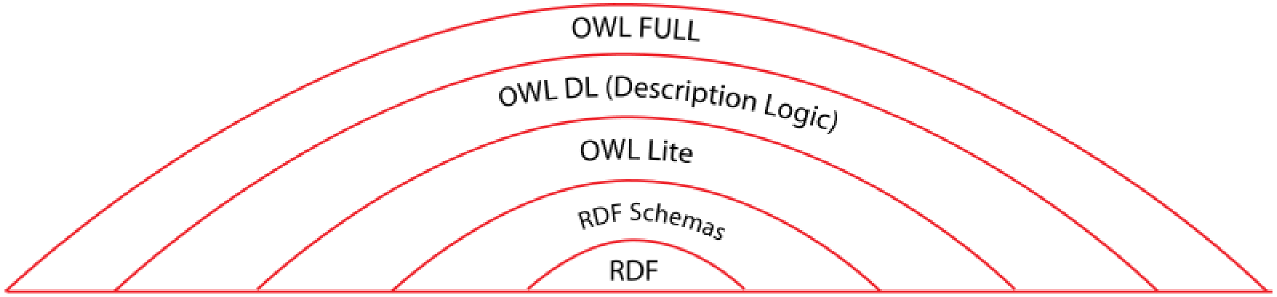
- Ontologies may be extremely a large:
  - *their management requires special care*
  - *they may consist of several modules*
  - *come from different places and must be integrated*
- Ontologies are *on the Web*. That means
  - *applications may use several, different ontologies, or…*
  - *… same ontologies but in different languages*
  - *equivalence of, and relations among terms become an issue*
- OWL includes possibilites for class/property equivalence, version and deprecation control, etc.

Example: Connecting to Hungarian



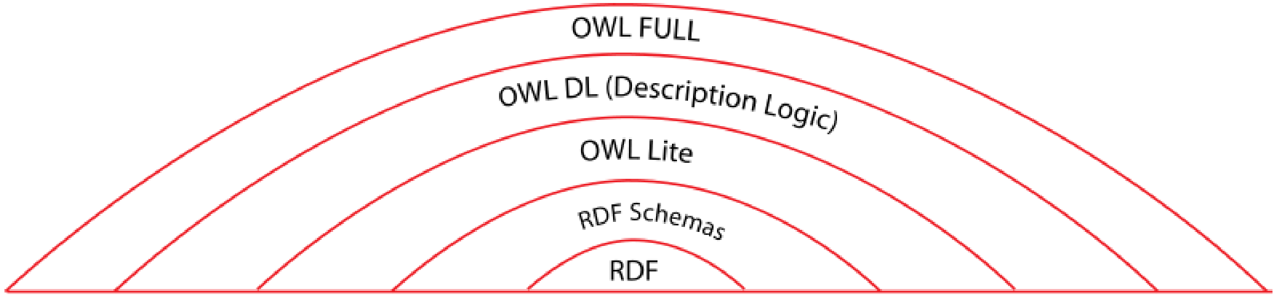
However: Ontologies are Hard!

- Hard to implement a full ontology management system
  - *may be superfluous for some applications*
- Hence the “onion” model of increasingly complex specs:
  - *no property expressions or datatypes in RDF Schemas*
  - *not all set operators, restricted cardinality in OWL Lite*
  - *some restrictions, but a computational guarantee in OWL DL*
  - *full expressive power in OWL Full (but no computational guarantee)*



Ontologies are Hard! (cont)

- “Lite” < “DL” < “Full”, but not completely true for RDFS
  - *RDFS is “almost” a subcategory*
  - *not all RDFS statements are valid in DL…*
  - *…but they are for Full*
- Applications may take what they really need!



The Work is Not Over

Rules

- more general logical rules to the Semantic Web infrastructure; also includes the *interchange* of rules among rule based systems

Evolution of the RDF model

- e.g., add time information, probabilities, “measure of fuzziness” to statements (still in research phase)

Evolution of OWL

- additional features, new (eg, even lighter) layers

Trust

- a trust infrastructure for SW (for example: “can I trust the author of this set of assertions?”); on the future stack of W3C…

