# Ways to the Semantic Web

Darmstadt, Germany 2007-10-18

Klaus Birkenbihl, W3C
based on a talk of Ivan Herman, W3C

# The challenge

- ask the Web about a train that gets you in time to flight XYZ001
  - *you query your airline's database for the departure time for flight XYZ001*
  - *you query your train operator's database for a train from your place that arrives 2h before flight departure at the airport*
- please notice that you took the departure time by hand from the flight query result, subtracted 2h and moved it to the train query
  - *it was simple*
  - *there might be more complex networks of questions in real life (e.g. in our example you might want to commit an appointment dependant from flight arrival, book a hotel for the same day ...)*
  - *would it be useful to have the computer do all the "copy, (compute) and pastes"?*
  - *is there a chance?*

# The foundations of today's Web

- *URL* to uniquely identify ressources on the Web
- *HTTP* to access ressources on the Web
- *HTML* to apply a simple structure to many ressources on the Web
  - *other options exist (e.g. SVG, XML, RDF, PDF ...)*

# Most information in the WEB today is stored in databases

- there is so much HTML out there ...
- for most of it scripts read the information from databases and transform it into HTML
- databases are not integrated into the Web
  - *consequently they are mostly not integrated with each other*
  - *you cannot make general cross database queries*
- transforming to HTML deletes a lot of the information about the data (aka metadata) like e.g.
  - *this is data about flight XYZ001*
  - *this is the flight's departure*
  - *...*
- not much damage if the information is for a human reader
- the vocabulary of HTML does not provide many means to maintain this information
- applications don't have a chance to guess the meaning of HTML content

# Example

## Your database knows

- *this information is about a flight*
- *operator:* Webair
- *flight number:* XYZ001
- *from:* Darmstadt
- *to:* Boston
- *departure:* 11:15
- *arrival:* 15:15
- ...

## Your HTML knows

- *this is an XHTML document*
- *dt:* operator *dd:* Webair
- *dt:* flight number *dd:* XYZ001
- *dt:* from *dd:* Darmstadt
- *dt:* to *dd:* Boston
- *dt:* departure *dd:* 11:15
- *dt:* arrival *dd:* 15:15
- ...

# Data(base) Integration

- Data sources (eg, HTML pages, databases, …) are very different in structure, in content
- Lots of applications require managing *several* data sources
  - *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)

# 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

# A rough structure of *data integration*

1. Map the various data onto an abstract data representation
   - *make the data independent of its internal representation…*
2. Merge the resulting representations
3. Start making queries on the whole!
   - *queries that could not have been done on the individual data sets*

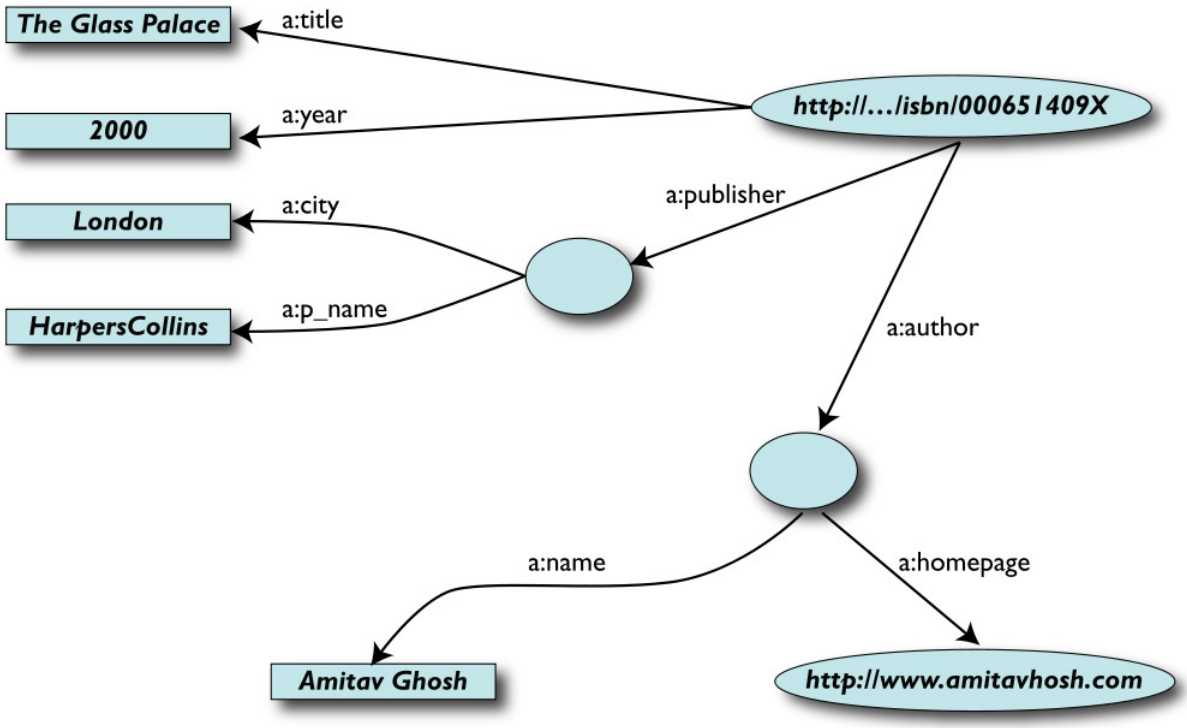
# A *simplifed* bookstore data (dataset “A”)

| ID | Author | Title | Publisher | Year |
|---|---|---|---|---|
| ISBN 0-00-651409-X | id_xyz | The Glass Palace | id_qpr | 2000 |

| ID | Name | Home page |
|---|---|---|
| id_xyz | Amitav Ghosh | http://www.amitavghosh.com/ |

| ID | Publisher Name | City |
|---|---|---|
| id_qpr | Harper Collins | London |

