

LINKED OPEN DATA

An introduction

Philippe GENOUD – Danielle ZIEBELIN - LIG-Steamer

Firstname.Lastname@imag.fr

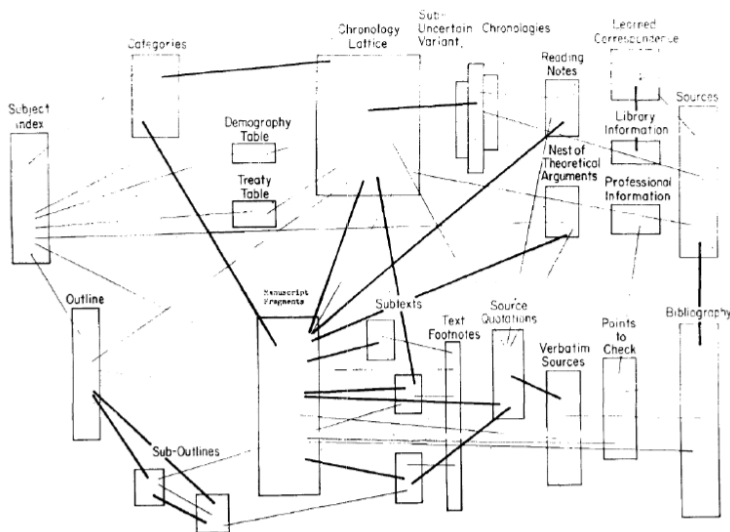
WEB Foundations*

1. Link together digital documents



Ted Nelson

Hypertexte - Hypermedia



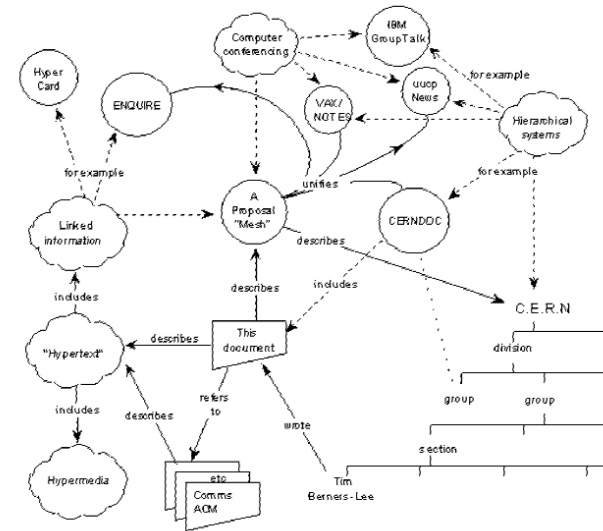
Complex information processing: a file structure for the complex, the changing and the indeterminate, T. H. Nelson, ACM, 1965

2. Link through the network



Tim Berners-Lee

Identify and link over the internet



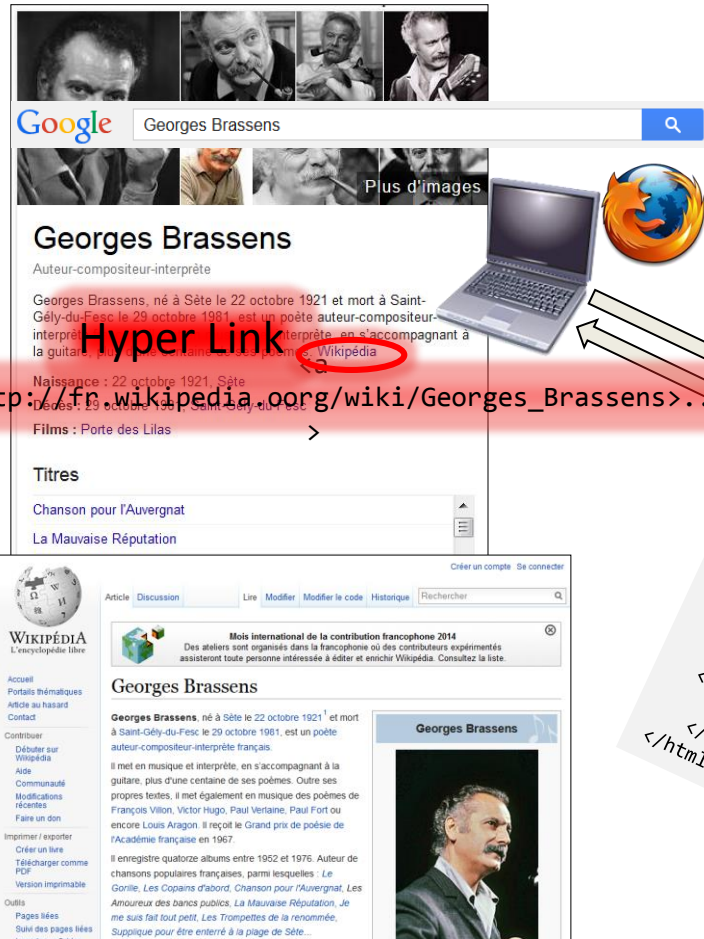
Information Management: A Proposal
Tim Berners-Lee, CERN, March 1989, May 1990

*Slide Inspired from MOOC : Web sémantique et Web de données – Fabien Gandon – FUN 2015

The WEB: a Success-Story

- WEB : a single global information space combining simplicity with decentralization and openness,
- Success of the Web is based on an distributed architecture built on a small set of simple **standards**
 - a globally unique identification mechanism: Uniform Resource Identifiers (URIs)
 - universal access mechanism: Hypertext Transfer Protocol (HTTP) protocol
 - a widely used content format : Hypertext Markup Language (HTML)
 - possibility of setting hyperlinks between Web documents that may reside on different Web servers

WEB architecture



URL

Request URL: `https://www.google.com/search?q=Georges+Brassens`
 Request method: GET

HTTP

<Status code: 200 OK
 <html>
 <head>...</head>
 <body>
 ...
 </body>
 </html>

www.google.fr

Hyper Link

`href="http://fr.wikipedia.org/wiki/Georges_Brassens">...`

Request URL: `http://fr.wikipedia.org/wiki/Georges_Brassens`
 Request method: GET

HTML

Status code: 200 OK
 <!DOCTYPE html>
 <html lang="fr">
 <head>
 <meta charset="UTF-8" />
 <title>Georges Brassens – Wikipédia</title>
 ...
 </body>
 </html>

fr.wikipedia.org

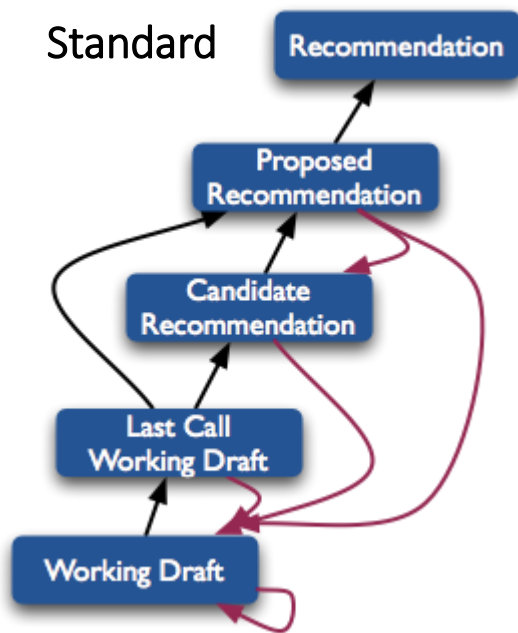


Web standardization

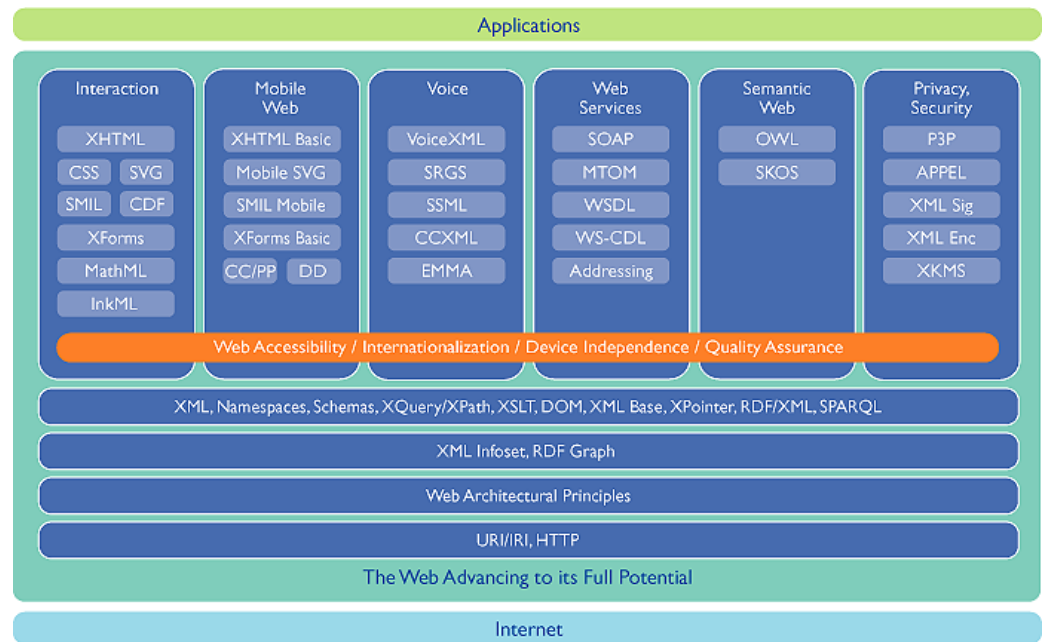


- 1994 creation of the W3C
- International consortium, around 400 Members
- Standardization of core Web technologies, publication of guidelines, technical notes, etc.

Based on a transparent and public Process



Standardization activities (2008)



<http://www.w3.org/2013/dd-epasorg.htm#%288%29>

Web evolution

Web 1.0

Web 2.0

Web 3.0

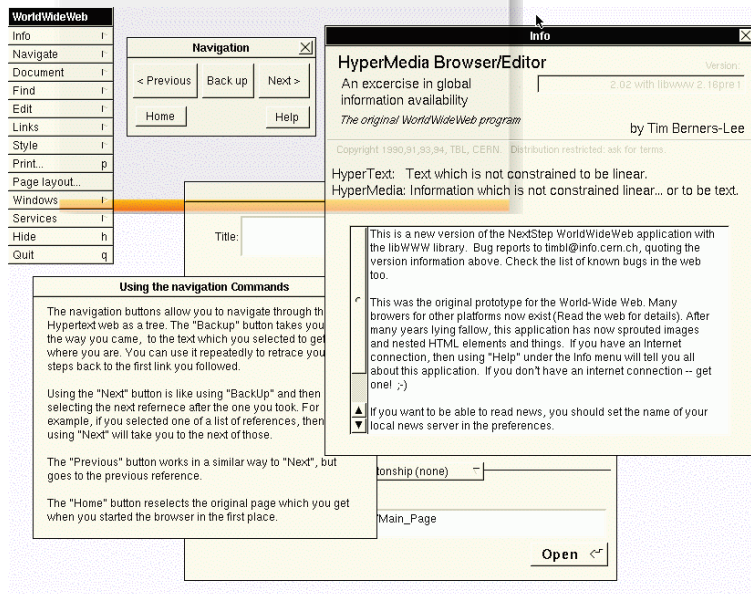
Web evolution

Web 1.0

- Utilisateur passif
- Essentiellement pro
- Réservé aux experts
- Guerre des navigateurs
- Contenu statique
- Formulaires
- Recherche par mots-clés

Web 2.0

Web 3.0

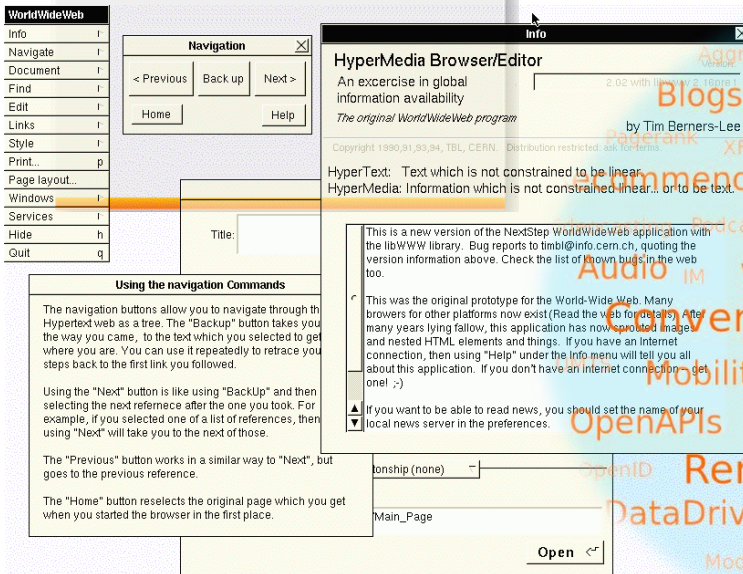


*d'après le cours Technologie du Web – A. Hombiat - Licence Professionnelle Études Statistiques et Systèmes d'Information Géographique (ESSIG) – UPMF - 2015

Web evolution

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Web 2.0

- Utilisateur acteur (Blogs, Wikis, Réseaux sociaux, Podcasts, etc.)
- Ouvert aux profanes (CMS)
- Syndication du contenu (RSS, Atom)
- Tags et folksonomies
- Contenu dynamique
- Collaboration et partage
- Recherche par mots-clés

Web 3.0

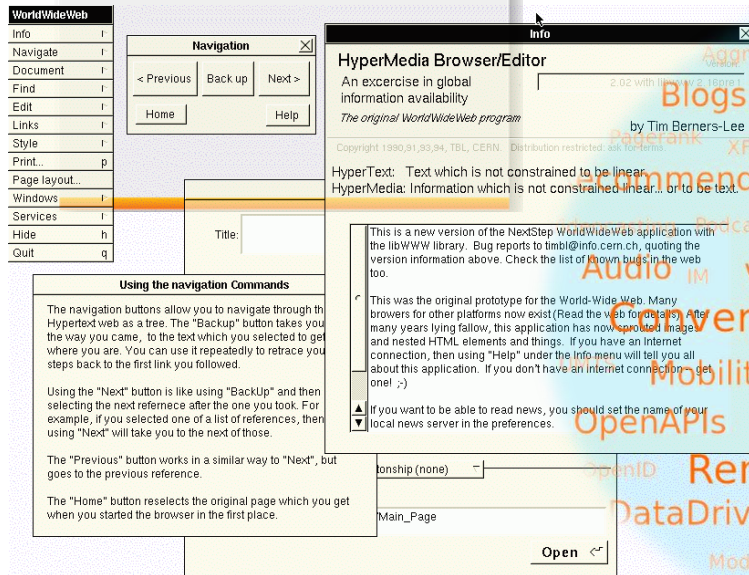
Web 2.0

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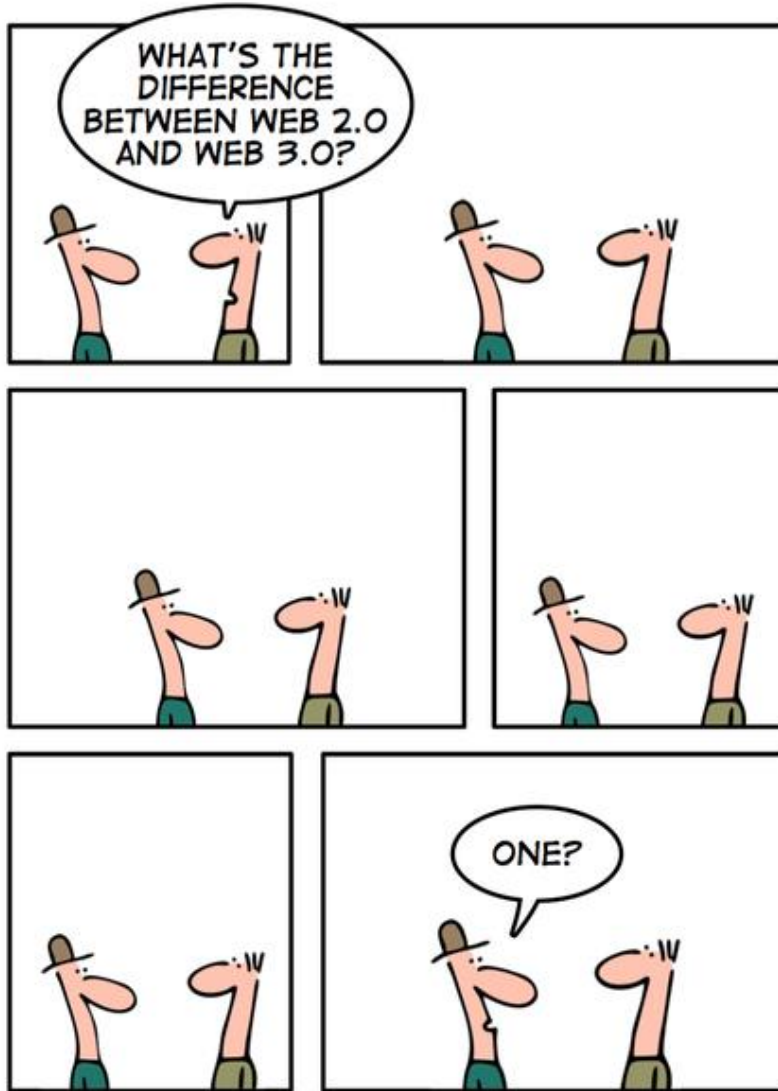
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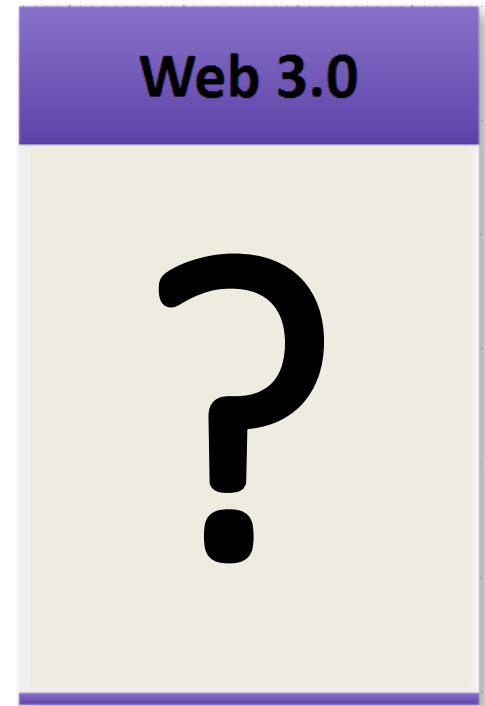
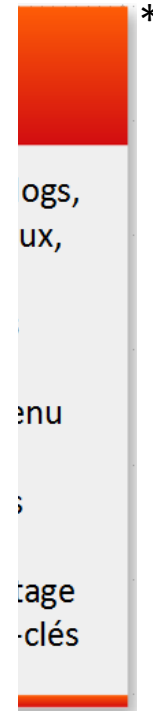


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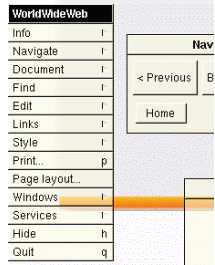
Web evolution



IT IS THAT EASY



- Utilisat
- Essenti
- Réserv
- Guerre
- Conten
- Formul
- Recher



Using the navigati

The navigation buttons allow you to view a Hypertext web as a tree. The "Back" button goes the way you came, to the text where you are. You can use it repeatedly to go back to the first link you followed.

Using the "Next" button is like using the "Back" button. It selects the next reference after the one you selected. For example, if you selected one of a list of links, using "Next" will take you to the next link in the list.

The "Previous" button works in a similar way. It goes to the previous reference.

The "Home" button resets the browser to the page you started the browser in.

*d'après le cou

: Systèmes d'Information Géographique (ESSIG) – UPMF - 2015

Web evolution

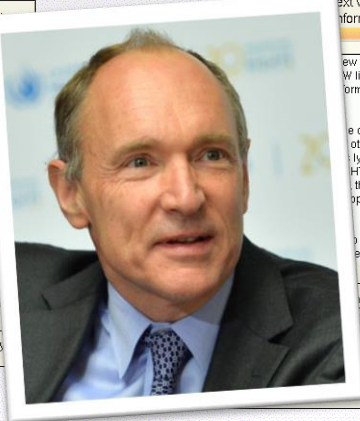
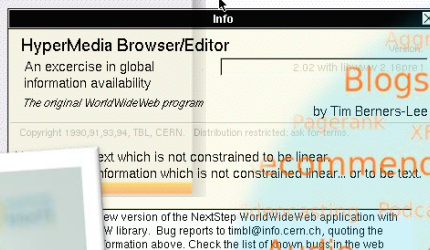
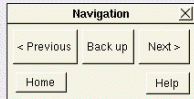
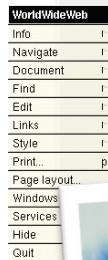
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Web 3.0



"The web of human-readable document is being merged with a web of machine understandable data. The potential of the mixture of humans and machines working together and communication through the web could be immense."

Tim Berners-Lee, [The World Wide Web: A very short personal history, May 1998](http://www.w3.org/People/Berners-Lee/ShortHistory.html)
<http://www.w3.org/People/Berners-Lee/ShortHistory.html>

*d'après le cours Technologie du Web – A. Hombiat - Licence Professionnelle Études Statistiques et Systèmes d'Information Géographique (ESSIG) – UPMF - 2015

From Web of Documents to Web of Data

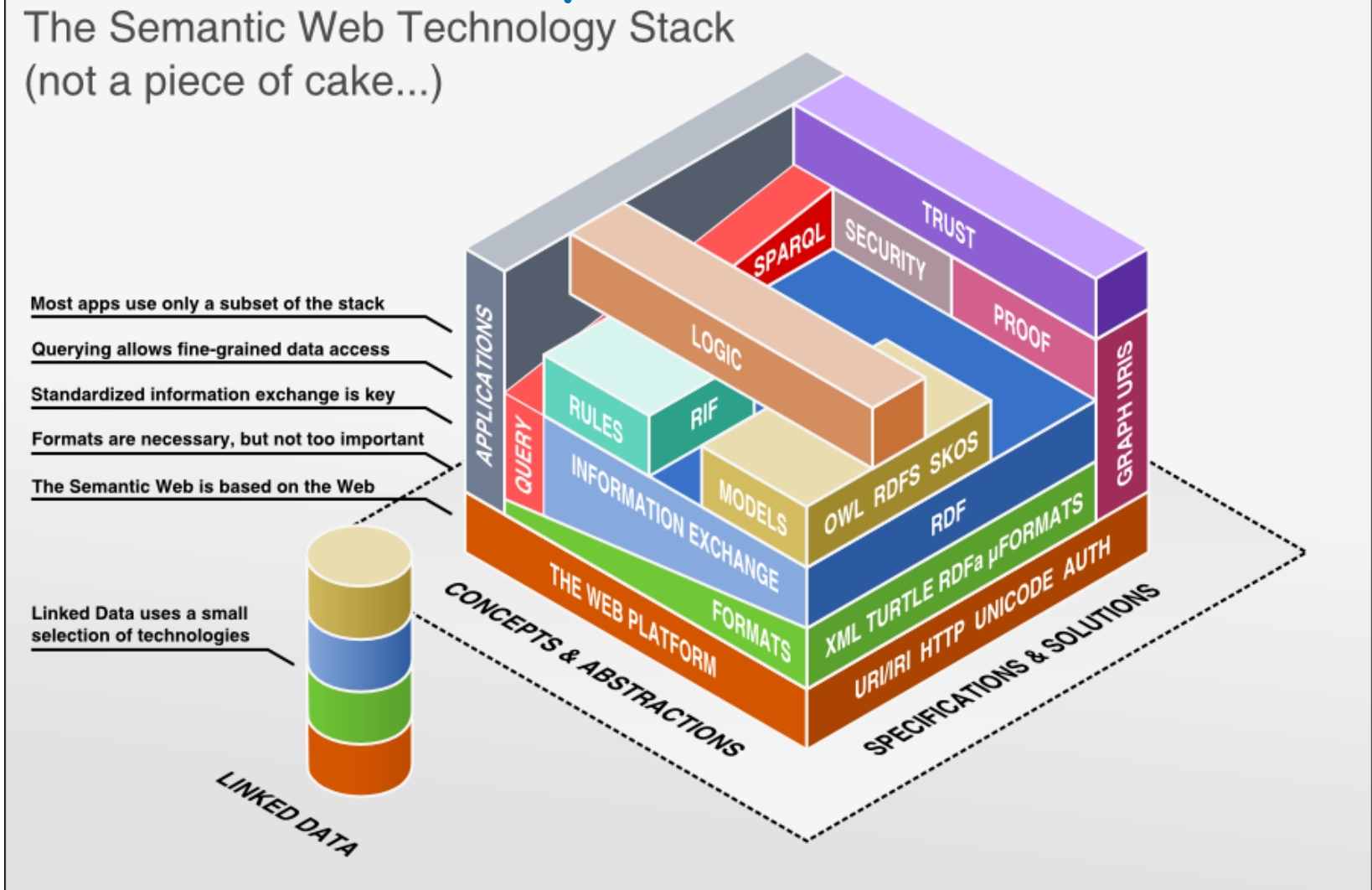
- Web can be seen as a (very) large distributed database (knowledge base) of information accessible to machines.

The Data Activity recognizes and works to overcome this diversity to facilitate potentially **Web-scale data integration and processing**. It does this by providing **standard** data exchange formats, models, tools, and guidance.

The screenshot shows the W3C Data Activity website. The main heading is "W3C DATA ACTIVITY *Building the Web of Data*". Below this, a paragraph states: "More and more Web applications provide a means of accessing data. From simple visualizations to sophisticated interactive tools, there is a growing reliance on the availability of data which can be 'big' or 'small', of diverse origin, and in different formats; it is usually published without prior coordination with other publishers — let alone with precise modeling or common vocabularies. The Data Activity recognizes and works to overcome this diversity to facilitate potentially Web-scale data integration and processing. It does this by providing standard data exchange formats, models, tools, and guidance." This paragraph is highlighted in a light green box. Below it, a red box contains the text: "The overall vision of the Data Activity is that people and organizations should be able to share data as far as possible using their existing tools and working practices but in a way that enables others to derive and add value, and to utilize it in ways that suit them. Achieving that requires a focus not just on the interoperability of data but of communities." To the right, there is a sidebar with "New W3C Documents" including "CSV on the Web: Metadata Vocabulary for Tabular Data and other updates" and "Data on the Web Best Practices UCR Published".

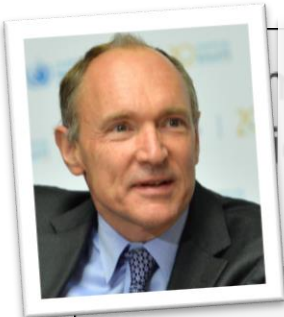
people and organizations should be able to share data as far as possible using their existing tools and working practices **but in a way that enables others to derive and add value, and to utilize it in ways that suit them**

Standards for Web of Data (formerly Semantic Web)



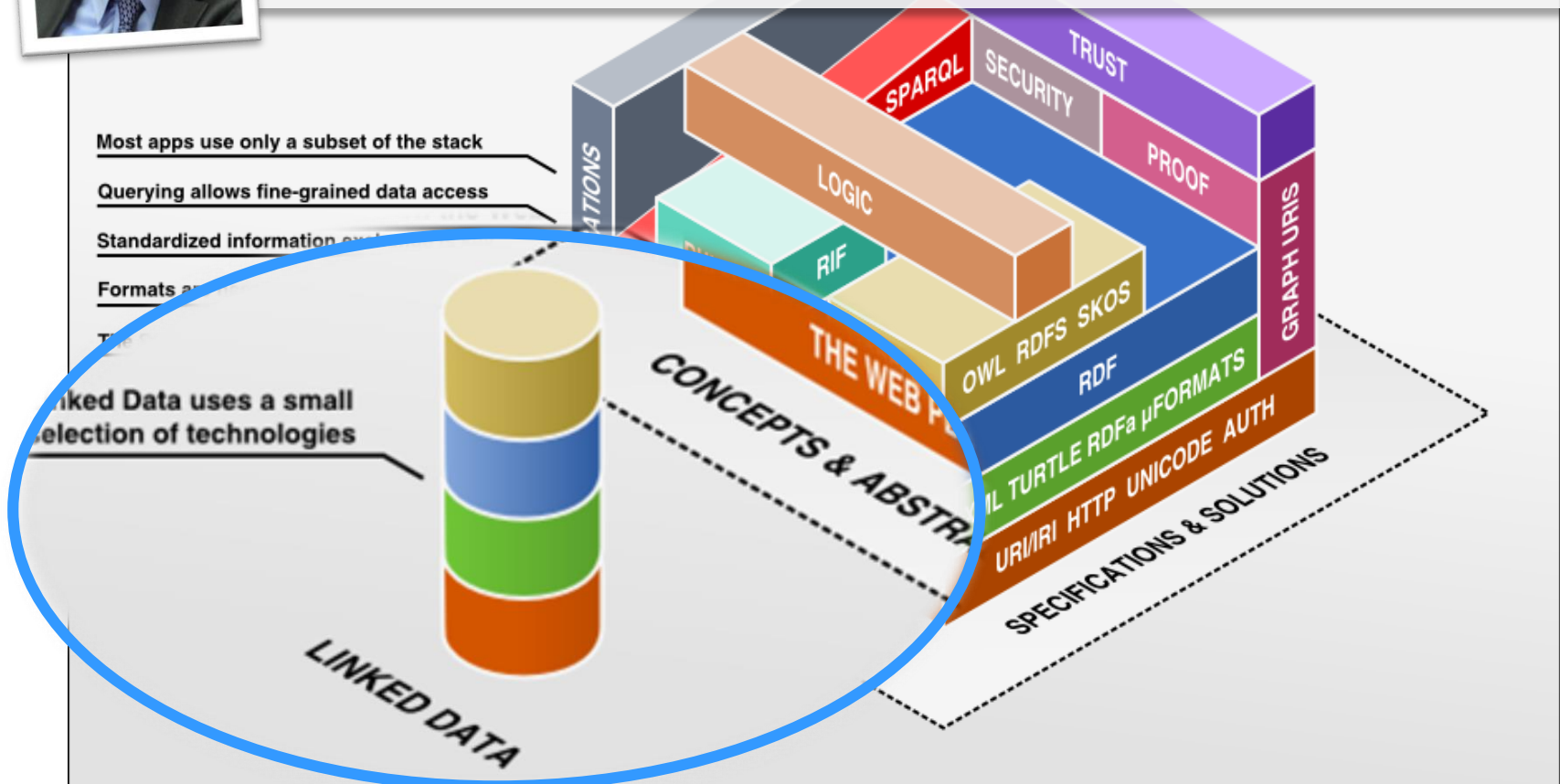
<http://www.bnode.org/blog/tag/layer%20cake> (Benjamin Nowack)

Linked Data



"The Semantic Web isn't just about putting data on the web. It is about making links, so that a person or machine can explore the web of data. With linked data, when you have some of it, you can find other, related, data."

Tim Berners-Lee - 2006 <http://www.w3.org/DesignIssues/LinkedData.html>



<http://www.bnode.org/blog/tag/layer%20cake> (Benjamin Nowack)

Linked Data Principles

Tim Berners-Lee

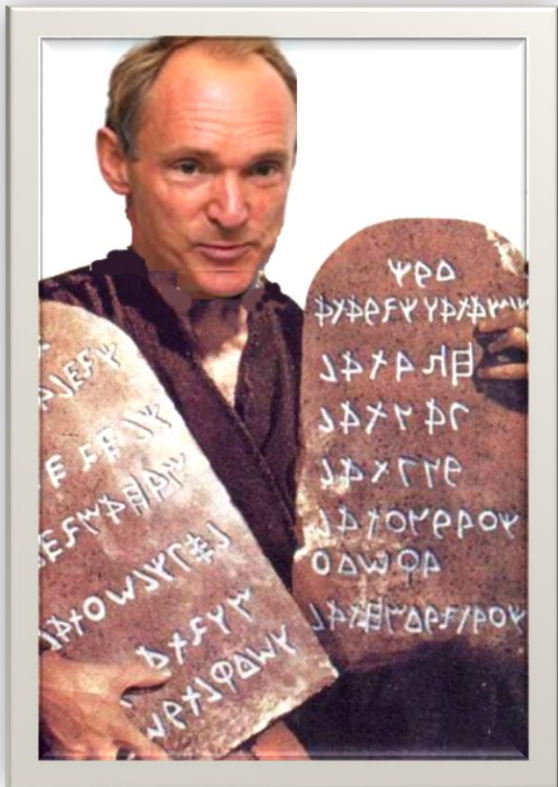
<http://www.w3.org/DesignIssues/LinkedData.html>

a set of best practices for publishing and interlinking structured data on the Web

Basic idea: to apply the general architecture of the World Wide Web to the task of sharing structured data on global scale.

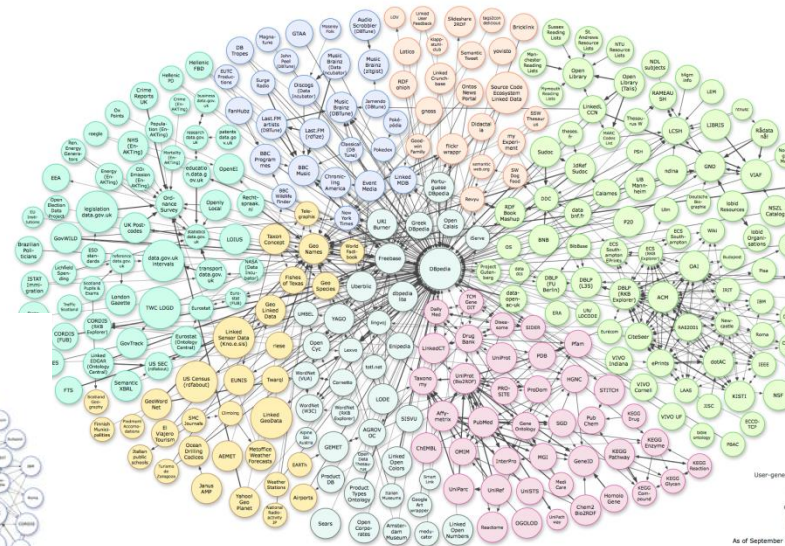


1. Use **URIs** as names for things.
2. Use **HTTP URIs**, so that people can look up those names.
3. When someone looks up a URI, **provide useful information, using the standards** (RDF, SPARQL).
4. Include **links** to other URIs, so that they **can discover more things**.



Linked Open Data Cloud

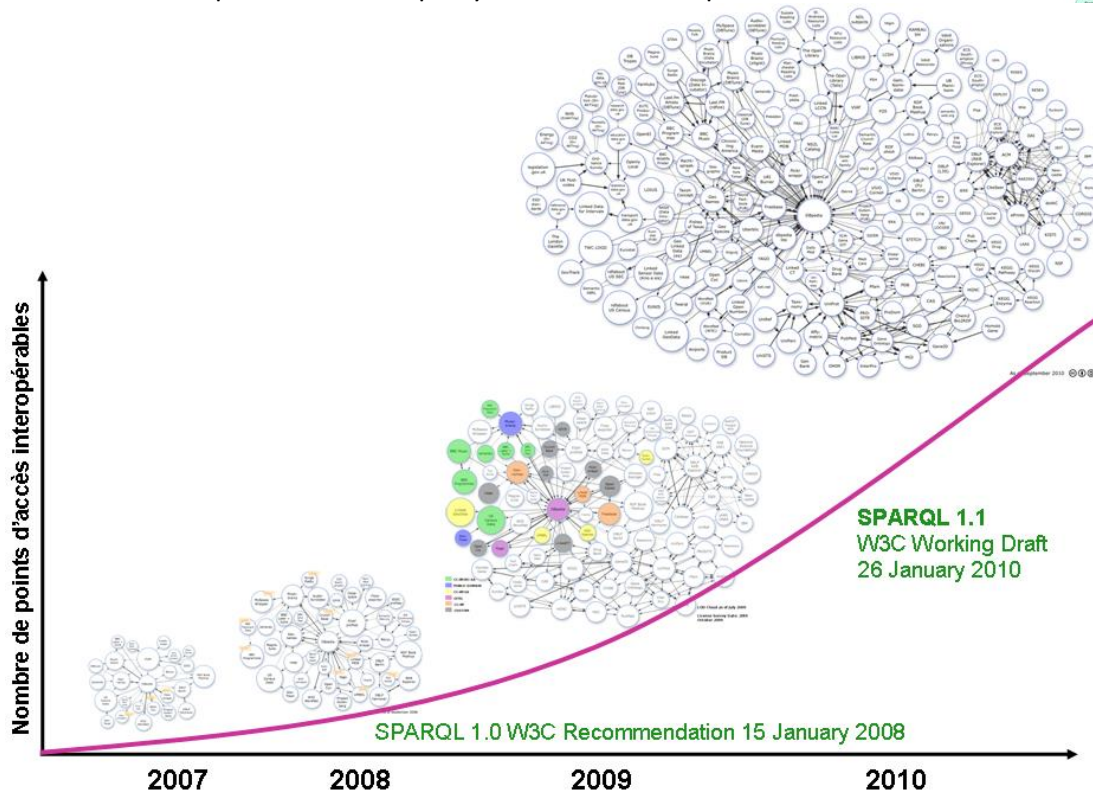
- Linking open data project
 - goals:
 - Use RDF to “expose” open data sets
 - Create RDF links between these datasets
 - If possible, deploy SPARQL endpoints



September 2011

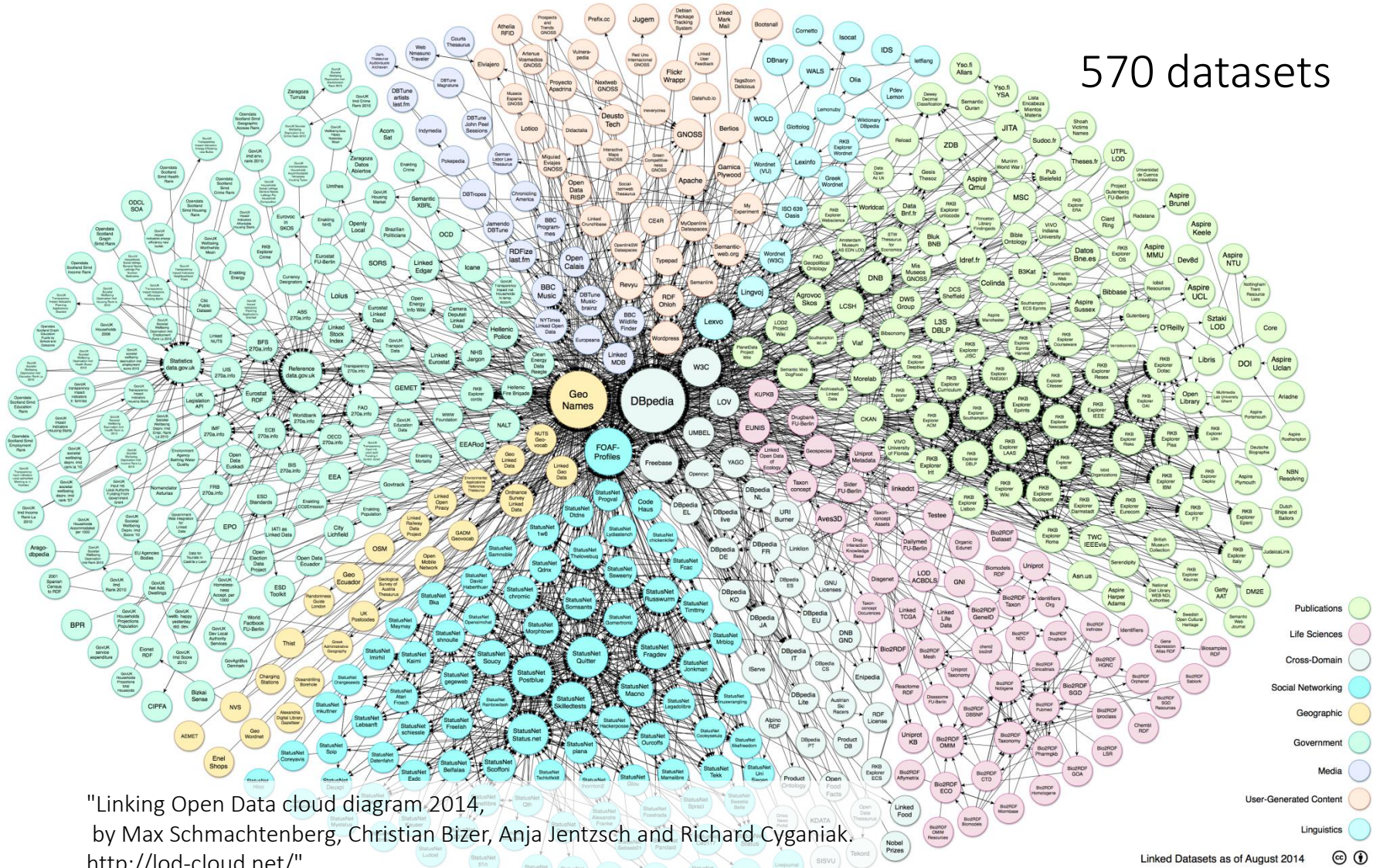
295 datasets
 31 Billion RDF triples
 interconnected by
 595 Million of RDF relations

<http://lod-cloud.net>



Linked Open Data Cloud

570 datasets



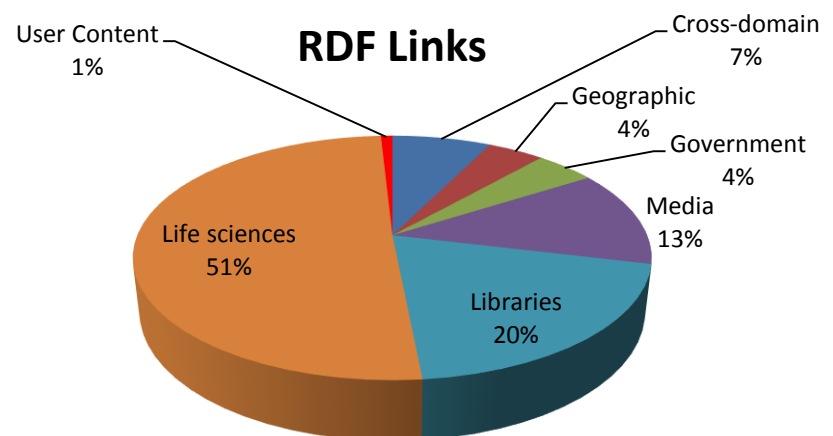
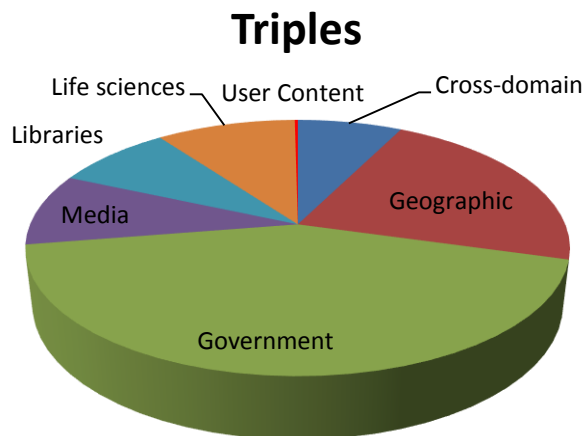
"Linking Open Data cloud diagram 2014,
by Max Schmachtenberg, Christian Bizer, Anja Jentzsch and Richard Cyganiak.
<http://lod-cloud.net/>"

Linked Datasets as of August 2014

Linked Open Data Cloud

Domain	Data Sets	Triples	Percent	RDF Links	Percent
Cross-domain	20	1,999,085,950	7.42	29,105,638	7.36
Geographic	16	5,904,980,833	21.93	16,589,086	4.19
Government	25	11,613,525,437	43.12	17,658,869	4.46
Media	26	2,453,898,811	9.11	50,374,304	12.74
Libraries	67	2,237,435,732	8.31	77,951,898	19.71
Life sciences	42	2,664,119,184	9.89	200,417,873	50.67
User Content	7	57,463,756	0.21	3,402,228	0.86
(2011 September)	203	26,930,509,703		395,499,896	

<http://lod-cloud.net/state>



Linked Open Data Cloud

Domain	Data Sets	Triples
Cross-domain	20	1,999,085
Geographic	16	5,904,980
Government	25	11,613,525
Media	26	2,453,898
Libraries	67	2,237,435
Life sciences	42	2,664,119
User Content	7	57,463
	203	26,930,509

(2011, September)

Datasets by topical domain.		
Topic	Datasets	%
Government	183	18.05%
Publications	96	9.47%
Life sciences	83	8.19%
User-generated content	48	4.73%
Cross-domain	41	4.04%
Media	22	2.17%
Geographic	21	2.07%
Social web	520	51.28%
Total	1014	

(2014, August)

State of the LOD Cloud 2014

Version 0.4, 08/30/2014

This document provides statistics about the structure and content of the crawled Linked Data sources implement the Linked Data best practices.