…

Lots of Tools

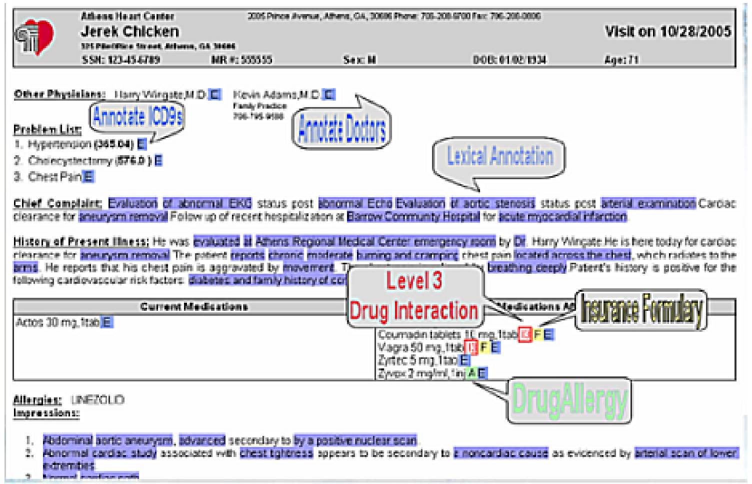
- (Graphical) Editors
  - *IsaViz (Xerox Research/W3C/Inria), RDFAuthor (Univ. of Bristol), Protege 2000 (Stanford Univ.), SWOOP (Univ. of Maryland), Orient (IBM)*
- Programming Environments
  - *Jena (for Java, includes OWL reasoning and SPARQL queries), RDFLib (fo Python), Redland (in C, with interfaces to Tcl, Java, PHP, Perl, Python, … and with SPARQL queries), SWI-Prolog, IBM's Semantic Web Toolkit, …*
- Databases (either based on an internal sql engine or fully triple based)
  - *Kowari, Gateway, 3Store, Jena's Joseki, Oracle's Database 10g , …*
- RDF and OWL validators and reasoners
  - *W3C's RDF Validator, BBN OWL Validator, Pellet OWL Reasoner, …*
- RDB→RDF layers, converters
  - *D2R Server, SquirrelRDF, SPASQL, R$_2$O, …*

SW Applications

- Applications patterns emerge
- Major companies offer (or will offer) Semantic Web tools or systems using Semantic Web: Adobe, Oracle, IBM, HP, Software AG, webMethods, Northrop Gruman, Altova, …
- 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, Merck, Pfizer, AstraZeneca, Sun, Citigroup, …
- “Corporate Semantic Web” listed as major technology by Gartner
- Various application patterns emerge
  - *often pioneered by specific communities, eg, life sciences, eGovernment, energy industry, …*

Applications are not always very complex…

- Eg: simple semantic annotations of patients’ data greatly enhances communications among doctors
- What is needed: some simple ontologies, an RDFa/microformat type editing environment
- Simple but powerful!



Athens Heart Center 2005 Prince Avenue, Athens, GA, 30606 Phone: 706-200-0700 Fax: 706-200-0000

Jerek Chicken

Visit on 10/28/2005

125 PlanOffice Street, Athens, GA 30606

SSN: 123-45-6789 MR #: 555555 Sex: M DOB: 01/02/1934 Age: 71

Other Physicians: Harry Wingate,M.D. E Kevin Adams,M.D. E
Family Practice
706-795-9588

Problem List:

1. Hypertension (**365.04**) E
2. Cholecystectomy (**576.0**) E
3. Chest Pain E

Chief Complaint: Evaluation of abnormal EKG status post abnormal Echo Evaluation of aortic stenosis status post arterial examination Cardiac clearance for aneurysm removal Follow up of recent hospitalization at Barrow Community Hospital for acute myocardial infarction

History of Present Illness: He was evaluated at Athens Regional Medical Center emergency room by Dr. Harry Wingate He is here today for cardiac clearance for aneurysm removal The patient reports chronic moderate burning and cramping chest pain located across the chest, which radiates to the arms. He reports that his chest pain is aggravated by movement. T… breathing deeply Patent's history is positive for the following cardiovascular risk factors: diabetes and family history of cor…

Current Medications	…Medications A…
Actos 30 mg, 1tab E	Coumadin tablets 10 mg, 1tab E F E Viagra 50 mg, 1tab E F E Zyrtec 5 mg, 1tab E Zyvox 2 mg/ml, 1inj A E