# 1st step: export your data as a set of *relations*



# Some notes on the exporting the data

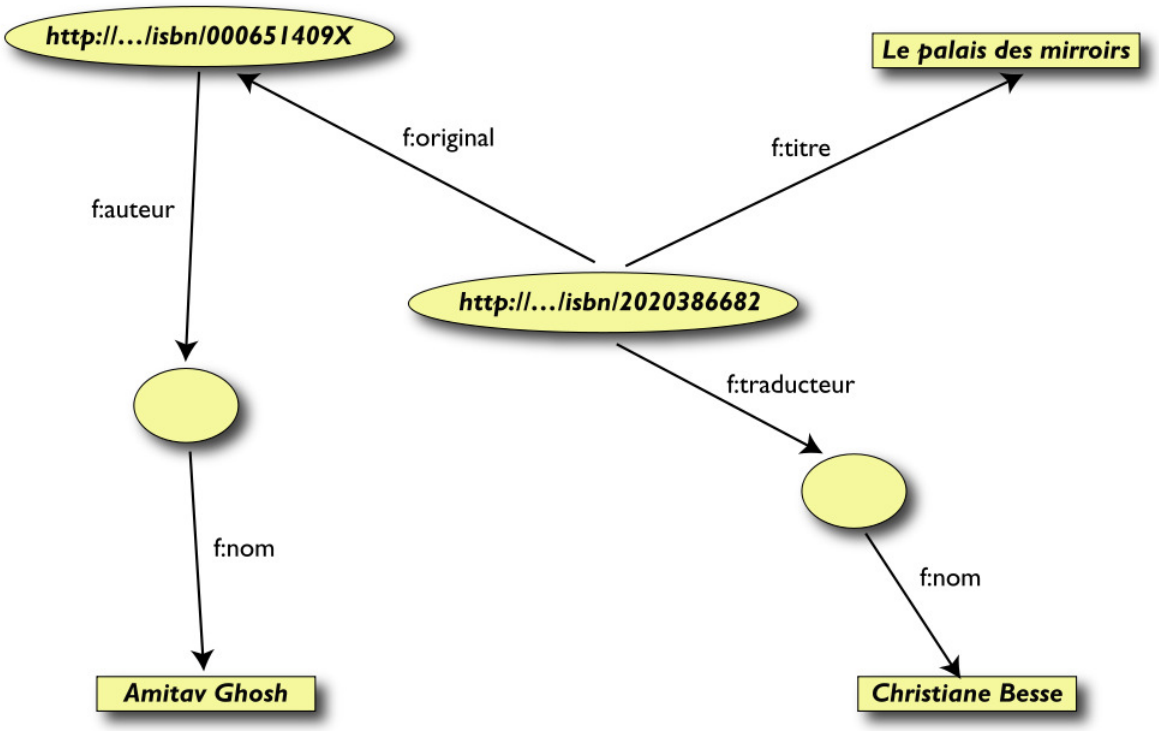
- Relations form a graph
  - *the nodes refer to the “real” data or contain some literal*
  - *how the graph is represented in machine is immaterial for now*
- Data export does *not* necessarily mean physical conversion of the data
  - *relations can be generated on-the-fly at query time*
    - via SQL “bridges”
    - scraping (X)HTML pages
    - extracting data from Excel sheets
    - etc.
- One can export *part* of the data

# Another bookstore data (dataset “F”)

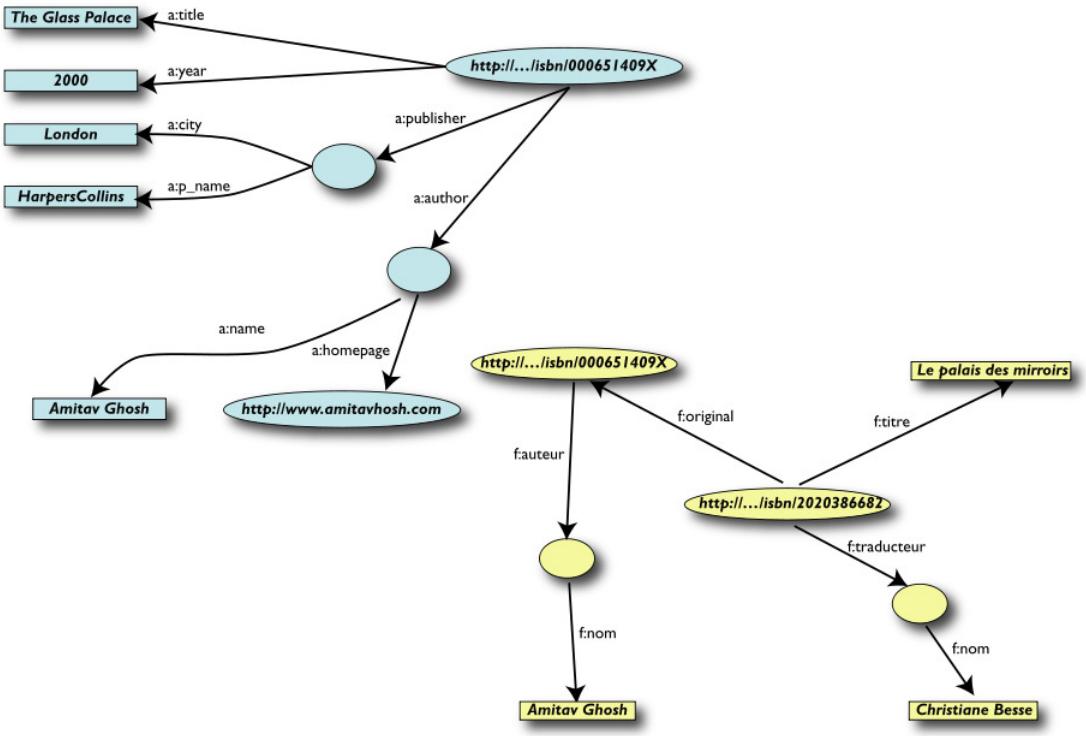
| ID | Titre | Auteur | Traducteur | Original |
|---|---|---|---|---|
| ISBN 2020386682 | Le Palais des miroirs | i_abc | i_qrs | ISBN 0-00-651409-X |