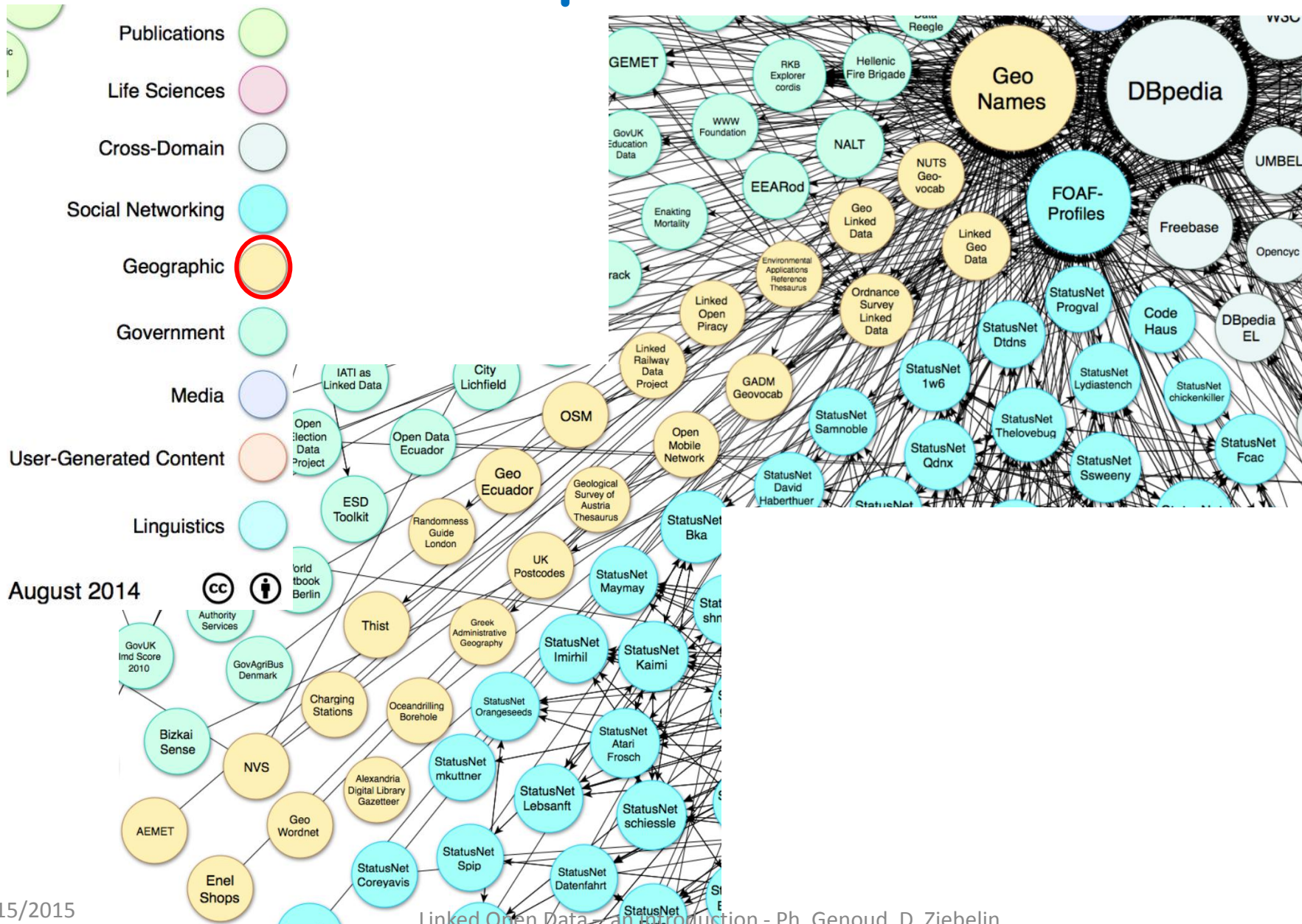
This document updates the findings of the original [State of the LOD Cloud](#) report. Publishers themselves via the [datahub.io](#) Linked Data catalog. This report is based on the ISWC2014 paper [Adoption of the Linked Data Best Practices in Different Topical Domains](#). This document links the statistics to the [Mannheim Linked Data catalog](#) and enables the

Contents

- [1. The Linked Data Crawl](#)
- [2. Linked Data by Domain](#)
- [3. Crawlable LOD Cloud Diagram](#)
- [4. Best Practices](#)
- [4.1 Interlinking Best Practice](#)
- [4.2 Vocabulary Best Practices](#)
- [4.2.1 Usage of Proprietary Vocabularies](#)
- [4.2.2 Usage of Dereferencable Vocabularies](#)
- [4.3 Adoption of Metadata Best Practices](#)

<http://linkeddatacatalog.dws.informatik.uni-mannheim.de/state/>

Linked Open Data Cloud



Pourquoi ce cours ?

Ces technologies sont en cours d'adoption

DATA.GOV

DATA TOPICS IMPACT APPLICATIONS DEVELOPERS CONTACT

DATA CATALOG / Datasets Organizations

geospatial

Datasets ordered by Relevance

You are searching in the list of datasets. Show results in [entire Data.gov site](#).

Filter by location Clear

Enter location...

90,628 datasets found for "geospa

Enterprise Geospatial Information Services
Department of Homeland Security – The Enterprise Geospatial Information Services

HRSA Geospatial Data Warehouses
U.S. Department of Health & Human Services Geospatial Data Warehouse (HGDW) provides health resources...

Distinct Agency Names in Geospatial Metadata
State of Oklahoma – Provides a listing of the unique agency names that contain the name from the geospatial metadata catalog on geo.data.gov.

Distinct Agency Names in Geospatial Metadata
State of Hawaii – Provides a listing of the unique agency names and the number of datasets that contain the name from the geospatial metadata catalog on geo.data.gov. The list was...

Distinct Agency Names in Geospatial Metadata
State of Oregon – Provides a listing of the unique agency names and the number of datasets that contain the name from the geospatial metadata catalog on geo.data.gov. The list was...

application/rdf+xml

Federal

State

State

State

<http://www.insee.fr/fr/methodes/default.asp?page=xml/xml.htm>

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Chercher sur le site

Accueil | Thèmes | Bases de données | Publications et services | Régions | Définitions et méthodes | Accès par

Définitions et méthodes

- Nomenclatures
- Définitions
- Sources et méthodes
- Grilles d'analyse
- Code officiel géographique, zonages d'études
- Outils statistiques
- Données RDF et espace XML

Accueil > Définitions et méthodes > Données RDF et espace XML

Données RDF et espace XML

Données au format RDF

L'Insee publie dans cette section des données modélisées selon le standard RDF du web sémantique. Cette formalisation facilite l'utilisation automatique des données par les applications compatibles avec ces nouvelles technologies. Pour plus d'information sur le web sémantique, on pourra consulter le site du W3C.

Les données suivantes sont disponibles :

- Données géographiques** : données issues du Code officiel géographique (COG) concernant les régions, les départements, les arrondissements, les cantons et les communes.
- Codes et nomenclatures** : nomenclature d'activités française (NAF), nomenclature des professions et catégories professionnelles (PCS).
- Données de population** : populations légales issues du Recensement.

D'autres données seront publiées dans les prochains mois.

Toutes les données RDF peuvent être interrogées dynamiquement grâce au langage d'interrogation SPARQL. Le point d'entrée SPARQL se trouve à l'adresse <http://rdf.insee.fr/sparql>.

- Accéder à l'espace RDF de l'Insee

<http://eurostat.linked-statistics.org/>



Overview · Usage · Dataspace · Support

Eurostat - Linked Data

This is a [Linked Data](#) version of the Eurostat data with the goal to provide 5 star Linked Open Data on the European level, in a contextually rich and up-to-date manner, useful for ETL-style business analysis or data warehousing purposes with benefits including but not limited to:

- It allows for a straight-forward comparison of statistical indicators across EU countries.
- Through providing context for statistics it facilitates the interpretation process.
- Enables you to re-use observations in a fine-grained way.

Overview

The following data is available

- <http://eurostat.linked-statistics.org/>
- <http://eurostat.linked-statistics.org/>
- <http://eurostat.linked-statistics.org/>

Via our SPARQL endpoint you

<http://www.bbc.co.uk/nature/feedsanddata>

Cookies on the BBC website

The BBC has updated its cookie policy. We use cookies to ensure that we give you the best experience on our website. This includes cookies from third party social media websites if you visit a page which contains embedded content from social media. Such third party cookies may track your use of the BBC website. We and our partners also use cookies to ensure we show you advertising that is relevant to you. If you continue without changing your settings, we'll assume that you are happy to receive all cookies on the BBC website. However, you can change your cookie settings at any time.

✓ Continue
⚙ Change settings
ℹ Find out more

BBC News Sport Weather Shop More Search

This page was last updated in October 2014.
We've left it here for reference [More information](#)

NATURE CONTACT

Home | News | Features | Video collections | Wildlife | Prehistoric life | Places | FAQs

Feeds and data

In addition to the standard web pages we are also publishing some of the information behind Wildlife Finder as RSS and RDF and providing semantic mark-up in the form of microformats.

Pourquoi ce cours ?

Il y a même des boulôts

Jobs / Job post



Research Scientist - Semantic Web Technologies

Researcher

Posted on 07 Sep 2015

Viseo
France, Grenoble

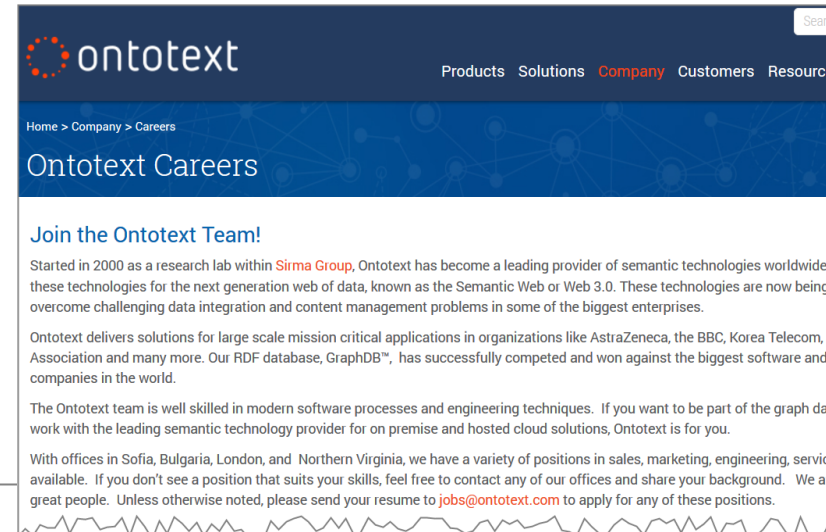
[Apply for this job](#)
20 days left to apply

JOB DESCRIPTION

Full Time position for a research scientist in Semantic Web technologies

Job Summary:

The Research and Development Centre of Viseo Technologies seeks a Research Scientist in Semantic Web technologies to complete its team working on data analysis. We are looking for an individual with Phd experience in data analysis in the context of Semantic Web and some familiarity with natural language processing and machine learning. Candidate researchers should have the desire to work on issues that have impact on the real world while demonstrating a good track in research and development, good international publication list, communication capability to work and interact with software developers and sales teams



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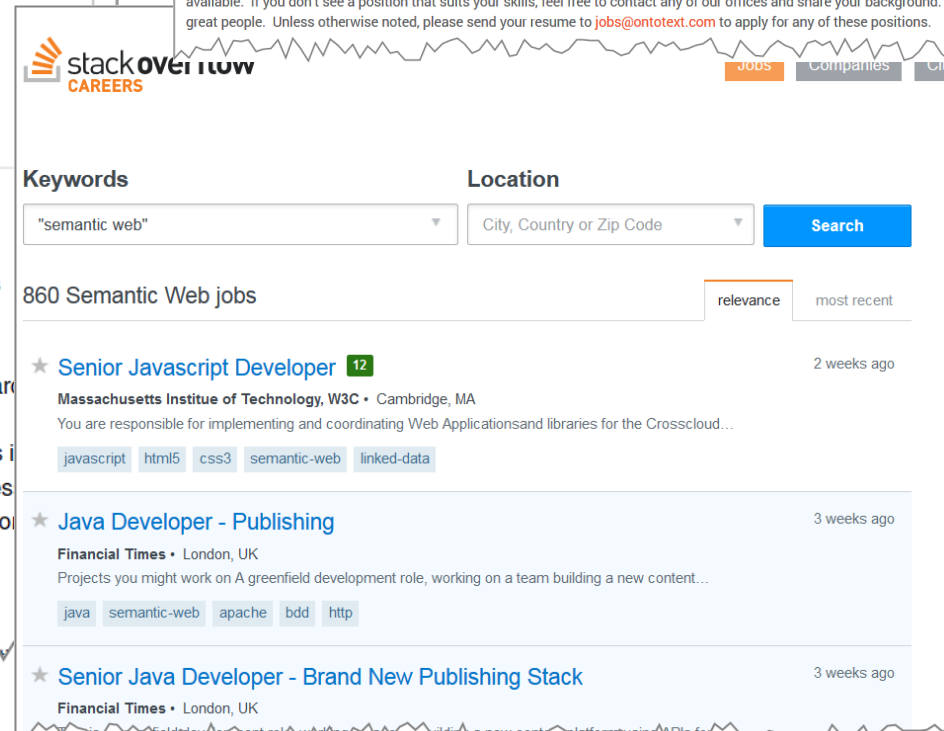
Join the Ontotext Team!

Started in 2000 as a research lab within **Sirma Group**, Ontotext has become a leading provider of semantic technologies worldwide. These technologies for the next generation web of data, known as the Semantic Web or Web 3.0. These technologies are now being used to overcome challenging data integration and content management problems in some of the biggest enterprises.

Ontotext delivers solutions for large scale mission critical applications in organizations like AstraZeneca, the BBC, Korea Telecom, the European Commission and many more. Our RDF database, GraphDB™, has successfully competed and won against the biggest software and hardware companies in the world.

The Ontotext team is well skilled in modern software processes and engineering techniques. If you want to be part of the graph data revolution and work with the leading semantic technology provider for on premise and hosted cloud solutions, Ontotext is for you.

With offices in Sofia, Bulgaria, London, and Northern Virginia, we have a variety of positions in sales, marketing, engineering, services and operations available. If you don't see a position that suits your skills, feel free to contact any of our offices and share your background. We are looking for great people. Unless otherwise noted, please send your resume to jobs@ontotext.com to apply for any of these positions.



stackoverflow
CAREERS

Jobs Companies

Keywords "semantic web" **Location** City, Country or Zip Code [Search](#)

860 Semantic Web jobs relevance most recent

- ★ **Senior Javascript Developer** 12 2 weeks ago
Massachusetts Institute of Technology, W3C • Cambridge, MA
You are responsible for implementing and coordinating Web Applications and libraries for the Crosscloud...
javascript html5 css3 semantic-web linked-data
- ★ **Java Developer - Publishing** 3 weeks ago
Financial Times • London, UK
Projects you might work on A greenfield development role, working on a team building a new content...
java semantic-web apache bdd http
- ★ **Senior Java Developer - Brand New Publishing Stack** 3 weeks ago
Financial Times • London, UK

Tutorial Objectives

- To present the common framework the Semantic Web provides to allow data to be shared and reused across application, enterprise, and community boundaries.
- To introduce the core technologies for data exchange and querying : RDF and SPARQL.
- To introduce to knowledge representation with ontology languages : RDFS - OWL

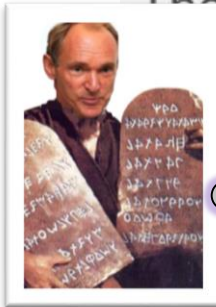
Outline

- Introduction
- Distributing Data on the web with RDF
 - Naming the Data : URIs (Uniform Resources Identifiers)
 - The RDF Data model
- Querying Linked Data with SPARQL
- Semantic modelling
 - RDFS
 - OWL
- From Open Data to Linked Open Data
- Conclusion

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 - The RDF Data model
- Querying Linked Data with SPARQL
- Semantic modelling
 - RDFS
 - OWL
- From Open Data to Linked Open Data
- Conclusion

Uniform Resource Identifiers (URIs)



Linked Data: 1st Principle
Use URIs (Uniform Resource Identifiers) to name things

Most apps use only a subset of the stack

Querying allows fine-grained data access

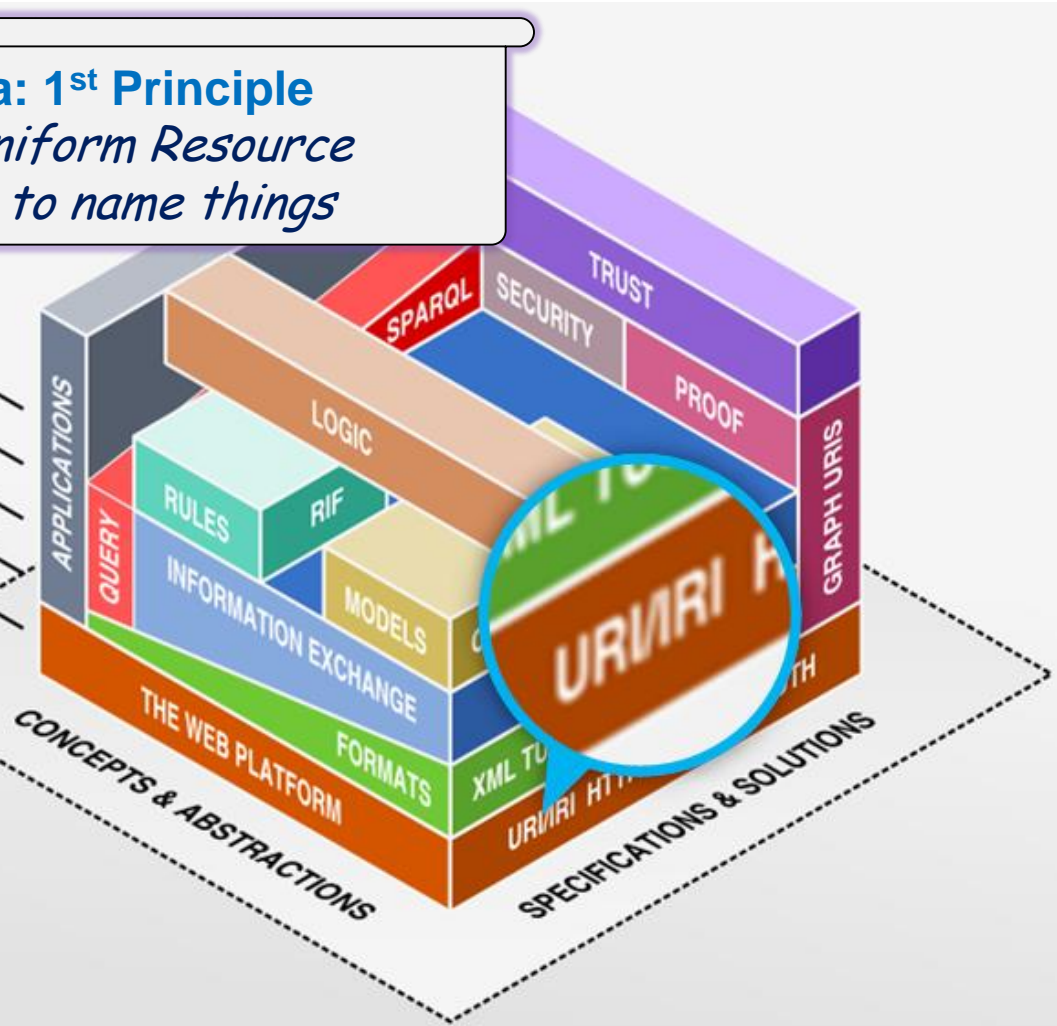
Standardized information exchange is key

Formats are necessary, but not too important

The Semantic Web is based on the Web

Linked Data uses a small selection of technologies

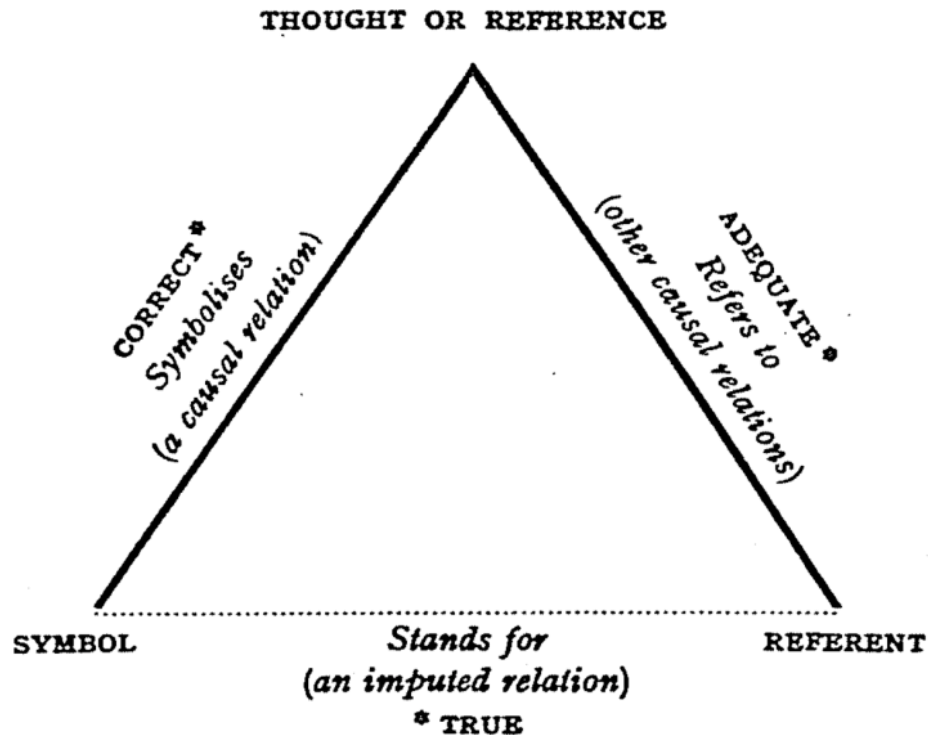
LINKED DATA



<http://www.bnode.org/blog/tag/layer%20cake> (Benjamin Nowack)

(Semiotics

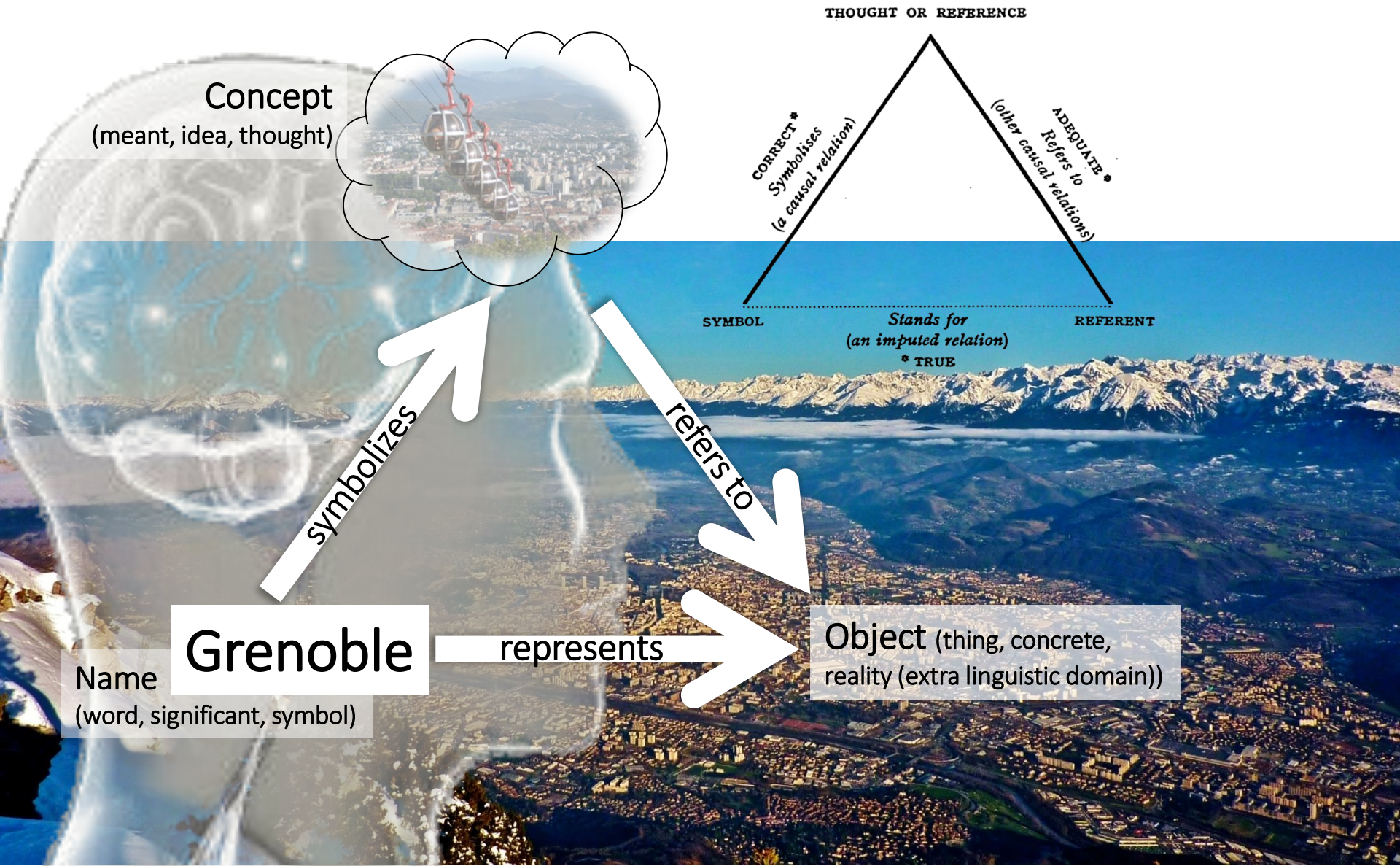
- **Semiotics** : The science of communication studied through the interpretation of signs and symbols as they operate in various fields, esp. language. Oxford English Dictionary (2003).



Semiotic Triangle by Ogden & Richard

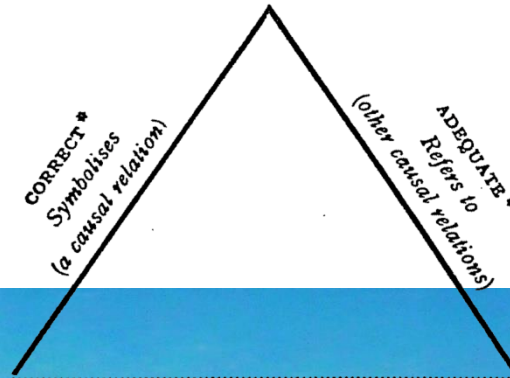
([The Meaning of Meaning](#) -A Study of the Influence of Language upon Thought and of the Science of Symbolism, 1923)

Semiotics



Semiotics)

THOUGHT OR REFERENCE



Stands for
(an imputed relation)
* TRUE

Concept
(meant, idea, thought)



symbolize

refers to

格勒诺布尔

represents

Object (thing, concrete,
reality (extra linguistic domain))

Name
(word, significant, symbol)

URI: definition

- "In computing, a **Uniform Resource Identifier (URI)** is a string of characters used to identify the name of a resource. Such identification enables interaction with representations of the resource over a network, typically the World Wide Web, using specific protocols. Schemes specifying a concrete syntax and associated protocols define each URI." (see RFC 3986)
https://en.wikipedia.org/wiki/Uniform_resource_identifier

Names in the Web...

10

**Uniform
Resource
Identifier**

- different types of resource identifiers all constructed according to a uniform schema
- whatever may be identified via URI
- to distinguish one resource from another

HPI Hasso Plattner Institut

Knowledge Engineering with Semantic Web Technologies, Dr. Harald Sack, Hasso-Plattner-Institut, Universität Potsdam

Knowledge Engineering with Semantic Web Technologies , Dr. Harald Sack, Hasso-Plattner-Institut, Universität Potsdam

URI: syntax

- URI : generic syntax

scheme ":" ["//" authority "/"] [path] ["?" query] ["#" fragment]

- **scheme:** http, ftp, mailto, ...
- **authority:** [userinfo@]host[:port]
 - **userinfo:** authentication section e.g: username:password
 - **host:** domain name, IP address
 - **port:** port number, ex: 80 for HTTP standard port
- **path:** a sequence of segments separated by slashes, e.g. : a path in the hierarchical file system of the HTTP server.
- **query:** a query string of non-hierarchical data. (e.g: a sequence of attribute–value pairs separated by a delimiter (&) for HTTP requests)
- **fragment:** a fragment identifier providing direction to a secondary resource (e.g.: anchor id in a HTML document)



Internationalized Resource Identifier (RFC 3987): extension to support Universal Character Set (Unicode/ISO 10646)

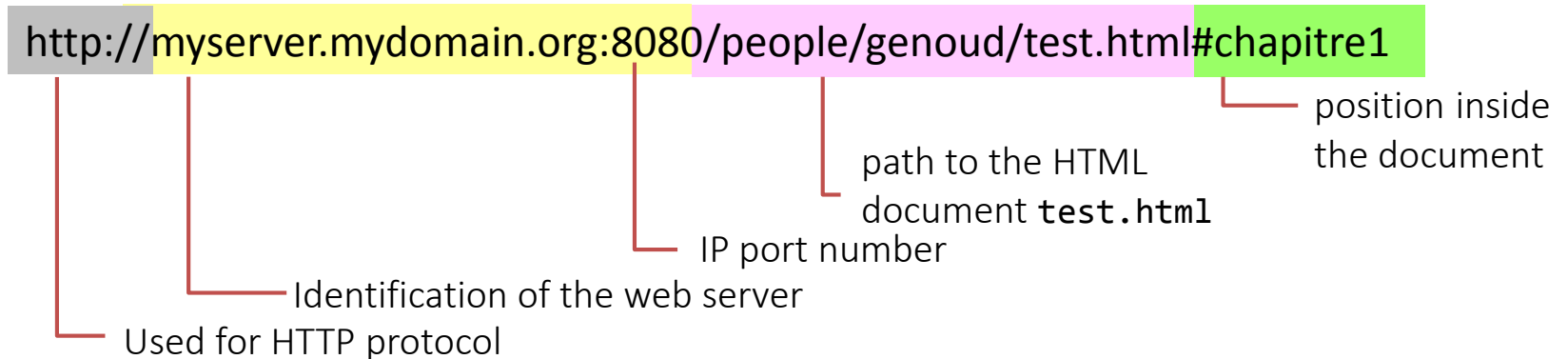
http://fa.dbpedia.org/resource/ژرژ_برسنس

URI: examples

- URI : generic syntax

scheme ":" ["//" authority "/"] [path] ["?" query] ["#" fragment]

example :

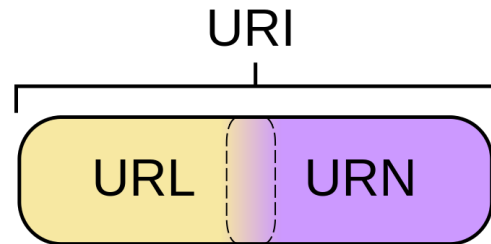


other URIs examples:

- `ftp://server.example.com/foo`
- `mailto:person@example.fr`
- `urn:isbn:978-0553283686`

URI - URL - URN

- an URI/IRI **doesn't necessarily** identifies a resource that is resolvable on the web



- Address (Locator)
 - **Uniform Resource Locator** (RFC 1738)
 - Tells where and how a resource can be found in the internet
 - *Can change during the life cycle of a resource*
- Identity (Name)
 - **Uniform Resource Name** (RFC 2141)
 - identifies a resource by name in a particular namespace. A URN can be used to talk about a resource without implying its location or how to access it.
 - *Remains unchanged during life cycle of the resource*

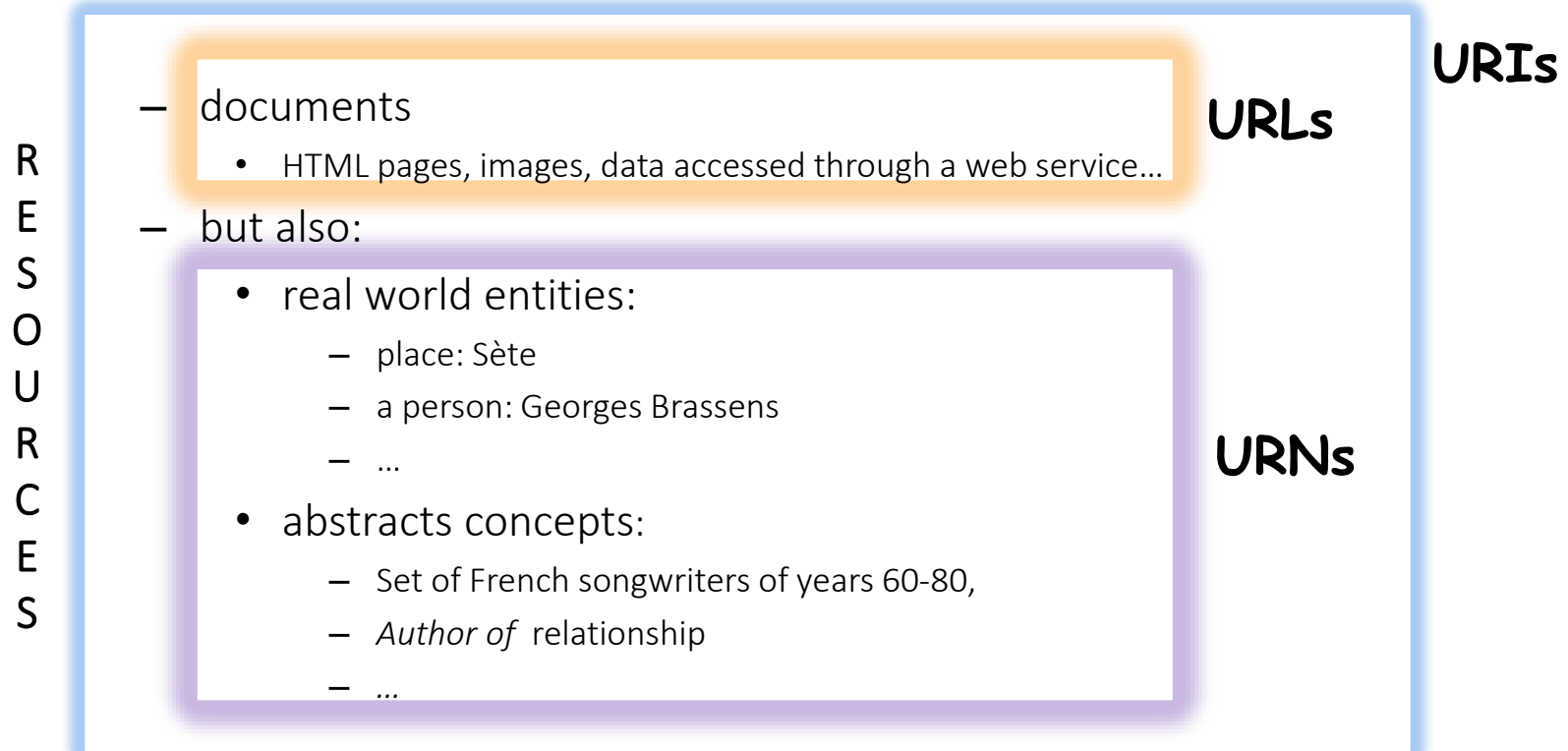
URIs, URLs, and URNs: Clarifications and Recommendations 1.0

Report from the joint W3C/IETF URI Planning Interest Group- W3C Note 21 September 2001

<http://www.w3.org/TR/uri-clarification/>

Resources in the Web of data

- Data describe elements (things) for a domain of interest through their properties and relationships.
- These elements can be:



- All these elements are resources identified by an URI

Examples of resources about Georges Brassens available in the web

Traditional web

Documents

identified
by URLs



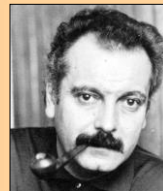
XML file containing structured data about Georges Brassens
http://dbpedia.org/data/Georges_Brassens.xml

Web page (HTML file)



http://fr.wikipedia.org/wiki/Georges_Brassens

Picture (jpeg file)



<http://culturetheque.org.uk/media/item/17545/800/brassens.jpg>



Video
(mp4 file)

<https://www.youtube.com/watch?v=rs1ShTbqNbo>

Examples of resources about Georges Brassens available in the web

Traditional web

Documents

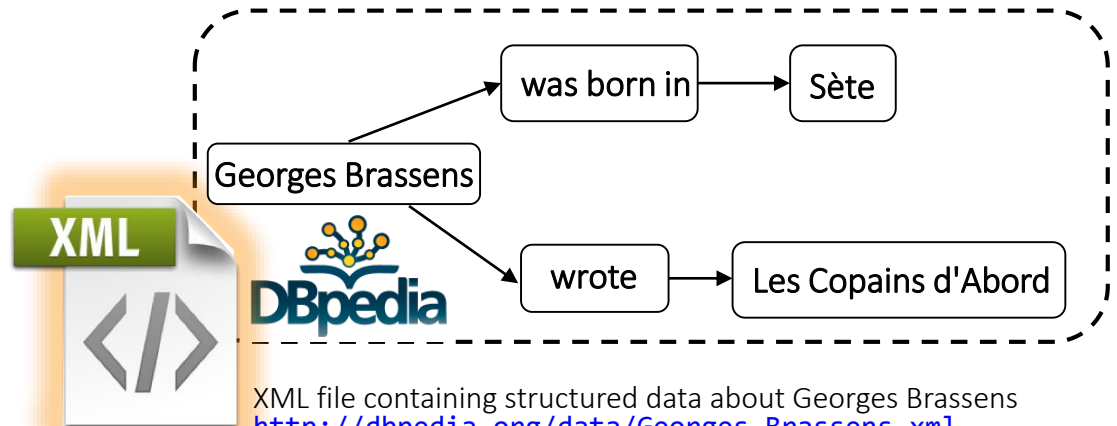
identified by URLs

Web of Data

Real world entities

identified by URNs

Abstract concepts



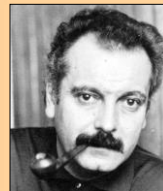
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Examples of resources about Georges Brassens available in the web

Traditional web

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identified by URLs

Web of Data

Real world entities

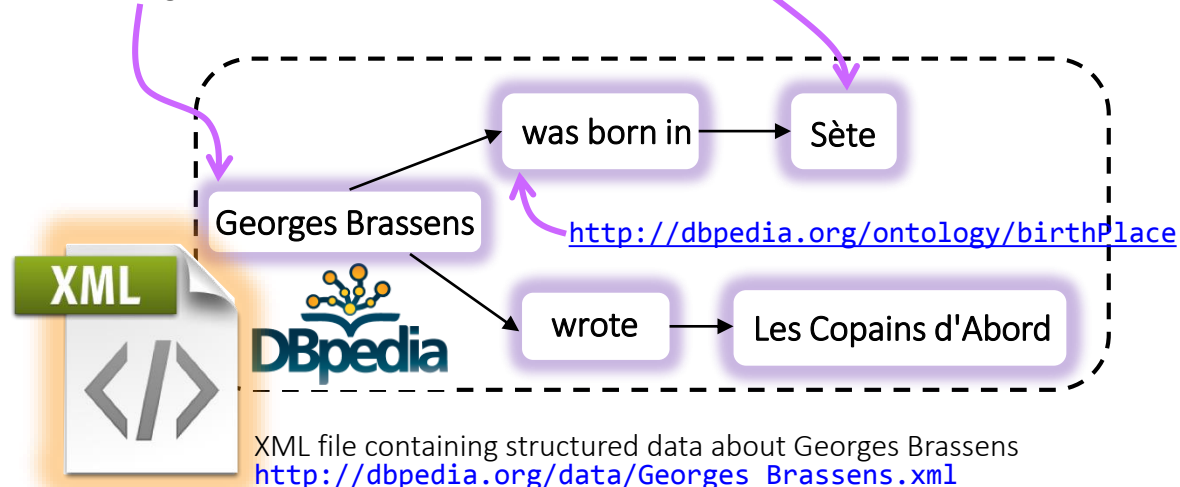
identified by URNs

Abstract concepts

http://dbpedia.org/resource/Georges_Brassens

DBpedia resource representing Georges Brassens

<http://dbpedia.org/resource/Sète>



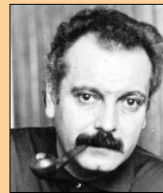
XML file containing structured data about Georges Brassens
http://dbpedia.org/data/Georges_Brassens.xml

Web page (HTML file)



http://fr.wikipedia.org/wiki/Georges_Brassens

Picture (jpeg file)



<http://culturetheque.org.uk/media/item/17545/800/brassens.jpg>



Video (mp4 file)

<https://www.youtube.com/watch?v=rs1ShTbqNbo>

Uniform Resource Identifiers (URIs)



represents

<http://dbpedia.org/resource/grenoble>

The name (URI) that represents the city of Grenoble in DBpedia

represents



GeoNames

<http://sws.geonames.org/3014728>

The name (URI) that represents the city of Grenoble in GeoNames

Different URIs (URNs) in different namespaces can represent the same thing

HTTP URIs



Linked Data: 2nd Principle
Use HTTP URIs, so that people and programs can look up those names

Most apps use only a subset of the stack

Querying allows fine-grained data access

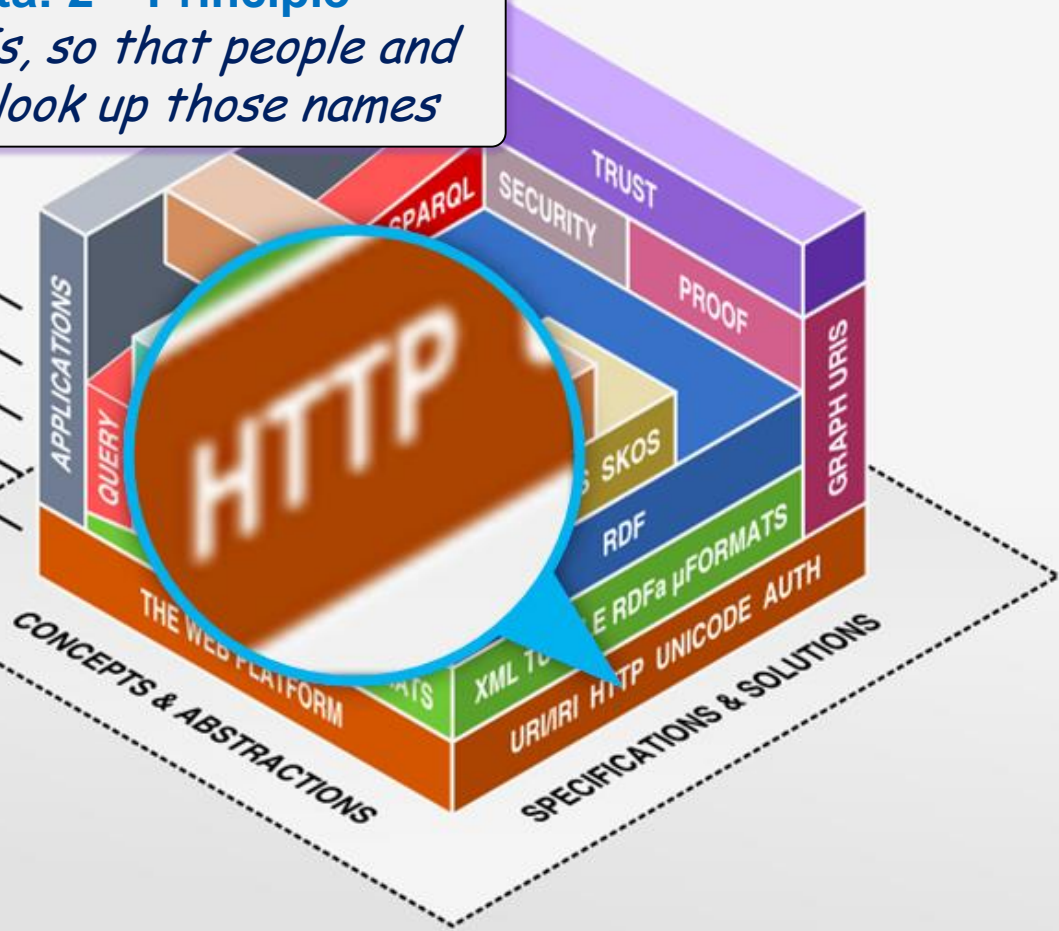
Standardized information exchange is key

Formats are necessary, but not too important

The Semantic Web is based on the Web

Linked Data uses a small selection of technologies

LINKED DATA



<http://www.bnode.org/blog/tag/layer%20cake> (Benjamin Nowack)

HTTP URIs

- HTTP (Hyper Text Transfer Protocol) protocol is the Web's universal access mechanism.
- HTTP URIs make good names for two reasons*:
 - They provide a simple way to create globally unique names in a decentralized fashion, as every owner of a domain name, or delegate of the domain name owner, may create new URI references.
 - They serve not just as a name but also as a means of accessing information describing the identified
 - HTTP clients can **dereference** (i.e., look up) the URI using the HTTP protocol and retrieve a description of the resource that is identified by the URI.

* Tom Heath and Christian Bizer (2011)

Linked Data: Evolving the Web into a Global Data Space (1st edition).

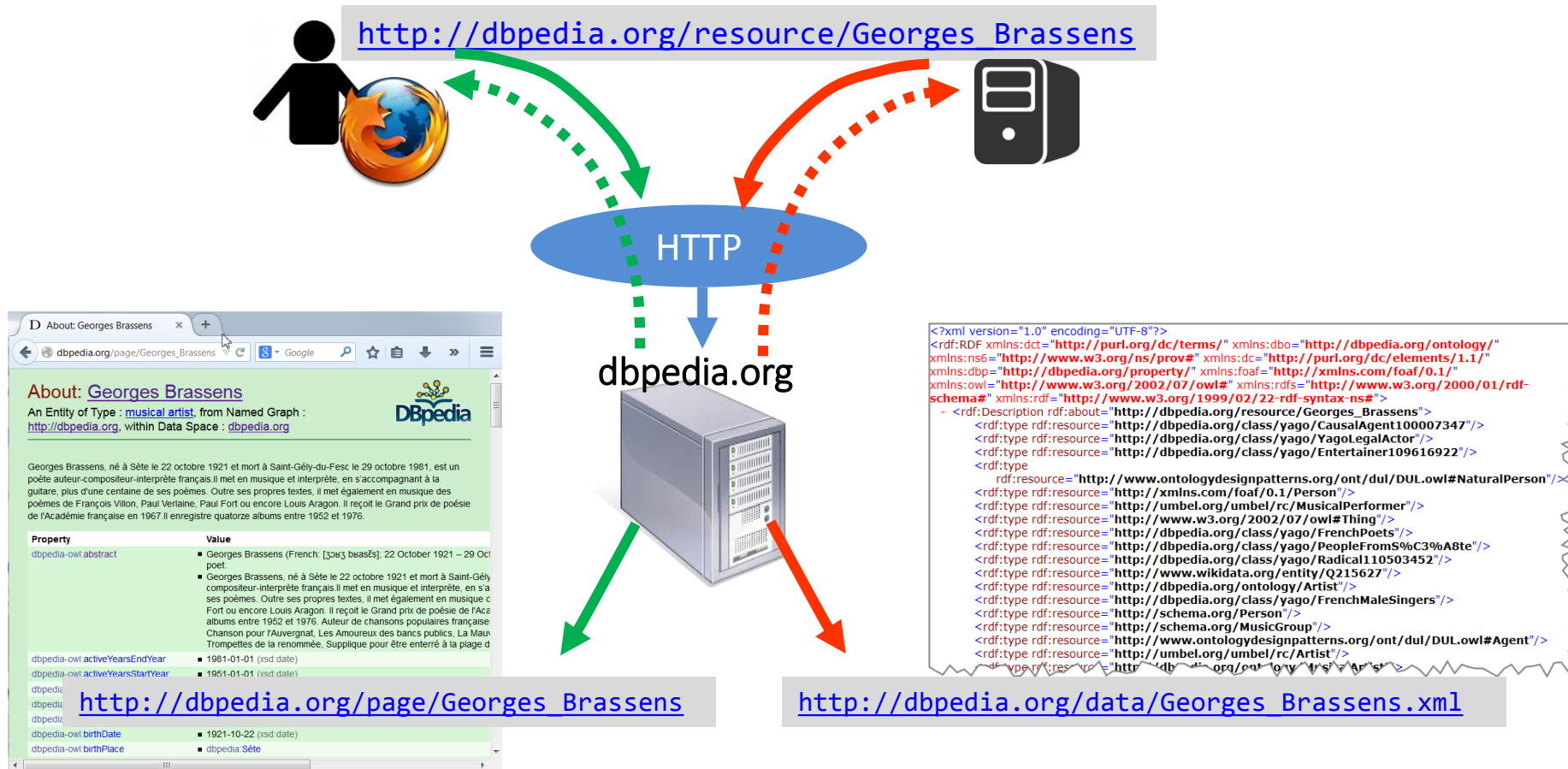
Synthesis Lectures on the Semantic Web: Theory and Technology, 1:1, 1-136. Morgan & Claypool.