Allergies: LINEZOLID

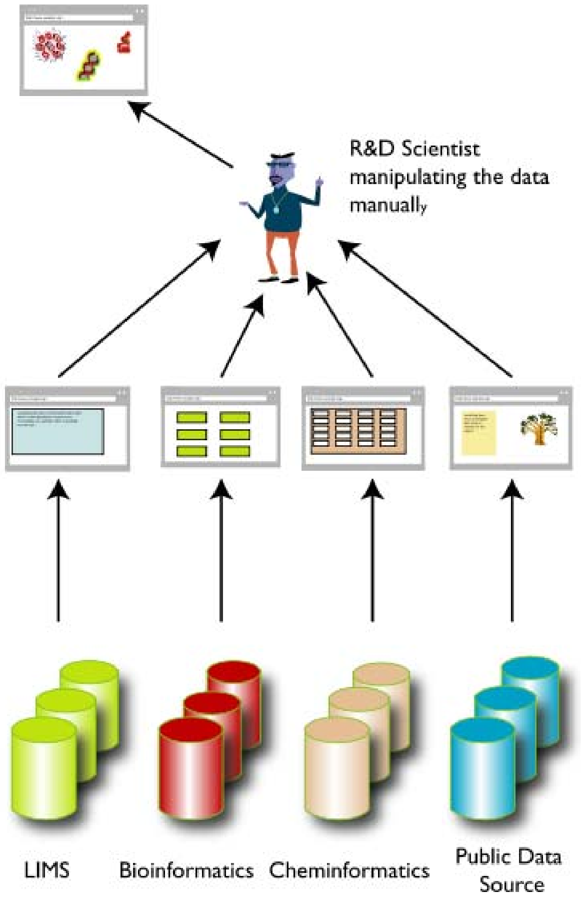
Impressions:

1. Abdominal aortic aneurysm, advanced secondary to by a positive nuclear scan
2. Abnormal cardiac study associated with chest tightness appears to be secondary to a noncardiac cause as evidenced by arterial scan of lower extremities
3. Normal cardiac cath

Data integration

- Data integration comes to the fore as one of *the* SW Application areas
- Very important for large application areas (life sciences, energy sector, eGovernment, financial institutions), as well as everyday applications (eg, reconciliation of calendar data)
- Life sciences example:
  - *data in different labs…*
  - *data aimed at scientists, managers, clinical trial participants…*
  - *large scale public ontologies (genes, proteins, antibodies, …)*
  - *different formats (databases, spreadsheets, XML data, XHTML pages)*
  - *etc*

Life Sciences (cont.)



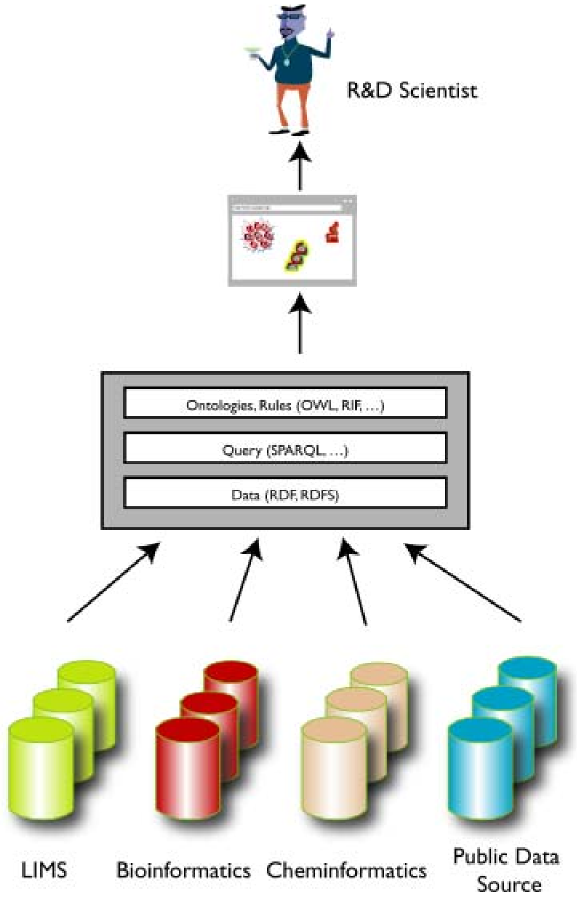
R&D Scientist manipulating the data manually

LIMS

Bioinformatics

Cheminformatics

Public Data Source



R&D Scientist

Ontologies, Rules (OWL, RIF, …)

Query (SPARQL, …)

Data (RDF, RDFS)