| ID | Nom |
|---|---|
| i_abc | Amitav Ghosh |
| i_qrs | Christiane Besse |

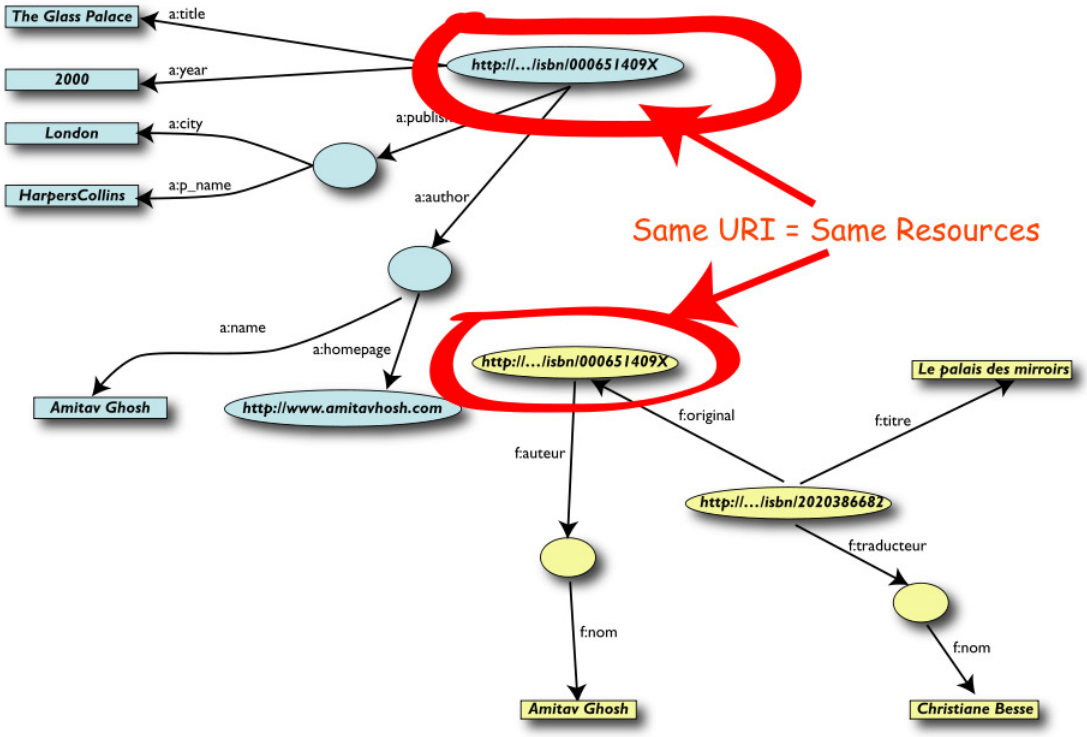
# 2nd step: export your second set of data