<http://linkeddatabook.com/editions/1.0/>

Making URIs Dereferenceable

Content negotiation (303 URIs)

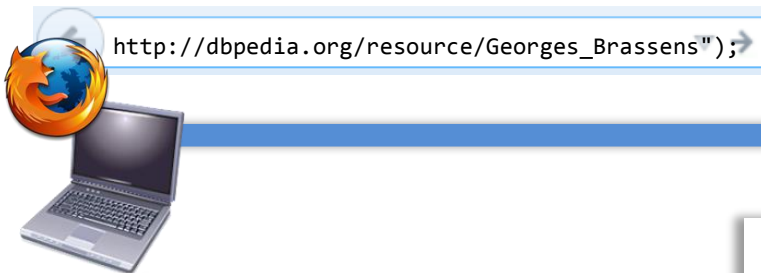
- The same URI can be used to retrieve different representations.



Making URIs Dereferenceable

Content negotiation (303 URIs)

- Contents negotiation uses HTTP headers to retrieve the resource description

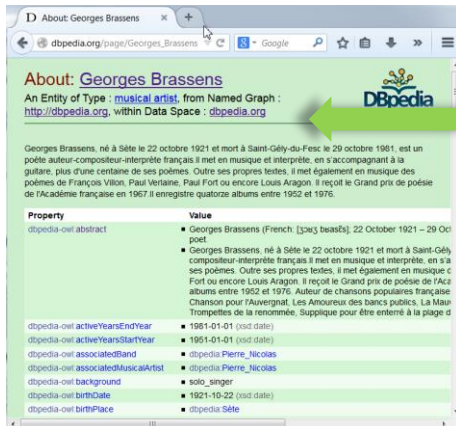


```
GET /resource/Georges_Brassens HTTP/1.1
Host: dbpedia.org
Accept: text/html
```



```
HTTP/1.1 303 See Other
Location: http://dbpedia.org/page/Georges_Brassens
Vary: Accept
```

```
GET /page/Georges_Brassens HTTP/1.1
Host: dbpedia.org
Accept: text/html
```



```
HTTP/1.1 200 OK
Content-Type: text/html
```

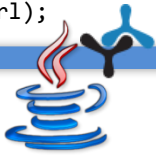
```
<?xml version="1.0" encoding="UTF-8" ?>
<!DOCTYPE html>
<head>
  <title>About: Georges Brassens</title>
  ...
</head>
<body onload="init();" >
  <div id="header">
    <h1 id="title">About: Georges Brassens</h1>
    ...
```

Making URIs Dereferenceable

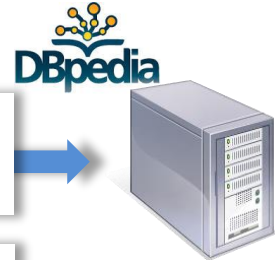
Content negotiation (303 URIs)

- Contents negotiation uses HTTP headers to retrieve the resource description

```
final String url = "http://dbpedia.org/resource/Georges_Brassens";  
final Model model = ModelFactory.createDefaultModel();  
model.read(url);
```



```
GET /resource/Georges_Brassens HTTP/1.1  
Host: dbpedia.org  
Accept: application/rdf+xml
```



```
HTTP/1.1 303 See Other  
Location: http://dbpedia.org/data/Georges_Brassens.xml  
Vary: Accept
```

```
GET /data/Georges_Brassens.xml HTTP/1.1  
Host: dbpedia.org  
Accept: text/html
```

```
HTTP/1.1 200 OK  
Content-Type: application/rdf+xml
```

```
<?xml version="1.0" encoding="utf-8" ?>  
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"...>  
  <rdf:Description rdf:about="http://dbpedia.org/resource/Georges_Brassens">  
    <rdf:type rdf:resource="http://dbpedia.org/class/yago/PeopleFromS%C3%A8te" />  
    <rdf:type  
      rdf:resource="http://dbpedia.org/class/yago/FrenchPeopleOfItalianDescent" />  
    ...
```


Making URIs Dereferenceable

Hash URIs

- An other way to identify real world objects or abstract concepts without creating ambiguity with the document that contains it 's description is to use hash URIs.

Example of a hash URI used by Dbpedia RDF description of Georges Brassens

http://dbpedia.org/data/Georges_Brassens.xml

```
HTTP/1.1 200 OK
Content-Type: application/rdf+xml

<?xml version="1.0" encoding="utf-8" ?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" ...>
  <rdf:Description rdf:about="http://dbpedia.org/resource/Georges_Brassens">
    <rdf:type rdf:resource="http://dbpedia.org/class/yago/PeopleFromS%C3%A8te" />
    <rdf:type
      rdf:resource="http://dbpedia.org/class/yago/FrenchPeopleOfItalianDescent" />
```

XML



Georges Brassens

is a

French of Italian origin

term from the RDF vocabulary
to describe the type of a resource

Hash URI

<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>

base

fragment identifier

Making URIs Dereferenceable

Hash URIs

When a client wants to retrieve a hash URI, the HTTP protocol requires the fragment part to be stripped off before requesting the URI from the server

<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>



URL the RDF/XML document containing a description of the whole RDF vocabulary

```
GET /1999/02/22-rdf-syntax-ns
Host: www.w3.org
Accept: application/rdf+xml
```



www.w3.org

```
HTTP/1.1 200 OK
Content-Type: application/rdf+xml
```

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf=http://www.w3.org/1999/02/22-rdf-syntax-ns#
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:dc="http://purl.org/dc/elements/1.1/">
```

```
...
<rdf:Property rdf:about="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">
  <rdfs:isDefinedBy rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#"/>
  <rdfs:label>type</rdfs:label>
  <rdfs:comment>The subject is an instance of a class.</rdfs:comment>
  <rdfs:range rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
  <rdfs:domain rdf:resource="http://www.w3.org/2000/01/rdf-schema#Resource"/>
</rdf:Property>
```

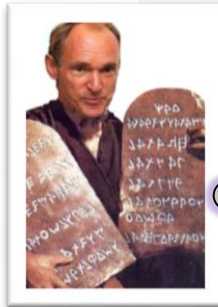
```
...
<rdfs:Class rdf:about="http://www.w3.org/1999/02/22-rdf-syntax-ns#Bag">
  <rdfs:isDefinedBy rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#"/>
  <rdfs:label>Bag</rdfs:label>
  <rdfs:comment>The class of unordered containers.</rdfs:comment>
```

Client is in charge of extracting the information associated to the fragment

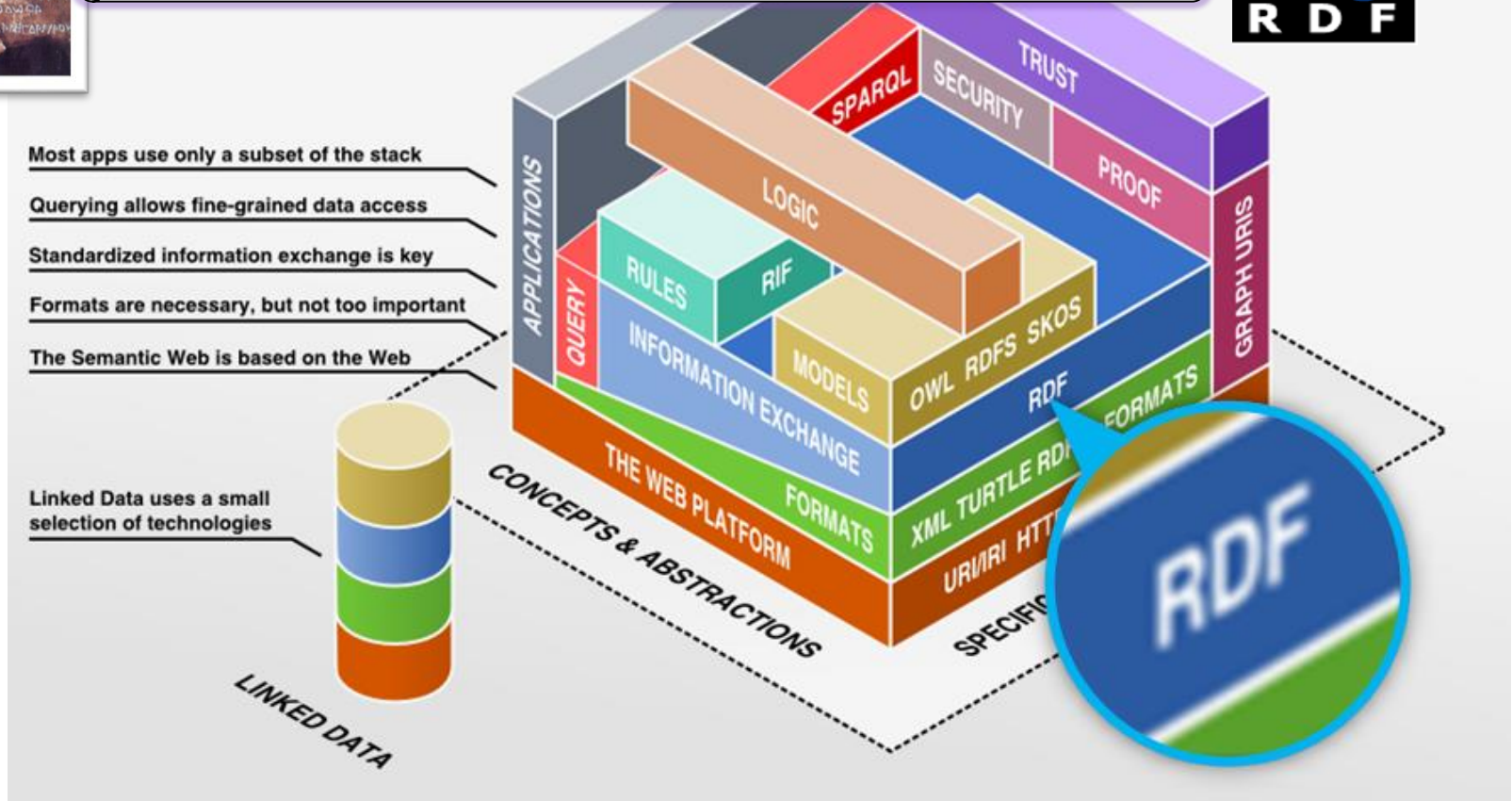
Outline

- “Theoretical” Session (morning)
 - Introduction
 - Distributing Data on the web with RDF
 - Naming the Data : URIs (Uniform Resources Identifiers)
 - The RDF Data model
 - Querying Linked Data with SPARQL
 - Semantic modelling
 - RDFS
 - OWL
 - From Open Data to Linked Open Data
 - Conclusion
- Hands-on session (afternoon)
 - From a CSV file to linked data
 - Querying linked data (SPARQL)

Resource Description Framework (RDF)



Linked Data: 3rd Principle
When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL).



<http://www.bnode.org/blog/tag/layer%20cake> (Benjamin Nowack)

Resource Description Framework

- RDF Resource Description Framework
 - a framework for describing resources on the web
 - "The Resource Description Framework (RDF) is a framework for representing information in the Web." [1]
 - is designed to be read and understood by computers
 - RDF is a part of the W3C's Semantic Web Activity
 - became a W3C recommendation 10. February 2004
 - Updated February 2014 (RDF 1.1)

<http://www.w3.org/TR/2014/REC-rdf11-concepts-20140225/> [1]

<http://www.w3.org/TR/2014/NOTE-rdf11-primer-20140624/> [2]

Resource ?

- *"The Resource Description Framework (RDF) is a language for **representing information about resources in the World Wide Web**. It is particularly intended for representing metadata about Web resources, such as the title, author, and modification date of a Web page, copyright and licensing information about a Web document, or the availability schedule for some shared resource. **However, by generalizing the concept of a "Web resource", RDF can also be used to represent information about things that can be identified on the Web, even when they cannot be directly retrieved on the Web.**"*

<http://www.w3.org/TR/rdf-primer/>

- *"To publish data on the Web, the **items in a domain of interest must first be identified**. These are the things whose properties and relationships will be described in the data, and may include Web documents as well as real-world entities and abstract concepts. As Linked Data builds directly on Web architecture , the Web architecture term **resource** is used to refer **to these things of interest**, which are, in turn, identified by HTTP URIs."*

Tom Heath, Christian Bizer : *Linked Data: Evolving the Web into a Global DataSpace*

<http://linkeddatabook.com/editions/1.0/>



RDF outline

- **RDF Data Model**
- RDF formats
- Blank nodes
- Typed literals
- Resources definition
- RDF an data integration
- Persisting RDF
- References

RDF Data Model

- With RDF, knowledge is represented by a set of assertions (statements)
- All RDF statements follow a simple structure composed of three parts :
 - **the thing** the statement describes
 - **the properties** of the thing the statement describes
 - **the values** of those properties the statement describe

the thing described	property	value
Georges Brassens	was born in	Sète

RDF Data Model

- RDF Statements are *triples*

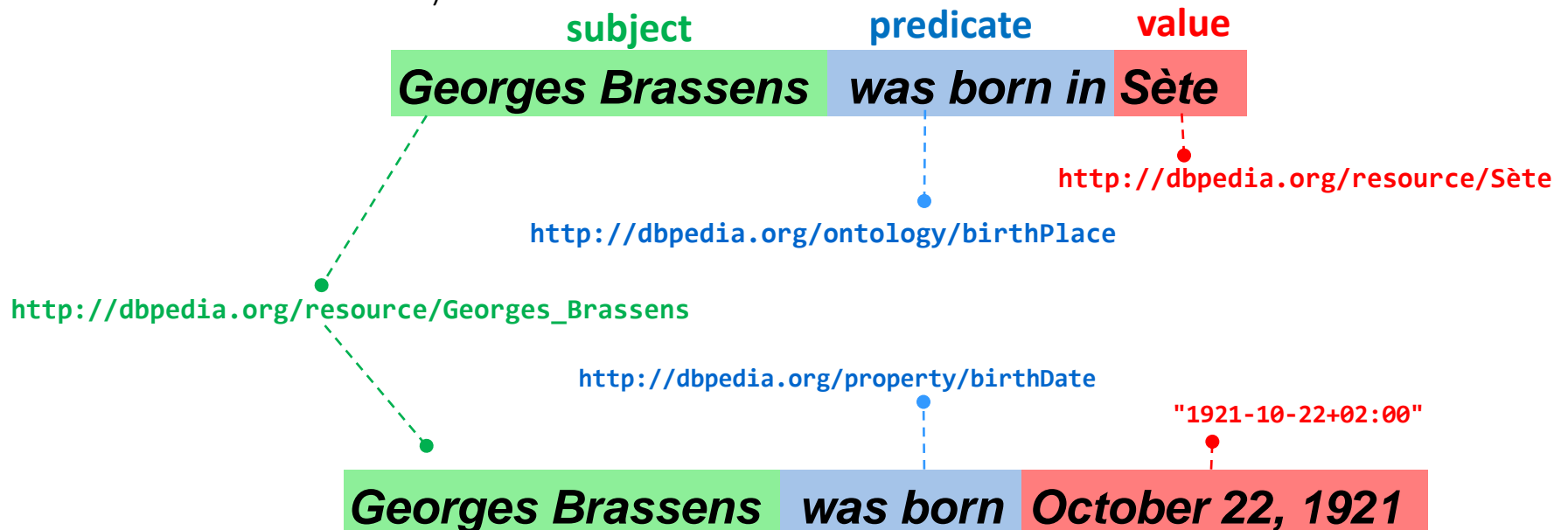
Subject **Predicate** **Object**

URI

URI

URI/Literal

- the subject and the predicate are resources : RDF uses URIs (Universal Resource Identifiers) for **uniquely identifying** them
- object can be a **resource** (URI) or a **literal** (constants that don't have other attributes that describe them)



RDF Data Model

- RDF Statements are *triples*

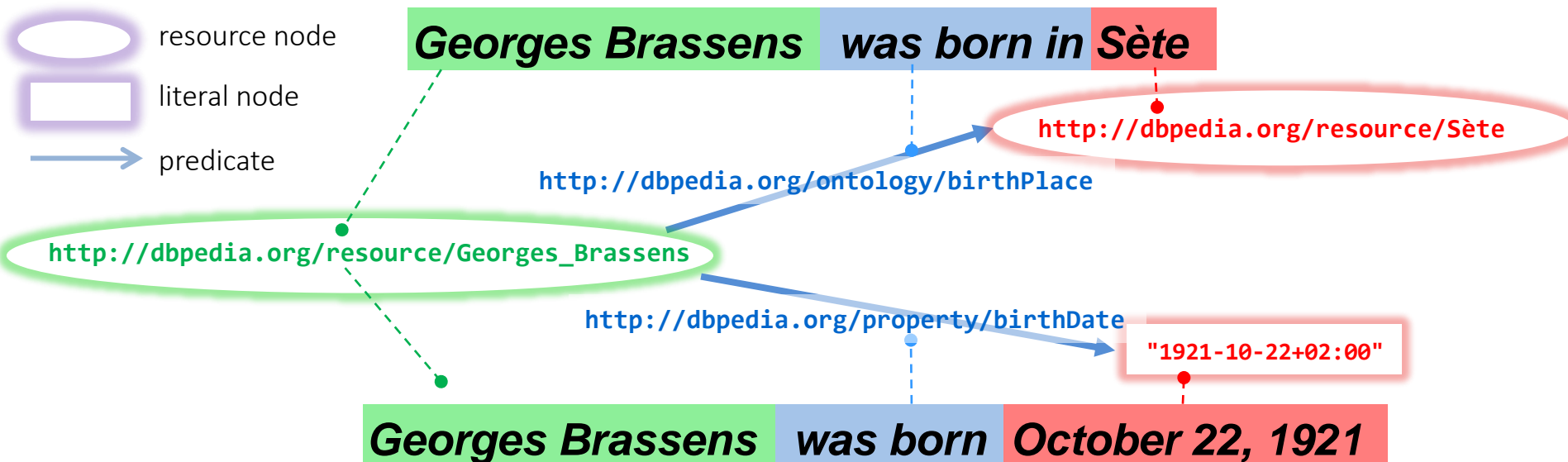
Subject **Predicate** **Object**

URI

URI

URI/Literal

- RDF data can be viewed as a directed labeled graph
 - subjects and objects are nodes (vertices)
 - predicates are oriented edges (arcs)



RDF outline

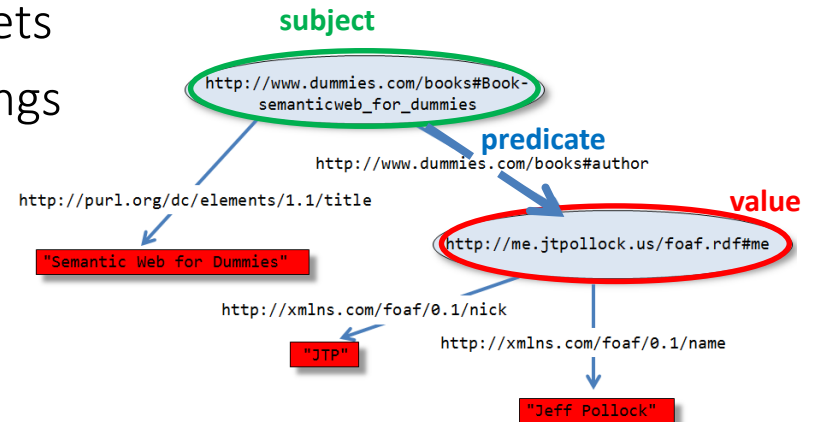
- RDF Model
- **RDF formats**
- Blank nodes
- Typed literals
- Resources definition
- RDF an data integration
- Persisting RDF
- References

RDF Serializations

- RDF Graphs
 - good for human analysis but unsuitable for application exchange
- RDF serialization
 - provides a way to convert between the abstract model and a concrete format (file or other byte stream)
 - several equally expressive serialization formats
 - XML/RDF (normative (standard) exchange format for serialization)
 - N-Triples
 - Turtle (Terse RDF Triple Language)
 - N3 (Notation3)
 - RDF/JSON
 - RDFa

RDF Serialization - N-Triples

- the simplest notation
 - each line of output represents a single statement followed by '.'
 - resources (subject, predicate, resource object) are expressed as absolute URI enclosed in angle brackets
 - object literals are double-quoted strings



example.nt

subject

```
<http://www.dummies.com/books#Book-semanticweb_for_dummies>
predicate <http://www.dummies.com/books#author> value <http://me.jtpollock.us/foaf.rdf#me>.
<http://www.dummies.com/books#Book-semanticweb_for_dummies>
  <http://purl.org/dc/elements/1.1/title> "Semantic Web for Dummies".
<http://me.jtpollock.us/foaf.rdf#me> <http://xmlns.com/foaf/0.1/name> "Jeff Pollock".
<http://me.jtpollock.us/foaf.rdf#me> <http://xmlns.com/foaf/0.1/nick> "JTP".
```

- useful when hand-crafting data sets for application testing and debugging
- ... but **verbose** (redundant information takes additional time to transmit and parse)

RDF Serialization - N3 - Turtle

- **Notation3 (N3)** more compact format than N-Triples.
 - has several absolute features that go beyond a serialization for RDF models (e.g. support for RDF-based rules).
- **Turtle (Terse RDF Triple Language)**
 - a simplified, RDF-only subset of N3.
- Both condense much of the repetitions of N-Triples
 - URIs can be shortened by using a prefix declared at the beginning of the document

```
<http://www.dummies.com/books#Book-semanticweb\_for\_dummies>  
<http://www.dummies.com/books#author> <http://me.jtpollock.us/foaf.rdf#me>.
```



```
@prefix swbook: <http://www.dummies.com/books#>.
```

```
@prefix jtp: <http://me.jtpollock.us/foaf.rdf#>.
```

```
swbook:Book-semanticweb_for_dummies swbook:author jtp:me.
```


RDF Serialization - N3 - Turtle

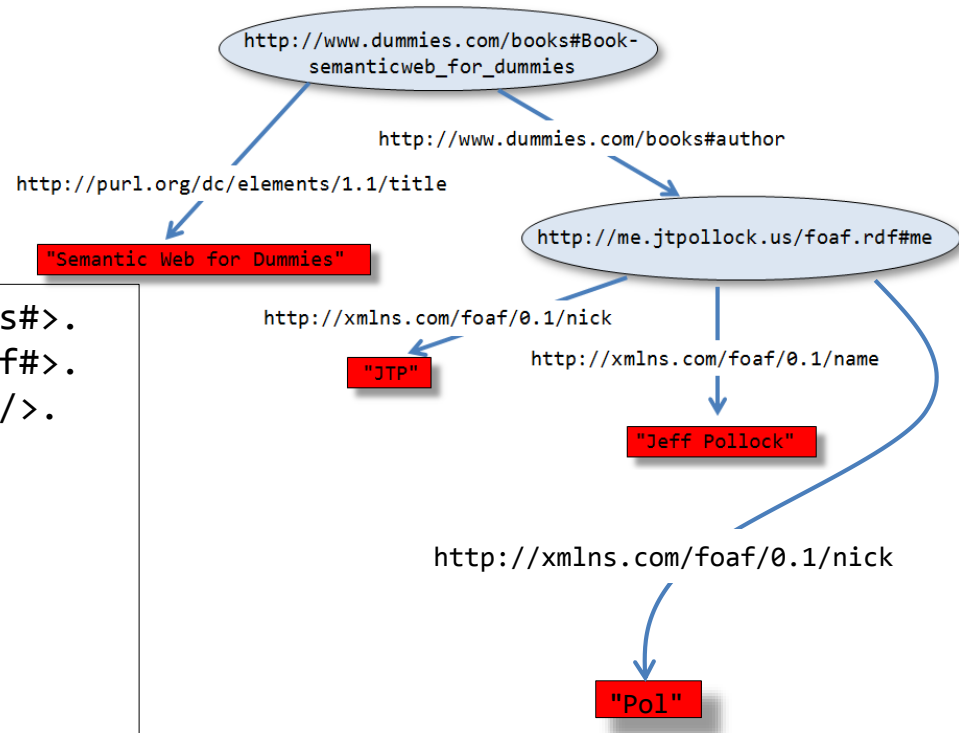
- possibility to combine multiple statements about the same subject using a semicolon (';')
- possibility to combine multiple statements involving the same subject and predicate using a coma (',')

example.ttl

```
@prefix swbook: <http://www.dummies.com/books#>.
@prefix jtp: <http://me.jtpollock.us/foaf.rdf#>.
@prefix dc: <http://purl.org/dc/elements/1.1/>.
@prefix foaf: <http://xmlns.com/foaf/0.1/>.
```

```
swbook:Book-semanticweb_for_dummies
  swbook:author jtp:me;
  dc:title "Semantic Web for Dummies".
```

```
jtp:me
  foaf:name "Jeff Pollock";
  foaf:nick "JTP", "Pol" .
```



RDF Serializations : RDF/XML

- RDF/XML , 1^{rst} syntax standardized by W3C (2004)
- Statements about a resource are grouped in a **rdf:Description** element
- general form

gives the subject of all statement within the description

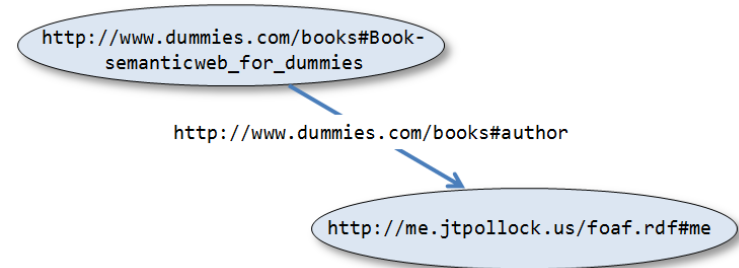
```
<rdf:Description rdf:about="subjectURI">  
  <predicate rdf:resource="objectURI" />  
  <predicate>literal value</predicate>  
</rdf:Description>
```

name of the internal tags represent a predicate

the object is represented differently depending on whether it is a resource or a literal

RDF Serializations : RDF/XML

- Example



XML declaration (states that's an XML document)

```
<?xml version="1.0"?>
```

```
<rdf:RDF
```

```
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:books="http://www.dummies.com/books#">
```

```
  <rdf:Description
```

```
    rdf:about="http://www.dummies.com/books#Book-semanticweb_for_dummies">
```

```
    <books:author
```

```
      rdf:resource="http://me.jtpollock.us/foaf.rdf#me" />
```

```
  </rdf:Description>
```

```
</rdf:RDF>
```

opening
and
closing
root tag

XML namespaces

`rdf:DescriptionElement`
for statements about a
resource

Resources URIs

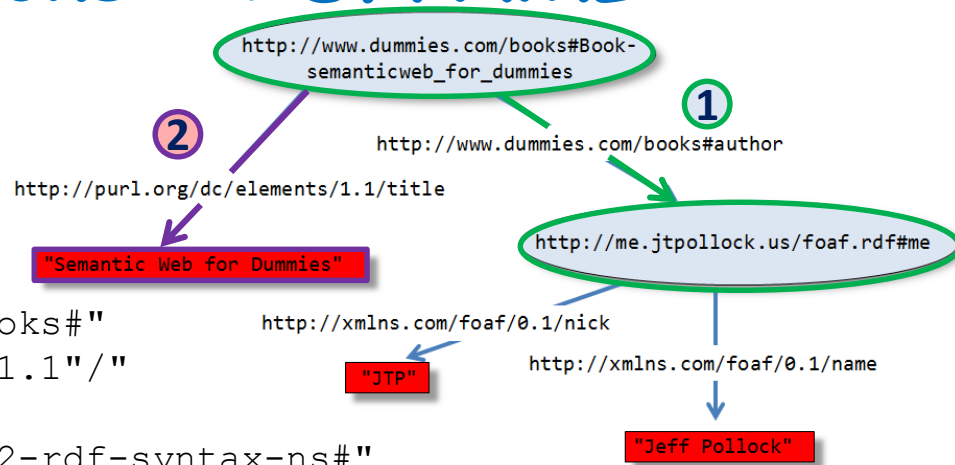
RDF Serializations : RDF/XML

- Example

```
<?xml version="1.0"?>
```

```
<rdf:RDF
```

```
  xmlns:books="http://www.dummies.com/books#"
  xmlns:dc="http://purl.org/dc/elements/1.1"/
  xmlns:foaf="http://xmlns.com/foaf"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
>
```



```
1 <rdf:Description
  rdf:about="http://www.dummies.com/books#Book-semanticweb_for_dummies">
  <books:author
    rdf:resource="http://me.jtpollock.us/foaf.rdf#me" />
</rdf:Description>
```

```
2 <rdf:Description
  rdf:about="http://www.dummies.com/books#Book-semanticweb_for_dummies">
  <dc:title>Semantic Web for Dumies<dc:title>
</rdf:Description>
```

```
<rdf:Description
  rdf:about="http://me.jtpollock.us/foaf.rdf#me">
  ...
</rdf:Description>
```

```
</rdf:RDF>
```

RDF Serializations : RDF/XML

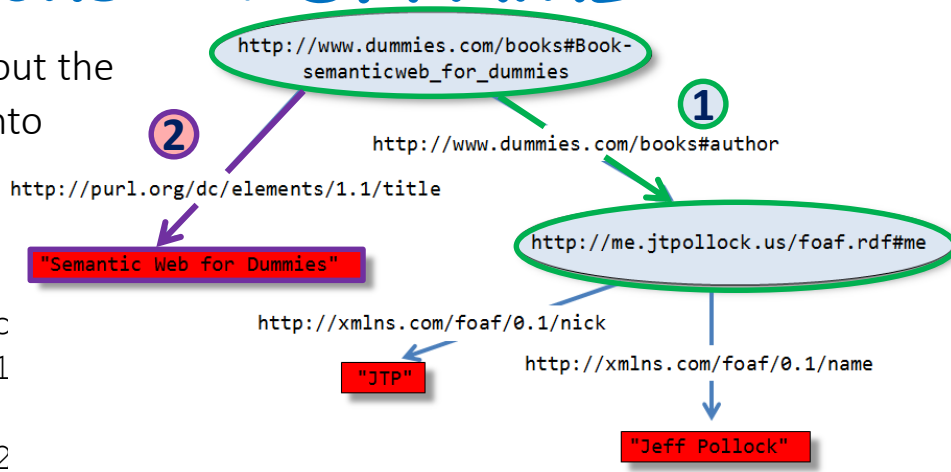
- **simplification:** when multiple descriptions about the same resource possibility to regroup them into one `rdf:Description` element

```
<?xml version="1.0"?>
```

```
<rdf:RDF
```

```
  xmlns:books="http://www.dummies.com/boc
  xmlns:dc="http://purl.org/dc/elements/1
  xmlns:foaf="http://xmlns.com/foaf"
  xmlns:rdf="http://www.w3.org/1999/02/22
```

```
>
```



```
<rdf:Description
  rdf:about="http://www.dummies.com/books#Book-semanticweb_for_dummies">
  <books:author
    rdf:resource="http://me.jtpollock.us/foaf.rdf#me" />
  <dc:title>Semantic Web for Dumies</dc:title>
</rdf:Description>
```

```
<rdf:Description
  rdf:about="http://me.jtpollock.us/foaf.rdf#me">
  ...
</rdf:Description>
```

```
</rdf:RDF>
```


RDF Serializations : RDF/XML

- simplification: use XML (DTD) entities to simplify URI attributes.

```
<?xml version="1.0"?>
```

```
<rdf:RDF
```

```
  xmlns:books="http://wwwdummies.com/books#"
  xmlns:dc="http://purl.org/dc/elements/1.1"/"
```

```
  xmlns:foaf="http://xmlns.com/foaf"
```

```
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
>
```

```
  <rdf:Description
```

```
    rdf:about="http://www.dummies.com/books#Book-semanticweb_for_dummies">
```

```
    <books:author
```

```
      rdf:resource="http://me.jtpollock.us/foaf.rdf#me" />
```

```
    <dc:title>Semantic Web for Dumies<dc:title>
```

```
  </rdf:Description>
```

```
  <rdf:Description
```

```
    rdf:about="http://me.jtpollock.us/foaf.rdf#me">
```

```
    ...
```

```
  </rdf:Description>
```

```
  ...
```

```
</rdf:RDF>
```

RDF Serializations : RDF/XML

- simplification: use XML (DTD) entities to simplify URI attributes.

<http://www.w3schools.com/dtd/default.asp>

- a **DTD** (Document Type Definition) defines the legal building blocks of an XML document → the document structure with a list of legal elements and attributes.

```
<!DOCTYPE NEWSPAPER [  
  
<!ELEMENT NEWSPAPER (ARTICLE+)>  
<!ELEMENT ARTICLE (HEADLINE,BYLINE,LEAD,BODY,NOTES)>  
<!ELEMENT HEADLINE (#PCDATA)>  
<!ELEMENT BYLINE (#PCDATA)>  
<!ELEMENT LEAD (#PCDATA)>  
<!ELEMENT BODY (#PCDATA)>  
<!ELEMENT NOTES (#PCDATA)>  
  
<!ATTLIST ARTICLE AUTHOR CDATA #REQUIRED>  
<!ATTLIST ARTICLE EDITOR CDATA #IMPLIED>  
<!ATTLIST ARTICLE DATE CDATA #IMPLIED>  
<!ATTLIST ARTICLE EDITION CDATA #IMPLIED>  
  

```

- **Entities** : variables used to define shortcuts to standard text or special characters.

entity declaration

```
<!ENTITY entity-name "entity-value">
```

entity usage

```
&entity-name;
```

example

```
<ENTITY writer "Donald Duck.">  
<ENTITY copyright "Copyright W3Schools.">  
  
<author>&writer;&copyright;</author>
```

RDF Serializations : RDF/XML

- simplification: use XML (DTD) entities to simplify URI attributes.

```
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF
  [ <!ENTITY books "http://www.dummies.com/books#">
    <!ENTITY myfoaf "http://me.jtpollock.us/foaf.rdf#" >
  ]
>
<rdf:RDF
  xmlns:books="http://www.dummies.com/books#"
  xmlns:dc="http://purl.org/dc/elements/1.1/"
  xmlns:foaf="http://xmlns.com/foaf"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
>
  <rdf:Description
    rdf:about="&books;Book-semanticweb_for_dummies">
    <books:author
      rdf:resource="&myfoaf;me">
    <dc:title>Semantic Web for Dumies</dc:title>
  </rdf:Description>
  <rdf:Description
    rdf:about="&myfoaf;me">
    ...
  </rdf:Description>
  ...

```

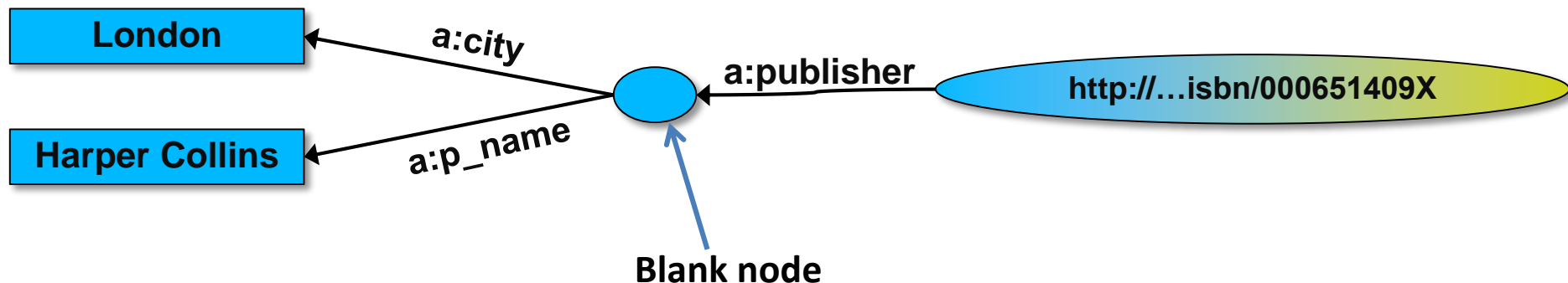
RDF outline

- RDF Model
- RDF formats
- **Blank nodes**
- Typed literals
- Resources definition
- RDF an data integration
- Persisting RDF
- References

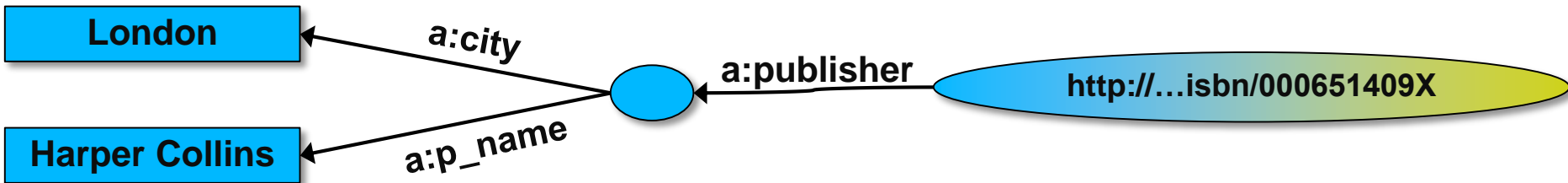
RDF Blank nodes

- there are some situations where you don't know the URI of the thing you would like to reference or there is no identifier available
 - but not having a URI for the item doesn't mean you can't talk about it
- RDF provides anonymous (blank) nodes

Consider the following statement: “the publisher is a «thing» that has a name and an address” ... what is the URI of «thing»?

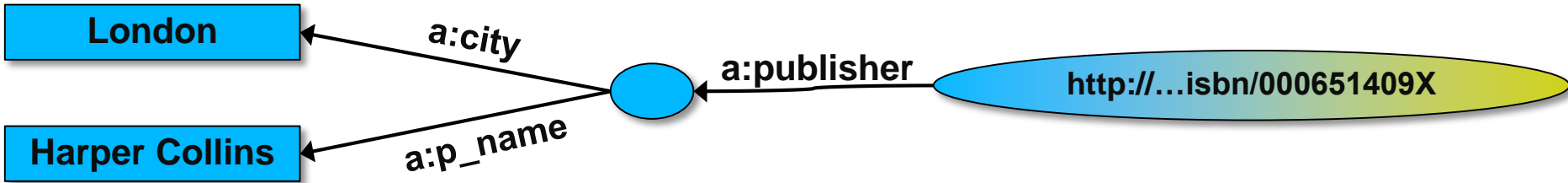


Blank nodes - RDF/XML



```
<rdf:Description rdf:about="http://.../isbn/000651409X">  
  <a:publisher rdf:nodeID="A234"/>  
</rdf:Description>  
<rdf:Description rdf:nodeID="A234">  
  <a:p_name>HarpersCollins</a:p_name>  
  <a:city>London</a:city>  
</rdf:Description>
```

Blank nodes - N3 - Turtle



dereferenceable
blank node

```
<http://.../isbn/2020386682> a:publisher _:A234.  
_:A234 a:p_name "HarpersCollins";  
a:city "London".
```

Anonymous
blank node

```
<http://.../isbn/000651409X> a:publisher [  
a:p_name "HarpersCollins";  
a:city "London".  
].
```

RDF outline

- RDF Model
- RDF formats
- Blank nodes
- **Typed literals**
- Resources definition
- RDF an data integration
- Persisting RDF
- References

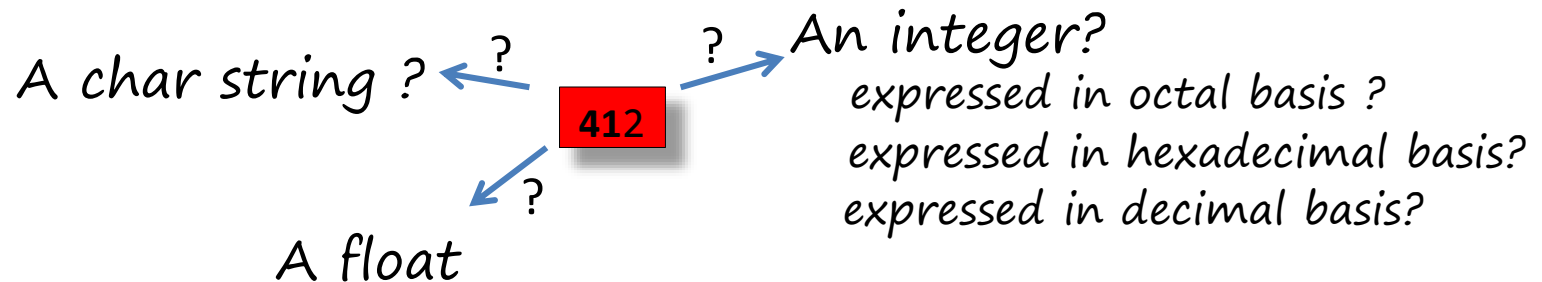
Typed Literals

- Literal are not resources : they are values



When looking at that description a human can easily realize that 412 is an integer.

But what about a computer program ?



You must provide **some context** if you intend to use the value in any other way than to just view it on a web page → **typed literals**

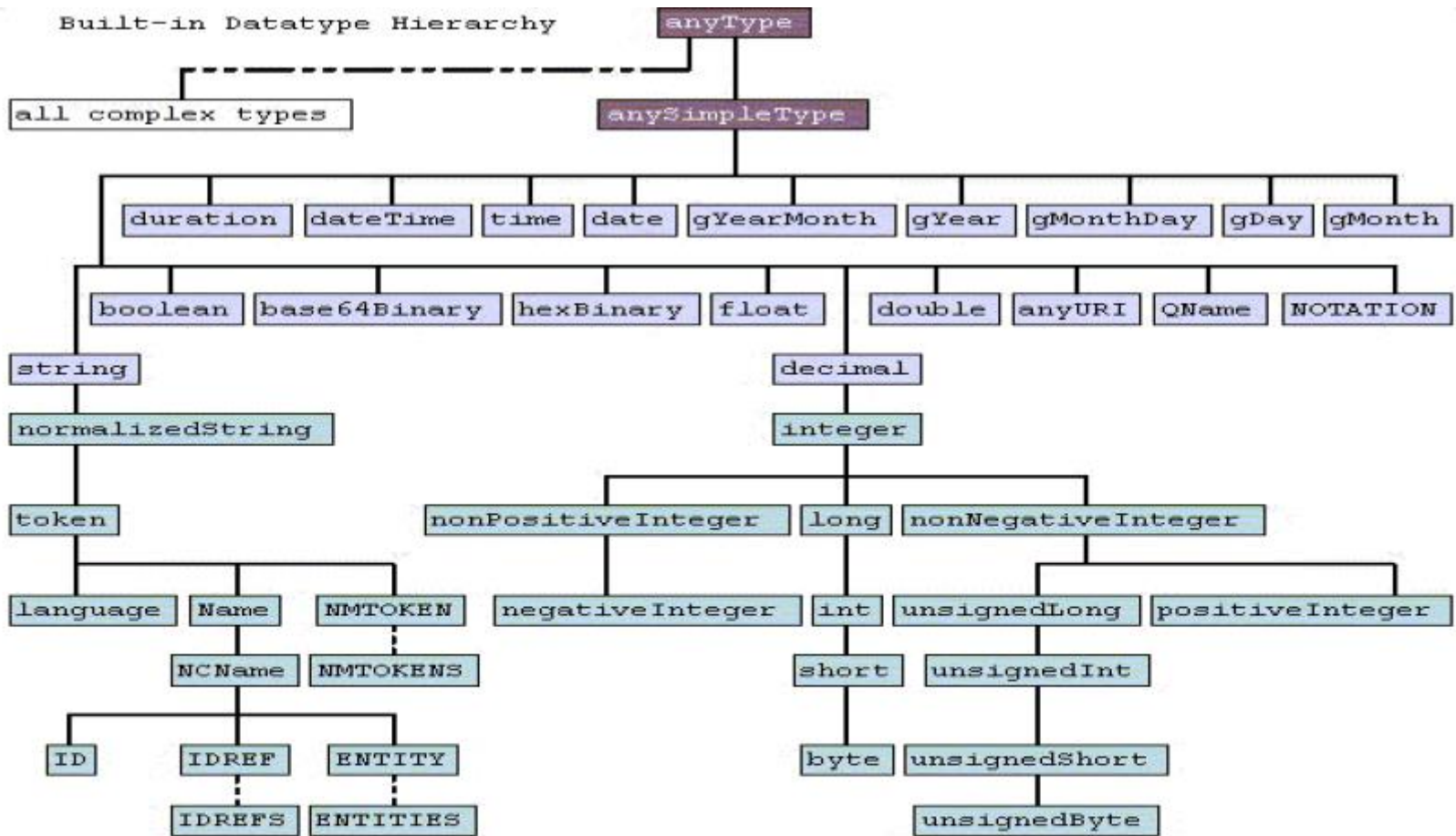
Typed Literals

- How to define a type (datatype) ?
 - **value space** : the set of values represented by the type
 - - e.g. an integer interval , dates,
 - **lexical space** : the set of char strings defining the representations of the values
 - eg. dates : `yy-mm-dd` or `dd-mm-yy`
 - a **mapping** between the lexical space and the value space
 - associating a concrete value with each eligible literal

Typed Literals : XSD

- To associate type to literals RDF uses XSD (XML Schema Definition)
 - W3C recommendations :
 - <http://www.w3.org/TR/xmlschema-2/>
 - <http://www.w3.org/TR/rdf-mt/>
 - XSD defines a predefined datatype hierarchy (see next slide)
 - primitive types (string, float, decimal, etc.)
 - derived types (integer, long, etc.)
 - new types can be defined by derivation
 - restriction
 - lists
 - union
 - extension

Typed Literals: XSD



- ur types
- built-in primitive types
- built-in derived types
- complex types
- derived by restriction
- derived by list
- derived by extension or restriction

Typed Literals: XSD

- examples of definition of new data types

new type derived by restrictions

```
<xsd:schema ...>
```

```
  <xsd:simpleType name="humanAge">
```

```
    <xsd:restriction base="integer">
```

```
      <xsd:minInclusive value="0">
```

```
      <xsd:maxExclusive value="150">
```

```
    </xsd:restriction>
```

```
  </xsd:simpleType>
```

```
  ...
```

```
</xsd:schema>
```

the "super" type

} constraints to express the restriction

new type derived by list

```
<simpleType name="listOfFloat">
```

```
  <list itemType="float"/>
```

```
</simpleType>
```

type of the list elements

+ constraints about the list length, maxLength, minLength

Typed Literals : XSD

new type derived by union and extension

```
<xsd:simpleType name="fontsize">  
  <xsd:union>  
    <xsd:simpleType>  
      <xsd:restriction base="xsd:positiveInteger">  
        <xsd:minInclusive value="8"/>  
        <xsd:maxInclusive value="72"/>  
      </xsd:restriction>  
    </xsd:simpleType>  
    <xsd:simpleType>  
      <xsd:restriction base="xsd:NMTOKEN">  
        <xsd:enumeration value="small"/>  
        <xsd:enumeration value="medium"/>  
        <xsd:enumeration value="large"/>  
      </xsd:restriction>  
    </xsd:simpleType>  
  </xsd:union>  
</xsd:simpleType>
```

type defined
by union

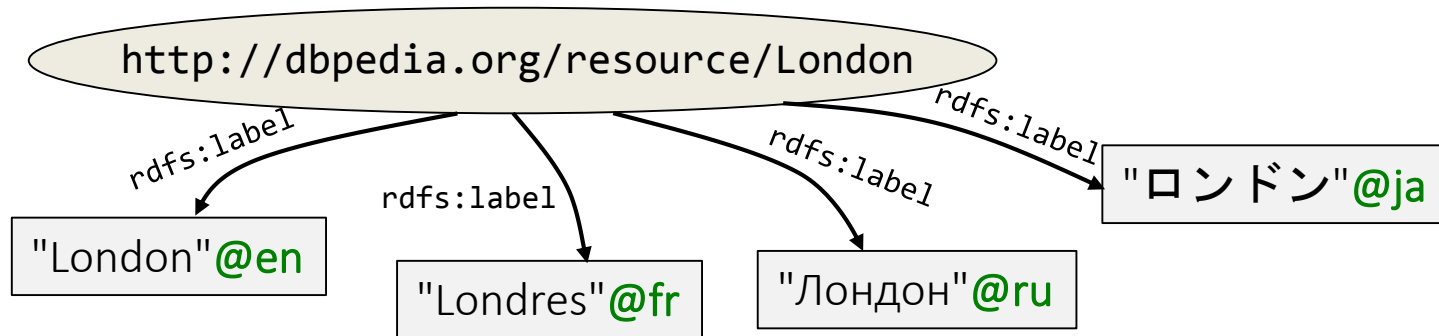
type defined by
restrictions

type defined
by extension

fontsize : 8-72 or small, medium, large

Localized textual literals

- A language can be associated to textual literals



RDF/XML

```
<rdf:RDF (...)>
<rdf:Description rdf:about="http://dbpedia.org/resource/London">
  <rdfs:label xml:lang='en'>London</rdfs:label>
  <rdfs:label xml:lang='fr'>Londres</rdfs:label>
  ...
</rdf:Description>
</rdf:RDF>
```

Turtle

```
@prefix rdfs:< http://www.w3.org/2000/01/rdf-schema#>.