LIMS

Bioinformatics

Cheminformatics

Public Data Source

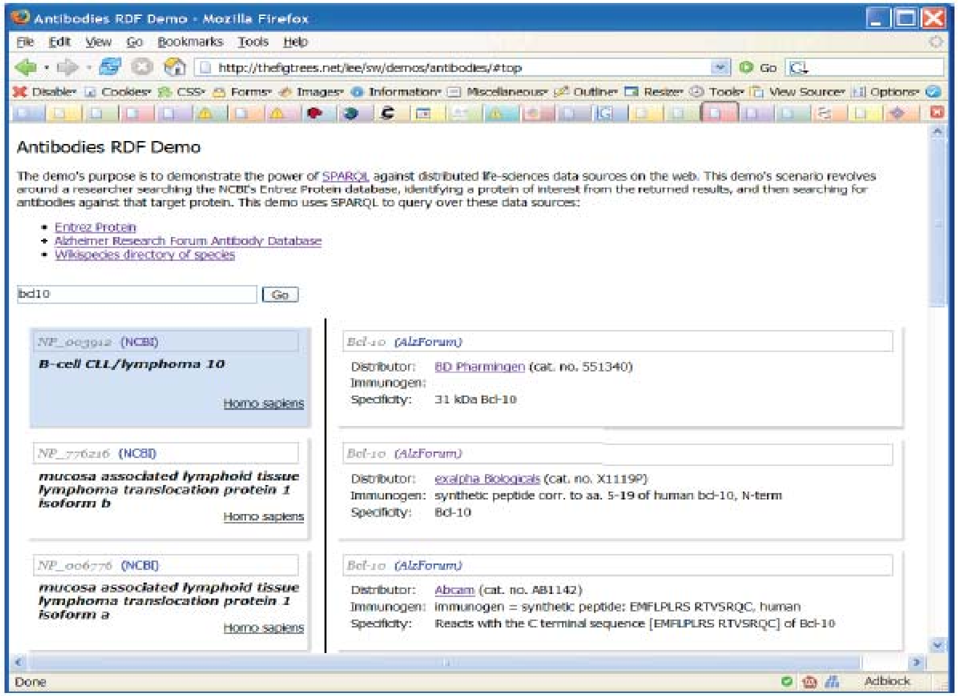
General approach

1. Map the various data onto RDF
    - *“mapping” may mean on-the-fly SPARQL to SQL conversion, “scraping”, etc*
2. Merge the resulting RDF graphs (with a possible help of ontologies, rules, etc, to combine the terms)
3. Start making queries on the whole!

- Remember the role of SPARQL?

Example: antibodies demo

- Scenario: find the known antibodies for a protein in a specific species
- Combine (“scrape”…) three different data sources
- Use SPARQL as an integration tool (see also demo online)


Antibodies RDF Demo - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://thefigtrees.net/lee/sw/demos/antibodies/#top
Go
Disable Cookies CSS Forms Images Information Miscellaneous Outline Resize Tools View Source Options
Done
Adblock

Antibodies RDF Demo

The demo's purpose is to demonstrate the power of SPARQL against distributed life-sciences data sources on the web. This demo's scenario revolves around a researcher searching the NCBI's Entrez Protein database, identifying a protein of interest from the returned results, and then searching for antibodies against that target protein. This demo uses SPARQL to query over these data sources:

- Entrez Protein
- Alzheimer Research Forum Antibody Database
- Wikispecies directory of species

bcl10 Go

NP_003912 (NCBI)
B-cell CLL/lymphoma 10
Homo sapiens

NP_776216 (NCBI)
mucosa associated lymphoid tissue lymphoma translocation protein 1 isoform b
Homo sapiens

NP_006776 (NCBI)
mucosa associated lymphoid tissue lymphoma translocation protein 1 isoform a
Homo sapiens

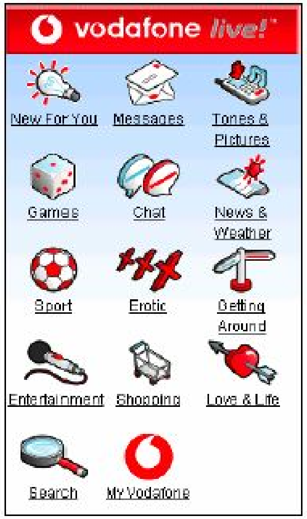
Bcl-10 (AlzForum)
Distributor: BD Pharmingen (cat. no. 551340)
Immunogen:
Specificity: 31 kDa Bcl-10

Bcl-10 (AlzForum)
Distributor: exalpha Biologicals (cat. no. X1119P)
Immunogen: synthetic peptide corr. to aa. 5-19 of human bcl-10, N-term
Specificity: Bcl-10

Bcl-10 (AlzForum)
Distributor: Abcam (cat. no. AB1142)
Immunogen: immunogen = synthetic peptide: EMFLPLRS RTVSRQC, human
Specificity: Reacts with the C terminal sequence [EMFLPLRS RTVSRQC] of Bcl-10