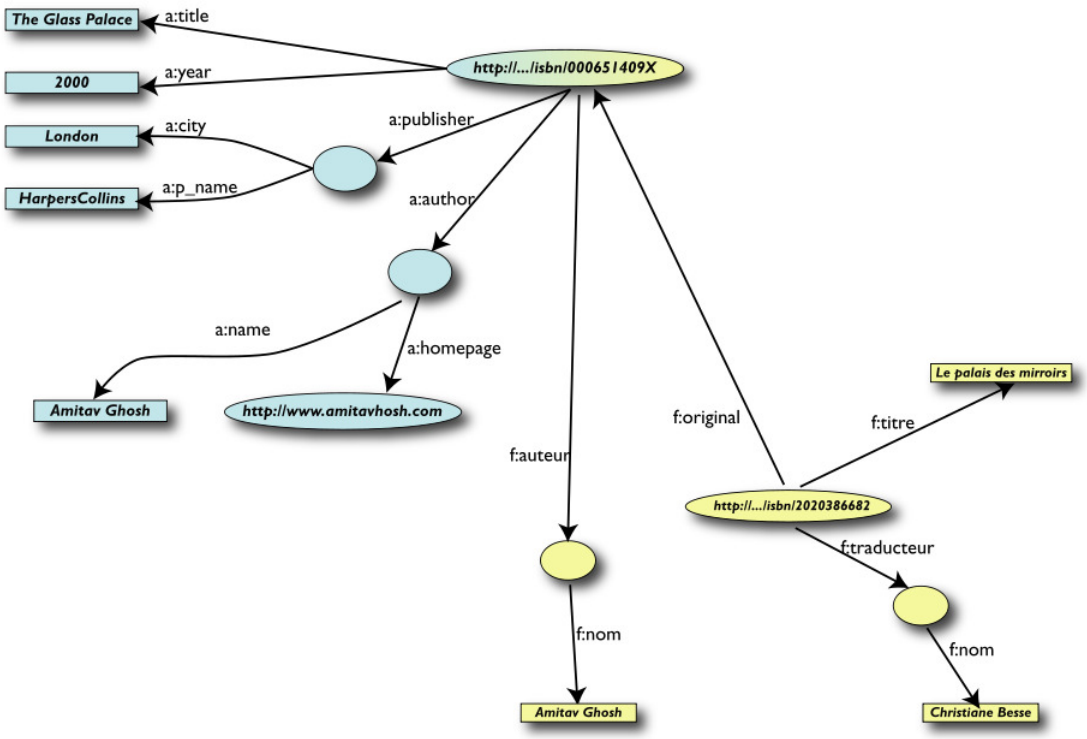
# 3rd step: start merging your data



# 3rd step: start merging your data (cont.)

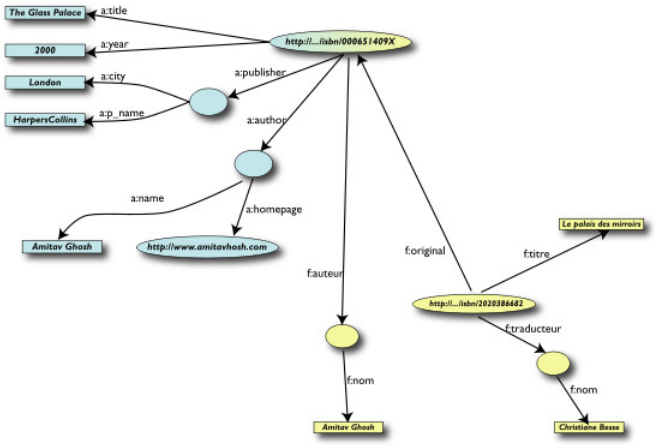


# 3rd step: merge identical resources



# Start making queries…

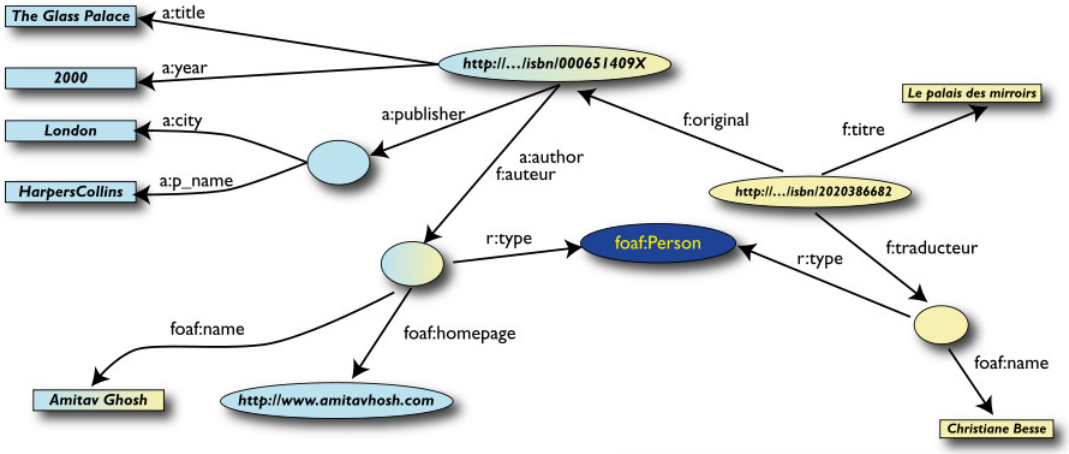
- User of data “F” can now ask queries like:
  - *« donnes-moi le titre de l’original »*
  - *(ie: “give me the title of the original”)*
- This information is not in the dataset “F”…
- …but can be automatically retrieved by merging with dataset “A”!

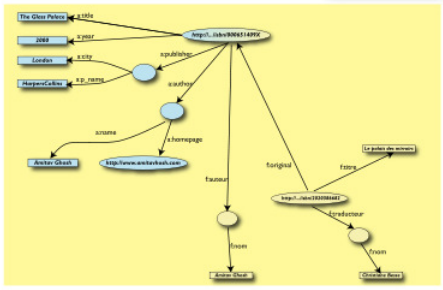


# However, more can be achieved…

- We “feel” that `a:author` and `f:auteur` should be the same
- But an automatic merge does not know that!
- Let us add some extra information to the merged data:
  - *`a:author` same as `f:auteur`*
  - *both identify a “Person”:*
    - a term that a community may have already defined:
      - a “Person” is uniquely identified by his/her name and, say, homepage
      - it can be used as a “category” for certain type of resources

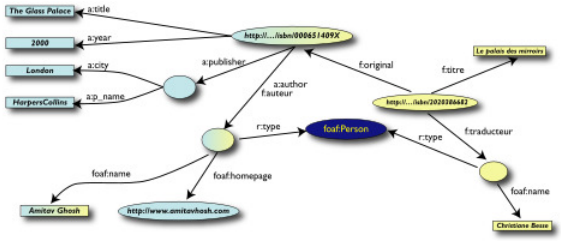
# 3rd step revisited: use the extra knowledge