<http://dbpedia.org/resource/London>
  rdfs:label "Londres"@fr, ... , "London"@en.
```

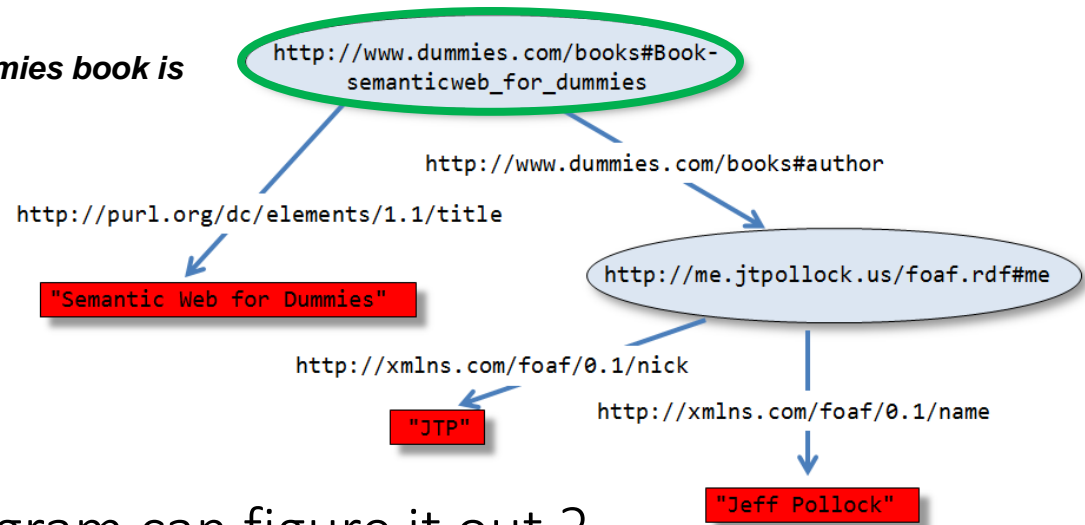
RDF outline

- RDF Model
- RDF formats
- Blank nodes
- Typed literals
- **Resources definition**
- RDF an data integration
- Persisting RDF
- References

Identifying the type of a resource

- the same way literals can be typed, it's possible to associate a type to a resource

The Semantic Web For Dummies book is authored by Jeff Pollock



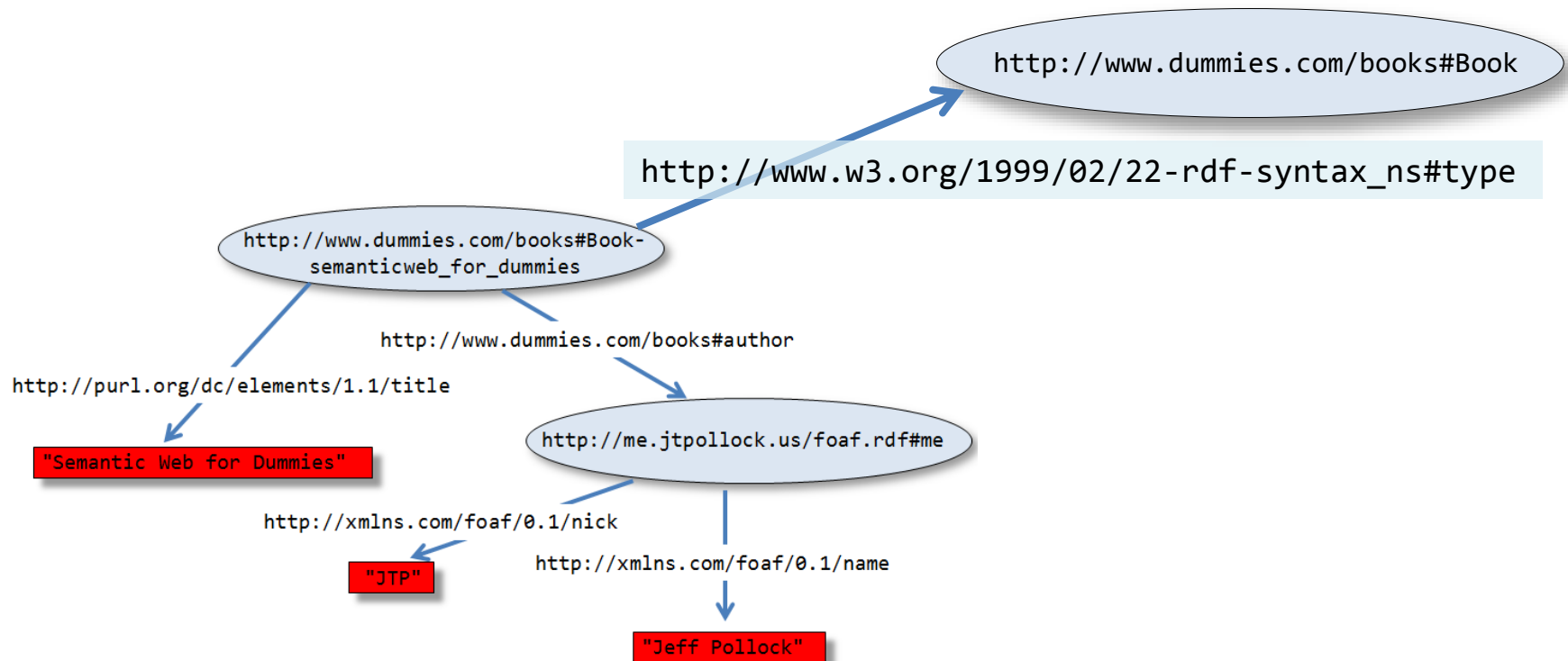
We know it's a book...

but how a computer program can figure it out ?

To solve the problem of classifying resources a way the software can understand, RDF vocabulary has a predefined predicate : `rdf:type`

Identifying the type of a resource

- `rdf:type` predicate's semantics
 - the value of this predicate is a resource and represents a class of things
 - the subject of this predicate is also an instance of that class



Identifying the type of a resource

- N3 - Turtle

```
@prefix swbook: <http://www.dummies.com/books#>.
```

```
swbook:Book-semanticweb_for_dummies
```

```
    swbook:author <http://me.jtpollock.us/foaf.rdf#me>;
```

shortcut for
rdf:type

↗ **a swbook:Book.**

- XML/RDF

```
<?xml version="1.0"?>
```

```
<rdf:RDF
```

```
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:books="http://www.dummies.com/books#">
```

```
  <rdf:Description
```

```
    <rdf:about="http://www.dummies.com/books#Book-semanticweb_for_dummies">
```

```
      <rdf:type rdf:resource="http://www.dummies.com/books#Book"/>
```

```
      <books:author
```

```
        <rdf:resource="http://me.jtpollock.us/foaf.rdf#me" />
```

```
      </rdf:Description>
```

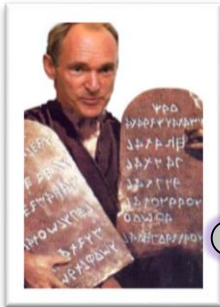
```
    </rdf:Description>
```

```
</rdf:RDF>
```

RDF outline

- RDF Model
- RDF formats
- Blank nodes
- Typed literals
- Resources definition
- **RDF an data integration**
- Persisting RDF
- References

RDF and Data Integration



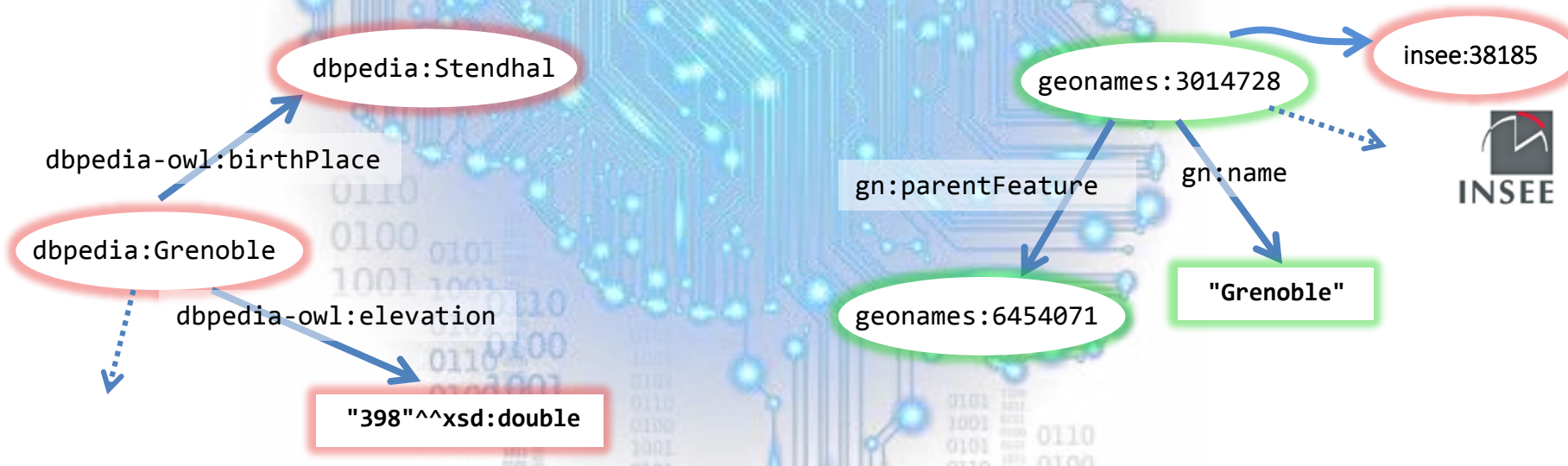
Linked Data : 4th Principle
Include links to other URIs, so that they can discover more things.



GeoNames

<http://dbpedia.org/resource/grenoble>

<http://sws.geonames.org/6454071>



RDF and Data Integration

adaptation of presentations by Ivan Herman (W3C) ivan@w3.org at
Semantic Technology Conferences 2009 et 2011
(San Jose, CA. USA, June, 2009) (San Francisco, CA. USA, June, 2011)

<http://www.w3.org/2009/Talks/0615-SanJose-tutorial-IH/>
<http://www.w3.org/2011/Talks/0606-SemTech-Tut-IH/>



- Dataset "A": a simplified bookstore data base

BOOKS

ID	Author	Title	Publisher	Year
ISBN 0-00-6511409-X	id_xyz	The Glass Palace	id_qpr	2000

FK

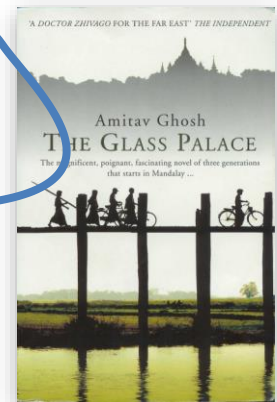
FK

AUTHORS

ID	Name	Homepage
id_xyz	Ghosh, Amitav	http://www.amitavghosh.com

PUBLISHERS

ID	Publisher's name	City
id_qpr	Harper Collins	London



RDF and Data Integration

BOOKS

ID	Author	Title	Publisher	Year
ISBN 0-00-6511409-X	id_xyz	The Glass Palace	id_qpr	2000

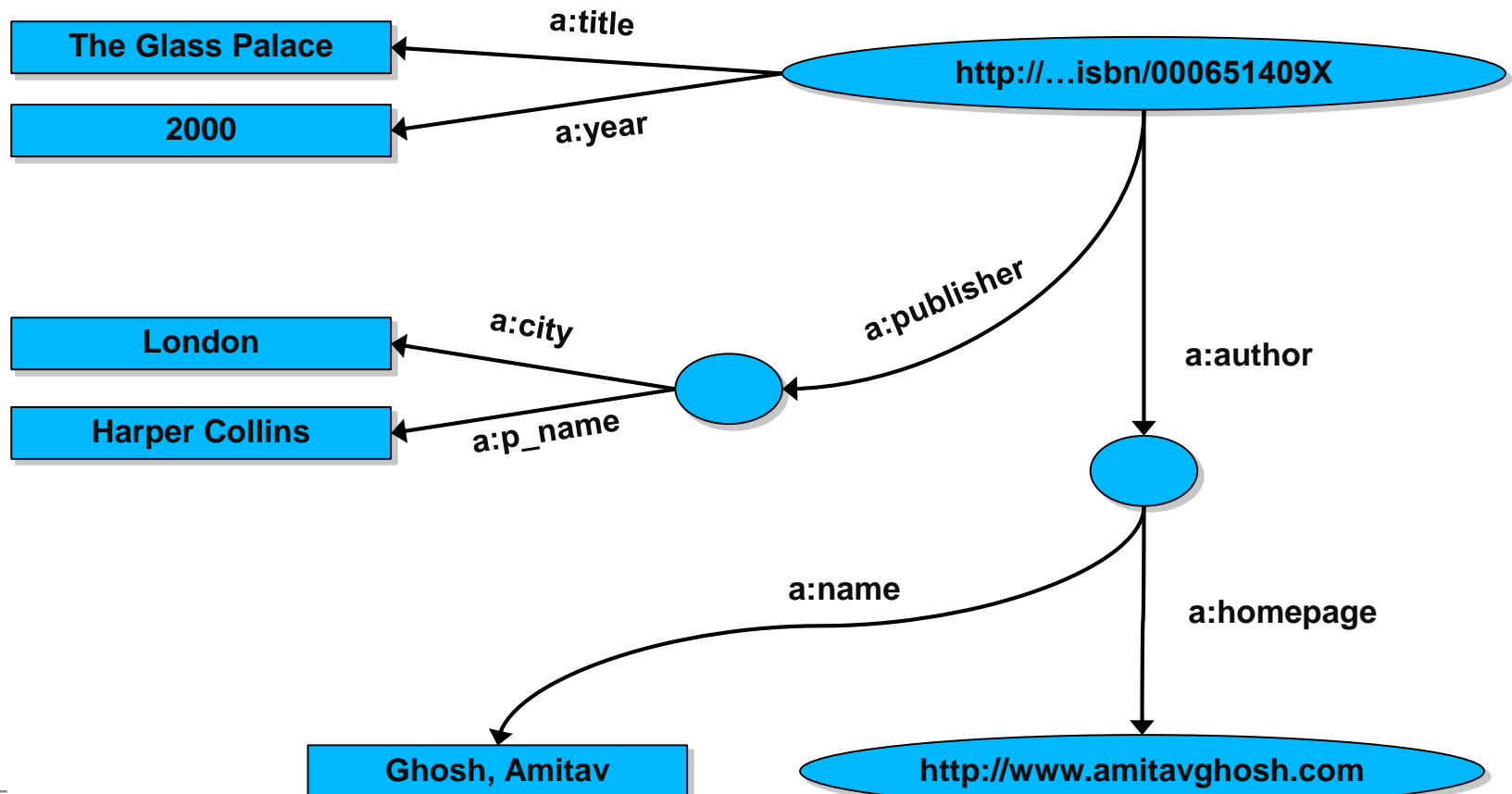
AUTHORS

ID	Name	Homepage
id_xyz	Ghosh, Amitav	http://www.amitavghosh.com

PUBLISHERS

ID	Publisher's name	City
id_qpr	Harper Collins	London

- 1st: export your data as a RDF graph



RDF and Data Integration

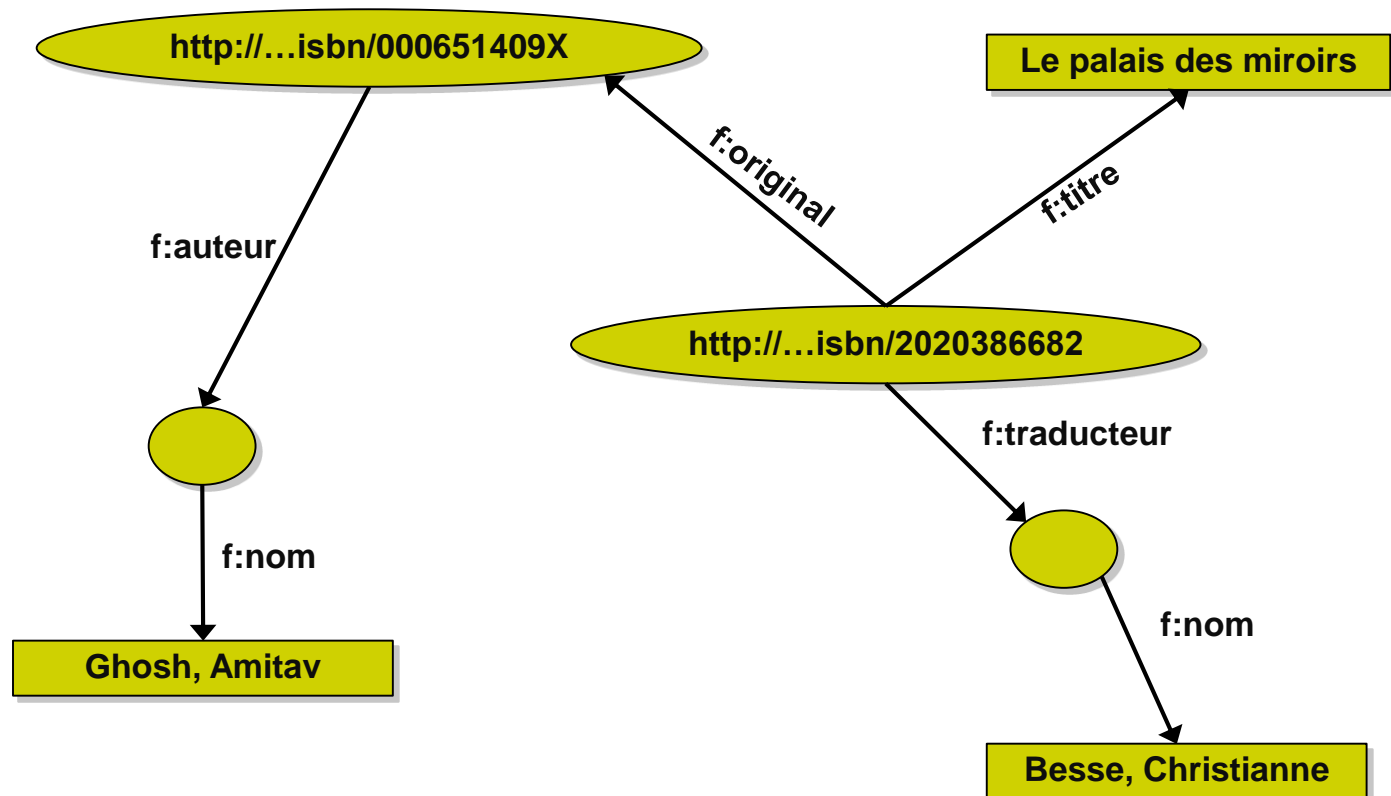
- Another dataset "F" : a google docs spreadsheet bookstore data

	A	B	C	D
1	ID	Titre	Traducteur	Original
2	ISBN 2020286682	Le Palais des Miroirs	\$A12\$	ISBN 0-00-6511409-X
3				
4				
5				
6	ID	Auteur		
7	ISBN 0-00-6511409-X	\$A11\$		
8				
9				
10	Nom			
11	Ghosh,Amitav			
12	Besse, Christianne			

RDF and Data Integration

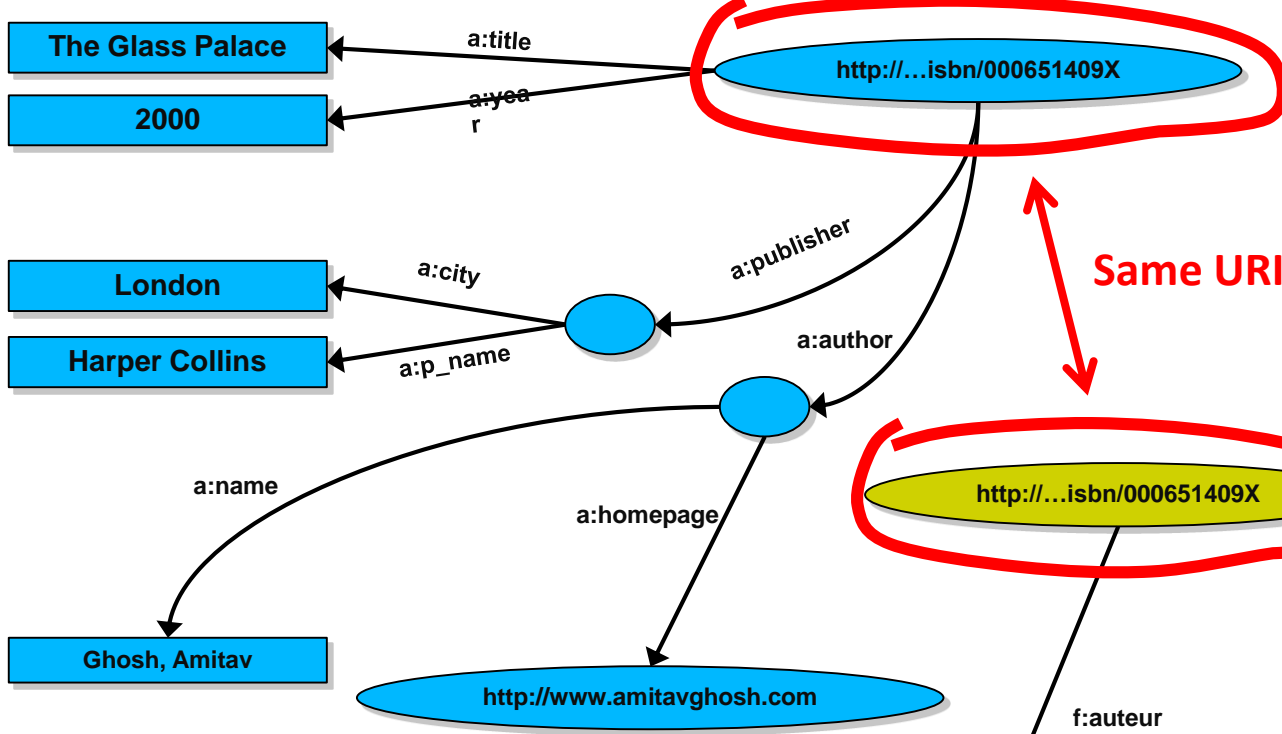
A	B	C	D	
1	ID	Titre	Traducteur	Original
2	ISBN 2020286682	Le Palais des Miroirs	\$A12\$	ISBN 0-00-6511409-X
3				
4				
5				
6	ID	Auteur		
7	ISBN 0-00-6511409-X	\$A11\$		
8				
9				
10	Nom			
11	Ghosh, Amitav			
12	Besse, Christianne			

- 2nd: export your second set of data to another RDF graph



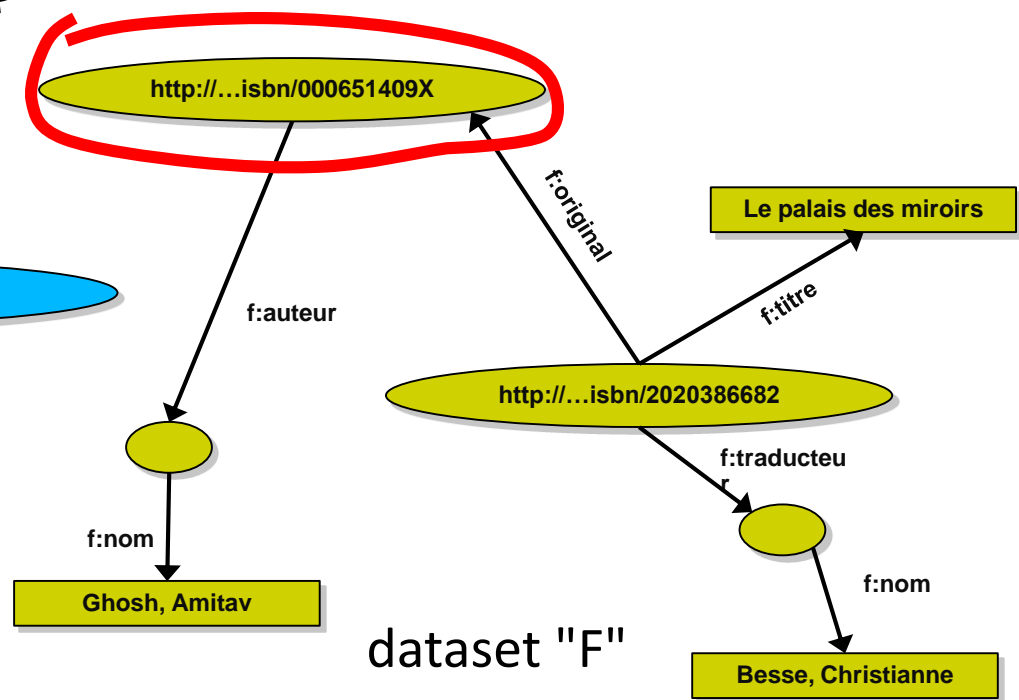
RDF and Data Integration

dataset "A"



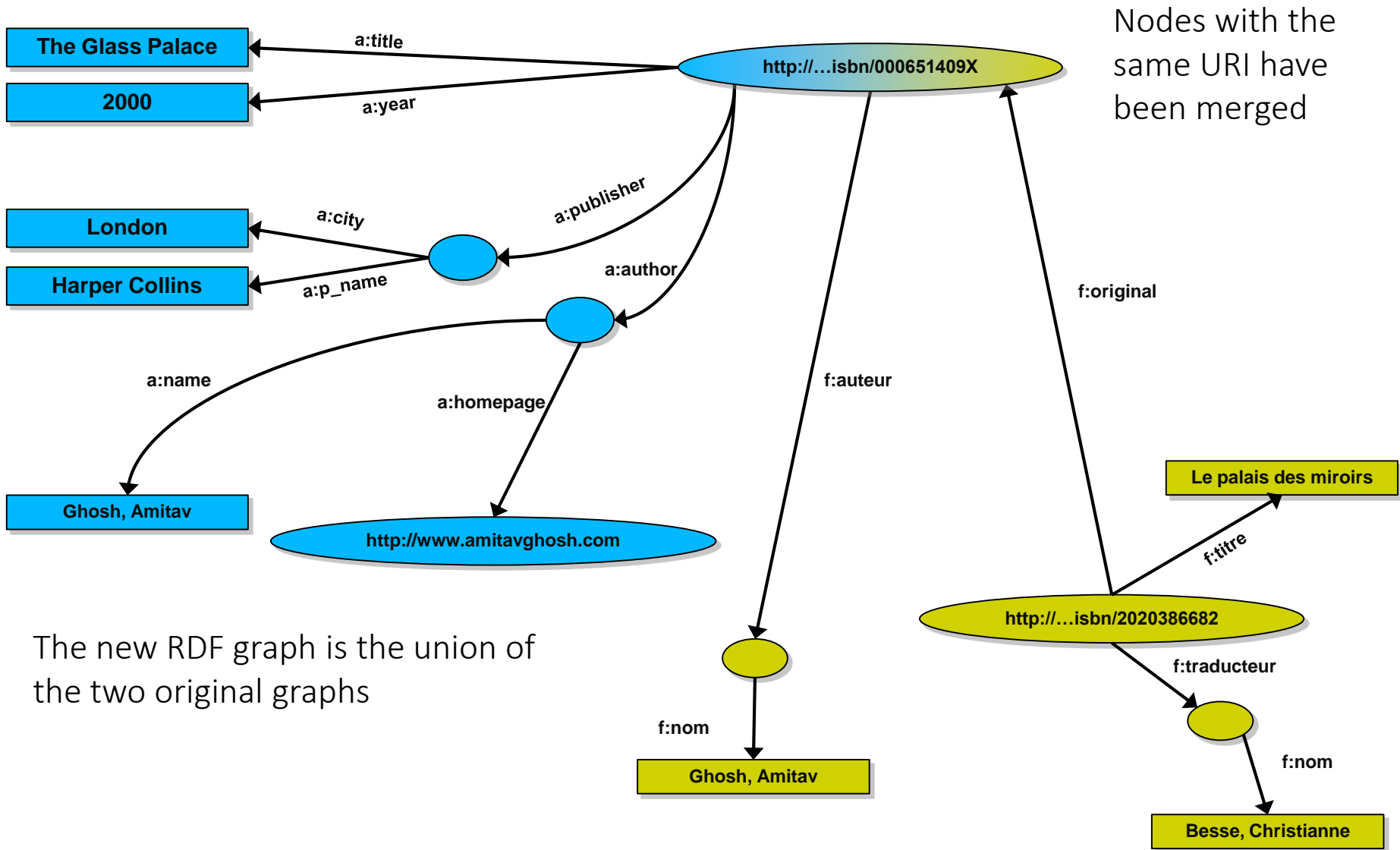
- 3rd: start merging your data

Same URI!



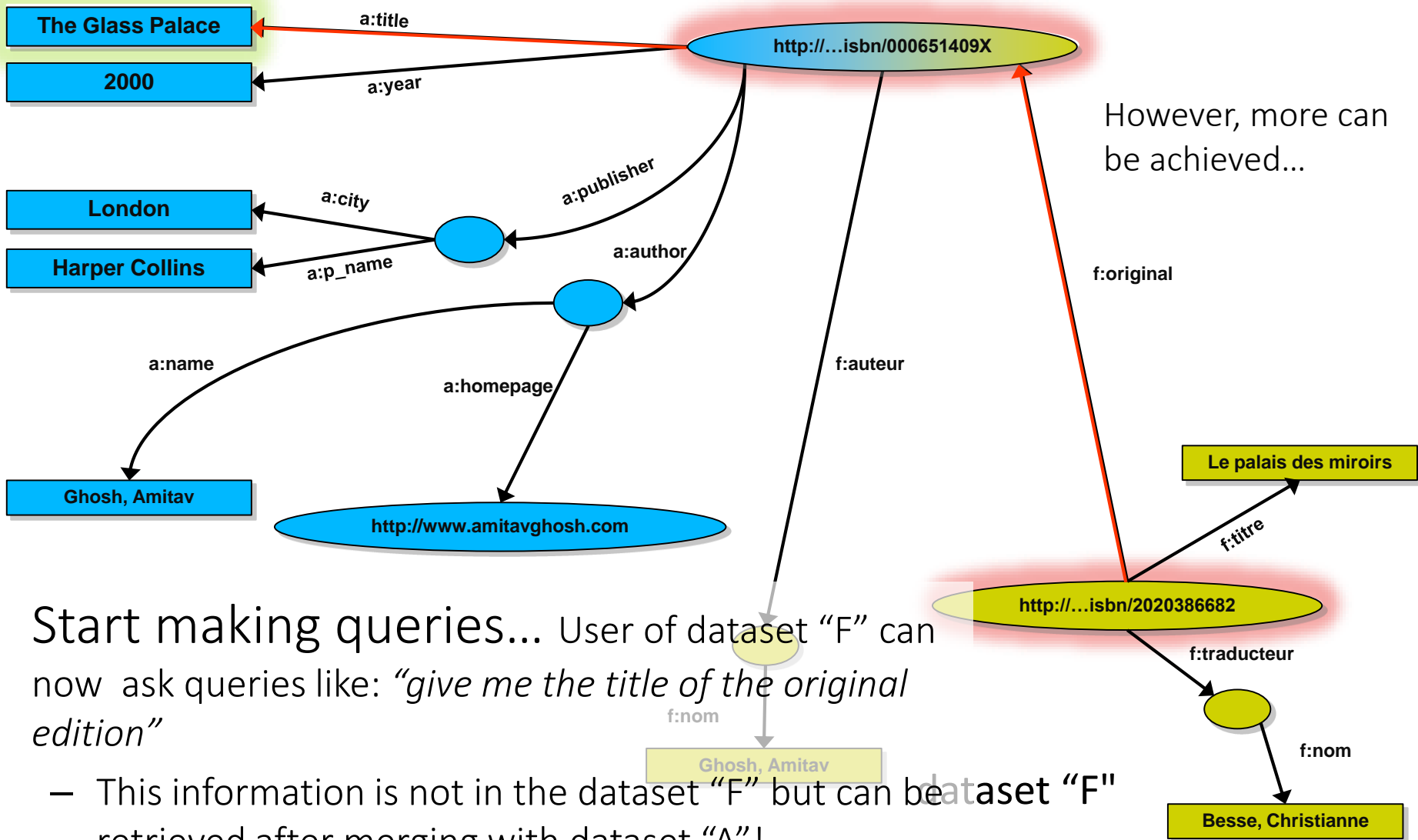
dataset "F"

RDF and Data Integration



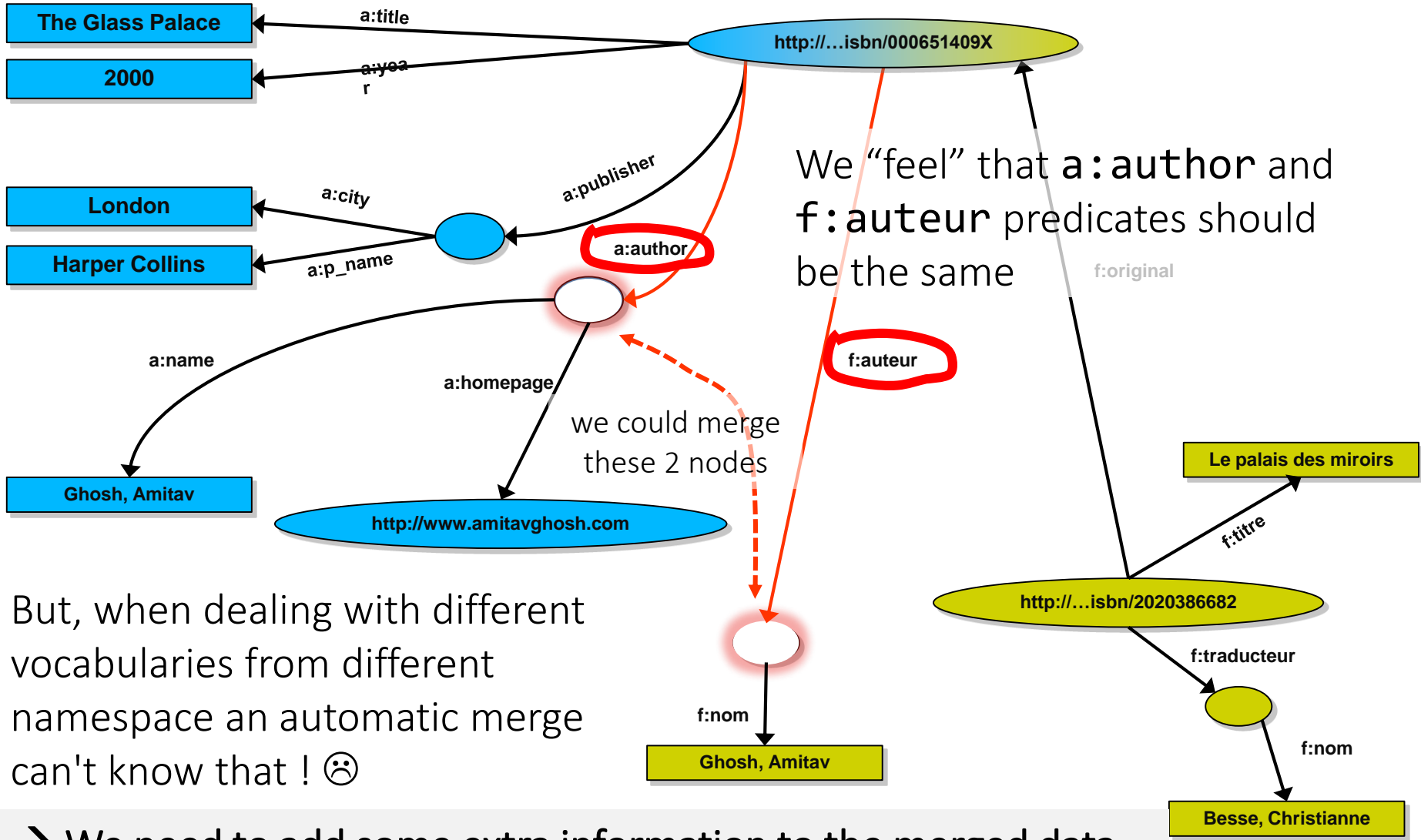
RDF and Data Integration

dataset "A"



- Start making queries... User of dataset "F" can now ask queries like: *"give me the title of the original edition"*
 - This information is not in the dataset "F" but can be retrieved after merging with dataset "A"!

RDF and Data Integration



But, when dealing with different vocabularies from different namespaces an automatic merge can't know that ! ☹️

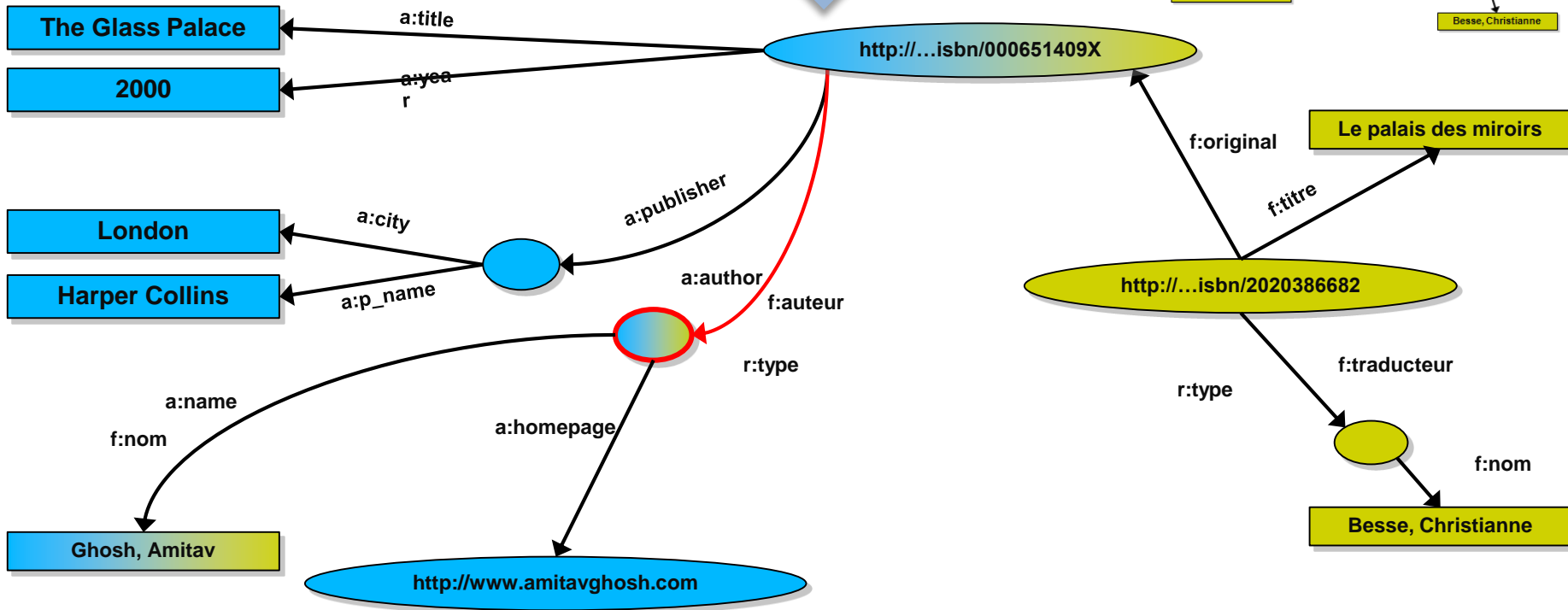
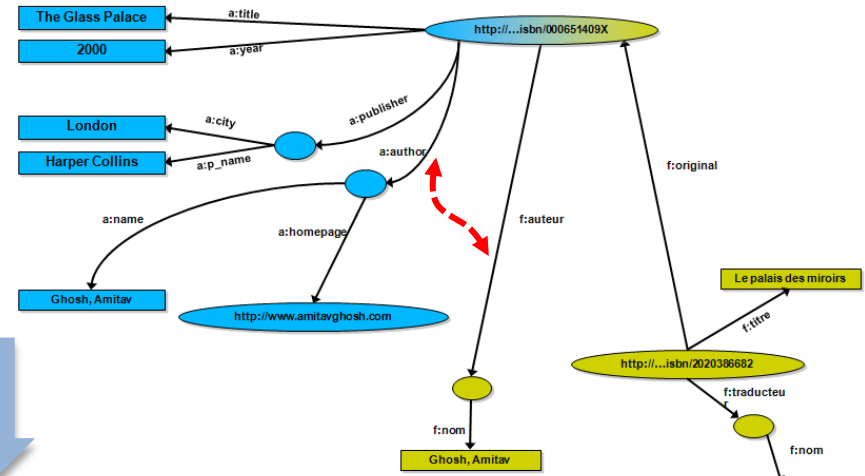
→ We need to add some extra information to the merged data

RDF and Data Integration

`a:author` and `f:auteur` are URIs identifying resources in different namespaces. We can add RDF statement about them in our RDF graph

`a:author owl:equivalentProperty f:auteur`

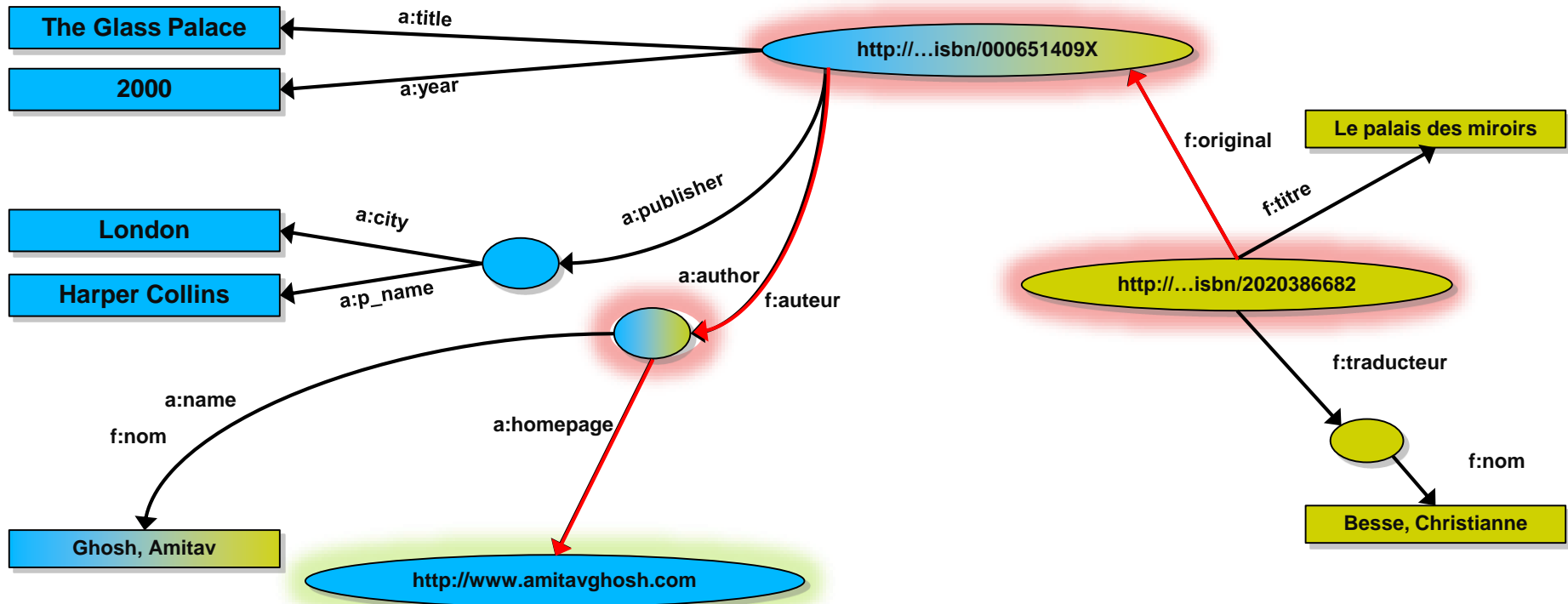
The well defined meaning (semantic) of this property allows to performs the merging



RDF and Data Integration

- By merging datasets “A” and datasets “F”
- By adding simple extra statements (owl:sameAs) as an extra “glue”
- It’s now possible to make richer queries

“donnes-moi la page d’accueil de l’auteur de l’édition originale”
“give me the home page of the original’s ‘auteur’”



Examples of Links between datasets



represents

<http://dbpedia.org/resource/grenoble>

The name (URI) that represents the city of Grenoble in DBpedia



represents

<http://sws.geonames.org/3014728>

The name (URI) that represents the city of Grenoble in GeoNames

Different URIs (URNs) in different namespaces can represent the same thing

Examples of Links between datasets

In the RDF representation of this Dbpedia resource there is a triple that links it to Geonames

subject
<http://dbpedia.org/resource/grenoble>

owl:sameAs

object
<http://sws.geonames.org/3014728/>

The screenshot shows a browser window with the URL <http://dbpedia.org/page/Grenoble>. The page title is "About: Grenoble" and it is identified as a "populated place" from the "dbpedia.org" data space. A table lists properties such as "dbo:PopulatedPlace/area" (18.44) and "dbo:country" (dbr:France). Below the table, a section titled "owl:sameAs" lists multiple equivalent URIs for Grenoble in various languages and from other datasets, including the Geonames URI <http://sws.geonames.org/3014728/>.

Examples of Links between datasets

The image shows two browser windows. The left window displays the GeoNames homepage with a search bar containing 'Grenoble'. The right window shows the search results for Grenoble, France, with a map and a data popup. The popup contains the following information:

- Grenoble** 215 m
- ADM4** fourth-order administrative division
- 6454071
- France FR » Rhône-Alpes 89 » Isère 38 » Arrondissement de Grenoble 381 » Grenoble 38185
- population : 155632
- 45.1872, 5.7266
- N 45°11'14" E 5°43'36"

At the bottom of the popup, there are several icons and links, including a blue callout bubble pointing to the **.rdf** link. Below the popup, a text box displays the URL: <http://sws.geonames.org/3014728/about.rdf>

Examples of Links between datasets

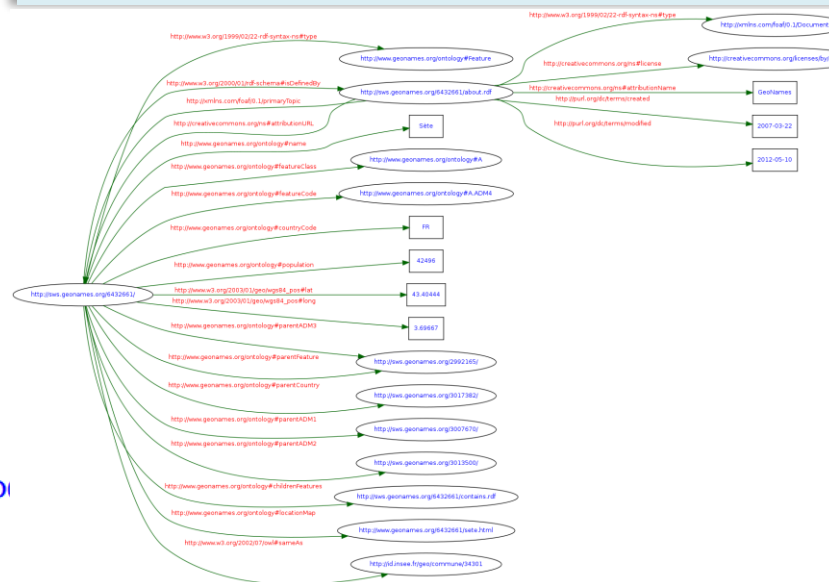
RDF description of Grenoble's parent feature in Geonames

<http://sws.geonames.org/6454071/about.rdf>