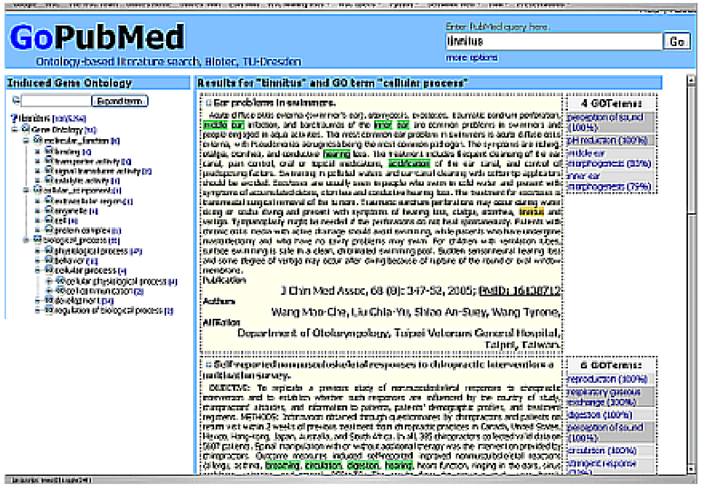
Portals

- Vodafone's Live Mobile Portal
  - *search application (e.g. ringtone, game, picture) using RDF*
    - page views per download decreased 50%
    - ringtone up 20% in 2 months
- A number of other portal examples: Sun’s White Paper Collections and System Handbook collections; Nokia’s S60 support portal; Harper’s Online magazine linking items via an internal ontology; Oracle’s virtual press room; Opera’s community site, Yahoo! Food,…



Improved Search via Ontology: GoPubMed

- Improved search on top of pubmed.org
  - *search results are ranked using the specialized ontologies*
  - *extra search terms are generated and terms are highlighted*
- Importance of *domain specific ontologies* for search improvement



Ear problems in swimmers.

[illegible]

Publication

J Chin Med Assoc, 68 (8): 347-52, 2005; PMID: 16138712

Authors

Wang Mao-Che, Liu Chia-Yu, Shiao An-Suey, Wang Tyrone,

Affiliation

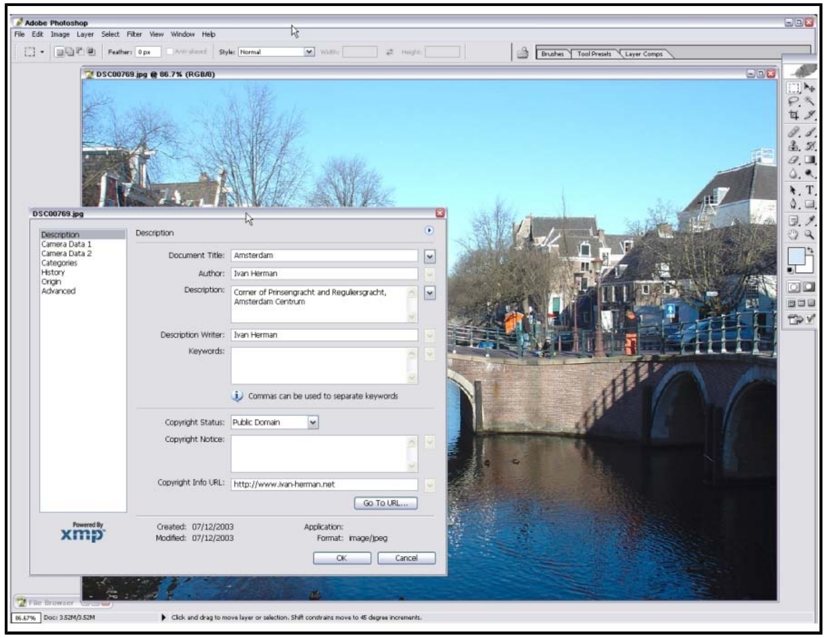
Department of Otolaryngology, Taipei Veterans General Hospital, Taipei, Taiwan.

Self-reported nonmusculoskeletal responses to chiropractic intervention: a multination survey.

OBJECTIVE: [illegible]

Adobe's XMP

- Adobe’s tool to add RDF-based metadata to *most* of their file formats
  - *used for more effective organization*
  - *supported in Adobe Creative Suite*
  - *support from 30+ major asset management vendors, with separate XMP conferences*
- The tool is available for all!



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