# Start making richer queries!

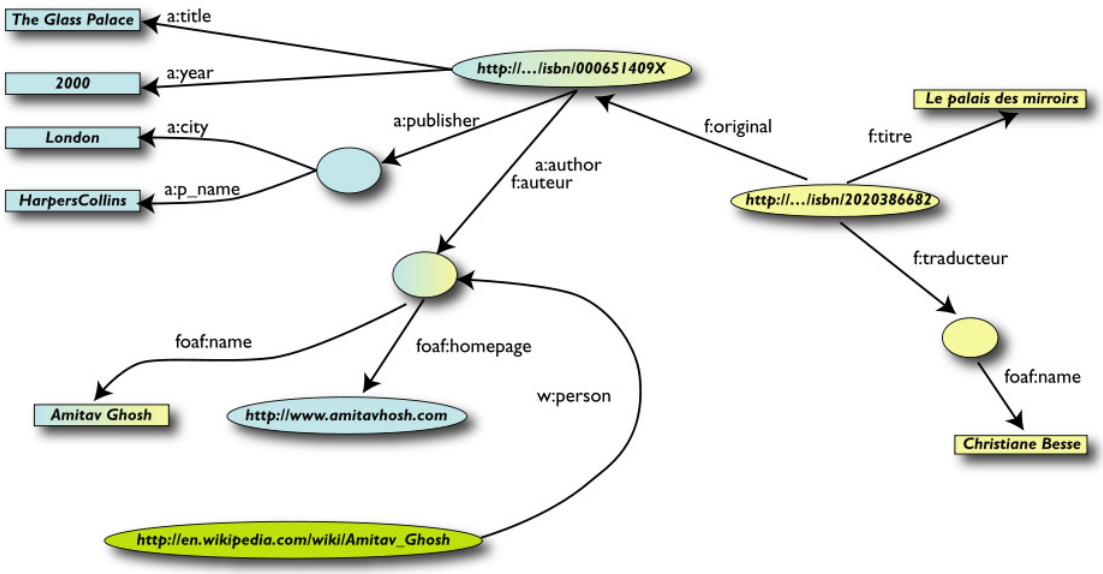
- User of dataset “F” can now query:
  - *« donnes-moi la page d’accueil de l’auteur de l’original »*
  - *(ie, “give me the home page of the original’s author”)*
- The data is not in dataset “F”…
- …but was made available by:
  - *merging datasets “A” and datasets “F”*
  - *adding three simple extra statements as an extra “glue”*
  - *using existing terminologies as part of the “glue”*



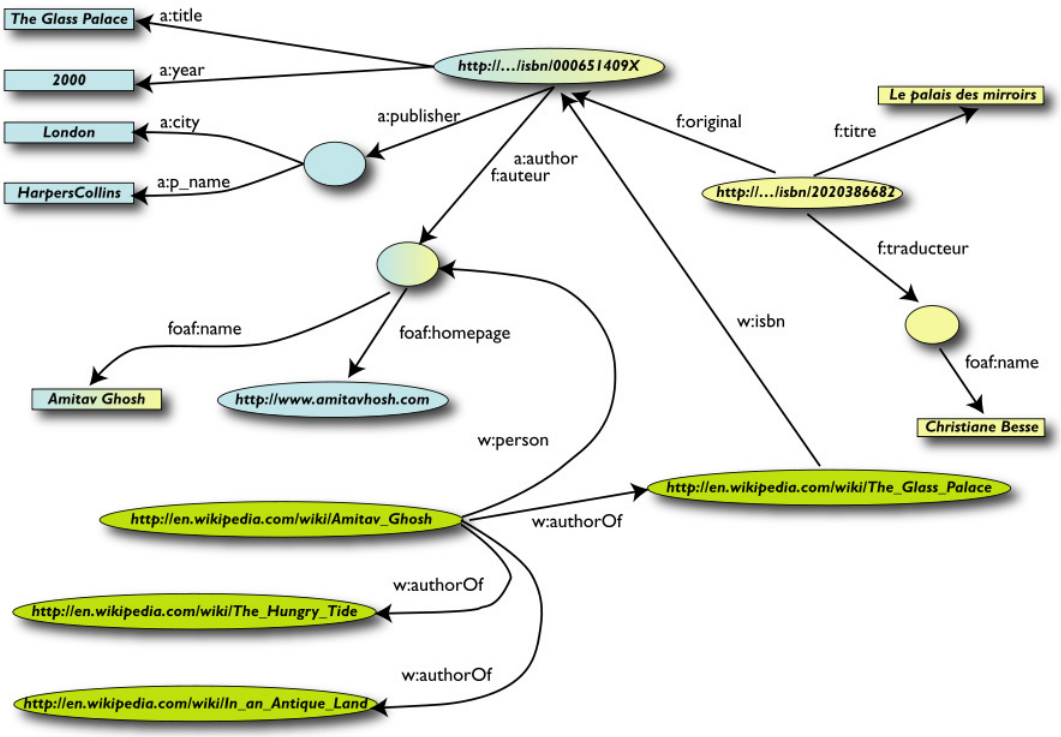
# Combine with different datasets

- Using, e.g., the “Person”, the dataset can be combined with other sources
- For example, data in Wikipedia can be extracted using simple (e.g., XSLT) tools
  - *there is an active development to add some simple semantic “tag” to wikipedia entries*
  - *we tacitly presuppose their existence in our example…*