```
<rdf:RDF>
- <gn:Feature rdf:about="http://sws.geonames.org/6454071/about.rdf">
  <rdfs:isDefinedBy rdf:resource="http://sws.geonames.org/6454071/about.rdf"/>
  <gn:name>Grenoble</gn:name>
  <gn:officialName xml:lang="de">Grenoble</gn:officialName>
  <gn:officialName xml:lang="en">Grenoble</gn:officialName>
  <gn:officialName xml:lang="fr">Grenoble</gn:officialName>
  <gn:featureClass rdf:resource="http://www.geonames.org/ontology#A"/>
  <gn:featureCode rdf:resource="http://www.geonames.org/ontology#A.ADM4"/>
  <gn:countryCode>FR</gn:countryCode>
  <gn:population>155632</gn:population>
  <wgs84_pos:lat>45.1872</wgs84_pos:lat>
  <wgs84_pos:long>5.7266</wgs84_pos:long>
  <wgs84_pos:alt>215</wgs84_pos:alt>
  <gn:parentFeature rdf:resource="http://sws.geonames.org/3014727"/>
  <gn:parentCountry rdf:resource="http://sws.geonames.org/3017382"/>
  <gn:parentADM1 rdf:resource="http://sws.geonames.org/2983751"/>
  <gn:parentADM2 rdf:resource="http://sws.geonames.org/3012715"/>
  <gn:parentADM3 rdf:resource="http://sws.geonames.org/3014727"/>
  <gn:childrenFeatures rdf:resource="http://sws.geonames.org/6454071/contains.rdf"/>
  <gn:locationMap rdf:resource="http://www.geonames.org/6454071/grenoble.html"/>
  <gn:wikipediaArticle rdf:resource="http://ru.wikipedia.org/wiki/%D0%93%D1%80%D1%8C"/>
  <owl:sameAs rdf:resource="http://id.insee.fr/geo/commune/38185"/>
</gn:Feature>
- <foaf:Document rdf:about="http://sws.geonames.org/6454071/about.rdf">
  <foaf:primaryTopic rdf:resource="http://sws.geonames.org/6454071"/>
  <cc:license rdf:resource="http://creativecommons.org/licenses/by/3.0"/>
  <cc:attributionURL rdf:resource="http://sws.geonames.org/6454071"/>
  <cc:attributionName rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Geonames</cc:attributionName>
  <dcterms:created rdf:datatype="http://www.w3.org/2001/XMLSchema#date">2014-07-18</dcterms:created>
  <dcterms:modified rdf:datatype="http://www.w3.org/2001/XMLSchema#date">2014-07-18</dcterms:modified>
</foaf:Document>
</rdf:RDF>
```

Grenoble's parent feature URI in Geonames

<http://sws.geonames.org/6454071/>



Préfixes:

gn: "http://www.geonames.org/ontology#"
wgs84_pos: "http://www.w3.org/2003/01/geo/wgs84_pos#"
PREFIX foaf: "http://xmlns.com/foaf/0.1/"
PREFIX cc: "http://creativecommons.org/ns#"

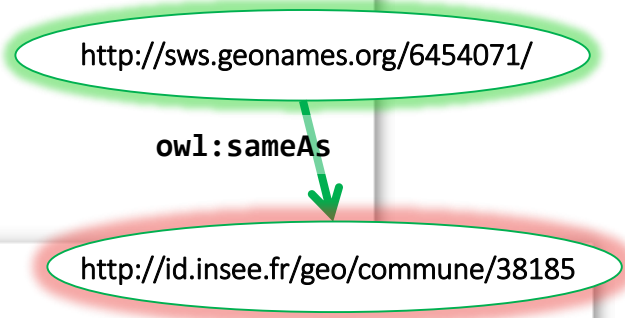
Examples of Links between datasets

```
<gn:childrenFeatures rdf:resource="http://sws.geonames.org/6454071/contains.rdf"/>
<gn:locationMap rdf:resource="http://www.geonames.org/6454071/grenoble.html"/>
<gn:wikipediaArticle rdf:resource="http://ru.wikipedia.org/wiki/%D0%93%D1%80%D0%B5%D0%BD%D0%BE%D0%B1%D0%BB%D1%8C"/>
<owl:sameAs rdf:resource="http://id.insee.fr/geo/commune/38185"/>
```

Geonames resource for Grenoble

```
</gn:Feature>
- <foaf:Document rdf:about="http://sws.geonames.org/6454071/">
  <foaf:primaryTopic rdf:resource="http://id.insee.fr/geo/commune/38185"/>
  <cc:license rdf:resource="http://creativecommons.org/licenses/by/3.0/">
  <cc:attributionURL rdf:resource="http://sws.geonames.org/6454071/">
  <cc:attributionName rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Geonames</cc:attributionName>
```

Un lien **owl:sameAs** permet de relier les deux jeux de données



INSEE resource for Grenoble



Description du nœud <http://id.insee.fr/geo/commune/38185>

Sujet	Prédicat	Objet
http://id.insee.fr/geo/commune/38185	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://rdf.insee.fr/def/geo#Commune
http://id.insee.fr/geo/commune/38185	http://rdf.insee.fr/def/geo#codeCommune	"38185"
http://id.insee.fr/geo/commune/38185	http://rdf.insee.fr/def/geo#codeINSEE	"38185"
http://id.insee.fr/geo/commune/38185	http://rdf.insee.fr/def/geo#nom	"Grenoble"
http://id.insee.fr/geo/commune/38185	http://rdf.insee.fr/def/geo#subdivisionDe	http://id.insee.fr/geo/arrondissement/381
http://id.insee.fr/geo/commune/38185	http://www.w3.org/2002/07/owl#sameAs	http://data.ign.fr/id/geofla/commune/38185

Examples of Links between datasets

Prefixes

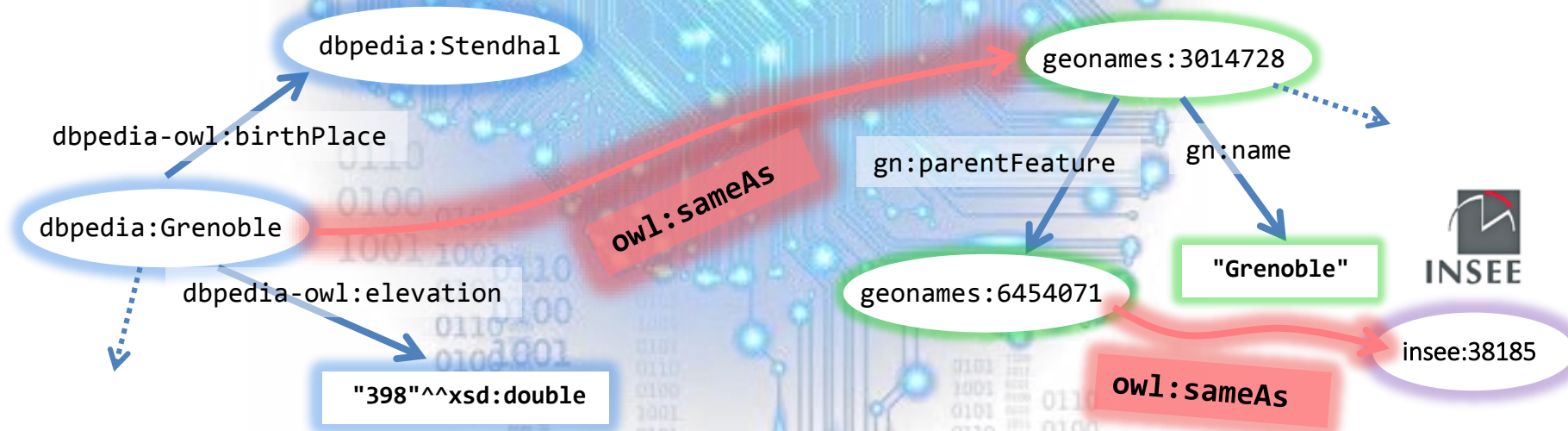
dbpedia: "http://dbpedia.org/resource/"
dbpedia-owl: "<http://dbpedia.org/ontology/>"
geonames: "http://sws.geonames.org/"
gn: "http://www.geonames.org/ontology#" 
insee: "http://id.insee.fr/geo/commune/"



GeoNames

<http://dbpedia.org/resource/grenoble>

<http://sws.geonames.org/3014728/>



It could become even more powerful

- We could add extra knowledge to the merged datasets
 - geographical information
 - a full classification of various types of library data (novel, fiction, travel, history...)
 - etc.
- This is where ontologies, extra rules, etc, come in
 - ontologies/rule sets can be relatively simple and small, or huge, or anything in between...
- Even more powerful queries can be asked as a result

RDF outline

- RDF Model
- RDF formats
- Blank nodes
- Typed literals
- Resources definition
- RDF an data integration
- **Persisting RDF**
- References

Persisting RDF Data

Database systems

- Mapping RDF-relational databases
 - W3C RDB2RDF Working Group published two recommendations (september 2012)
 - R2RML: RDB to RDF Mapping Language, <http://www.w3.org/TR/r2rml/>
 - A Direct Mapping of Relational Data to RDF, <http://www.w3.org/TR/rdb-direct-mapping/>
 - DR2Q Accessing Relational Databases as Virtual RDF Graphs
<http://d2rq.org/>
- Save triples into Relational Database
 - Various strategies: 1 giant table for alls triplet → hexastore (create indexes for all possible combinaisons: spo, pos, osp, sop, pso, ops)
 - Building an Efficient RDF Store Over a Relational Database (Mihaela A. Bornea et al., [SIGMOD '13](#) Proceedings of the 2013 ACM SIGMOD International Conference on Management of Data)
<https://cs.uwaterloo.ca/~gweddell/cs848/papers/Bornea.pdf>

Persisting RDF Data

RDF Triple Stores

- W3C maintains a list of triplestores
 - [http://www.w3.org/wiki/SemanticWebTools#RDF Triple Store Systems](http://www.w3.org/wiki/SemanticWebTools#RDF_Triple_Store_Systems)
- Commercial:
 - Open Link Virtuoso - <http://virtuoso.openlinksw.com>
 - AllegroGraph - <http://www.franz.com/agraph/allegrograph/>
 - Ontotext GraphDB (SwiftOWLIM) :
<http://www.ontotext.com/products/ontotext-graphdb-owlim/>
 - ...
- Open source
 - Apache Jena - <http://jena.apache.org>
 - Sesame - <http://www.openrdf.org>
 - Parliament – <http://parliament.semwebcentral.org>
 - ...

RDF outline

- RDF Model
- RDF formats
- Blank nodes
- Typed literals
- Resources definition
- RDF an data integration
- Persisting RDF
- **References**

References

- RDF is part of W3C Semantic Web W3C activity

"The **Resource Description Framework (RDF)** is a framework for representing information in the Web." [1]

- W3C recommendation February 2004 (RDF 1.0)
- Updated February 2014 (RDF 1.1)

RDF Working Group

Recommendations

- [RDF 1.1 Concepts and Abstract Syntax](#) [1] } RDF model
- [RDF 1.1 Semantics](#)
- [JSON-LD 1.0](#)
- [JSON-LD 1.0 Processing Algorithms and API](#)
- [RDF 1.1 Turtle](#)
- [RDF 1.1 TriG](#)
- [RDF 1.1 N-Triples](#)
- [RDF 1.1 N-Quads](#)
- [RDF 1.1 XML Syntax](#)

RDF
serialization
formats

Notes

- [RDF 1.1 Primer](#) [2]
- [What's new in RDF 1.1](#)
- [RDF 1.1: On Semantics of RDF Datasets](#)
- [RDF 1.1 Test Cases](#)
- [RDF 1.1 JSON Alternate Serialization \(RDF/JSON\)](#)

RDFa Working Group

Recommendations

- [RDFa Core 1.1 - Second Edition](#)
- [XHTML+RDFa 1.1 - Second Edition](#)
- [HTML+RDFa 1.1](#)
- [RDFa Lite 1.1](#)

Notes

- [RDFa 1.1 Primer - Second Edition](#) [3]
- [Linked Data Glossary](#) [4]
- [HTML Data Guide](#)

- [1] <http://www.w3.org/TR/2014/REC-rdf11-concepts-20140225/>
- [2] <http://www.w3.org/TR/2014/NOTE-rdf11-primer-20140624/>
- [3] <http://www.w3.org/TR/2013/NOTE-rdfa-primer-20130822/>
- [4] <http://www.w3.org/TR/2013/NOTE-ld-glossary-20130627/>

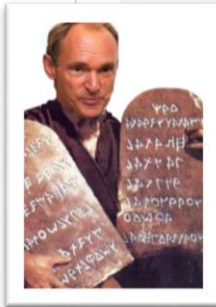
Outline

- “Theoretical” Session (morning)
 - Introduction
 - Distributing Data on the web with RDF
 - Naming the Data : URIs (Uniform Resources Identifiers)
 - The RDF Data model
 - Querying Linked Data with SPARQL
 - Semantic modelling
 - RDFS
 - OWL
 - From Open Data to Linked Open Data
 - Conclusion
- Hands-on session (afternoon)
 - From a CSV file to linked data
 - Querying linked data (SPARQL)

Querying Linked Data with SPARQL

Linked Data: 3rd Principle

*When someone looks up a URI, provide useful information, using the standards (RDF, **SPARQL**).*



Most apps use only a subset of the stack

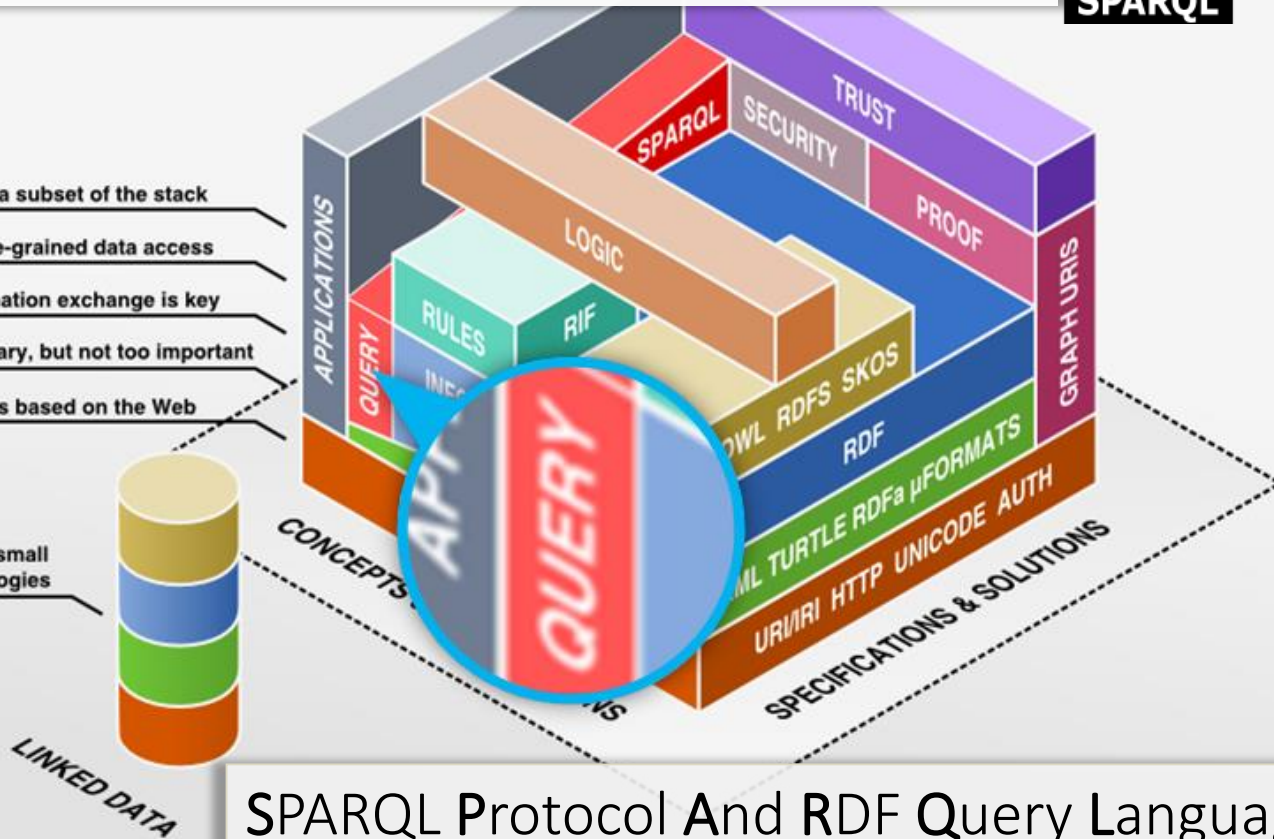
Querying allows fine-grained data access

Standardized information exchange is key

Formats are necessary, but not too important

The Semantic Web is based on the Web

Linked Data uses a small selection of technologies

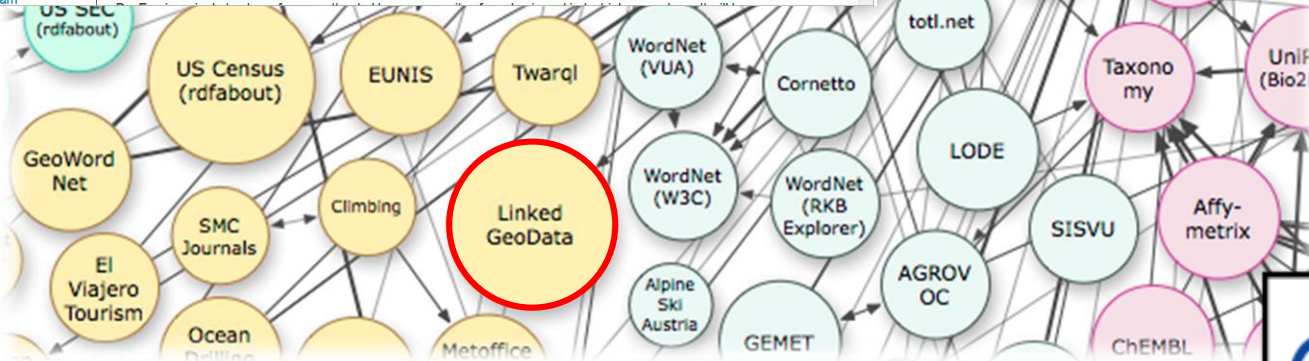
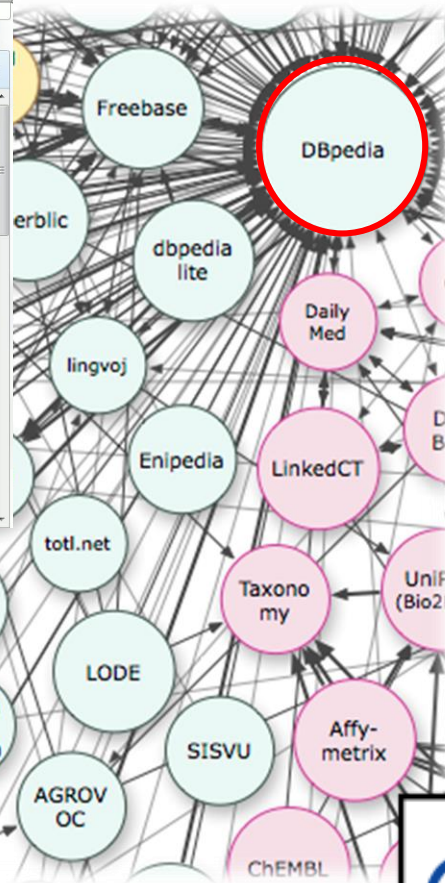
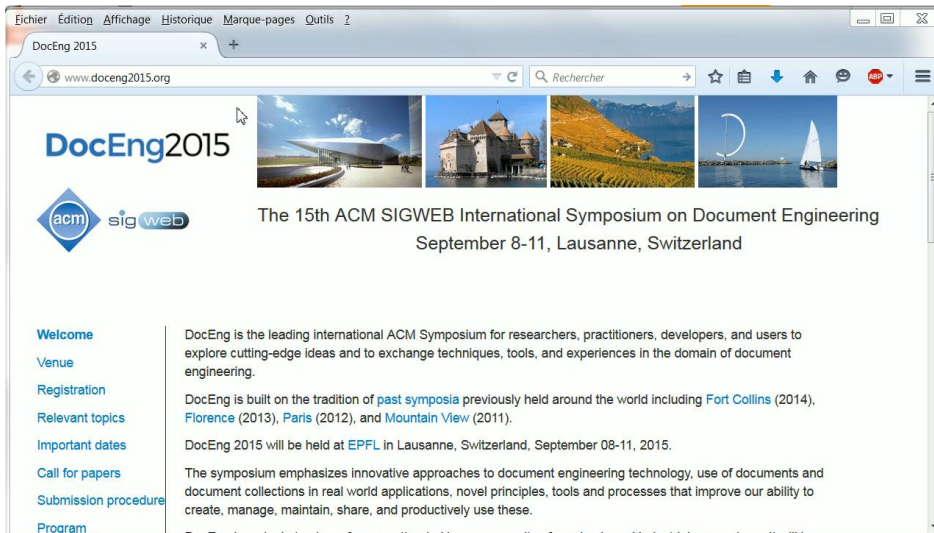


SPARQL Protocol And RDF Query Language

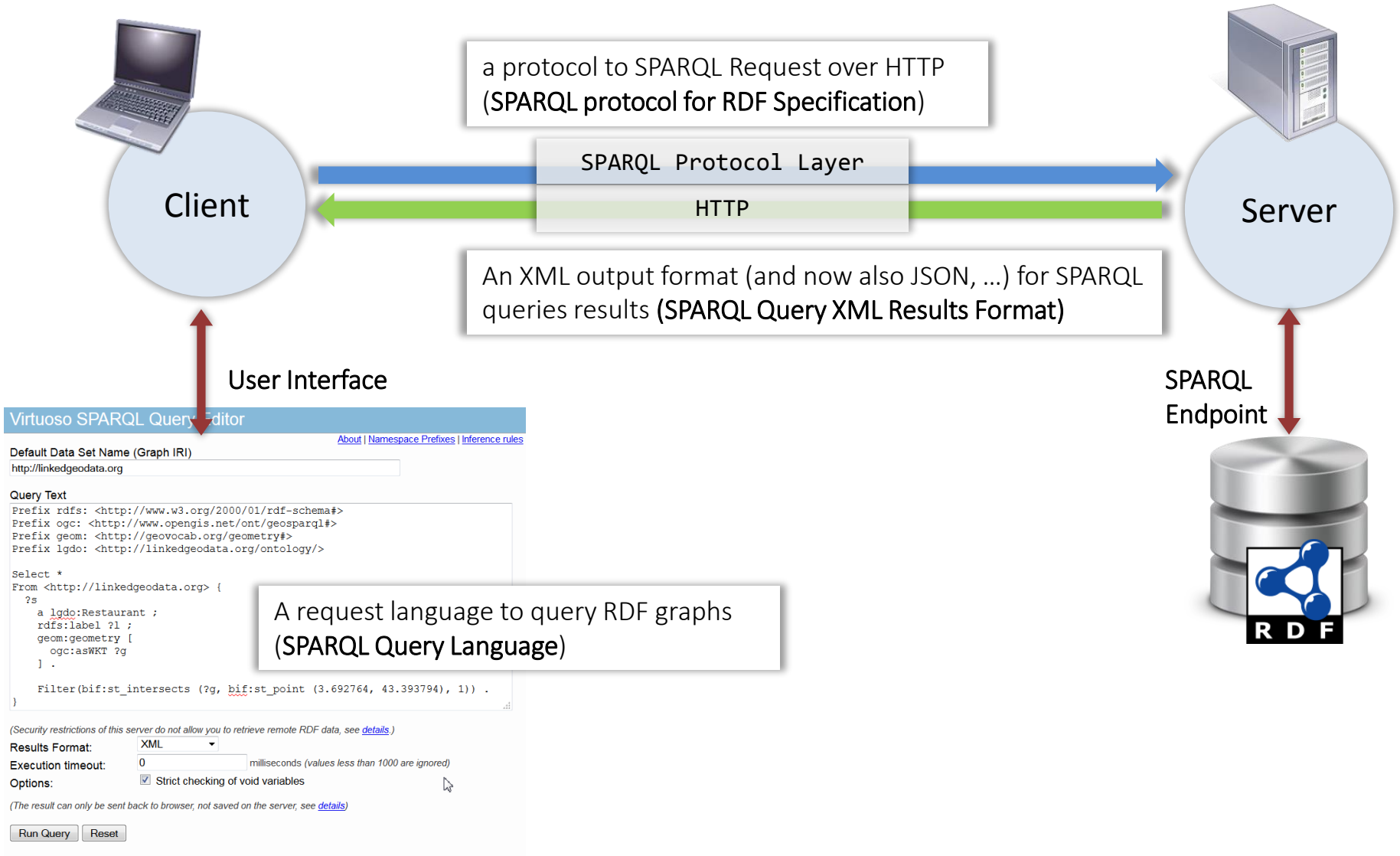
SPARQL : introduction

- **RDF (Resource Description Framework)**
 - Flexible and extensible way to represent information about resources of the web
- **SPARQL (SPARQL Protocol And RDF Query Language)**
 - A W3C standard
 - SPARQL 1.0 recommendation - January 2008,
 - SPARQL 1.1 recommendation – March 2013
<http://www.w3.org/TR/2013/REC-sparql11-overview-20130321/>
 - a request language to access a RDF graph (SPARQL Query Language Specification) inspired from SQL
 - a protocol to submit request through HTTP GET, HTTP POST or SOAP (SPARQL protocol for RDF Specification)
 - an XML format for the results (SPARQL Query XML Results Format), and now JSON

SPARQL in action with LinkedGeoData

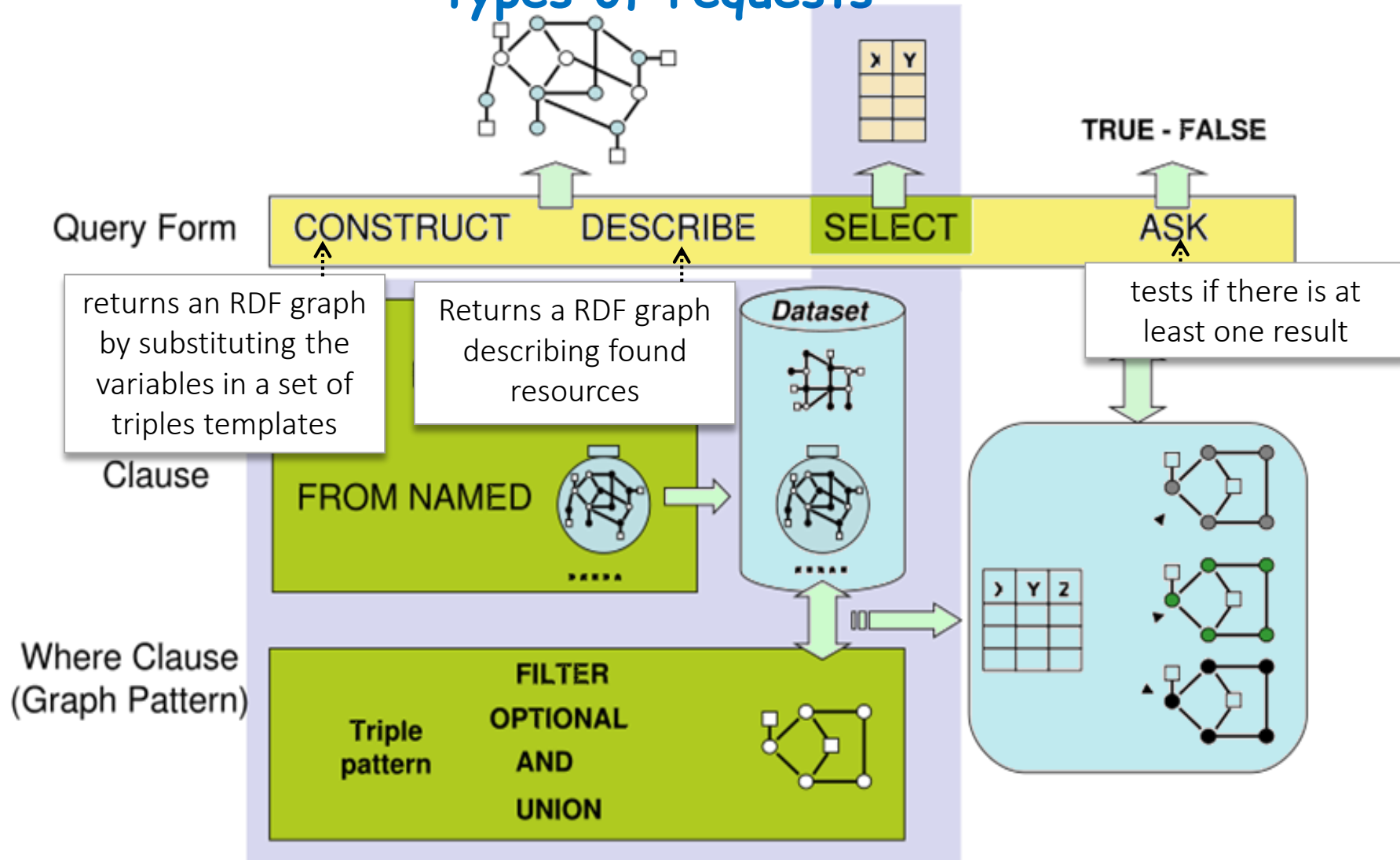


SPARQL Protocol And RDF Query Language overview



SPARQL Query Language

types of requests



from: Pérez, Arenas and Gutierrez, Chapter 1: On the Semantics of SPARQL, Semantic Web Information Management: A Model Based Perspective, Springer 2010

SPARQL Query Language

Select

- find all the restaurants that are less than 1km from Fort Saint-Pierre (Théâtre de la Mer – Sète)

```
Prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
Prefix ogc:  <http://www.opengis.net/ont/geosparql#>
Prefix geom: <http://geovocab.org/geometry#>
Prefix lgdo: <http://linkedgeodata.org/ontology/>
```

```
Select ?s, ?l From <http://linkedgeodata.org>
```

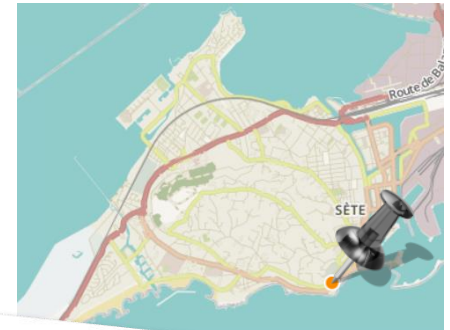
```
Where
```

```
{
```

```
  ?s    a lgdo:Restaurant ;
        rdfs:label ?l ;
        geom:geometry [
          ogc:asWKT ?g
        ] .
```

```
  Filter(bif:st_intersects (?g, bif:st_point (3.692764, 43.393794), 1)) .
```

```
}
```



SPARQL Query Language

- SPARQL based on :
 - RDF serialization with Turtle
 - Graph Pattern Matching

```
Prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
Prefix ogc:  <http://www.opengis.net/ont/geosparql#>
Prefix geom: <http://geovocab.org/geometry#>
Prefix lgdo: <http://linkedgeodata.org/ontology/>
```

```
Select ?s, ?l From <http://linkedgeodata.org>
```

```
Where
```

```
{
```

```
  ?s a lgdo:Restaurant ;
    rdfs:label ?l ;
    geom:geometry [
      ogc:asWKT ?g
    ] .
```

variable

Graph Pattern: RDF triple containing one or more variables at any position (subject, predicate, object)

```
Filter(bif:st_intersects (?g, bif:st_point (3.692764, 43.393794), 1)) .
```

```
}
```

SPARQL Query Language

Select

- Graph patterns can be combined to construct complex (conjunctive) requests.

Prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>

Prefix ogc: <http://www.opengis.net/ont/geosparql#>

Prefix geom: <http://geovocab.org/geometry#>

Prefix lgdo: <http://linkedgeodata.org/ontology/>

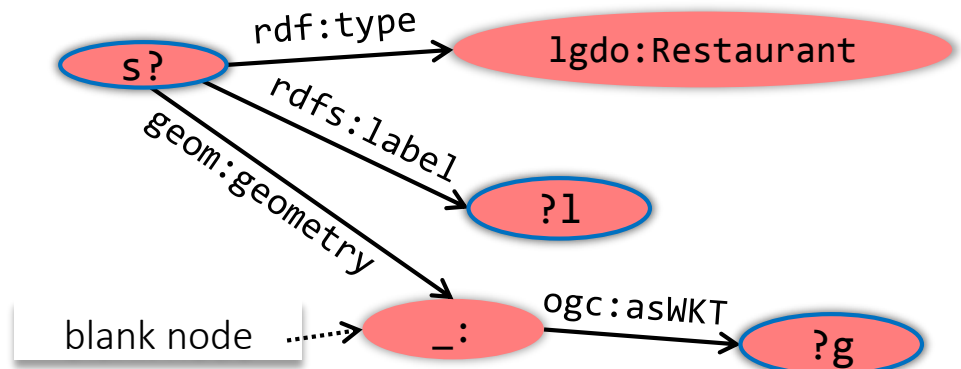
Select ?s, ?l From <http://linkedgeodata.org>

Where

{

variable → ?s

```
a lgdo:Restaurant ;  
rdfs:label ?l ;  
geom:geometry [  
  ogc:asWKT ?g  
] .
```



```
Filter(bif:st_intersects (?g, bif:st_point (3.692764, 43.393794), 1)) .
```

}

SPARQL Query Language

Select

- The SELECT clause indicates which variables to consider in the result
- * all the variables (like SQL)

Prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>

Prefix ogc: <http://www.opengis.net/ont/geosparql#>

Prefix geom: <http://geovocab.org/geometry#>

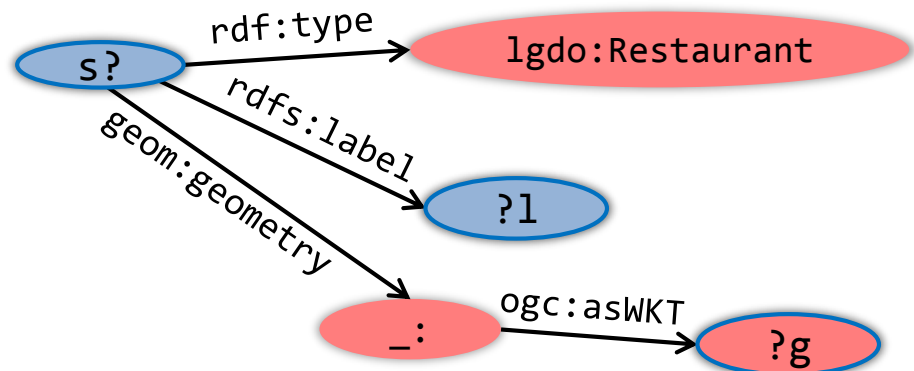
Prefix lgdo: <http://linkedgeodata.org/ontology/>

Select ?s, ?l From <http://linkedgeodata.org>

Where

{

```
?s    a lgdo:Restaurant ;
      rdfs:label ?l ;
      geom:geometry [
        ogc:asWKT ?g
      ] .
```



```
Filter(bif:st_intersects (?g, bif:st_point (3.692764, 43.393794), 1)) .
```

}

SPARQL Query Language

Select clause - DataSets

- The RDF data-store service can handle one or more RDF graphs, the SPARQL query is executed against a data set (RDF Dataset) that represents a collection of one or more graphs.

```
Prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
```

```
Prefix ogc: <http://www.opengis.net/ont/geosparql#>
```

```
Prefix geom: <http://geovocab.org/geometry#>
```

```
Prefix lgdo: <http://linkedgeodata.org/ontology/>
```

```
Select ?s, ?l From <http://linkedgeodata.org>
```

```
Where
```

```
{
```

```
  ?s a lgdo:Restaurant ;
```

```
    rdfs:label ?l ;
```

```
    geom:geometry [
```

```
      ogc:asWKT ?g
```

```
    ] .
```

```
  Filter(bif:st_intersects (?g, bif:st_point (3.692764, 43.393794), 1)) .
```

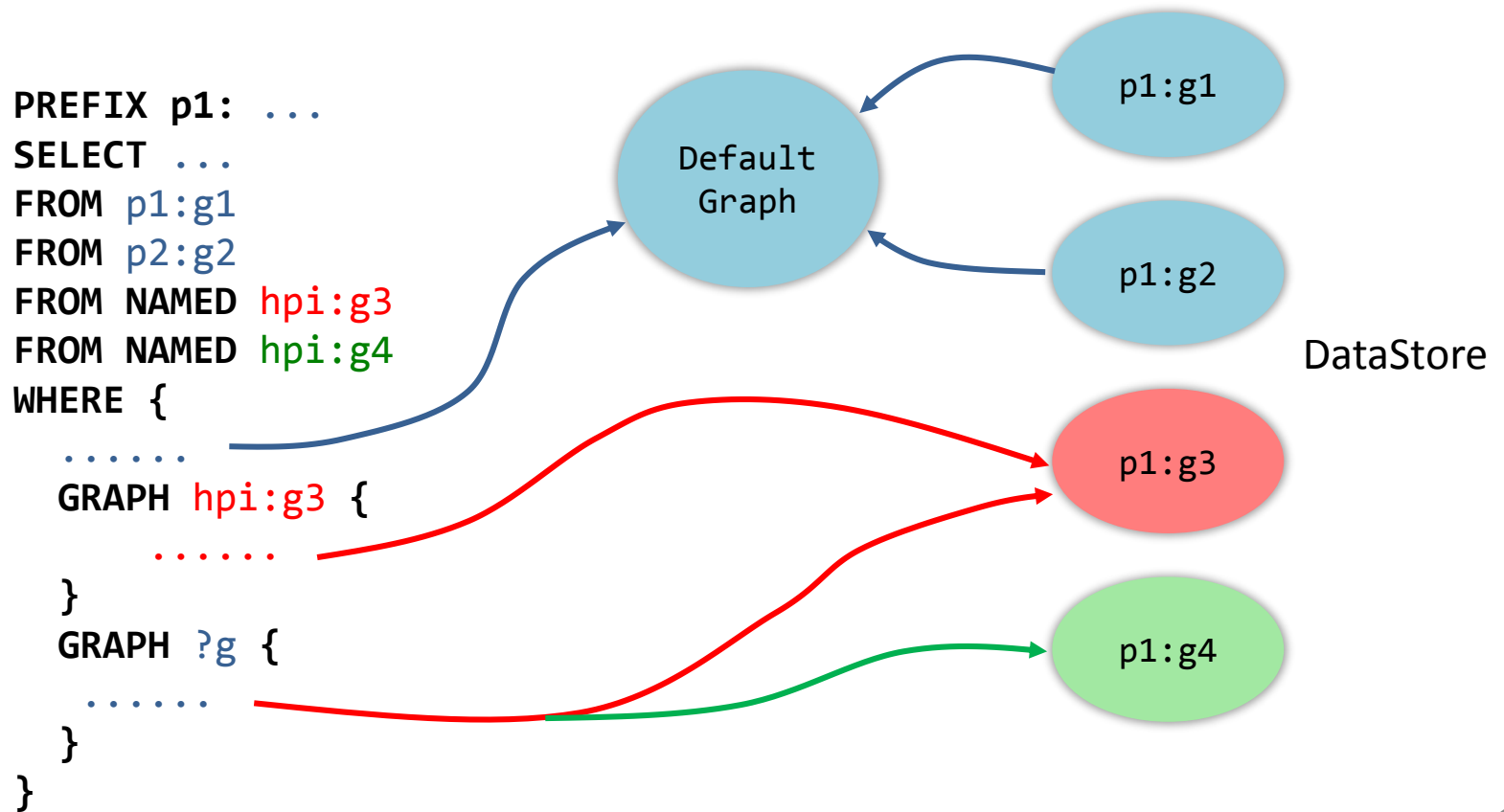
```
}
```

graph on which the
query is executed

SPARQL Query Language

Select - DataSets

- a SPARQL request can associate different graph patterns to different named graphs.
 - FROM defines the default graph (this may be merging several graphs)
 - FROM NAMED defines graphs which then can be explicitly named in the WHERE part of the query through the GRAPH keyword



SPARQL Query Language

Select -Filters

- Possibility to filter results
 - A filter allows to constrain solution values

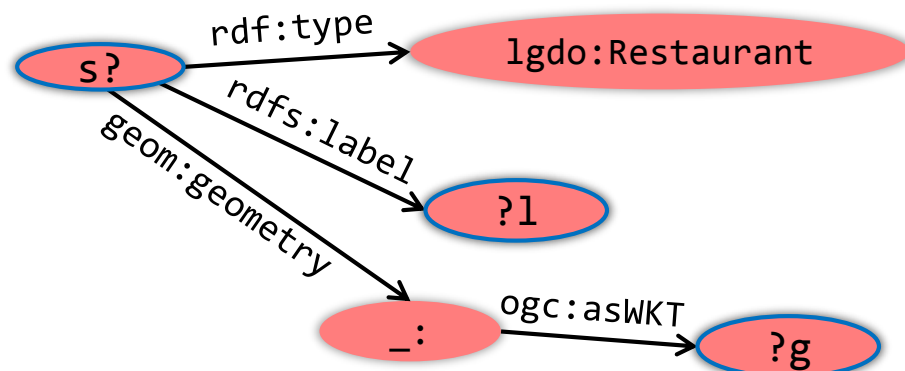
```
Prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
Prefix ogc:  <http://www.opengis.net/ont/geosparql#>
Prefix geom: <http://geovocab.org/geometry#>
Prefix lgdo: <http://linkedgeodata.org/ontology/>
```

```
Select ?s, ?l From <http://linkedgeodata.org>
```

```
Where
```

```
{
```

```
?s a lgdo:Restaurant ;
  rdfs:label ?l ;
  geom:geometry [
    ogc:asWKT ?g
  ] .
```



```
Filter(bif:st_intersects (?g, bif:st_point (3.692764, 43.393794), 1)) .
```

Filter on ?g variable

SPARQL Query Language

Select -Filters

- Filters : allow to restrict the values in a solution
 - Boolean expression the request solutions must satisfy.
 - rich expression language based on Xpath, XQuery and special operators defined by SPARQL.
- see section 11 of SPARQL specification document <http://www.w3.org/TR/rdf-sparql-query/#tests>
- Relational operators: `<`, `>`, `=`, `<=`, `>=`, `!=`
 - Boolean operators: `&&`, `||`, `!`
 - Arithmetic operator: `+` `*` `-` `/`
 - Variable binding tests: `isURI(?x)`, `isBlank(?x)`, `isLiteral(?x)`, `bound(?x)`
 - Regular expressions: `regex(?x, "A.*")`
 - Access to attributes/values `lang()`, `datatype()`, `str()`
 - Casting ((re-)typing functions) `xsd:integer(?x)`
 - External functions / extensions

SPARQL Query Language

Solution Modifiers

- The set of solution produced by graphs pattern matching can be modified in various ways:
 - Projection - keep only selected variables
 - OFFSET/LIMIT - chop the number solutions (best used with ORDER BY)
 - OFFSET the start index,
 - LIMIT the number of solutions to be returned.
 - Using LIMIT alone useful to ensure not too many solutions are returned, to restrict the effect of some unexpected situation
 - ORDER BY - sorted results
 - DISTINCT - yield only one row for one combination of variables and values.
- The solution modifiers OFFSET/LIMIT and ORDER BY always apply to all result forms

example

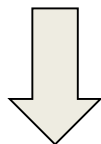
```
prefix foaf: <http://xmlns.com/foaf/0.1/>
SELECT DISTINCT * where {
    ?x foaf:name ?name;
       foaf:age ?age.
}
ORDER BY ?name DESC(?age)
```

SPARQL Query Language

ASK query

- ASK – ask a boolean query.
 - to verify that there is at least one response.
 - Is there a student over 30 years?