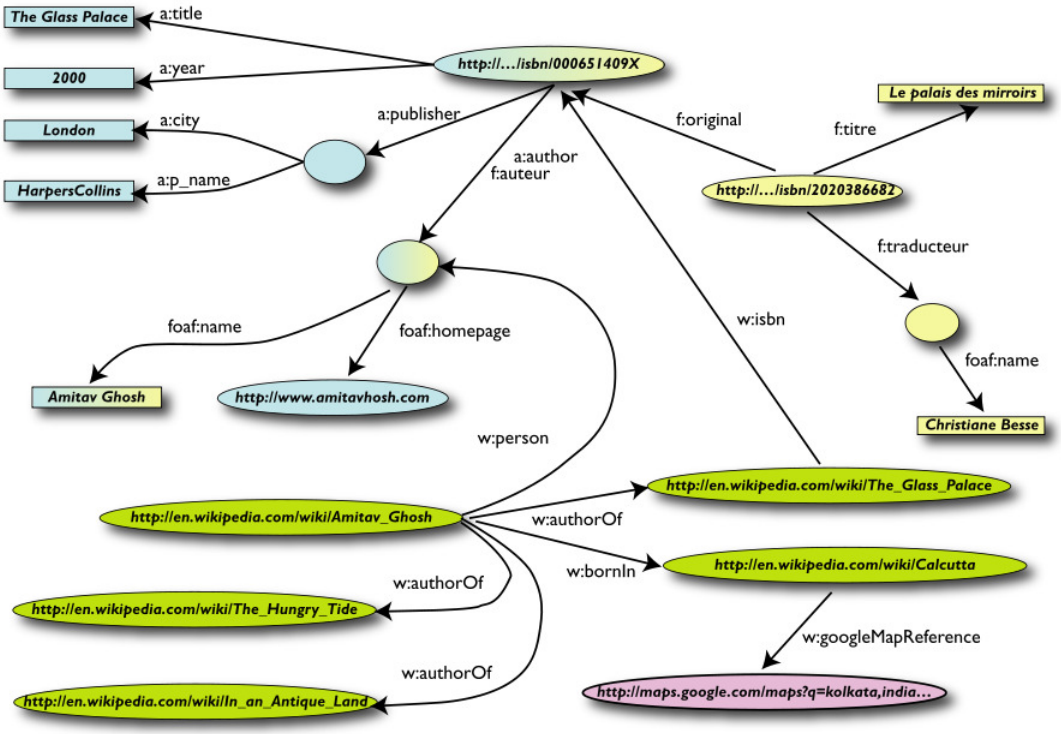
# Merge with Wikipedia data



# Merge with Wikipedia data



# Merge with Wikipedia data



# Is that surprising?

- Maybe but, in fact, no…
- What happened via automatic means is done all the time, every day by the users of the Web!
- The difference: a bit of extra rigor (e.g., *naming* the relationships) is necessary so that machines could do this, too

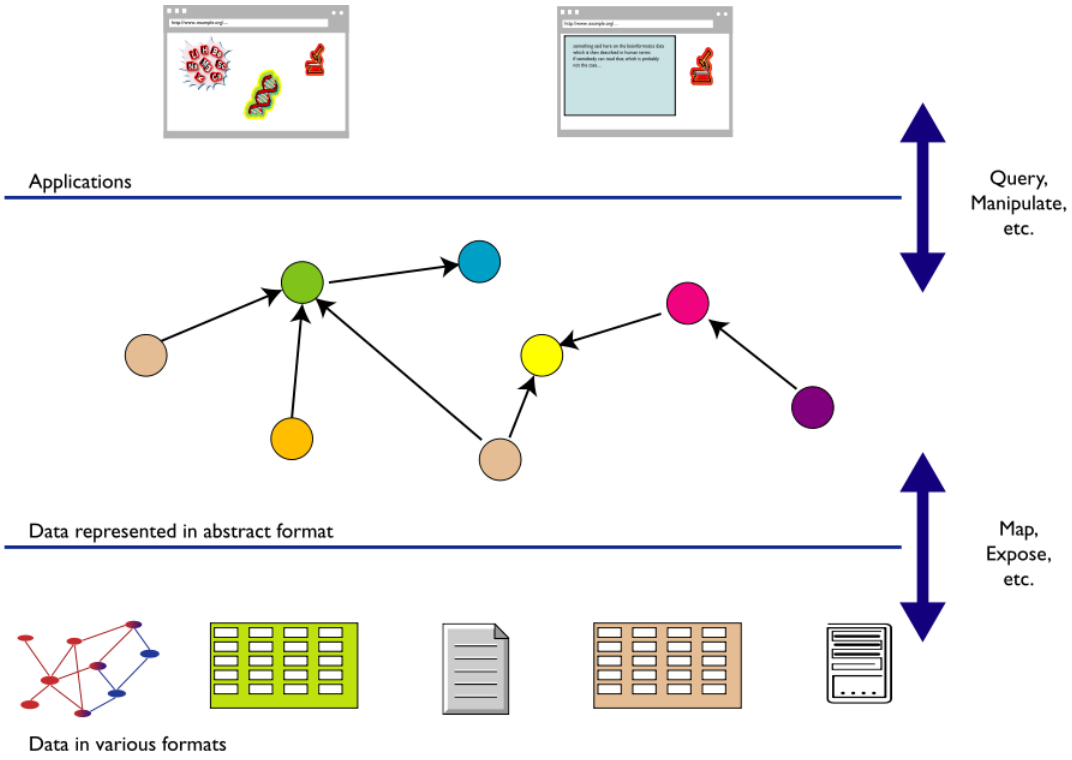
# What did we do?