```
PREFIX ufrimag: <http://www.ufrimag.fr#>
ASK {
  ?etudiant ufrimag:inscrit ?x .
  ?x ufrimag:siteweb <http://www.ufrimag.fr> .
  ?etudiant ufrimag:age ?age .
  FILTER (?age > 30)
}
```



the boolean result

```
<sparql xmlns="http://www.w3.org/2005/sparql-results#">
  <head> ... </head>
  <boolean> true </boolean>
</sparql>
```

SPARQL Query Language

CONSTRUCT query

- **SELECT** returns a flat list of variables bindings
 - the application program is in charge of processing these bindings (often by converting solution tuples into triples and adding them to a RDF graph)
- **CONSTRUCT** allows you to directly product a RDF graph containing the variables values
 - the WHERE and FILTER clause works the same way as the SELECT form
 - bindings of the variables are inserted into a new graph constructed from template triples specified in the CONSTRUCT clause (which replace the SELECT clause).

SPARQL Query Language

CONSTRUCT query

```
PREFIX foaf:    <http://xmlns.com/foaf/0.1/>
PREFIX vcard:  <http://www.w3.org/2001/vcard-rdf/3.0#>

CONSTRUCT { ?x foaf:firstName ?y .
             ?x foaf:lastName ?z .
           }

FROM <vca-db-1rd.rdf>
WHERE
{
    ?x vcard:N ?u .
    ?u vcard:Given ?y .
    ?u vcard:Family ?z.
}
```

CONSTRUCT avec un graph-gabarit à un seul sujet et deux triplets



```
@prefix foaf:    <http://xmlns.com/foaf/0.1/> .
@prefix vcard:  <http://www.w3.org/2001/vcard-rdf/3.0#> .

<http://somewhere/RebeccaSmith/>
  foaf:firstName  "Rebecca" ;
  foaf:lastName   "Smith" .

<http://somewhere/MattJones/>
  foaf:firstName  "Matthew" ;
  foaf:lastName   "Jones" .

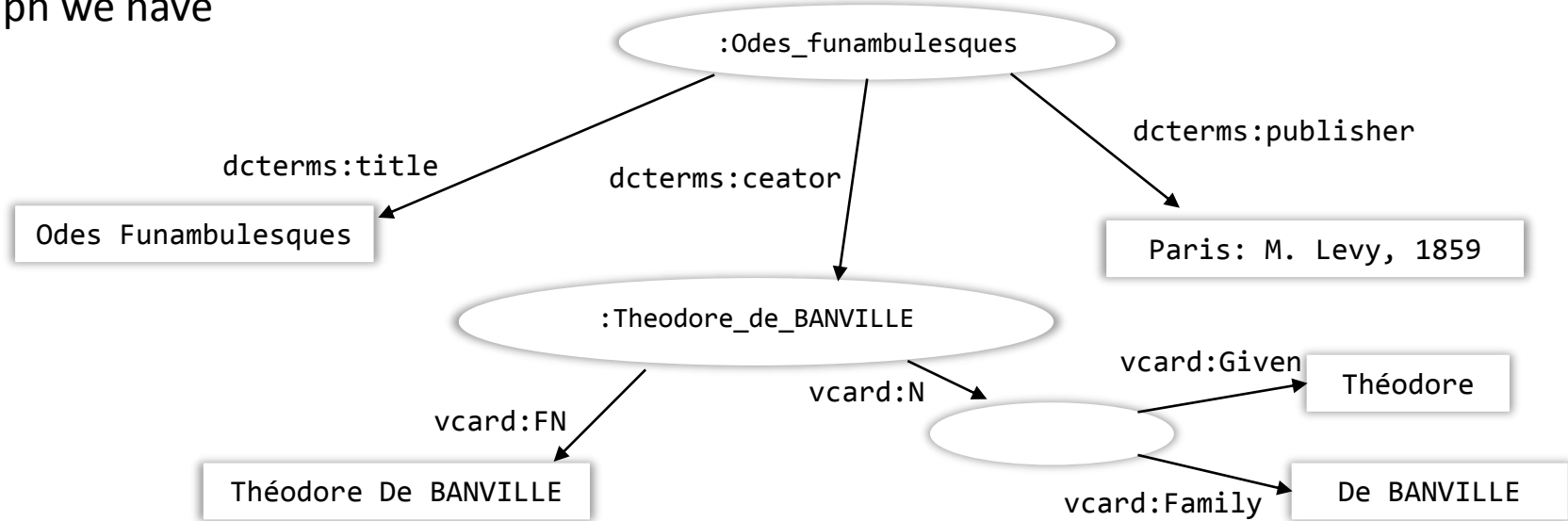
<http://somewhere/SarahJones/>
  foaf:firstName  "Sarah" ;
  foaf:lastName   "Jones" .

<http://somewhere/JohnSmith/>
  foaf:firstName  "John" ;
  foaf:lastName   "Smith" .
```

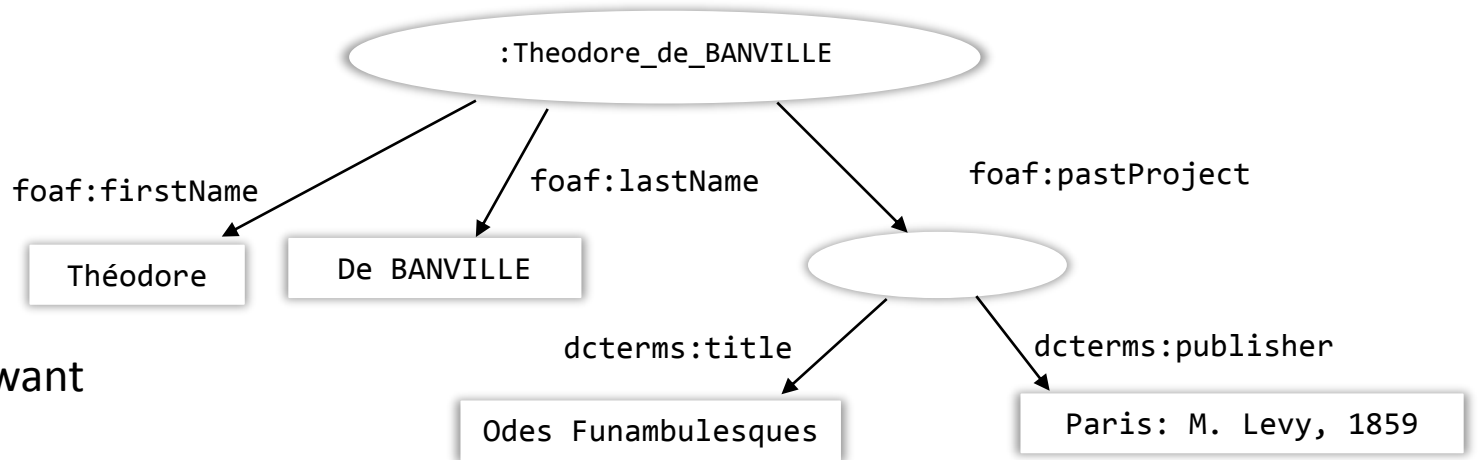
SPARQL Query Language

CONSTRUCT query

The graph we have



The graph we want



SPARQL Query Language

CONSTRUCT query

```
PREFIX foaf:    <http://xmlns.com/foaf/0.1/>
PREFIX dc:     <http://purl.org/dc/elements/1.1/>
PREFIX vcard:  <http://www.w3.org/2001/vcard-rdf/3.0#>

CONSTRUCT { ?auteur foaf:pastProject _:oeuvre .
             _:oeuvre dc:title ?nom .
             _:oeuvre dc:publisher ?editeur .
             ?auteur foaf:firstName ?p .
             ?auteur foaf:lastName ?n .
           }

FROM <http://pagesperso-systeme.lip6.fr/Jean-Francois.Perrot/inalco/XML/RDF/Frantext/RRb.rdf>
WHERE
{
  ?oe dc:creator ?auteur .
  ?oe dc:title ?nom .
  ?oe dc:publisher ?editeur .
  ?auteur vcard:N ?vc .
  ?vc vcard:Family ?n .
  ?vb vcard:Given ?p .
}
```



```
@prefix vcard:  <http://www.w3.org/2001/vcard-rdf/3.0#> .
@prefix dc:    <http://purl.org/dc/elements/1.1/> .
@prefix foaf:  <http://xmlns.com/foaf/0.1/> .

<http://inalco/M2-Trad/poetes#Théodore_de_BANVILLE>
  foaf:firstName "Théodore" ;
  foaf:lastName  "de BANVILLE" ;
  foaf:pastProject
    [ dc:publisher "Paris : M. Levy, 1859." ;
      dc:title     "Odes funambulesques"
    ] .
```


SPARQL Query Language

DESCRIBE query

- **DESCRIBE** – Returns an RDF graph, based on what the query processor is configured to return.
 - SPARQL specification says : "the useful information the service has about a resource"
 - in theory this should help you understand the context of the resources returned... but there is no warranty.

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX ex: <http://example.com/>
DESCRIBE ex:karen ?friend {
  ex:karen foaf:knows ?friend .
}
```

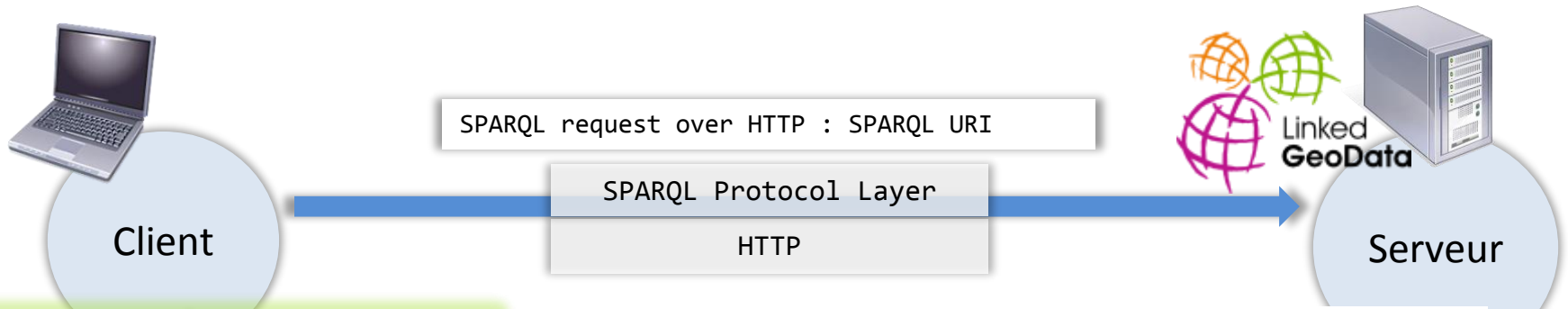
asks for a description of karen ad her friends

Subject	Predicate	Object	
ex:karen	foaf:knows	ex:alex	×
ex:karen	foaf:name	"Karen"	×
ex:alex	foaf:name	"Alex"	×

```
DESCRIBE <http://example.com/fish> ?x WHERE {
  ?x ?y <http://example.com/fish>
}
```

asks for a description of fish, and any resource directly related to fish.

SPARQL Protocol



the SPARQL endpoint URL
<http://linkedgeo.org/sparql>

SPARQL request (SPARQL URI) has 4 components:

SPARQL Query Language

```

http://linkedgeo.org/sparql?default-graph-uri=http%3A%2F%2Flinkedgeo.org
&query=Prefix+rdfs%3A+%3Chttp%3A%2F%2Fwww.
schema%23%3E%0D%0APrefix+ogc%3A+%3Chttp%3
rql%23%3E%0D%0APrefix+geom%3A+%3Chttp%3A
%0A%0APrefix+lgdo%3A+%3Chttp%3A%2F%2Flinkedgeo.org%2Fontology%2F%3E%0D%0A%0D%
%0A++++a+lgdo%3ARestaurant+%3B%0D%0A++++rdfs%3Alabel+%3FI+%3B++++%0D%0A++++geom
%3Ageometry+%5B%0D%0A+++++ogc%3AasWKT+%3Fg%0D%0A++++%5D+.%0D%0A%0D%0A++
++Filter%28bif%3Ast_intersects+%28%3Fg%2C+bif%3Ast_point+%283.692764%2C+43.393794%29
%2C+1%29%29+.%0D%0A%7D&format=application%2Fsparql-results%2Bxml
    
```

The RDF graphs to request (optional)
default-graph-uri=http://linkedgeo.org
named-graph-uri=...

The query string

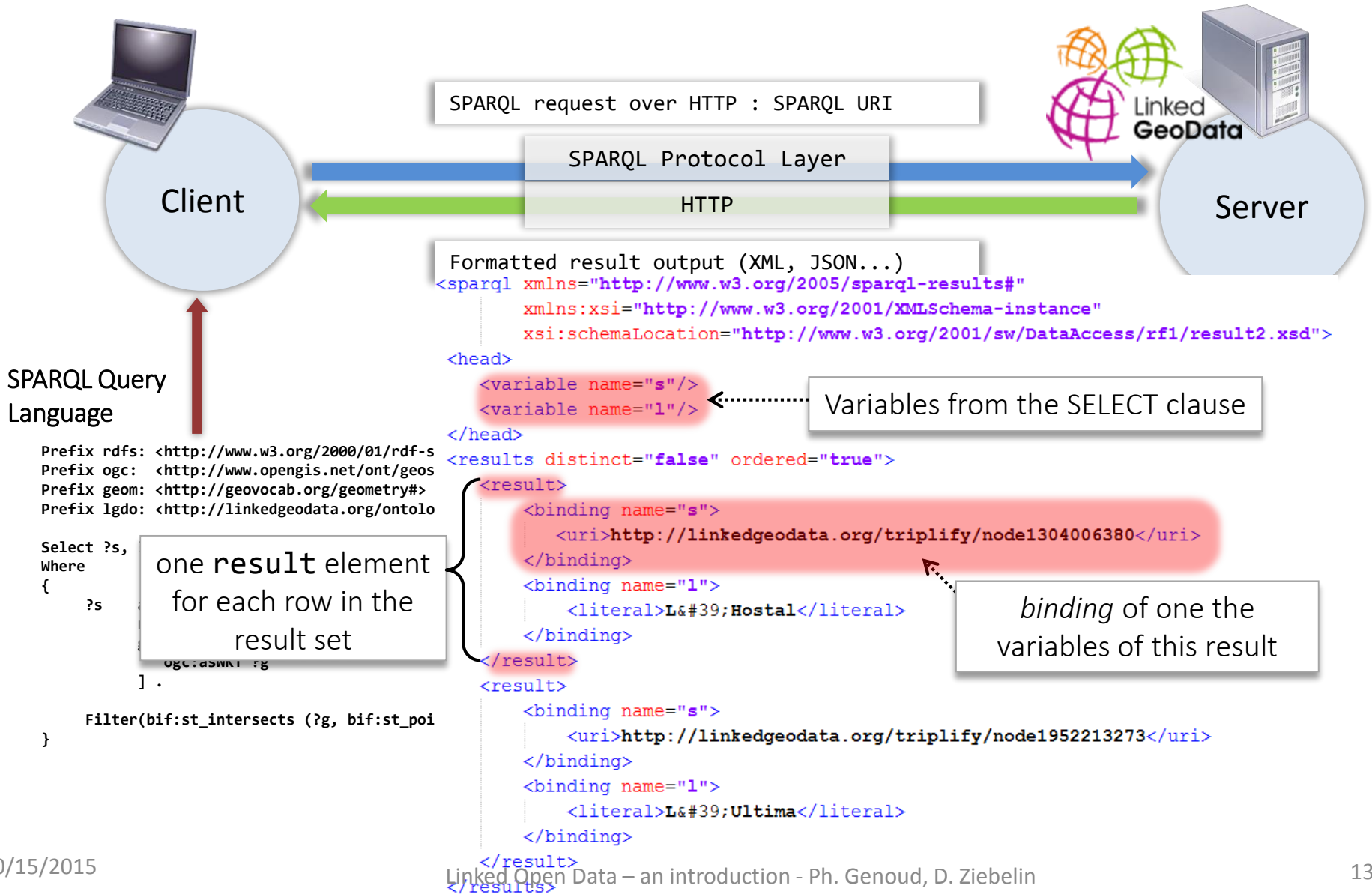
```

Select ?s, ?l From
Where
{
  ?s a lgdo:
  rdfs:la
  geom:ge
  ogc:
  ] .
}
    
```

```
Filter(bif:st_intersects (?g, bif:st_point (3.692764, 43.393794), 1)) .
```

Output format
format=application/sparql-results+xml
 (text/html, json...)

SPARQL : output format (XML)



SPARQL 1.1: new functionalities

- W3C Recommendation, March 2013, 21
 - <http://www.w3.org/TR/2013/REC-sparql11-overview-20130321/>
- Query
 - New aggregation functions for results (**count**, **min**, **max**, **group by**, etc.)
 - Variables assignment
 - `SELECT (COUNT(DISTINCT ?s)) AS ?num` *number of distinct restaurants*
 - Negation - MINUS
 - **NOT EXISTS**, **EXIST** :filtering results depending on whether a graph pattern does or does not match in the context of the query solution being filtered,

```
PREFIX rdf:    <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf:  <http://xmlns.com/foaf/0.1/>
```

```
SELECT ?person
WHERE
{
  ?person rdf:type  foaf:Person .
  FILTER NOT EXISTS { ?person foaf:name ?name }
}
```

Persons who don't have a name

Example from

<http://www.w3.org/TR/2013/REC-sparql11-query-20130321/#negation>

- **MINUS** removing solutions related to another pattern.

SPARQL 1.1: new functionalities

- Query...
 - subqueries: possibility to embed SPARQL queries within other queries
 - e.g. for limiting the number of results from some sub-expression within the query
 - subqueries are evaluated logically first, and the results are projected up to the outer query.

Example*: *Return a name (the one with the lowest sort order) for all the people that know Alice and have a name.* • From <http://www.w3.org/TR/2013/REC-sparql11-query-20130321/#subqueries>

```
@prefix : <http://people.example/> . The data
:alice :name "Alice", "Alice Foo", "A. Foo" .
:alice :knows :bob, :carol .
:bob :name "Bob", "Bob Bar", "B. Bar" .
:carol :name "Carol", "Carol Baz", "C. Baz" .
```

y	minName
:bob	"B. Bar"
:carol	"C. Baz"

y
:bob
:carol

```
PREFIX : <http://people.example/>
PREFIX : <http://people.example/>
SELECT ?y ?minName
WHERE {
  :alice :knows ?y .
  {
    SELECT ?y (MIN(?name) AS ?minName)
    WHERE {
      ?y :name ?name .
    } GROUP BY ?y
  }
}
```

1: inner query evaluation

2: outer query evaluation

3: results of 1. are joined with results of 2.

y	minName
:alice	"A. Foo"
:bob	"B. Bar"
:carol	"C. Baz"

SPARQL 1.1: new functionalities

- Query...
 - Basic federated queries (**SERVICE, BINDING**)
 - To execute requests distributed over different SPARQL endpoints

Example*: *is there anyone among Alice's friends with the same name as the resource identified by the IRI `<http://dbpedia.org/resource/Snoopy>` at Dbpedia?*

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name
WHERE {
  <http://example.org/alice#me> foaf:knows [ foaf:name ?name ] .
  SERVICE <http://dbpedia.org/sparql> {
    <http://dbpedia.org/resource/Snoopy> foaf:name ?name
  }
}
```

names of Alice's friend. This pattern is matched against the local SPARQL service

find out the name of <http://dbpedia.org/resource/Snoopy>
evaluation of this pattern is delegated to the respective remote SPARQL service `http://dbpedia.org/sparql`

* From <http://www.w3.org/TR/sparql11-overview/>

SPARQL 1.1: new functionalities ...

- New serialization formats for request results (JSON...)
- CRUD operations
 - Graph update: INSERT, INSERT DATA, DELETE DATA, DELETE, DELETE WHERE, LOAD, CLEAR)
 - Graph management: CREATE, DROP, COPY, MOVE, ADD
- Entailments
 - RDF, RDFS, OWL, RIF
- ...

<http://www.w3.org/TR/2013/REC-sparql11-overview-20130321/>

Outline

- “Theoretical” Session (morning)
 - Introduction
 - Distributing Data on the web with RDF
 - Naming the Data : URIs (Uniform Resources Identifiers)
 - The RDF Data model
 - Querying Linked Data with SPARQL
 - Semantic modelling
 - RDFS
 - OWL
 - From Open Data to Linked Open Data
 - Conclusion
- Hands-on session (afternoon)
 - From a CSV file to linked data
 - Querying linked data (SPARQL)

RDF limitations

- RDF provides a standard way to express simple statements about resources, using named properties and values...

But you can't express knowledge about the properties and types of the resources

- what are the types allowed for resources ?
- what are the properties allowed for a given type of resource ?
- what are the allowed values for a given property ?
- what are the relations between types of resources (generalization/specialization) ?
- ...

Resource Description Framework

- RDF a simple model (labelled graph) for data exchange



http://dbpedia.org/page/Rin_Tin_Tin

<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>

<http://dbpedia.org/class/yago/AnimalActors>

But...

- Which labels for the nodes and edges??
- How to interpret them ?

Semantic Web : formally capture some aspects of the meaning of these labels.



"On the Internet, nobody knows you're a dog."

RDF Schema (RDFS)

Officially called “RDF Vocabulary Description Language”
“Schema” is retained for historical reasons (XMLmania...)

→ provides user communities this ability to define the **vocabularies** (terms) they intend to use in their RDF statements

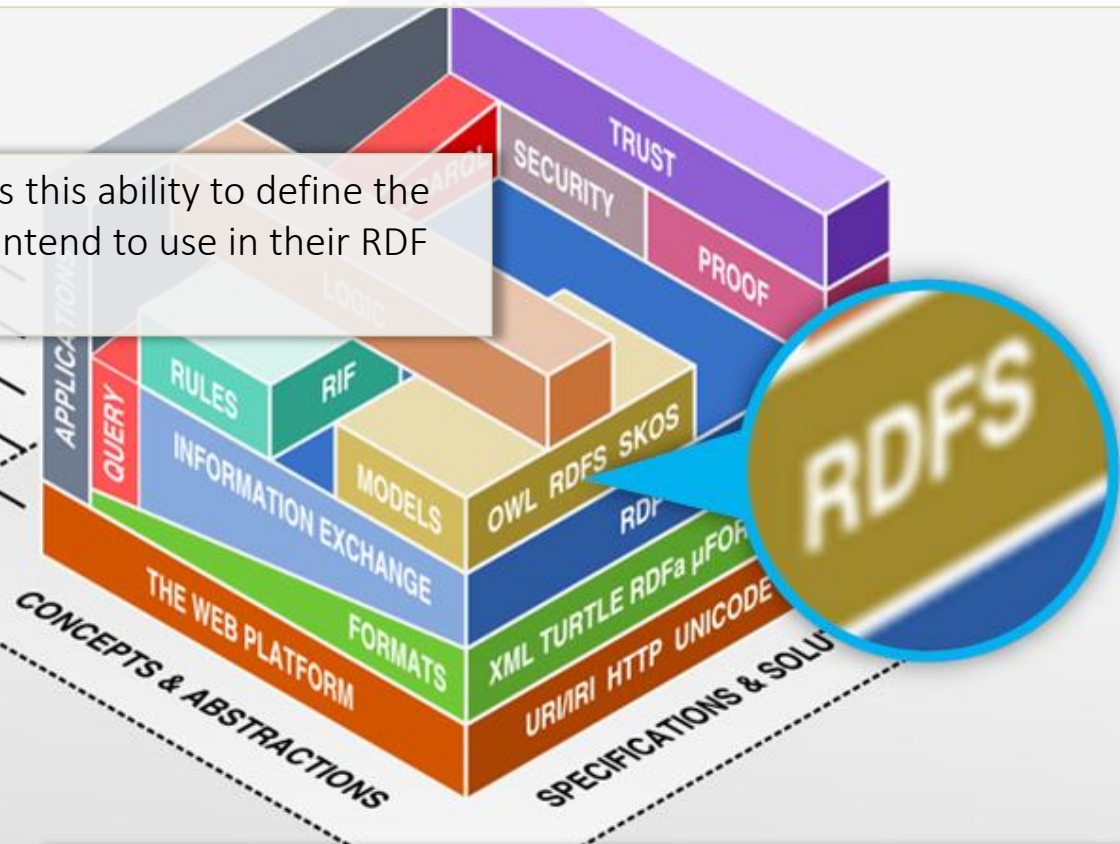
→ Standardized information exchange is key

Formats are necessary, but not too important

The Semantic Web is based on the Web

Linked Data uses a small selection of technologies

LINKED DATA



→ a **RDF vocabulary** : a specialized set of predefined RDF resources with their own special meanings

RDF Schema (RDF(S))

- Introduction
- RDF(S) Classes
- RDF(S) Properties
- Interpreting RDF(S) Schema Declarations
- More RDF(S) properties
- Conclusion

What is a vocabulary ?

- On the Semantic Web, vocabularies define the concepts and relationships (also referred to as “terms”) used to describe and represent an area of concern. Vocabularies are used to classify the terms that can be used in a particular application, characterize possible relationships, and define possible constraints on using those terms. In practice, vocabularies can be very complex (with several thousands of terms) or very simple (describing one or two concepts only).
- There is no clear division between what is referred to as “**vocabularies**” and “**ontologies**”. The trend is to use the word “ontology” for more complex, and possibly quite formal collection of terms, whereas “vocabulary” is used when such strict formalism is not necessarily used or only in a very loose sense. Vocabularies are the basic building blocks for inference techniques on the Semantic Web.

<http://www.w3.org/standards/semanticweb/ontology>

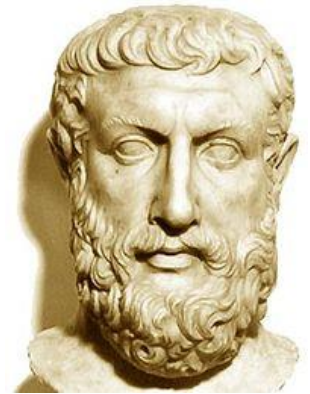
RDF Schema - RDF(S)

- RDF(S) extends RDF with a *schema vocabulary* (*Resource*, *Class*, *Property*, *subClassOf*, *subPropertyOf*, *range*, *domain*) that allows us to define basic vocabulary terms and the relations between them.
 - W3C recommendation RDF Vocabulary Description Language –RDF 1.1 (Feb. 2014)
<http://www.w3.org/TR/rdf-schema/> (previous rec. RDF 1.0 Feb. 2004)
- A well-defined **semantics** gives “extra meaning” to these particular RDF predicates and resources
 - specifies how terms should be interpreted
 - allows us to draw simple inferences (*entailments*)
- the RDF(S) schema vocabulary is itself provided in the form of an RDF vocabulary
 - resources in the RDF Schema vocabulary have URIs with the prefix <http://www.w3.org/2000/01/rdf-schema#>
(conventional abbreviation **rdfs:**)

What is an Ontology ?

- "**ontology** is the philosophical study of the nature of being, becoming, existence, or reality, as well as the basic categories of being and their relations. Traditionally listed as a part of the major branch of philosophy known as **metaphysics**, ontology deals with questions concerning what entities exist or can be said to exist, and how such entities can be grouped, related within a hierarchy, and subdivided according to similarities and differences."

<http://en.wikipedia.org/wiki/Ontology>



Parmenides
(c. 515 BCE - c. 460 BCE)

- "In computer science ..., an ontology is a formal framework for representing knowledge. This framework names and defines the types, properties, and interrelationships of the entities in a domain of discourse. The entities are conceptualizations (limited abstractions) of phenomena."

http://en.wikipedia.org/wiki/Ontology_%28information_science%29

An ontology is an explicit specification of a conceptualization. [...] A conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose.

Thomas R. Gruber, *Towards Principles for the Design of Ontologies Used for Knowledge Sharing in Formal Ontology in Conceptual Analysis and Knowledge Representation*, Kluwer Academic Publishers, 1993

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.91.6025&rep=rep1&type=pdf>



Thomas R. Gruber
(1959 -)

The Concept of Ontology in Computer Science

14

"An ontology is an **explicit, formal specification of a shared conceptualization**. The term is borrowed from philosophy, where an Ontology is a systematic account of Existence. For AI systems, what 'exists' is that which can be represented."

Thomas R. Gruber: A Translation Approach to Portable Ontology Specifications. Knowledge Acquisition, 5(2):199-220, 1993.

conceptualization:	abstract model (domain, identified relevant concepts, relations)
explicit:	meaning of all concepts must be defined
formal:	machine understandable
shared:	consensus about ontology

RDF Schema - RDF(S)

- Vocabulary descriptions (schemas) written in the RDF(S) language are legal RDF graphs.
 - any software that can process RDF can also interpret a RDF(S) schema as a legal RDF graph
 - ... but must be extended to understand the additional built-in meanings of the RDF Schema terms.

RDF Schema - RDF(S)

- RDF(S) provides a *type system* for RDF
 - similar in some respects to the type systems of object-oriented programming languages such as Java
 - Classes \leftrightarrow Types
 - Attributes \leftrightarrow Properties
 - Instances \leftrightarrow Resources
 - inheritance \leftrightarrow Hierarchical organization of types
 - but RDF Schema is a description language not a programming language : no methods

RDF Schema - RDF(S)

- RDF(S) extends RDF with a *schema vocabulary* (*Resource, Class, Property, subclassOf, subPropertyOf, range, domain...*) that allows us to define basic vocabulary terms and the relations between them.
 - W3C recommendation RDF Vocabulary Description Language
<http://www.w3.org/TR/rdf-schema/>
- the RDF(S) schema vocabulary is itself provided in the form of an RDF vocabulary
 - resources in the RDF Schema vocabulary have URIrefs with the prefix <http://www.w3.org/2000/01/rdf-schema#> (conventional prefix `rdfs:`)
 - Semantics gives “extra meaning” to these particular RDF predicates and resources
 - specifies how terms should be interpreted
 - allows us to draw inferences

RDF Schema - RDF(S)

- Vocabulary descriptions (schemas) written in the RDF(S) language are legal RDF graphs.
 - any software that can process RDF can also interpret a RDF(S) schema as a legal RDF graph
 - ... but must be extended to understand the additional built-in meanings of the RDF Schema terms.

RDF Schema (RDF(S))

- Introduction
- RDF(S) Classes
- RDF(S) Properties
- Interpreting RDF(S) Schema Declarations
- More RDF(S) properties
- Conclusion

RDF(S) Classes

- **classes** : Sets of objects/instances/individuals sharing certain characteristics
- in RDF(S) a class is any resource having an **rdf:type** property whose value is the resource **rdfs:Class**.

```
ex:MotorVehicle rdf:type rdfs:Class .
```

```
ex:BlackThing  $\updownarrow$  a rdfs:Class .
```

- **rdf:type** property to indicate that a resource is an instance of a class.

```
rdfs:Class rdf:type rdfs:Class.
```

```
exthings:companyCar rdf:type ex:MotorVehicle , ex:BlackThing.
```

A resource may be an instance of more than one class.

RDF(S) Classes

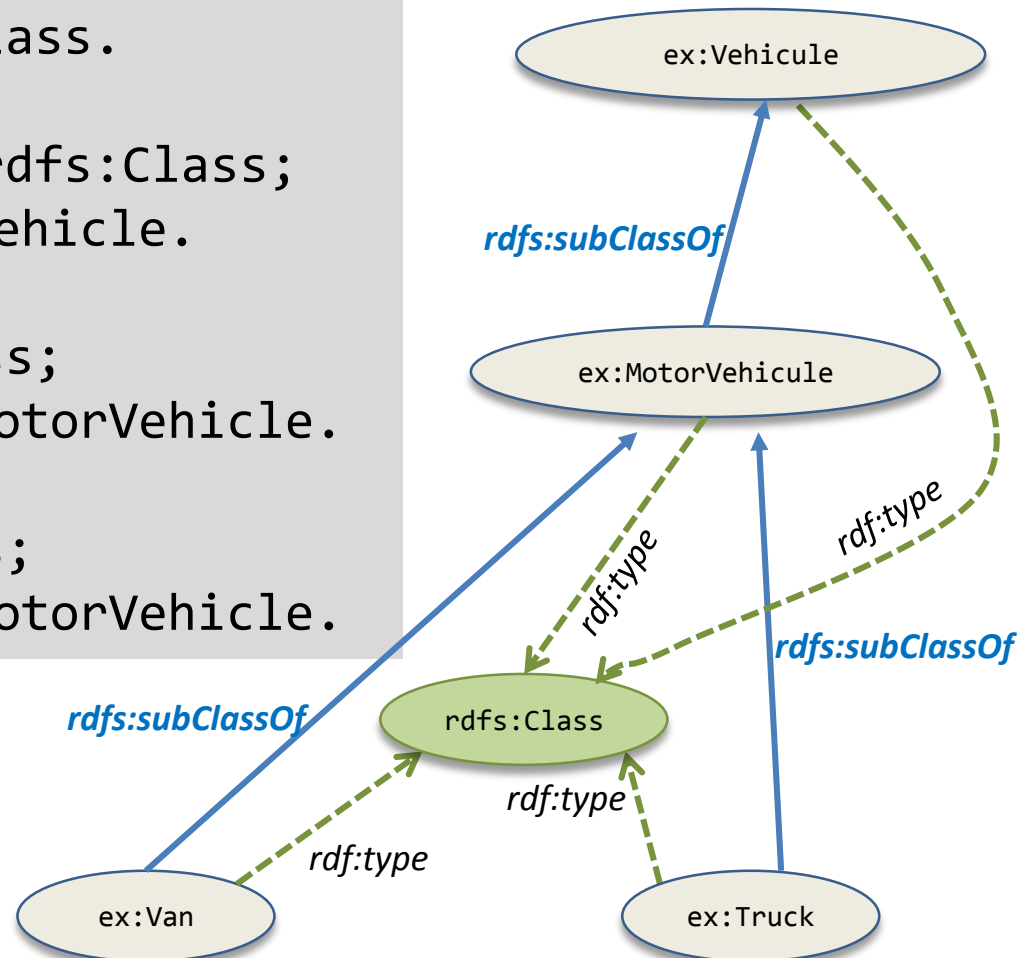
- Specialization relationship between two classes is described using the predefined **rdfs:subClassOf** property

```
ex:Vehicle rdf:type rdfs:Class.
```

```
ex:MotorVehicule rdf:type rdfs:Class;  
  rdfs:subClassOf ex:Vehicle.
```

```
ex:Truck rdf:type rdfs:Class;  
  rdfs:subClassOf ex:MotorVehicule.
```

```
ex:Van rdf:type rdfs:Class;  
  rdfs:subClassOf ex:MotorVehicule.
```



RDF(S) Classes

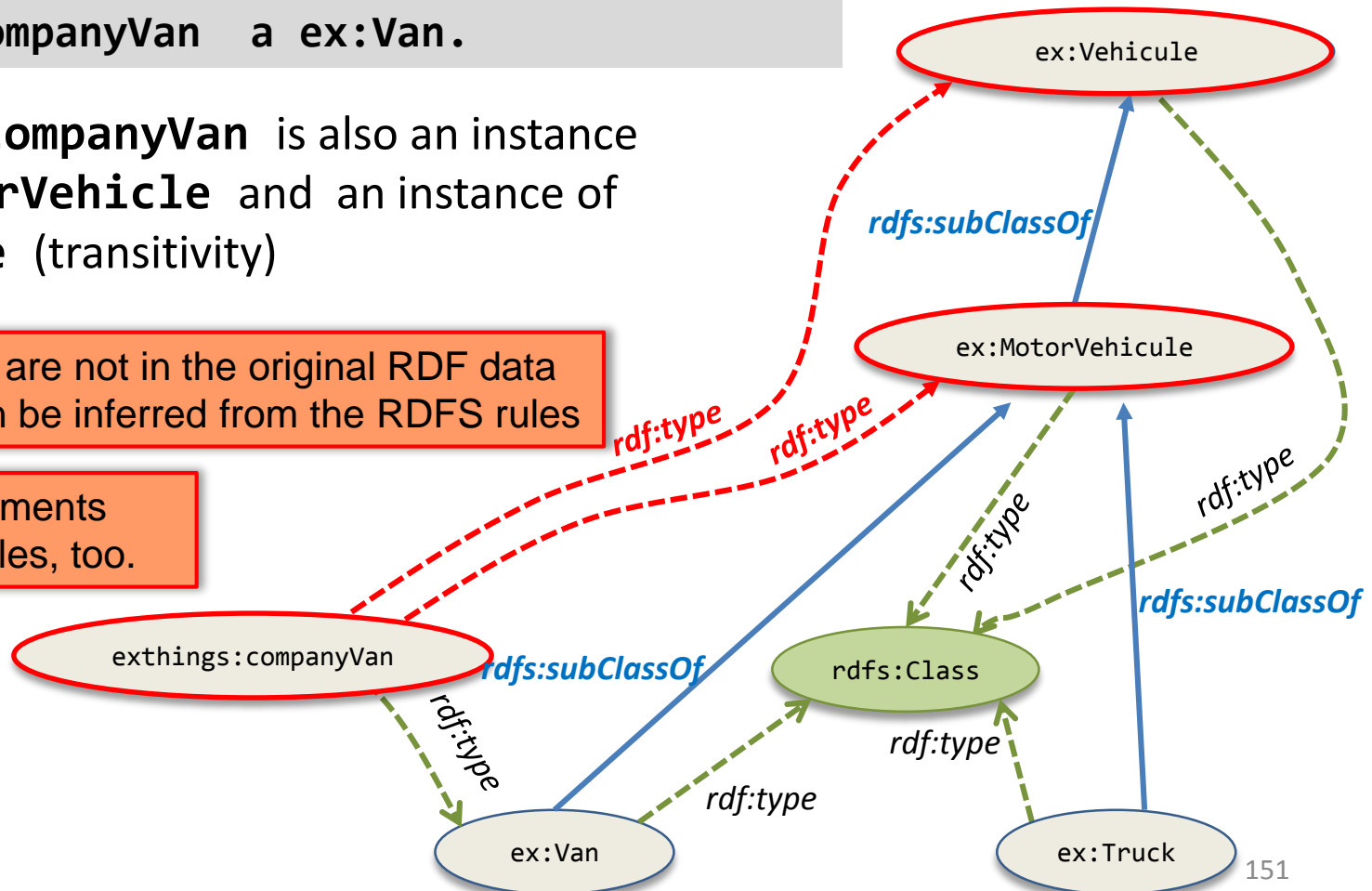
- **subClassOf** meaning : any instance of a subclass is also an instance of all the superclasses

```
exthings:companyVan a ex:Van.
```

→ **exthings:companyVan** is also an instance of **ex:MotorVehicle** and an instance of **ex:Vehicle** (transitivity)

Triples are not in the original RDF data but can be inferred from the RDFS rules

RDFS environments return that triples, too.



Inference: let us be formal...

YOU KNOW, I DON'T
THINK MATH IS A SCIENCE.
I THINK IT'S A RELIGION.
ALL THESE EQUATIONS
ARE LIKE MIRACLES YOU
TAKE TWO NUMBERS AND WHEN
YOU ADD THEM, THEY MAGICALLY
BECOME ONE *NEW* NUMBER!
NO ONE CAN SAY HOW IT
HAPPENS. YOU EITHER BELIEVE
IT OR YOU DON'T.



- The RDF Semantics document has a list of (33) entailment rules:
 - “if such and such triples are in the graph, add this and this”
 - do that recursively until the graph does not change
- The relevant rule for our example:

- Type propagation

```
If:  
  C2 rdfs:subClassOf C1.  
  x rdf:type C2.  
Then add:  
  x rdf:type C1.
```

RDFS Class semantics (...)

- Any `rdfs:Class` is a subclass of `rdfs:Resource`

```
If:  
  C rdf:type rdfs:Class.  
Then add:  
  C rdfs:subClassOf rdfs:Resource.
```

- Subsumption Reflexivity

```
If:  
  C rdf:type rdfs:Class.  
Then add:  
  C rdfs:subClassOf C.
```

Enables to model the fact that 2 classes contains the same individuals (are extensionally equivalent) by establishing a mutual subclass relationship

```
C1 rdfs:subClassOf C2  
C2 rdfs:subClassOf C1
```

- Subsumption Transitivity

```
If:  
  C2 rdfs:subClassOf C1.  
  C3 rdfs:subClassOf C2.  
Then add:  
  C3 rdfs:subClassOf C1.
```

RDF(S) Classes

- A class may be a subclass of more than one class



```
ex:MotorVehicle    rdf:type          rdfs:Class .
ex:PassengerVehicle  rdf:type          rdfs:Class ;
                   rdfs:subClassOf  ex:MotorVehicle .
ex:Van              rdf:type          rdfs:Class ,
                   rdfs:subClassOf  ex:MotorVehicle .
ex:Truck            rdf:type          rdfs:Class;
                   rdfs:subClassOf  ex:MotorVehicle .
ex:MiniVan          rdf:type          rdfs:Class ;
                   rdfs:subClassOf  ex:Van, ex:PassengerVehicle .
```

RDF Schema (RDF(S))

- Introduction
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RDF(S) Properties

- All properties in RDF are described as instances of class **rdf:Property**.
- RDF(S) properties **rdfs:domain**, **rdfs:range**, and **rdfs:subPropertyOf** describe how properties and classes are intended to be used together in RDF data.
 - **rdfs:domain** specifies the type of all individuals that are the subject of statements using the described property.
 - **rdfs:range** specifies the type of all individuals or the datatype of all literals that are the object of statements using the described property.

RDF(S) Properties

- example of a property with a domain and range

```
ex:Person    rdf:type    rdfs:Class .
ex:Book      rdf:type    rdfs:Class .

ex:author    rdf:type    rdf:Property;
              rdfs:domain ex:Book;
              rdfs:range  ex:Person .
```

```
ex:SemanticWebForDummies ex:author ex:JeffPollock.
```



```
ex:SemanticWebForDummies rdf:type ex:Book.
ex:JeffPollock           rdf:type ex:Person.
```

- example of a property with a datatype range

```
ex:price    rdf:type    rdf:Property;
              rdfs:range xsd:Integer .
```

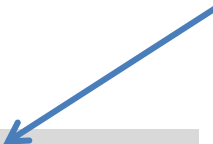
RDF(S) Properties

- A property can have zero, one, or more than one range property
 - **0 range property** : nothing is said about the values of the property. Anything (resource or literal) can be used as an object of the property
 - **1 range property** : this says that the objects of the property are instances (literals) of the given class (datatype)
 - **more than 1 range property** : this says that the objects of the property are instances (literals) of **all** classes (datatypes) specified as a range

```
ex:hasMother    rdfs:range    ex:Female ;  
                rdfs:range    ex:Person .
```

```
exstaff:frank  ex:hasMother  exstaff:frances .
```

must be both an instance of `ex:Female` and of `ex:Person`.



RDF(S) Properties

- A property can have zero, one, or more than one domain property
 - **0 domain property**: nothing is said about the subjects of the property. Any resource can be used as a subject of the property
 - **1 domain property** : this says that the subjects of the property are instances of the given class
 - **more than 1 domain property** : this says that the subjects of the property are instances of **all** classes specified as a range

```
ex:isMotherOf    rdfs:domain    ex:Female ;  
                 rdfs:domain    ex:Person .
```

```
exstaff:frances  ex:isMotherOf  exstaff:frank .
```



must be both an instance of `ex:Female` and of `ex:Person`.

RDF(S) Properties

- the predefined `rdfs:subPropertyOf` property allows to describe specialization relationship between two properties

```
property1    rdfs:subPropertyOf    property2.
```

- property1 is a specialization of property2
- any two resources related using property1 are implicitly related by property2

```
ex:driver    rdf:type    rdf:Property .  
ex:primaryDriver    rdf:type    rdf:Property ;  
                rdfs:subPropertyOf    ex:driver .
```

```
exstaff:fred ex:primaryDriver ex:companyVan
```



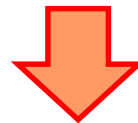
```
exstaff:fred ex:driver ex:companyVan
```

RDF(S) Properties

- A property may be a subproperty of zero, one or more properties
- All RDF Schema `rdfs:range` and `rdfs:domain` properties that apply to an RDF property also apply to each of its subproperties.

```
ex:driver          rdf:type          rdf:Property ;  
                  rdf:range          ex:Person;  
                  rdf:domain         ex:Vehicle.  
ex:primaryDriver  rdf:type          rdf:Property ;  
                  rdfs:subPropertyOf ex:driver .
```

```
exstaff:fred ex:primaryDriver ex:companyVan.
```



```
exstaff:fred ex:driver ex:companyVan.
```

```
exstaff:fred rdf:type ex:Person.
```

```
ex:companyVan rdf:type ex:Vehicle.
```

RDFS Property semantics

- Type inference (domain)

```
If:  
  p rdfs:domain d.  
  x p y  
Then add:  
  x rdf:type d.
```

- Type inference (range)

```
If:  
  p rdfs:range r.  
  x p y  
Then add:  
  y rdf:type r.
```

- Property inheritance

```
If:  
  p2 rdfs:subPropertyOf p1.  
  x p2 y.  
Then add:  
  x p1 y.
```


RDF(S) Properties

- by default properties are defined independently of classes descriptions

```
ex:hasParent a rdf:Property.
```

hasParent has a *global scope* and could then be used to describe instances of any class

```
ex:Human a rdfs:Class.
```

```
ex:John a          ex:Human;  
        ex:hasParent ex:Mary.
```

```
ex:Dog a rdfs:Class.
```

```
ex:Daisy a ex:Dog;  
        ex:hasParent ex:Amber.
```

this flexibility facilitates the use of property in situations that might not have been anticipated in the original description

```
ex:Book a rdfs:Class.
```

```
ex:SemwebForDummies a ex:Book;  
                    ex:hasParent ex:Jeff.
```

but properties can be mis-applied in inappropriate situations

RDF(S) properties

- with `rdfs:domain` and `rdfs:range` you can "constraint" properties...

```
ex:hasParent a rdf:Property;  
             rdfs:domain ex:Human;  
             rdfs:range ex:Human.
```

```
ex:John a ex:Human;  
        ex:hasParent ex:Mary.
```

- but this introduce inflexibility and should be used with caution

```
ex:Daisy a ex:Dog.
```

```
ex:Mary ex:hasParent ex:Daisy.
```

→ `ex:Daisy a Dog` **and** `a Human` ?

any range defined for an RDF property applies to all uses of the property

it is not possible in an RDF schema to define a specific property as having locally-different ranges depending on the class of the resource it is applied to.

RDF(S) Properties

```
ex:LivingOrganism a rdfs:Class.
```

```
ex:Human a rdfs:Class;  
  rdfs:subClassOf ex:LivingOrganism.
```

```
ex:Dog a rdfs:Class;  
  rdfs:subClassOf ex:LivingOrganism.
```

```
ex:Cat a rdfs:Class;  
  rdfs:subClassOf ex:LivingOrganism.
```

```
ex:hasParent a rdf:Property;  
  rdfs:domain ex:LivingOrganism;  
  rdfs:range ex:LivingOrganism.
```

Not enough :

A Dog can have a Cat as parent



```
ex:hasHumanParent a rdf:Property;  
  rdfs:subPropertyOf ex:hasParent;  
  rdfs:domain ex:Human;  
  rdfs:range ex:Human.
```

Add new properties
specializing hasParent

```
ex:hasCatParent a rdf:Property;  
  rdfs:subPropertyOf ex:hasParent;
```

...



RDF Schema (RDF(S))

- Introduction
- RDF(S) Classes
- RDF(S) Properties
- Interpreting RDF(S) Schema Declarations
- More RDF(S) properties
- Conclusion

Interpreting RDF(S) Schema Declarations

- RDF(S) descriptions are not (necessarily) *prescriptive* like OOP languages are.
→ RDF(S) doesn't prescribe how the statements should be used by an application

OOP Language (Java)

```
public Class Person{  
    private String name;  
  
    Person(String name) {  
        this.name = name;  
    }  
}
```

every instance of Person has a property (attribute) name and this attribute is unique

this attribute is unique

instance of Person have no other property than name

RDF(S)

```
ex:Person a rdfs:Class.
```

```
ex:hasName a rdf:Property;  
    rdfs:domain ex:Person;  
    rdfs:range xsd:String;
```

the property is not mandatory for instances of Person

```
ex:John a ex:Person;  
    ex:hasName "Johnny Defool".
```

```
ex:Jane a rdfs:Person.
```

you can have multiple values

```
ex:John ex:hasName "Johnny".
```

you can have other properties

```
ex:John foaf:knows ex:Mary.
```

Interpreting RDF(S) Schema Declarations

- RDF(S) might be used in different ways according to applications

```
ex:hasParent a rdf:Property;  
             rdfs:domain ex:Human;  
             rdfs:range  ex:Human.
```

- Constraint
 - a Human doesn't have a parent → application error
 - a Human has a parent p but its type is unknown → application error
 - a Human has a parent p with an other type than Human → application error
- Inferences
 - a Human doesn't have a parent → application adds an unknown (Human) parent
 - a Human has a parent p but its type is unknown → application infers that p is of Human type
 - a Human has a parent p with an other type than Human → application infers that p is of Human type (in addition to other known types)
 - this can lead to inconsistencies that must be detected

RDF Schema (RDF(S))

- Introduction
- RDF(S) Classes
- RDF(S) Properties
- Interpreting RDF(S) Schema Declarations
- **More RDF(S) properties**
- Conclusion

more RDF(S) properties

- *rdfs:Resource* **rdfs:comment** *rdfs:Literal*
 - used to provide a human-readable description of a resource
- *rdfs:Resource* **rdfs:label** *rdfs:Literal*
 - a human-readable version of a resource's name
- *rdfs:Resource* **rdfs:seeAlso** *rdfs:Resource*
 - used to indicate a resource that might provide additional information about the subject resource
- *rdfs:Resource* **rdfs:isDefinedBy** *rdfs:Resource*
 - to indicate a resource defining the subject resource. This property may be used to indicate an RDF vocabulary in which a resource is described
- ...

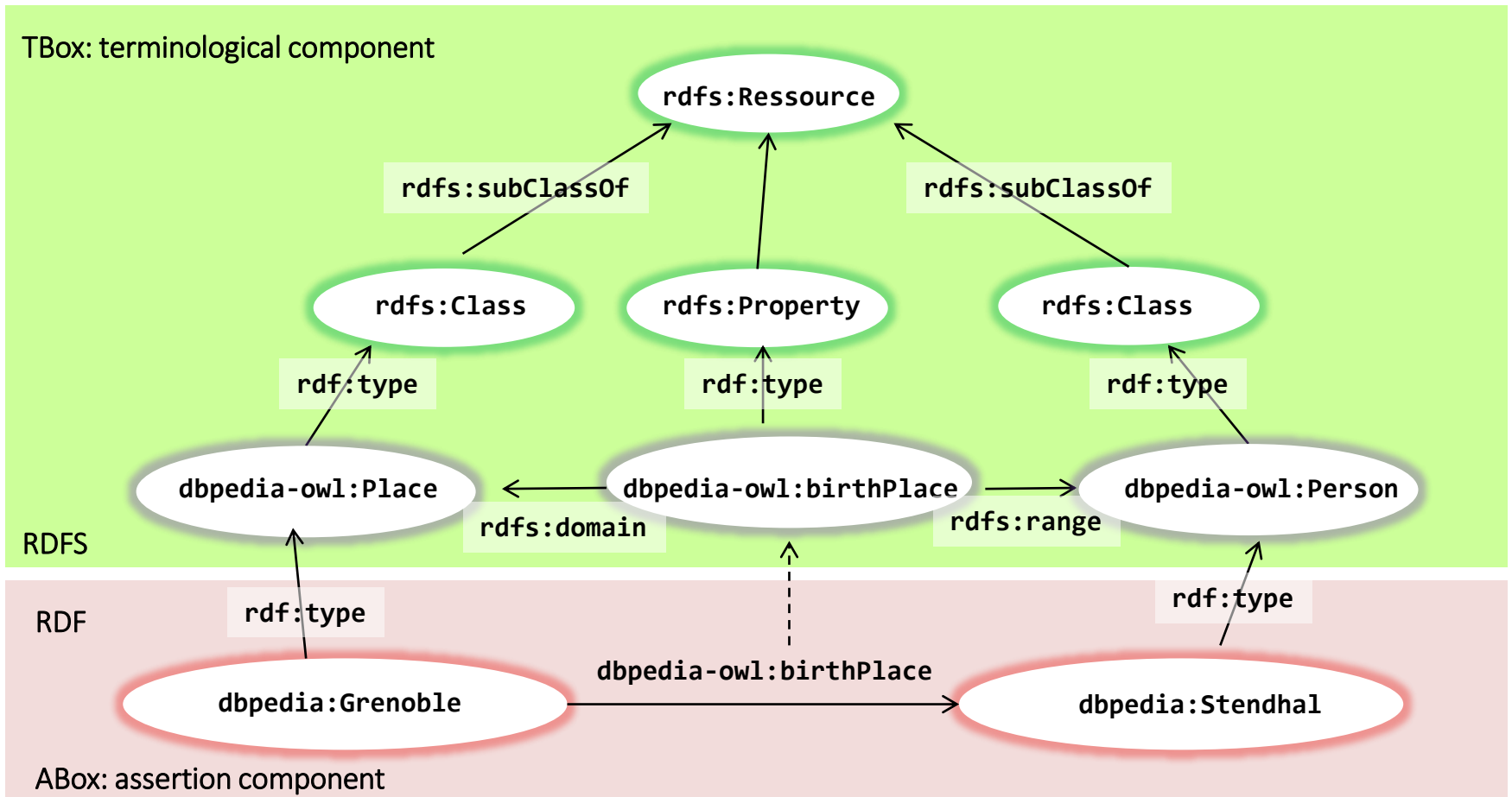
<http://www.w3.org/TR/rdf-schema/>

RDF Schema (RDF(S))

- Introduction
- RDF(S) Classes
- RDF(S) Properties
- Interpreting RDF(S) Schema Declarations
- more RDF(S) properties
- Conclusion

RDF Schema (RDFS)

Prefixes
dbpedia: http://dbpedia.org/resource/
dbpedia-owl: http://dbpedia.org/ontology/
rdfs: http://www.w3.org/2000/01/rdf-schema#



What does RDF(S) give us ?

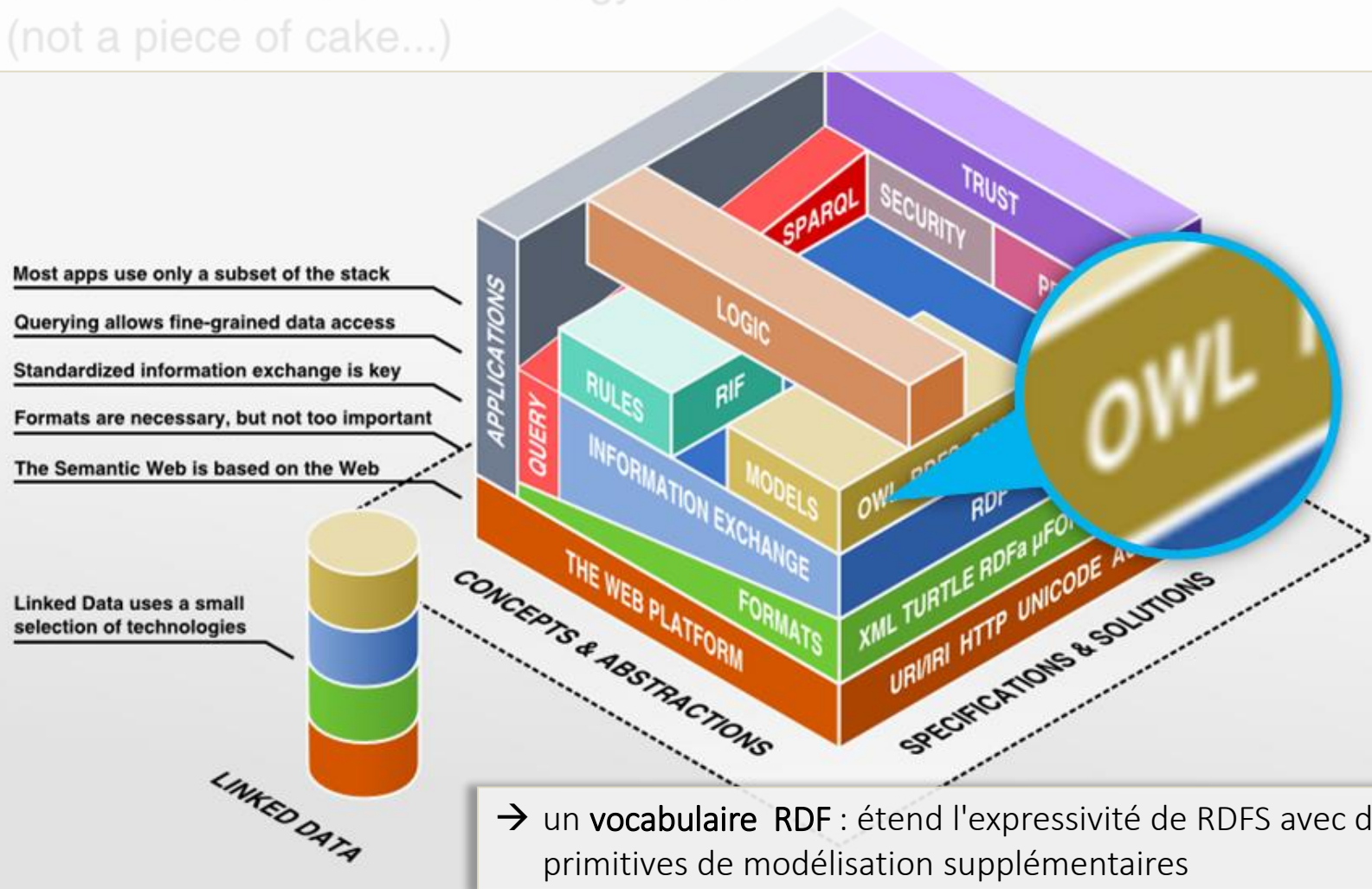
- RDF
 - A mechanism for publishing data.
 - Single (simple) data model.
 - Syntactic consistency between names (IRIs).
 - Low level integration of data.
 - Mash the graphs together and we're done.
- RDF(S)
 - Ability to use simple schema/vocabularies when describing our resources.
 - Consistent vocabulary use and sharing.
 - Basic inference

Problems with RDF(S)

- RDF(S) is **too weak** to describe resources in sufficient detail
 - No **localized range and domain** constraints
 - Can't say that the range of **hasParent** is **Person** when applied to **Persons** and **Dog** when applied to **Dogs**
 - No **existence/cardinality** constraints
 - Can't say that all instances of **Person** have a mother that is also a **Person**, or that **Persons** have exactly 2 parents
 - No **transitive, inverse** or **symmetrical** properties
 - Can't say that **isPartOf** is a transitive property, that **hasPart** is the inverse of **isPartOf** or that **touches** is symmetrical
 - ...

Web Ontology Language (OWL)

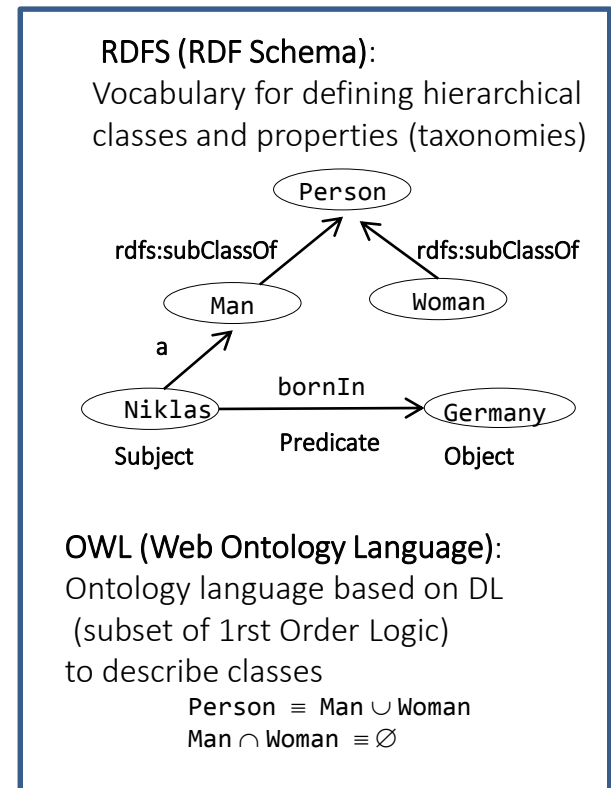
The Semantic Web Technology Stack
(not a piece of cake...)



→ un vocabulaire RDF : étend l'expressivité de RDFS avec des primitives de modélisation supplémentaires

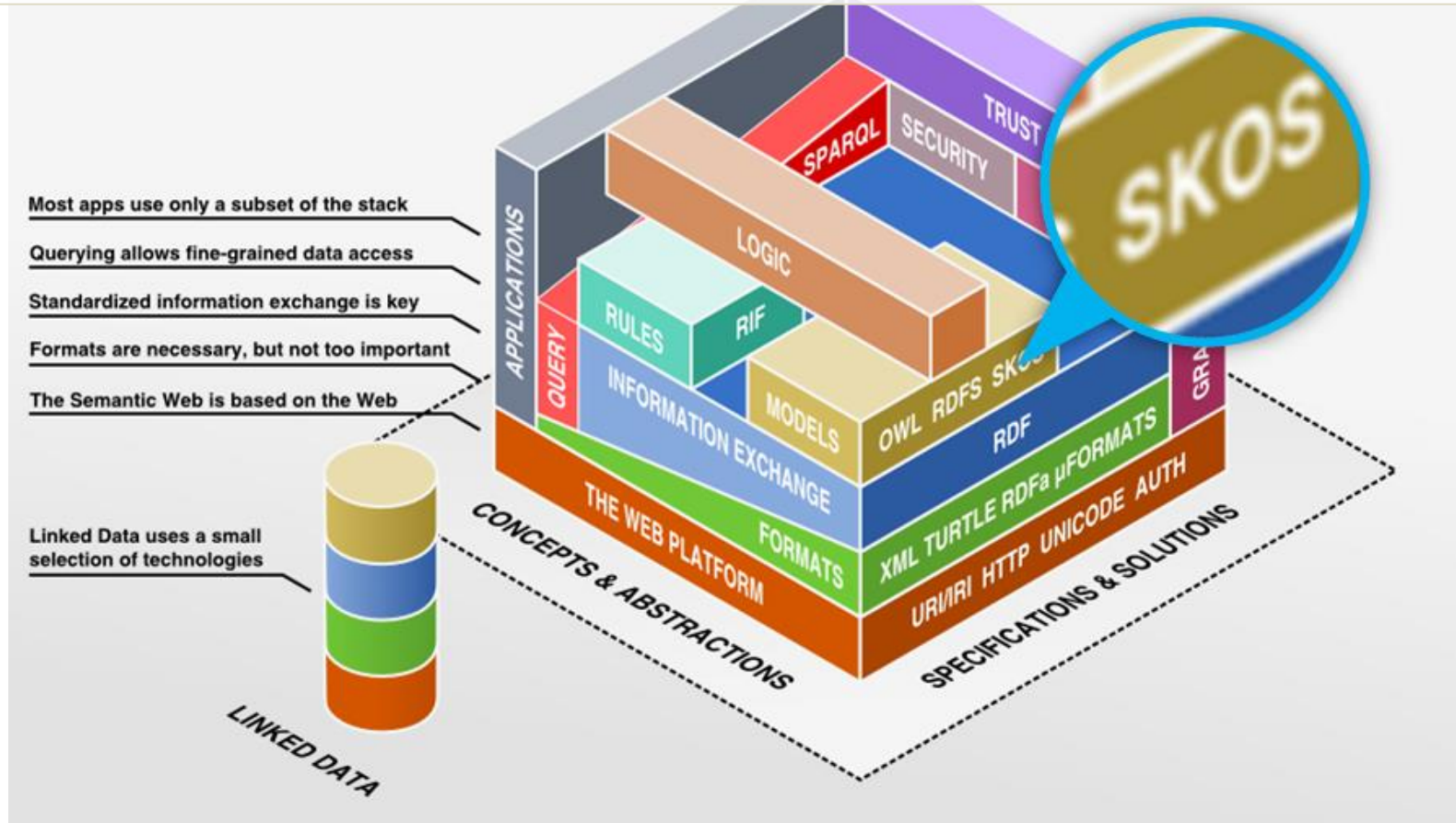
Web Ontology Language (OWL)

- a W3C standard
 - OWL 1 : W3C recommendation 10 Feb. 2004 <http://www.w3.org/TR/owl-features/>
 - OWL 2 : W3C recommendation 11 Dec. 2012 <http://www.w3.org/TR/owl2-overview/>
- OWL vocabulary : a set of primitives described in RDF that extends RDFS vocabulary
 - namespace
<http://www.w3.org/2002/07/owl#> ⇔ **owl:**
- Far more expressive than RDFS
 - Classes can be describe by union, intersection, complement, properties restrictions.
 - notions of classes or properties equivalence, resources equality,
 - notions of inverse, symmetric, transitive ... properties
 - properties cardinality...
- Formal specification (based on Description Logics)
→ support for automated reasoning



Simple Knowledge Organization System (SKOS)

modèle commun pour partager et lier (via RDF) sur le web différents systèmes d'organisation de connaissances tels thésaurus, taxinomies, systèmes de classification, système d'index.



Simple Knowledge Organization System (SKOS)

- OWL → Ontologie SKOS → thesaurus
 - *"l'objectif d'un thésaurus est de constituer des vocabulaires normalisés et d'organiser la liste des termes de ces vocabulaire sans forcément les définir, dans le but notamment d'indexer un corpus de ressources documentaires et de faciliter les recherches dans ce corpus"* Le web Sémantique, Fabien Gandon, Catherine Faron-Zucker, Olivier Corby, ed. Dunod 2012
- Hierarchical relationships (d'après <http://fr.wikipedia.org/wiki/Thésaurus>)
 - Generic term (BT: broader term) , specific term (NT: narrower term).
 - Partitives relationships (whole-part relations) , instantiation relationships (to give examples)
- Associative relationships
 - RT: related term.
- Equivalent terms
 - ...

Simple Knowledge Organization System (SKOS)

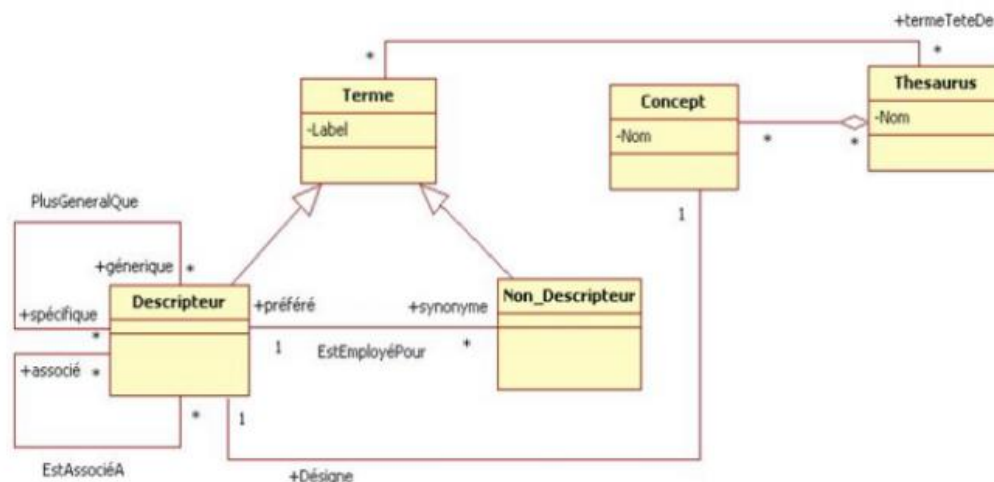
- W3C Standard (recommandation) :

SKOS Simple Knowledge Organization System Reference (August 2009)

<http://www.w3.org/TR/2009/REC-skos-reference-20090818/>

"SKOS a common data model for sharing and linking knowledge organization systems via the Web. Many knowledge organization systems, such as thesauri, taxonomies, classification schemes and subject heading systems, share a similar structure, and are used in similar applications. SKOS captures much of this similarity and makes it explicit, to enable data and technology sharing across diverse applications

The SKOS data model provides a standard, low-cost migration path for porting existing knowledge organization systems to the Semantic Web. SKOS also provides a lightweight, intuitive language for developing and sharing new knowledge organization systems. It may be used on its own, or in combination with formal knowledge representation languages such as the Web Ontology language (OWL)"



- Technical notes:

- SKOS Simple Knowledge Organization System Primer <http://www.w3.org/TR/2009/NOTE-skos-primer-20090818/>
- SKOS Use Cases and Requirements <http://www.w3.org/TR/2009/NOTE-skos-ucr-20090818/>

Outline

- “Theoretical” Session (morning)
 - Introduction
 - Distributing Data on the web with RDF
 - Naming the Data : URIs (Uniform Resources Identifiers)
 - The RDF Data model
 - Querying Linked Data with SPARQL
 - Semantic modelling
 - RDFS
 - OWL
 - From Open Data to Linked Open Data
 - Conclusion
- Hands-on session (afternoon)
 - From a CSV file to linked data
 - Querying linked data (SPARQL)

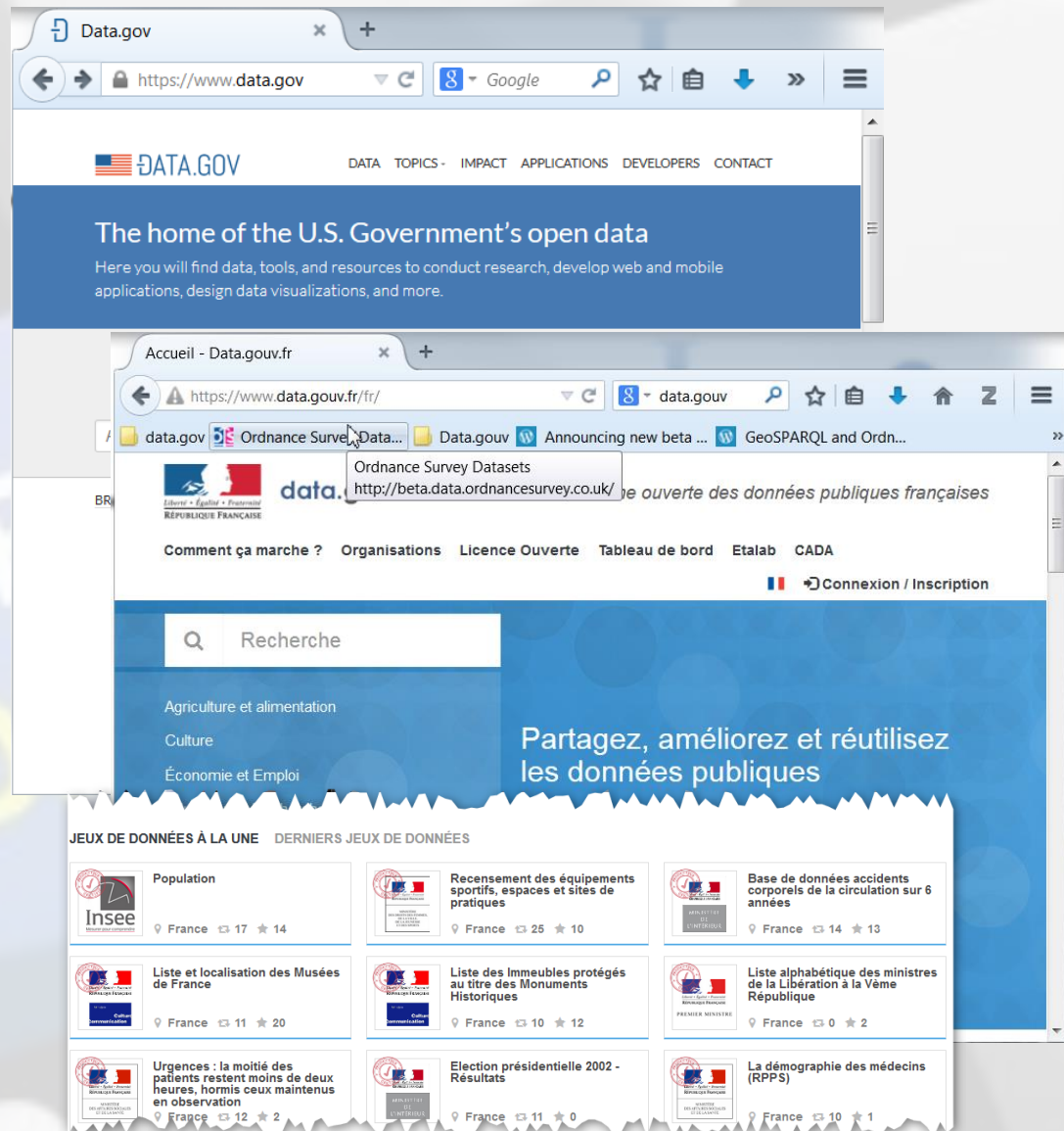
Open Data

- Open Data Movement

- “A piece of content or data is open if anyone is free to use, reuse, and redistribute it — subject only, at most, to the requirement to attribute and/or share-alike.”

- <http://opendefinition.org/>

- an old idea but a recent term gaining popularity
 - with the rise of the Internet and World Wide Web
 - with the launch of open-data government initiatives such as Data.gov (USA), data.gouv.fr (FR)...



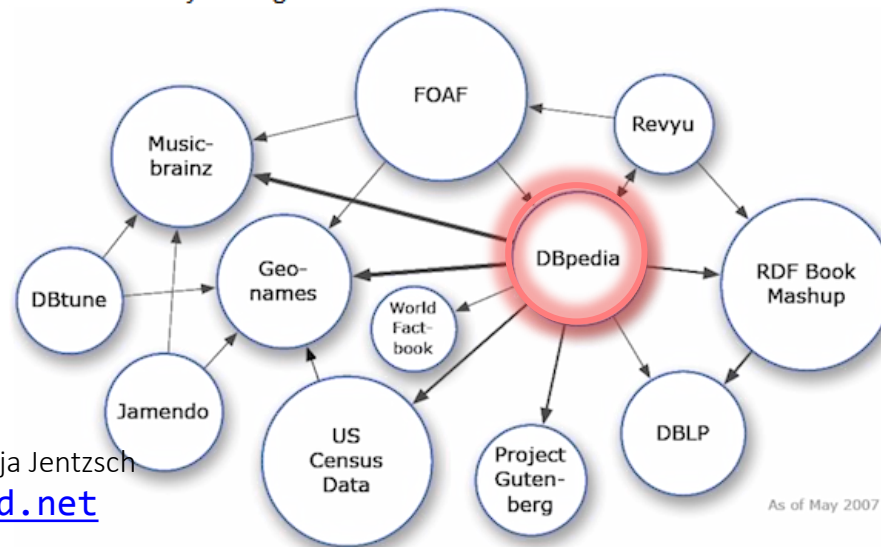
What is This Thing Called Linked Data?
M. Atencia, J. David, Ph. Genoud

Linked Open Data



The [Open Data Movement](#) aims at making data freely available to everyone. There are already various interesting open data sets available on the Web. Examples include [Wikipedia](#), [Wikibooks](#), [Geonames](#), [MusicBrainz](#), [WordNet](#), the [DBLP bibliography](#) and many more which are published under [Creative Commons](#) or [Talis](#) licenses.

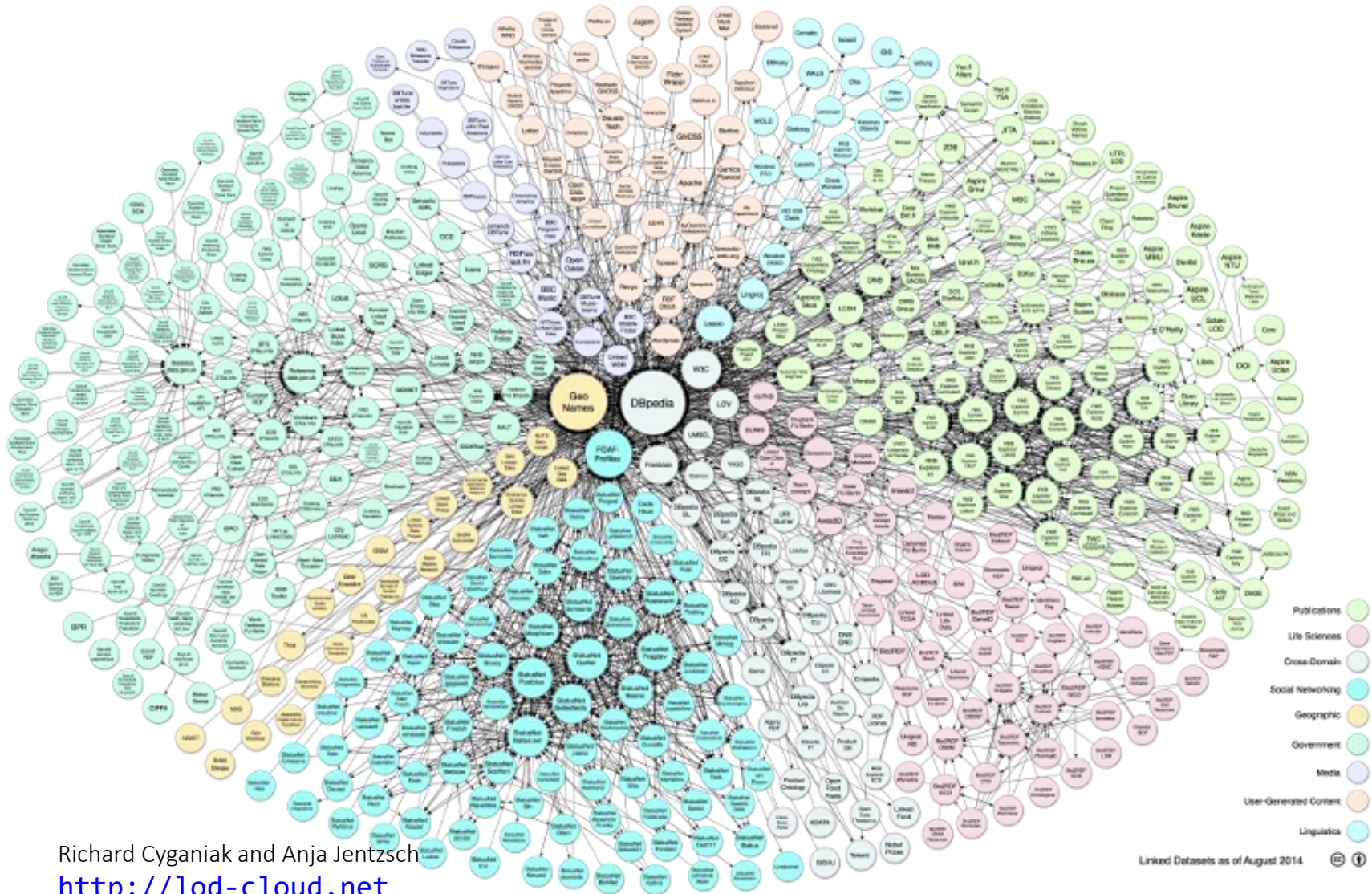
The goal of the W3C SWEQ Linking Open Data community project is to extend the Web with a data commons by publishing various open data sets as RDF on the Web and by setting RDF links between data items from different data sources.



Richard Cyganiak and Anja Jentzsch
<http://lod-cloud.net>

As of May 2007

Linked Open Data



From Open Data to Linked Open Data



- 2006: defines basic principles for publishing Linked Data
- 2010: added a 5 star rating system for Linked Open Data (LOD)

"in order to encourage people -- especially government data owners -- along the road to good linked data..."

Tim Berners-Lee

<http://www.w3.org/DesignIssues/LinkedData.html>



★ Open Data

make your stuff available on the Web (whatever format)
under an open license

A Creative Commons license icon showing 'CC' in a circle, followed by icons for Attribution (BY), Non-Commercial (NC), and No Derivatives (ND).

Temperature forecast for Galway, Ireland	
Day	Lowest Temperature (°C)
Saturday, 13 November 2010	2
Sunday, 14 November 2010	4
Monday, 15 November 2010	7

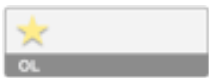
Michael Hausenblas <http://5stardata.info/>

Costs & benefits of ★ Web data

- As a consumer ...
 - ✓ You can look at it.
 - ✓ You can print it.
 - ✓ You can store it locally (on your hard drive or on a USB stick).
 - ✓ You can enter the data into any other system.
 - ✓ You can change the data as you wish.
 - ✓ You can share the data with anyone you like.
- As a publisher ...
 - ✓ It's simple to publish.
 - ✓ You do not have to explain repeatedly to others that they can use your data.

★★ Open Data

make it available as structured data (e.g., Excel instead of image scan of a table)



The screenshot shows a Microsoft Excel spreadsheet with the following data:

	A	B	C
1	Temperature forecast for Galway, Ireland		
2			
3	Day	Lowest Temperature (°C)	
4	Saturday, 13 November 2010	2	
5	Sunday, 14 November 2010	4	
6	Monday, 15 November 2010	7	
7			

Costs & benefits of ★★ Web data

- As a consumer, you can do all what you can do with ★ Web data and additionally:
 - ✓ You can directly process it with proprietary software to aggregate it, perform calculations, visualise it, etc.
 - ✓ You can export it into another (structured) format.
- As a publisher ...
 - ✓ It's still simple to publish.

☆☆☆ Open Data

use non-proprietary formats (e.g., CSV instead of Excel)



```
gtd-3.csv
1 "Temperature forecast for Galway, Ireland",
2
3 "Day", "Lowest Temperature (C)"
4 "Saturday, 13 November 2010",2
5 "Sunday, 14 November 2010",4
6 "Monday, 15 November 2010",7
```

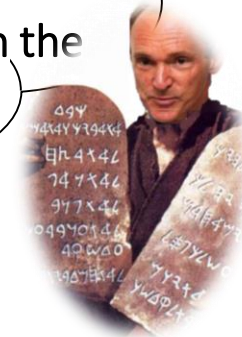
length: 164 lines: 6 Ln: 1 Col: 1 Sel: 0 Macintosh ANSI as UTF-8 INS

Costs & benefits of ★★★ Web data

- As a consumer, you can do all what you can do with
★ ★ Web data and additionally:
 - ✓ You can manipulate the data in any way you like, without being confined by the capabilities of any particular software.
- As a publisher ...
 - ⚠ You might need converters or plug-ins to export the data from the proprietary format.
 - ✓ It's still rather simple to publish.

Is ★★★ open data enough ?

Excellent! The data is not only available via the Web but now everyone can use the data easily. On the other hand, it's still data on the Web and not data in the Web*.



**Data and the Web – a great many of choices.* Woddiscovery (M. Hausenblas' blog)• 2010-03-01
<https://webofdata.wordpress.com/2010/03/01/data-and-the-web-choices/>

★★★★ Linked data



http://data...

1. Use URIs as names for things.
2. Use HTTP URIs, so that people can look up those names.
3. When someone looks up a URI, **provide useful information, using the standards**(RDF, SPARQL).

RDFa = RDF in attributes

- to add metadata (RDF annotations) in (X)HTML documents
- use existing attributes (e.g. `href`, `src`) et introduce new ones (`vocab`, `typeof`, `property`, `resource`, `prefix`)

Day	Lowest Temperature (°C)
Saturday, 13 November 2010	2
Sunday, 14 November 2010	4
Monday, 15 November 2010	7

```
<h1 property="dcterms:title">Temperature forecast for Galway, Ireland</h1>

<div id="data" about="#Galway" typeof="meteo:Place">
<table border="1px">
  <tr>
    <th>Day</th>
    <th>Lowest Temperature (<deg>C)</th>
  </tr>
  <tr rel="meteo:forecast" resource="#forecast20101113">
    <td>
      <div about="#forecast20101113">
        <span property="meteo:predicted" content="2010-11-13T00:00:00Z" datatype="xsd:dateTime">Saturda
      </div>
    </td>
    <td rel="meteo:temperature">
      <div about="#temp20101113">
        <span property="meteo:celsius" datatype="xsd:decimal">2</span>
      </div>
    </td>
  </tr>
</table>
```



RDFa

```
<h1 property="dcterms:title">Temperature forecast for Galway, Ireland</h1>

<div id="data" about="#Galway" typeof="meteo:Place">
<table border="1px">
  <tr>
    <th>Day</th>
    <th>Lowest Temperature (&deg;C)</th>
  </tr>
  <tr rel="meteo:forecast" resource="#forecast20101113">
    <td>
      <div about="#forecast20101113">
        <span property="meteo:predicted" content="2010-11-13T00:00:00Z" datatype="xsd:dateTime">Saturday, 13 November 2010</span>
      </div>
    </td>
    <td rel="meteo:temperature">
      <div about="#temp20101113">
        <span property="meteo:celsius" data-
      </div>
    </td>
  </tr>
</table>
```



Extracted RDF

```
@prefix dc: <http://purl.org/dc/terms/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

<http://rdfa.info/play/>
  dc:title "Temperature forecast for Galway, Ireland";
  dc:date "2012-01-22"^^xsd:date;
  dc:creator <http://sw-app.org/mic.xhtml#i> .
<http://rdfa.info/play/#Galway>
  rdf:type <http://purl.org/ns/meteo#Place>;
  <http://purl.org/ns/meteo#forecast> <http://rdfa.info/play/#forecast20101113>;
  <http://purl.org/ns/meteo#forecast> <http://rdfa.info/play/#forecast20101114>;
  <http://purl.org/ns/meteo#forecast> <http://rdfa.info/play/#forecast20101115> .
<http://rdfa.info/play/#forecast20101113>
  <http://purl.org/ns/meteo#predicted> "2010-11-13T00:00:00Z"^^xsd:dateTime;
  <http://purl.org/ns/meteo#temperature> <http://rdfa.info/play/#temp20101113> .
<http://rdfa.info/play/#temp20101113>
  <http://purl.org/ns/meteo#celsius> "2"^^xsd:decimal .
<http://rdfa.info/play/#forecast20101114>
  <http://purl.org/ns/meteo#predicted> "2010-11-14T00:00:00Z"^^xsd:dateTime;
  <http://purl.org/ns/meteo#temperature> <http://rdfa.info/play/#temp20101114> .
<http://rdfa.info/play/#temp20101114>
  <http://purl.org/ns/meteo#celsius> "4"^^xsd:decimal .
<http://rdfa.info/play/#forecast20101115>
  <http://purl.org/ns/meteo#predicted> "2010-11-15T00:00:00Z"^^xsd:dateTime;
  <http://purl.org/ns/meteo#temperature> <http://rdfa.info/play/#temp20101115> .
<http://rdfa.info/play/#temp20101115>
  <http://purl.org/ns/meteo#celsius> "7"^^xsd:decimal .
```

RDFa

```
<h1 property="dcterms:title">Temperature forecast for Galway, Ireland</h1>
```

```
<div id="data" about="#Galway" typeof="meteo:Place">
```

```
<table border="1px">
```

```
<tr>
```

```
<th>Day</th>
```

```
<th>Lowest Temperature (&deg;C)</th>
```

```
</tr>
```

```
<tr rel="meteo:forecast" resource="#forecast20101113">
```

```
<td>
```

```
<div about="#forecast20101113">
```

```
<span property="meteo:forecast" resource="#forecast20101113">
```

```
</div>
```

```
</td>
```

```
<td rel="meteo:temp" resource="#temp20101113">
```

```
<div about="#temp20101113">
```

```
<span property="meteo:temp" resource="#temp20101113">
```

```
</div>
```

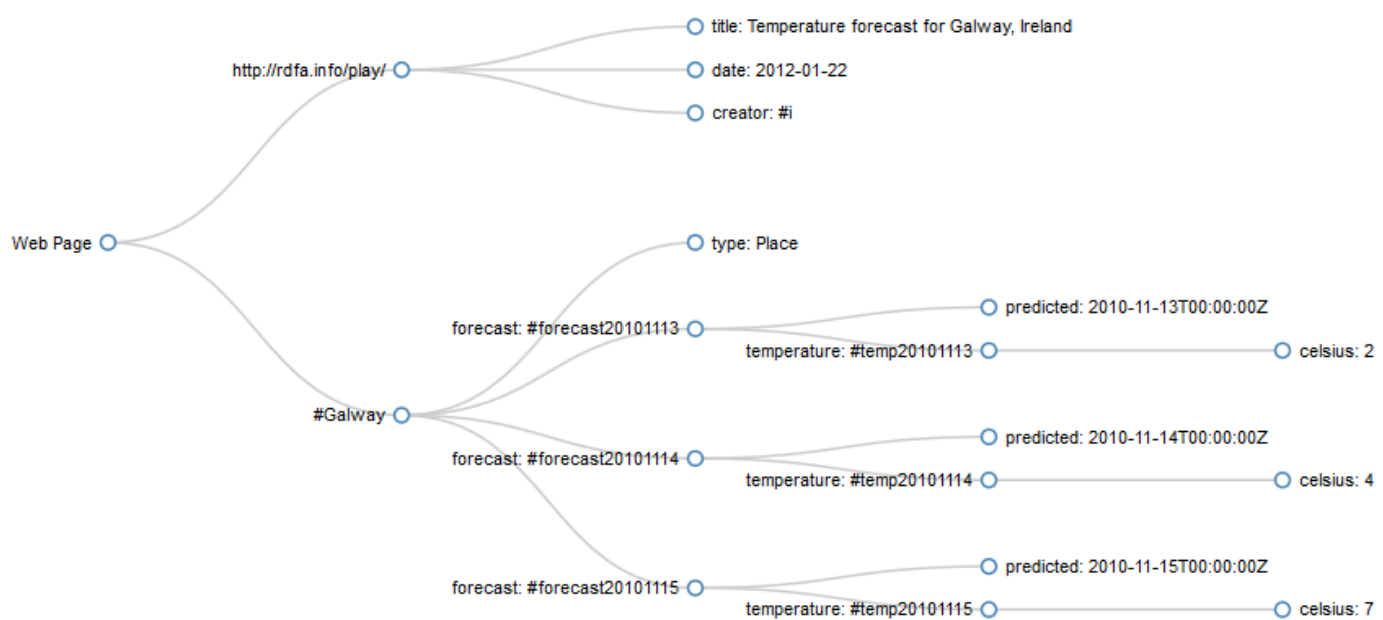
```
</td>
```

```
</tr>
```

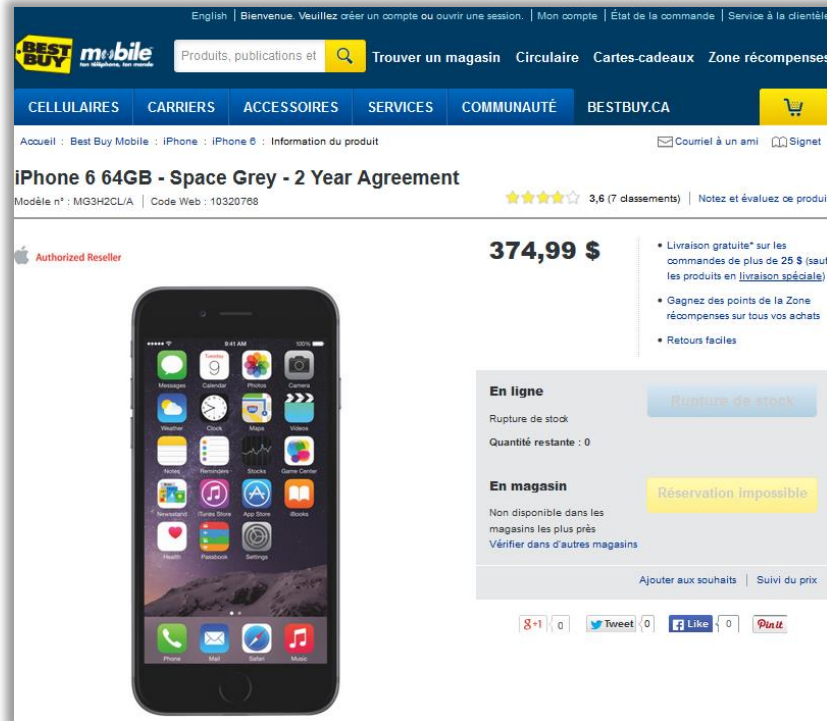


Visualization Raw Data

RDFa extractor <http://rdfa.info/play/>



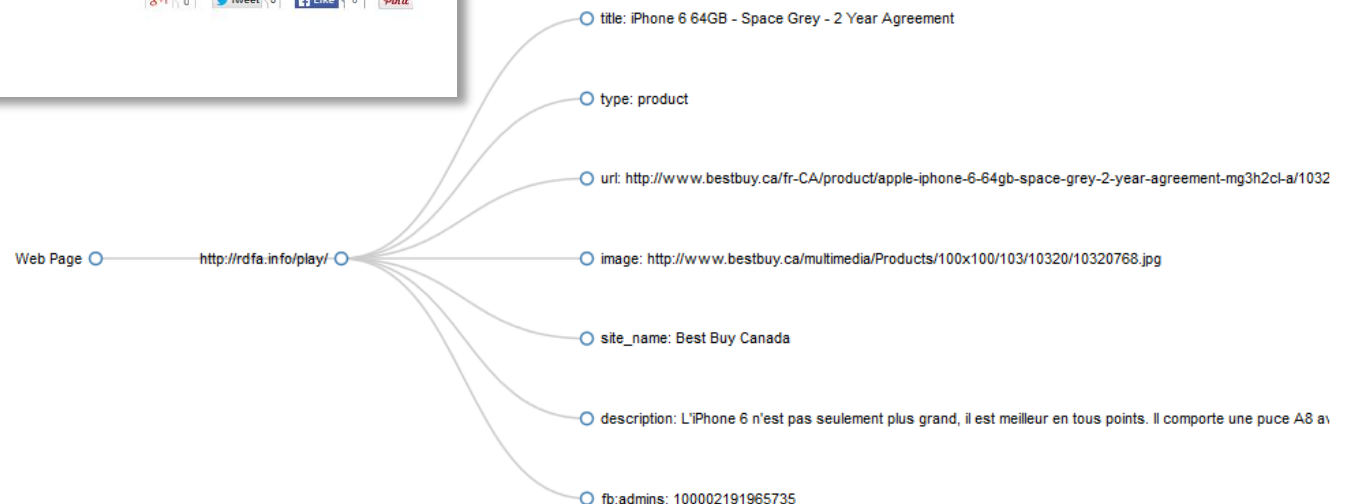
RDFa



RDFa used par :

- Google, Yahoo
- Facebook, MySpace, LinkedIn
- Best Buy, O'Reilly ...
- Newsweek, BBC
- WhiteHouse.gov, UK government, Library of Congress

...



Costs & benefits of ★★★★★ Web data

- As a consumer, you can do all what you can do with
★ ★ ★ Web data and additionally:
 - ✓ You can link to it from any other place (on the Web or locally).
 - ✓ You can bookmark it.
 - ✓ You can reuse parts of the data.
 - ✓ You may be able to reuse existing tools and libraries, even if they only understand parts of the pattern the publisher used.
 - ⚠ Understanding the structure of an RDF "Graph" of data can be more effort than tabular (Excel/CSV) or tree (XML/JSON) data.
 - ✓ You can combine the data safely with other data. URIs are a global scheme so if two things have the same URI then it's intentional, and if so that's well on it's way to being 5 star data!

Michael Hausenblas <http://5stardata.info/>

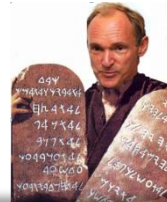
Costs & benefits of ★★★★★ Web data

– As a publisher ...

- ✓ You have fine-granular control over the data items and can optimise their access (load balancing, caching, etc.)
- ✓ Other data publishers can now link into your data, promoting it to 5 star!
- ⚠ You typically invest some time slicing and dicing your data.
- ⚠ You'll need to assign URIs to data items and think about how to represent the data.
- ⚠ You need to either find existing patterns to reuse or create your own.

★★★★★ Linked Open Data

4. Include links to other URIs, so that they can discover more things.