- We combined different datasets
  - *all may be of different origin somewhere on the web*
  - *all may have different formats (mysql, excel sheet, XHTML, etc)*
  - *all may have different names for relations (e.g., multilingual)*
- We could combine the data because some URI-s were identical (the ISBN-s in this case)
- We could add some simple additional information (the "glue"), also using common terminologies that a community has produced
- As a result, *new relations* could be found and retrieved

# It could become even more powerful

- We could add extra knowledge to the merged datasets
  - *e.g., a full classification of various type of library data*
  - *geographical information*
  - *etc.*
- This is where *ontologies*, extra *rules*, etc, may come in
- Even more powerful queries can be asked as a result

# What did we do? (cont)



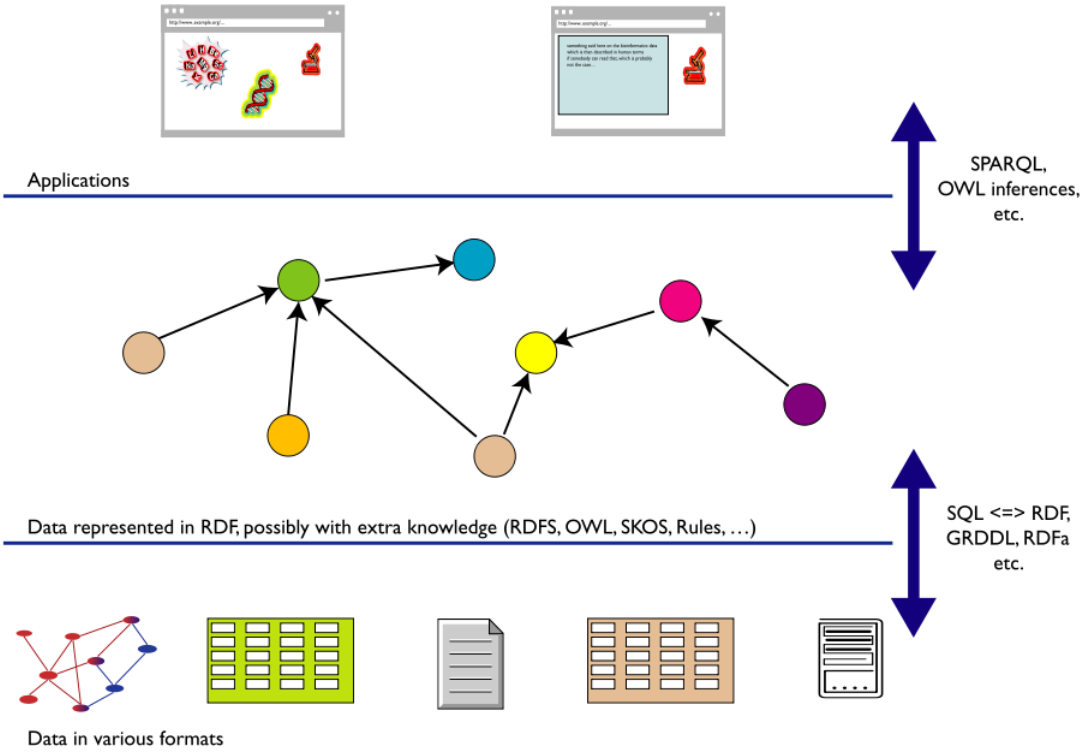
# The abstraction pays off because…

- … the graph representation is independent on the *exact* structures in, say, a relational database
- … a change in local database schemas, XHTML structures, etc, do *not* affect the whole, only the “export” step
  - *“schema independence”*
- … new data, new connections can be added seamlessly, regardless of the structure of other datasources

# So where is the Semantic Web?

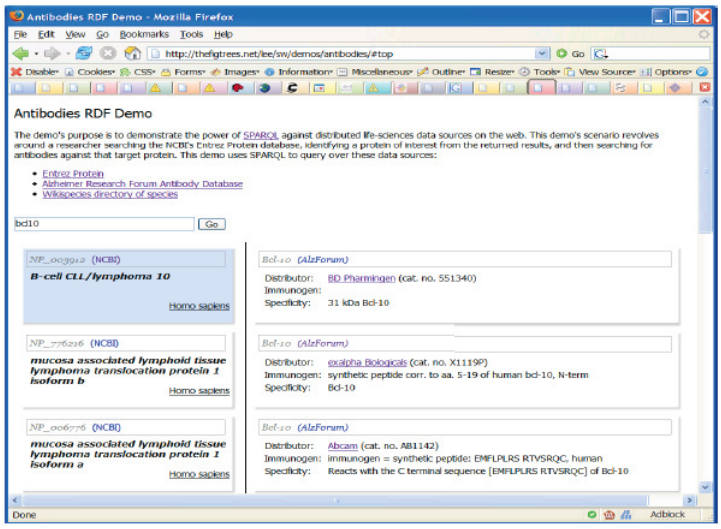
- The Semantic Web provides technologies to make such integration possible! For example:
  - *an abstract model for the relational graphs:* ***RDF***
  - *means to extract RDF information from XML (eg, XHTML) pages:* ***GRDDL***
  - *means to add structured information to XHTML pages:* ***RDFa***
  - *a query language adapted for the relational graphs:* ***SPARQL***
  - *various technologies to characterize the relationships, categorize resources:* ***RDFS*** *(RDF Schemas),* ***OWL*** *(Web Ontology Language),* ***SKOS***, ***Rule Interchange Format***
    - depending on the complexity required, applications may choose among the different technologies
    - some of them may be relatively simple with simple tools (RDFS), whereas some require sophisticated systems (OWL, Rules)
  - *reuse of existing "ontologies" that others have produced (FOAF in our case)*
- Some of these technologies are stable, others are being developed