```
<h1 property="dcterms:title">Temperature forecast for Galway, Ireland</h1>
<div id="data" about="#Galway" typeof="meteo:Place">
  <span rel="owl:sameAs" resource="http://dbpedia.org/resource/Galway"></span>
  <table border="lpx">
```



dbpedia.org/page/Galway

Ontologies and Vocabu... What is URI (Uniform R...

About: Galway

An Entity of Type : populated place, from Named Graph : http://dbpedia.org, within Data Space : dbpedia.org

Galway est une ville de la province de Connacht, dans le Comté de Galway, sur la côte ouest de l'Irlande. Son nom vient de la rivière Corrib (Gaillimh) qui traverse la ville. Elle est également surnommée la « ville des tribus » en référence aux quatorze tribus qui se partageaient la ville à l'époque anglo-normande. La population de la ville est de habitants. L'agglomération de Galway est la quatrième du pays par le nombre d'habitants, après celles de Dublin, de Cork et de Limerick.

Property	Value
dbpedia-owl:abstract	<ul style="list-style-type: none"> Galway és una ciutat d'Irlanda, capital del comtat de Galway, a la p és una institució local de Galway. Antigament es digué Galway Cor el desembre del 1484 pel rei Ricard III d'Anglaterra. El primer alcalde Galway, però revifat el 1937 com a municipi i el 1985 com a municipi Galway (írsky Gaillimh, nebo také An Gaillimh) je město v západní části Irska. V írštině je označováno také ja rostoucí írské město. Počet obyvatel v roce 2006 činil rovných 70 000 Galway ist die Hauptstadt der Grafschaft Galway in der Provinz Con Galway or City of Galway (Cathair na Gaillimhe) is a city on the west Galway Bay and is surrounded by County Galway. It is the third largest city in Ireland, behind Dublin and Limerick. The population of Galway city at the 2006 census was 70,000. Galway es la capital del condado de Galway, en Irlanda. La ciudad :

Firefox

Temperature forecast for Galwa... +

5stardata.info/gtd-5.html

LarKC weblog » Blog A... Linking Open D

Temperature forecast for Galway, Ireland

Day	Lowest Temperature (°C)
Saturday, 13 November 2010	2
Sunday, 14 November 2010	4
Monday, 15 November 2010	7

Last update: 2012-01-22 by Michael | Code available via GitHub

zotero

Michael Hausenblas <http://5stardata.info/>

Costs & benefits of ★★★★★ Web data

- As a consumer, you can do all what you can do with ★★★★★ Web data and additionally:
 - ✓ You can discover more (related) data while consuming the data.
 - ✓ You can directly learn about the data schema.
 - ⚠ You now have to deal with broken data links, just like 404 errors in web pages.
 - ⚠ Presenting data from an arbitrary link as fact is as risky as letting people include content from any website in your pages. Caution, trust and common sense are all still necessary.

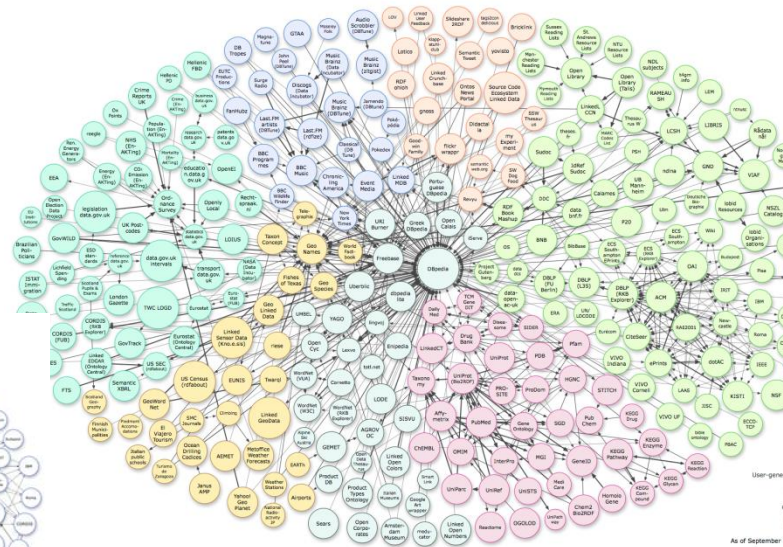
Costs & benefits of ★★★★★ Web data

– As a publisher ...

- ✓ You make your data discoverable.
- ✓ You increase the value of your data.
- ✓ Your own organisation will gain the same benefits from the links as the consumers.
- ⚠ You'll need to invest resources to link your data to other data on the Web.
- ⚠ You may need to repair broken or incorrect links.

Linked Open Data Cloud

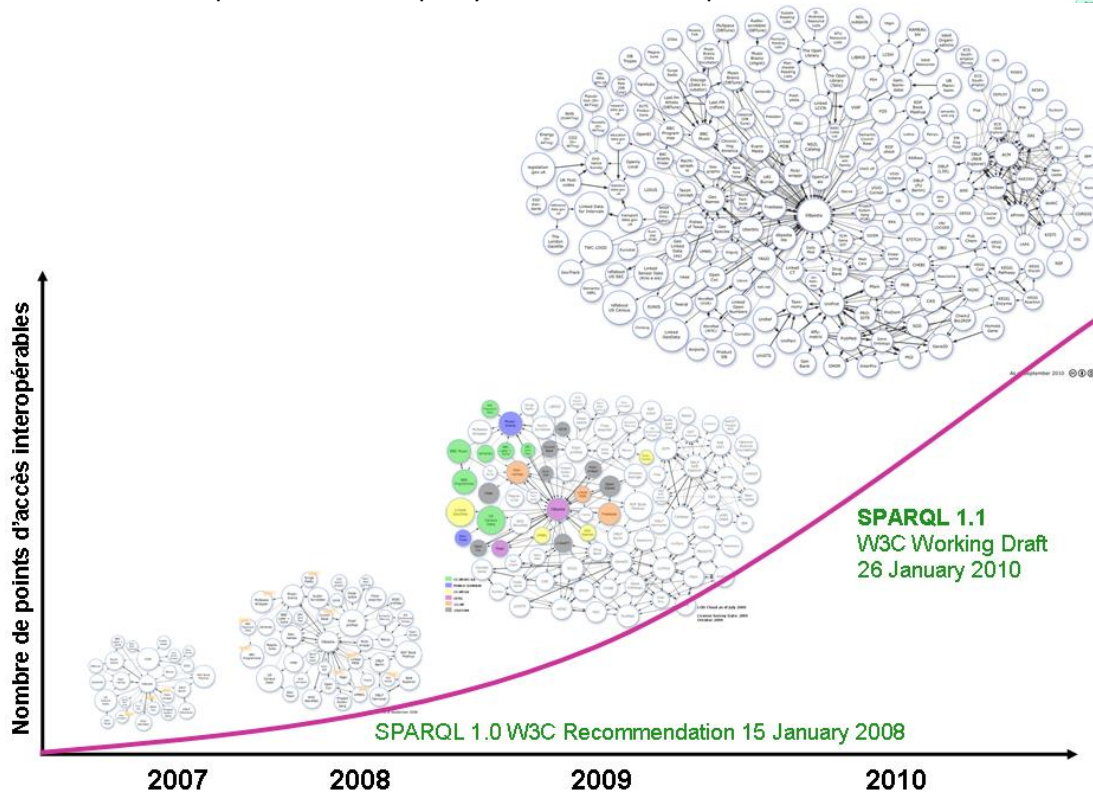
- Linking open data project
 - goals:
 - Use RDF to “expose” open data sets
 - Create RDF links between these datasets
 - If possible, deploy SPARQL endpoints



September 2011

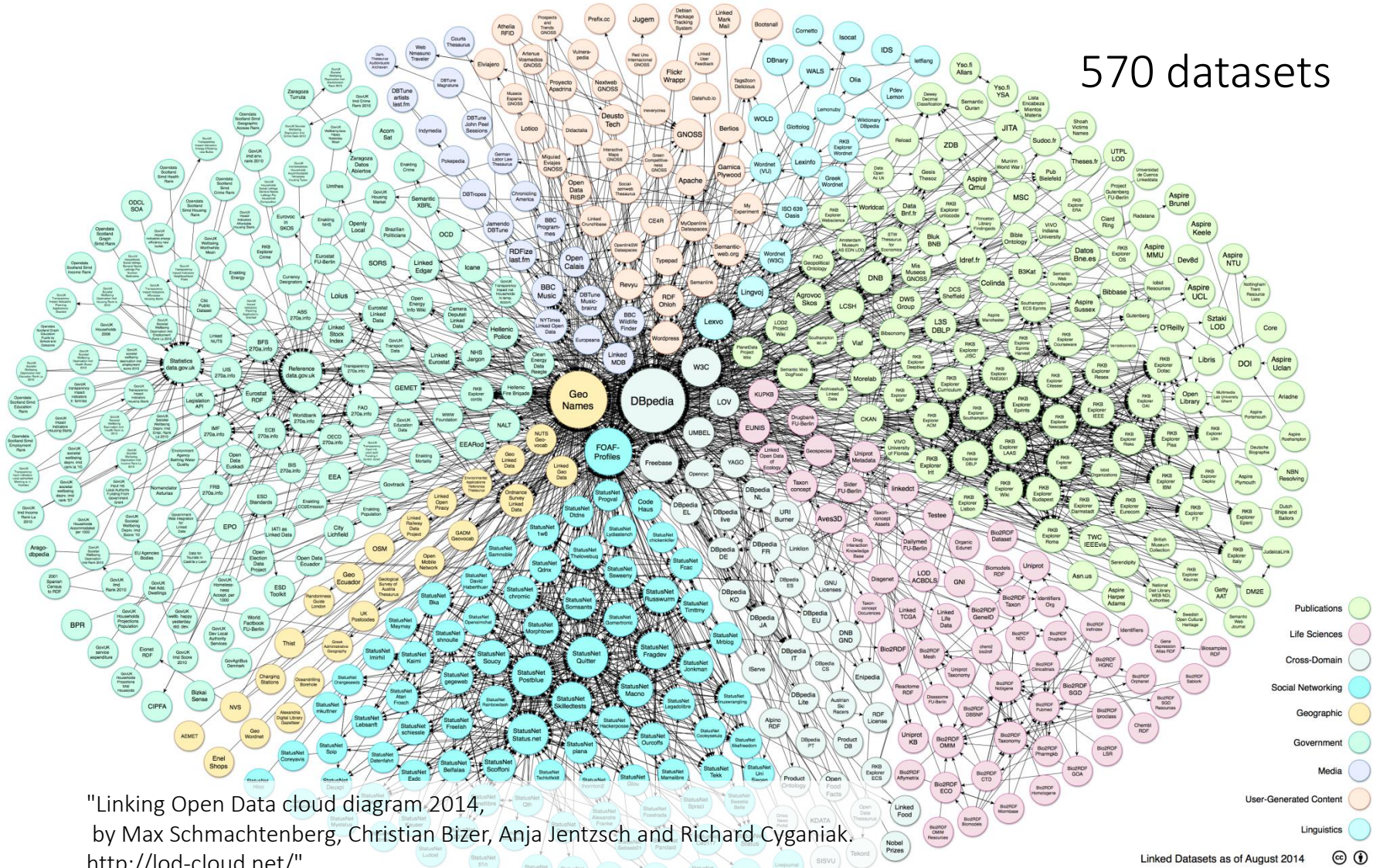
295 datasets
 31 Billion RDF triples
 interconnected by
 595 Million of RDF relations

<http://lod-cloud.net>



Linked Open Data Cloud

570 datasets



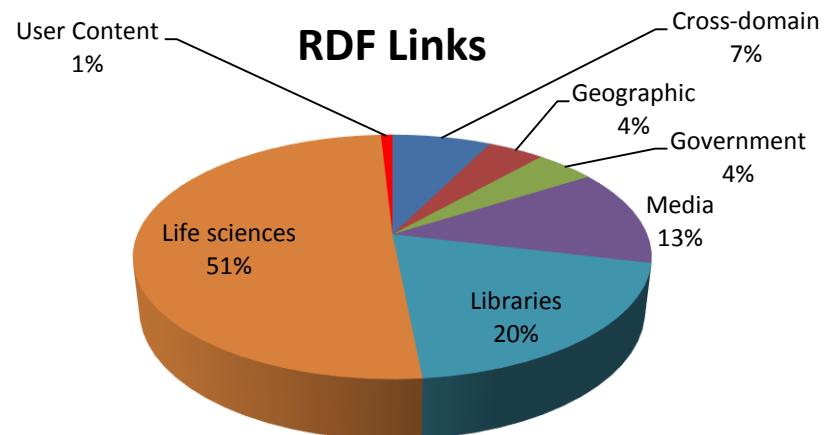
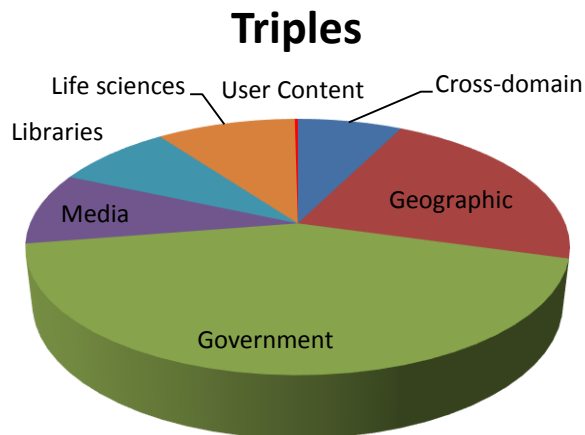
"Linking Open Data cloud diagram 2014,
by Max Schmachtenberg, Christian Bizer, Anja Jentzsch and Richard Cyganiak.
<http://lod-cloud.net/>"

Linked Datasets as of August 2014

Linked Open Data Cloud

Domain	Data Sets	Triples	Percent	RDF Links	Percent
Cross-domain	20	1,999,085,950	7.42	29,105,638	7.36
Geographic	16	5,904,980,833	21.93	16,589,086	4.19
Government	25	11,613,525,437	43.12	17,658,869	4.46
Media	26	2,453,898,811	9.11	50,374,304	12.74
Libraries	67	2,237,435,732	8.31	77,951,898	19.71
Life sciences	42	2,664,119,184	9.89	200,417,873	50.67
User Content	7	57,463,756	0.21	3,402,228	0.86
(2011 September)	203	26,930,509,703		395,499,896	

<http://lod-cloud.net/state>



Linked Open Data Cloud

Domain	Data Sets	Triples
Cross-domain	20	1,999,085
Geographic	16	5,904,980
Government	25	11,613,525
Media	26	2,453,898
Libraries	67	2,237,435
Life sciences	42	2,664,119
User Content	7	57,463
	203	26,930,509

(2011, September)

Datasets by topical domain.		
Topic	Datasets	%
Government	183	18.05%
Publications	96	9.47%
Life sciences	83	8.19%
User-generated content	48	4.73%
Cross-domain	41	4.04%
Media	22	2.17%
Geographic	21	2.07%
Social web	520	51.28%
Total	1014	

(2014, August)

State of the LOD Cloud 2014

Version 0.4, 08/30/2014

This document provides statistics about the structure and content of the crawled Linked Data sources implement the Linked Data best practices.

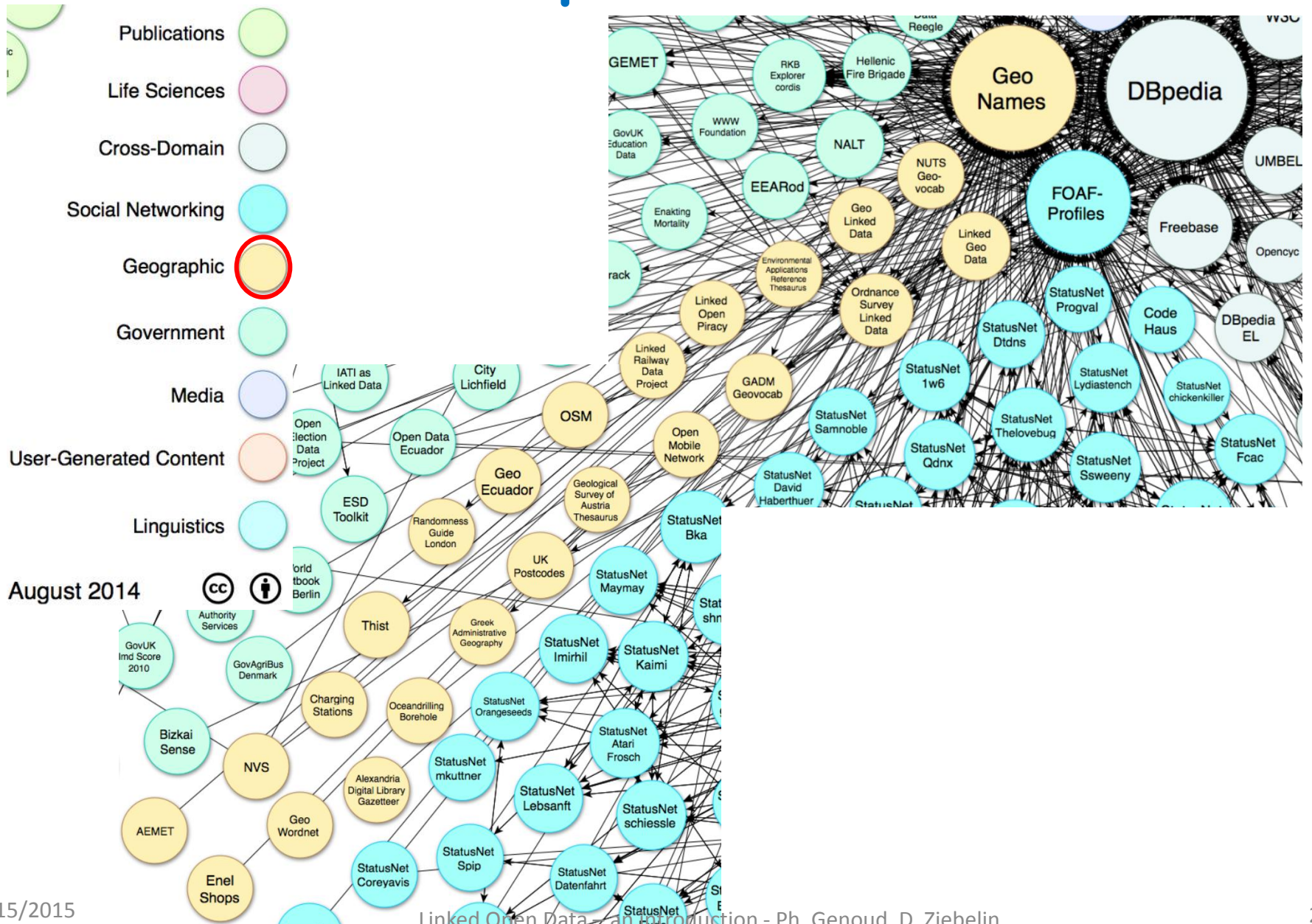
This document updates the findings of the original [State of the LOD Cloud](#) report. Publishers themselves via the [datahub.io](#) Linked Data catalog. This report is based on the ISWC2014 paper [Adoption of the Linked Data Best Practices in Different Topical Domains](#). This document links the statistics to the [Mannheim Linked Data catalog](#) and enables the

Contents

- [1. The Linked Data Crawl](#)
- [2. Linked Data by Domain](#)
- [3. Crawlable LOD Cloud Diagram](#)
- [4. Best Practices](#)
- [4.1 Interlinking Best Practice](#)
- [4.2 Vocabulary Best Practices](#)
- [4.2.1 Usage of Proprietary Vocabularies](#)
- [4.2.2 Usage of Dereferencable Vocabularies](#)
- [4.3 Adoption of Metadata Best Practices](#)

<http://linkeddatacatalog.dws.informatik.uni-mannheim.de/state/>

Linked Open Data Cloud



data.gov

DATA TOPICS ▾ IMPACT APPLICATIONS DEVELOPERS CONTACT

DATA CATALOG / Datasets Organizations ?

Federal datasets are subject to the U.S. Federal Government **Data Policy**. Non-federal participants (e.g., universities, organizations, and tribal, state, and local governments) maintain their own data policies. Data policies influence the usefulness of the data. [Learn more](#) about how to search for data and use this catalog.

geospatial

Datasets ordered by Relevance

You are searching in the list of datasets. [Show results in entire Data.gov site.](#)

Filter by location

Enter location...

90.628 datasets found for

Organization Types

- Federal Government (42698)
- State (34097)
- University (8229)
- State Government (5375)
- Other (102)

Organizations

- NSGIC GIS Inventory... (34097)
- National Oceanic an... (33170)
- Earth Data Analysis... (5535)

Topics

- AAPI (363)
- Ocean (294)
- Climate (156)
- Ecosystems (44)
- Disaster (39)

Topic Categories

- Pacific Islands (261)
- Environment (189)
- Hawaii (189)
- Guam (85)
- Northern Mariana Is... (75)

HRSA Geospatial Data

U.S. Department of Health Geospatial Data Warehouse health resources... [query tool](#)

Distinct Agency Name

State of Oklahoma — Provides a listing of the unique agency names and the number of datasets that contain the name from the geospatial metadata catalog on geo.data.gov. The list was... [CSV](#) [application/rdf+xml](#) [JSON](#) [XML](#)

Distinct Agency Names in Geospatial

State of Hawaii — Provides a listing of the unique agency names and the number of datasets that contain the name from the geospatial metadata catalog on geo.data.gov. The list was... [CSV](#) [application/rdf+xml](#) [JSON](#) [XML](#)

Distinct Agency Names in Geospatial Metadata

State of Oregon — Provides a listing of the unique agency names and the number of datasets that contain the name from the geospatial metadata catalog on geo.data.gov. The list was... [CSV](#) [application/rdf+xml](#) [JSON](#) [XML](#)

Geospatial display of current weather radar images (RIDGE Weather Radar)

National Weather Service, Department of Commerce — Provides GIS overlays for current weather radar results [kml/kmz](#)

Geospatial display of current weather radar images (RIDGE Weather Radar)

State of Oregon — Provides GIS overlays for current weather radar results [CSV](#) [application/rdf+xml](#) [JSON](#) [XML](#)

Geospatial display of current weather radar images (RIDGE Weather Radar)

State of Hawaii — Provides GIS overlays for current weather radar results [CSV](#) [application/rdf+xml](#) [JSON](#) [XML](#)

Geospatial display of current weather radar images (RIDGE Weather Radar)

State of Oklahoma — Provides GIS overlays for current weather radar results [CSV](#) [application/rdf+xml](#) [JSON](#) [XML](#)

application/rdf+xml

Federal
State
State
State
State

http://www.ordnancesurvey.co.uk/

<http://www.ordnancesurvey.co.uk/blog/2013/06/new-linked-data-service-launches/>



About this blog Blog

Home / Using GI and maps / New Linked Data service launches



JUN 03
2013

By Gemma
In Using GI and
maps

Comments (5)

Gemma works in our
Corporate
Communications team
as our Social Media
Manager

Author RSS

New Linked Data service launches

We are delighted to launch the next iteration of our Linked Data service today at: <http://data.ordnancesurvey.co.uk>.

In preparation for this launch we created a beta version, which was designed for you to have a play around, test, and review against your current applications.

We had over 2,000 people test the beta version, thank you for your helpful feedback.

We launched Linked Data in April 2010 as part of the drive to increase innovative Public Data Public" initiative and have seen a continued growth in government and research. This has allowed us to c



You are here: [linked-data](#)

Ordnance Survey Linked Data Platform

Quick Search:

Ordnance Survey is Great Britain's national mapping agency, providing the most accurate and up-to-date geographic data, relied on by government, business and individuals.

OS OpenData is the opening up of Ordnance Survey data as part of the drive to increase innovation and support the "Making Public Data Public" initiative. As part of this initiative Ordnance Survey has published a number of its products as Linked Data. Linked Data is a growing part of the Web where data is published on the Web and then linked to other published data in much the same way that web pages are interlinked using hypertext.

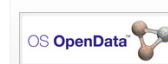
The term **Linked Data** is used to describe a method of exposing, sharing, and connecting data via URIs on the Web. To find more **Linked Data** published as part of this initiative please go to data.gov.uk.

If you are not familiar with Linked Data, OS OpenData products are also available in alternative formats from the OS OpenData website. Ordnance Survey can provide support for the Ordnance Survey OpenData products, but cannot give advice or support on using RDF, SPARQL or SPARQL Endpoints.

Ordnance Survey has published three OS Open Data products as Linked Data: the 1:50 000 Scale Gazetteer, Code-Point Open and the administrative geography for Great Britain taken from Boundary Line. A combined OS Linked Data dataset combines these products into one database to support more flexible data access.

<http://data.ordnancesurvey.co.uk/>

Current Datasets



Ordnance Survey Linked Data

36,773,687 triples



Code-Point Open Linked Data

33,750,456 triples



50K Gazetteer Linked Data

2,368,655 triples



Boundary Line Linked Data

653,433 triples

data.gouv.fr

Recherche Thématiques + CONTRIBUTUEZ!

Recensement des équipements sportifs, espaces et sites de pratiques

Ce jeu de données provient d'un service public certifié
Publié le 8 juillet 2013 par Ministère des droits des femmes, de la ville, de la jeunesse
Le recensement national de l'intégralité des équipements sportifs, espaces et sites de pratiques est conduit par le ministère chargé des sports. La démarche engagée a pour objectif de recenser, partager et mettre à jour les données relatives aux équipements et sites existants et d'aider à une meilleure perception de ces équipements. C'est un élément préalable à toute démarche prospective d'aménagement.

Ressources

- CSV RECENSEMENT DES ÉQUIPEMENTS SPORTIFS > FICHES INSTALLATIONS
Caractéristiques des installations sportives recensées dans le cadre du RES
- CSV RECENSEMENT DES ÉQUIPEMENTS SPORTIFS > FICHES EQUIPEMENTS
Caractéristiques des équipements sportifs recensés dans le cadre du RES
- CSV RECENSEMENT DES ÉQUIPEMENTS SPORTIFS > ACTIVITES
Activités physiques et/ou sportives (APS) recensées dans les équipements
- PDF RECENSEMENT DES ÉQUIPEMENTS SPORTIFS > DOCUMENTATION
Deux types de fiches permettent de collecter l'information sur les installations
- XLS RECENSEMENT DES ÉQUIPEMENTS SPORTIFS > DICTIONNAIRE
Dictionnaires des variables proposées dans les tables de données : 2014
- CSV RECENSEMENT DES ÉQUIPEMENTS SPORTIFS > DONNEES COMMUNALES
Décomptes communaux des équipements, espaces et sites de pratiques

rdf Thématiques +

Jeux de données 9 Réutilisations 3 Organisations 0 Utilisateurs 0

-  **Data.bnf.fr : les données de la BnF en RDF**
La Bibliothèque nationale de France vous guide dans ses ressources patrimoniales, en publiant des fiches de référence inédites sur les auteurs, sur les œuvres et sur les thèmes. data.bnf.fr répertorie tous les oeuvres pour un auteur, ainsi que toutes les éditions...
Mensuelle France Pays 1 4
-  **Jeux de données de Ressources pédagogiques pour l'enseignement de l'histoire des arts (en rdf)**
Ce jeux de données résulte de la transformation du fichier CSV en RDF à l'aide de DATALIFT. Le fichier CSV est mis à disposition par le Ministère de la Culture et de la Communication ...
Inconnu France Pays 0 1
-  **Jeux de données de Ressources pédagogiques pour l'enseignement de l'histoire des arts (en rdf)**
DBpedia.fr ou DBpédia en français est le chapitre francophone de DBpedia, il s'inscrit dans l'effort d'internationalisation de DBpedia dont le but est de maintenir des données structurées extraites de différents chapitres de Wikipedia. Le développement de DBpedia...
01/01/2011 à 01/01/2014 Bimestrielle Autre 5 2
-  **Données géographiques: Régions, Départements, Arrondissements, Cantons**
L'Insee publie dans cette section des données issues du code officiel géographique (COG) modélisées selon le standard RDF du web sémantique. Le fichier "Régions" contient la liste des régions ainsi que leur chef-lieu et les départements inclus dans ces régions. Le...

encore un effort !!!



<http://www.insee.fr/fr/methodes/default.asp?page=xml/xml.htm>

Institut national de la statistique et des études économiques
Mesurer pour comprendre

Mobile | Actualités | Agendas | Contactez-nous | Aide

Chercher sur le site

Accueil | Thèmes | Bases de données | Publications et services | Régions | Définitions et méthodes | Accès par

Définitions et méthodes

- Nomenclatures
- Définitions
- Sources et méthodes
- Grilles d'analyse
- Code officiel géographique, zonages d'études
- Outils statistiques
- Données RDF et espace XML

Accueil > Définitions et méthodes > Données RDF et espace XML

Données RDF et espace XML

Données au format RDF

L'Insee publie dans cette section des données modélisées selon le standard RDF du web sémantique. Cette formalisation facilite l'utilisation automatique des données par les applications compatibles avec ces nouvelles technologies. Pour plus d'information sur le web sémantique, on pourra consulter le site du W3C.

Les données suivantes sont disponibles :

- Données géographiques** : données issues du Code officiel géographique (COG) concernant les régions, les départements, les arrondissements, les cantons et les communes.
- Codes et nomenclatures** : nomenclature d'activités française (NAF), nomenclature des professions et catégories professionnelles (PCS).
- Données de population** : populations légales issues du Recensement.

D'autres données seront publiées dans les prochains mois.

Toutes les données RDF peuvent être interrogées dynamiquement grâce au langage d'interrogation SPARQL. Le point d'entrée SPARQL se trouve à l'adresse <http://rdf.insee.fr/sparql>.

- Accéder à l'espace RDF de l'Insee

<http://eurostat.linked-statistics.org/>



Overview · Usage · Dataspace · Support

Eurostat - Linked Data

This is a [Linked Data](#) version of the Eurostat data with the goal to provide 5 star Linked Open Data on the European level, in a contextually rich and up-to-date manner, useful for ETL-style business analysis or data warehousing purposes with benefits including but not limited to:

- It allows for a straight-forward comparison of statistical indicators across EU countries.
- Through providing context for statistics it facilitates the interpretation process.
- Enables you to re-use observations in a fine-grained way.

Overview

The following data is available

- <http://eurostat.linked-statistics.org/>
- <http://eurostat.linked-statistics.org/>
- <http://eurostat.linked-statistics.org/>

Via our SPARQL endpoint you

<http://www.bbc.co.uk/nature/feedsanddata>

Cookies on the BBC website

The BBC has updated its cookie policy. We use cookies to ensure that we give you the best experience on our website. This includes cookies from third party social media websites if you visit a page which contains embedded content from social media. Such third party cookies may track your use of the BBC website. We and our partners also use cookies to ensure we show you advertising that is relevant to you. If you continue without changing your settings, we'll assume that you are happy to receive all cookies on the BBC website. However, you can change your cookie settings at any time.

✓ Continue
⚙ Change settings
ℹ Find out more

BBC News Sport Weather Shop More Search

This page was last updated in October 2014.
We've left it here for reference [More information](#)

NATURE CONTACT

Home | News | Features | Video collections | Wildlife | Prehistoric life | Places | FAQs

Feeds and data

In addition to the standard web pages we are also publishing some of the information behind Wildlife Finder as RSS and RDF and providing semantic mark-up in the form of microformats.

Outline

- “Theoretical” Session (morning)
 - Introduction
 - Distributing Data on the web with RDF
 - Naming the Data : URIs (Uniform Resources Identifiers)
 - The RDF Data model
 - Querying Linked Data with SPARQL
 - Semantic modelling
 - RDFS
 - OWL
 - From Open Data to Linked Open Data
 - Conclusion
- Hands-on session (afternoon)
 - From a CSV file to linked data
 - Querying linked data (SPARQL)

The importance of Linked Data

Ivan Herman <http://www.w3.org/2009/Talks/0615-SanJose-tutorial-IH/>

- It provides a core set of data that Semantic Web applications can build on
 - stable references for “things”,
 - e.g., <http://dbpedia.org/resource/Grenoble>
 - many many relationships that applications may reuse
 - e.g., the BBC application!
 - a “nucleus” for a larger, semantically enabled Web!
- For many, publishing data may be the first step into the world of Semantic Web

Some things to remember if you publish data

Ivan Herman <http://www.w3.org/2009/Talks/0615-SanJose-tutorial-IH/>

- Publish your data first, care about sexy user interfaces later!
 - the “raw data” can become useful on its own right and others may use it
 - you can add your added value later by providing nice user access
- If possible, publish your data in RDF but if you cannot, others may help you in conversions
 - trust the community...
- Add links to other data. “Just” publishing isn’t enough...

Open challenges for LOD

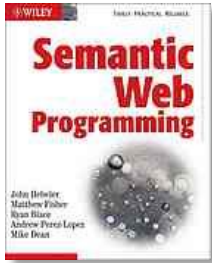
- Contradictions:
Population of Grenoble
 - DBpedia: 156,659
 - Freebase: **155,632**
- **Identity crisis:** is the capital of the Roman Empire the *same* As the capital of modern Italy?
- Data ownership, copyright, access control



LOD challenges

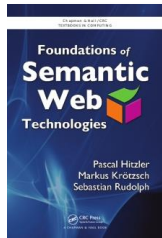
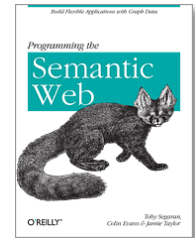
- Ontological modeling :
 - design patterns
- Reasoning
- Large-scale processing of Linked Data
- Data interlinking
 - Ontologies alignments
- Quality of links and the data
- ...

Bibliography



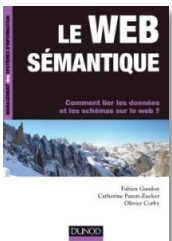
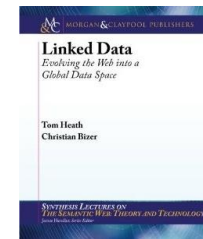
- John Hebel, Matthew Fisher, Ryan Blace, Andrew Perez-Lopez, Mike Dean, *Semantic Web Programming*, Wiley, (2009)

- Toby Segaran, Jamie Taylor, and Colin Evans, *Programming the Semantic Web*, O'Reilly, (2009)



- P. Hitzler, R. Sebastian, and M. Krötzsch: *Foundation of Semantic Web Technologies*, (2009)

- T. Heath and C. Bizer: *Linked Data: Evolving the Web into a Global Data Space*, (2011)



- F. Gandon, C. Faron-Zucker, O. corby : *Le Web Sémantique* (Dunod 2012)

- ... W3C wiki page to find more references : <http://www.w3.org/2001/sw/wiki/Books>

SW MOOCs

The screenshot shows the Inria website header with the logo and navigation links for 'Scientifiques' and 'Entrepreneurs'. Below the header is a search bar and a navigation menu for 'Centre de recherche Inria Sophia Antipolis - Méditerranée'. The main content area features a section titled 'Enseignement' with a sub-section 'MOOC web sémantique et web de données'. The text describes a new course by MocoLab, available on the France Université Numérique platform, taught by Fabien Gandon, Olivier Corby, and Catherine Faron-Zucker. It mentions that over 2700 people are enrolled and the course starts on March 2nd. A date range of '2/03/2015 au 27/04/2015' is provided. A small video player is visible on the right side of the page.

The screenshot shows the Hasso Plattner Institut website header with the 'OPEN' logo and navigation links for 'About openHPI' and 'Cou'. The main content area features a large image of a hand reaching towards a complex network diagram. Below the image is the title 'Knowledge Engineering with Semantic Web Technologies 2015' by Dr. Harald Sack. The course dates are listed as 'November 2, 2015 - December 14, 2015' and the language is 'English'. A description states: 'The knowledge contained in the World Wide Web is available in interlinked documents written in natural language. To make use of this knowledge,'. At the bottom, there are two buttons: 'Show course details' and 'Enroll me for this course'.

Many tools (not an exhaustive list!)

■ Few names:

- Jena, AllegroGraph, Mulgara, Sesame, flickurl, 4Store, ...
- TopBraid Suite, Virtuoso environment, Falcon, Drupal 7, Redland, Pellet, HermiT ...
- Disco, Oracle 11g, RacerPro, IODT, Ontobroker, OWLIM, Talis Platform, ...
- RDF Gateway, RDFLib, Open Anzo, DartGrid, Zitgist, Ontotext, Protégé, ...
- Thetus publisher, SemanticWorks, SWI-Prolog, RDFStore...

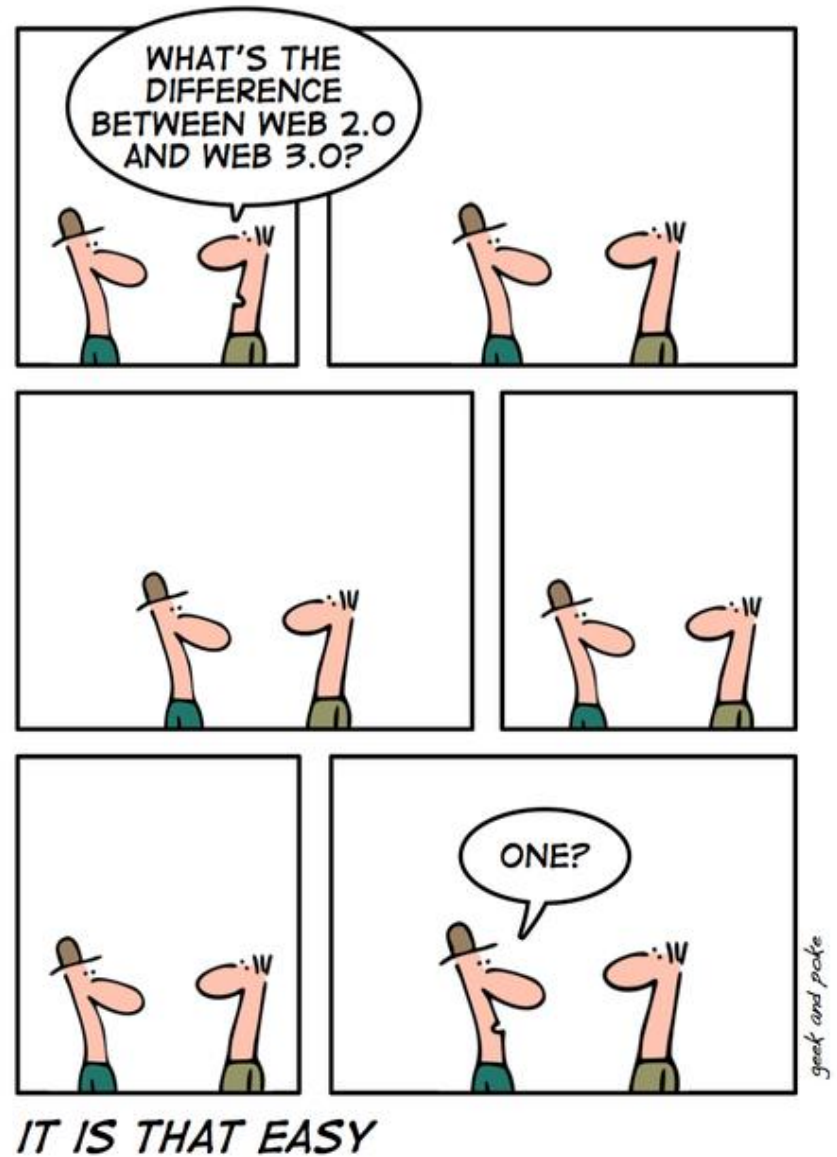
■ ...

more on <http://www.w3.org/2001/sw/wiki/Tools>

■ Categories:

- Triple Stores
- Inference engines
- Converters
- Search engines
- Middleware
- CMS
- Semantic Web browsers
- Development environments
- Semantic Wikis
- ...

Merci de
votre attention



IT IS THAT EASY

```

PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX dbo: <http://dbpedia.org/ontology/>
PREFIX abo: <http://artemisBookstore.com/ontology#>

SELECT DISTINCT ?v1 ?b1 ?v2 ?b2
WHERE {
  ?b1 abo:author ?v1 .
  ?b2 abo:author ?v2 .
  ?v1 owl:sameAs ?w1 .
  ?v2 owl:sameAs ?w2 .
  SERVICE <http://dbpedia.org/sparql> {
    SELECT DISTINCT ?w1 ?w2 WHERE {
      ?w1 a dbo:Writer ;
        dbo:spouse ?w2 .
      ?w2 a dbo:Writer .
      FILTER ( NOT EXISTS {?w1 dbo:deathDate ?date1} &&
        NOT EXISTS {?w2 dbo:deathDate ?date2} )
    }
  }
ORDER BY ?v1 ?v2

```

v1	b1	v2	b2
<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/307947300>	<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/453006264>
<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/307947300>	<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/525942416>
<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/451169514>	<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/453006264>
<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/451169514>	<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/525942416>
<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/9780307743657>	<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/453006264>
<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/9780307743657>	<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/525942416>
<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/453006264>	<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/307947300>
<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/453006264>	<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/451169514>
<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/453006264>	<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/9780307743657>
<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/525942416>	<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/307947300>
<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/525942416>	<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/451169514>
<http://artemisBookstore.com/authors/6>	<http://artemisBookstore.com/books/525942416>	<http://artemisBookstore.com/authors/5>	<http://artemisBookstore.com/books/9780307743657>


```

PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX dbo: <http://dbpedia.org/ontology/>
PREFIX abo: <http://artemisBookstore.com/ontology#>

```

```

SELECT DISTINCT ?fn1 ?ln1 ?t1 ?fn2 ?ln2 ?t2
WHERE {
  ?b1 dcterms:title ?t1 ;
      abo:author ?v1 .
  ?b2 dcterms:title ?t2 ;
      abo:author ?v2 .
  ?v1 foaf:firstName ?fn1 ;
      foaf:lastName ?ln1 ;
      owl:sameAs ?w1 .
  ?v2 foaf:firstName ?fn2 ;
      foaf:lastName ?ln2 ;
      owl:sameAs ?w2 .
}

```

fn1	ln1	t1	fn2	ln2	t2
"Stephen"	"King"	"It"	"Tabitha"	"King"	"Pearl"
"Stephen"	"King"	"It"	"Tabitha"	"King"	"Survivor"
"Stephen"	"King"	"The Shining"	"Tabitha"	"King"	"Pearl"
"Stephen"	"King"	"The Shining"	"Tabitha"	"King"	"Survivor"
"Stephen"	"King"	"The Stand"	"Tabitha"	"King"	"Pearl"
"Stephen"	"King"	"The Stand"	"Tabitha"	"King"	"Survivor"

```

SERVICE <http://dbpedia.org/sparql> {
  SELECT DISTINCT ?w1 ?w2
  WHERE {
    ?w1 a dbo:Writer ;
        dbo:spouse ?w2 .
    ?w2 a dbo:Writer .
    FILTER ( NOT EXISTS {?w1 dbo:deathDate ?date1} &&
            NOT EXISTS {?w2 dbo:deathDate ?date2} &&
            (str(?w1) <= str(?w2)) )
  }
}
ORDER BY ?ln1 ?ln2

```

```

PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX dbo: <http://dbpedia.org/ontology/>
PREFIX abo: <http://artemisBookstore.com/ontology#>

```

```

SELECT DISTINCT ?fn1 ?ln1 ?t1 ?fn2 ?ln2 ?t2
WHERE {
  ?b1 dcterms:title ?t1 ;
      abo:author ?v1 .
  ?b2 dcterms:title ?t2 ;
      abo:author ?v2 .
  ?v1 foaf:firstName ?fn1 ;
      foaf:lastName ?ln1 ;
      owl:sameAs ?w1 .
  ?v2 foaf:firstName ?fn2 ;
      foaf:lastName ?ln2 ;
      owl:sameAs ?w2 .
}

```

fn1	ln1	t1	fn2	ln2	t2
"Stephen"	"King"	"It"	"Tabitha"	"King"	"Pearl"
"Stephen"	"King"	"It"	"Tabitha"	"King"	"Survivor"
"Stephen"	"King"	"The Shining"	"Tabitha"	"King"	"Pearl"
"Stephen"	"King"	"The Shining"	"Tabitha"	"King"	"Survivor"
"Stephen"	"King"	"The Stand"	"Tabitha"	"King"	"Pearl"
"Stephen"	"King"	"The Stand"	"Tabitha"	"King"	"Survivor"

```

SERVICE <http://dbpedia.org/sparql> {
  SELECT DISTINCT ?w1 ?w2
  WHERE {
    ?w1 a dbo:Writer ;
        dbo:spouse ?w2 .
    ?w2 a dbo:Writer .
    FILTER ( NOT EXISTS {?w1 dbo:deathDate ?date1} &&
            NOT EXISTS {?w2 dbo:deathDate ?date2} &&
            (str(?w1) <= str(?w2)) )
  }
}
ORDER BY ?ln1 ?ln2

```