# So where is the Semantic Web? (cont)



# A real life data integration: Antibodies Demo

- Scenario: find the known antibodies for a protein in a specific species
- Combine four different data sources
  - *"Entrez protein sequence" from National Center for Biotechnology Information; conversion to RDF*
  - *"Antibody Directory" from Alzheimer Research Forum; scraping RDF from HTML*
  - *Mapping data between genes and antibodies; convert spreadsheet to RDF*
  - *"Taxonomy information" from Wikispecies; use XSLT to extract RDF from XHTML*



# Semantic Web data begins to accumulate on the Web

- Large datasets are accumulating. E.g.:
  - *IngentaConnect bibliographic metadata storage: over 200 million statements*
  - *RDF version of Wikipedia: more than 47 million triplets, based also on SKOS, soon with a SPARQL interface*
  - *tracking the US Congress: data stored in RDF (around 25 million triplets) with a SPARQL interface*
  - *"Département/canton/commune" structure of France published by the French Statistical Institute*
- Some mesaures claim that there are over $10^7$ Semantic Web documents… (ready to be integrated…)

# Evolution of (Semantic) Web

- SW has indeed a strong foundation in research results
- But remember:
  1. *the Web was born at CERN…*
  2. *…was first picked up by high energy physicists…*
  3. *…then by academia at large…*
  4. *…then by small businesses and start-ups…*
  5. *…"big business" came only later (first used it on intranets)!*
- network effect kicked in early…
- Semantic Web is now at #4, and moving to #5!

# May start with small communities

- The needs of a deployment application area:
  - *have serious problem or opportunity*
  - *have the intellectual interest to pick up new things*
  - *have motivation to fix the problem*
  - *its data connects to other application areas*
  - *have an influence as a showcase for others*
- The high energy physics community played this role for the Web in the 90's

# Some RDF deployment areas

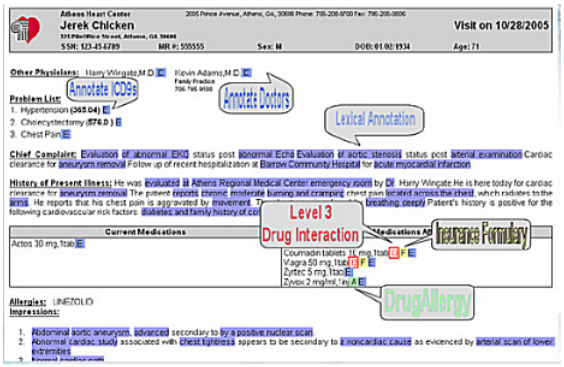
| | Library metadata | Defense | Life sciences |
|---|---|---|---|
| Problem to solve? | single-domain integration | yes, serious data integration needs | yes, connections among genetics, proteomics, clinical trials, regulatory, … |
| Willingness to adopt? | yes: OCLC push and Dublin Core initiative | yes: funded early DAML (OWL) work | yes: intellectual level high, much modeling done already. |
| Motivation | light | strong | very strong |
| Links to | other library data | phone calls records, etc | chemistry, regulatory, medical, etc |
| Showcase? | very specialized | not at all | yes, model for other industries. |

# Some RDF deployment areas (cont)

- These are just examples
- Others are coming to the fore: *eGovernment*, energy sector (oil industry), financial services, …

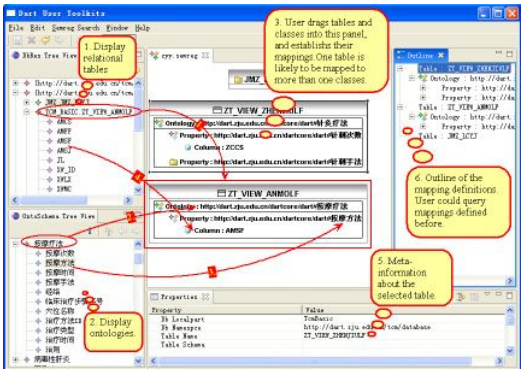
# Applications are not always very complex…

- 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!



# Data Integration R&D

- Boeing, MITRE Corp., Elsevier, EU Projects like Sculpteur and Artiste, national projects like MuseoSuomi, DartGrid from Zhe Jiang University, …

# 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,…
- Another example: semantic "harvester" of environmental agencies and information

# Creative Commons

- To express rights of digital content on the Web
  - *legal constraints referred to in RDF, added to pages*
- There are specialized browsers, browser plugins
- More than 1,000,000 users worldwide (!)
  - *without knowing that they use RDF…*

# Other Application Areas Come to the Fore

- Knowledge management
- Business intelligence
- Linking virtual communities
- Management of multimedia data (e.g., video and image depositories)
- Content adaptation and labeling (e.g., for mobile usage)
- etc

# Conclusions

- The Semantic Web is there to integrate data on the Web
- The goal is the creation of a *Web of Data*

# Thank you for your attention!

These slides are available on the Web:
http://www.w3.org/2007/Talks/1018Darmstadt-KB/

(slides are available in XHTML and PDF)