

Semantic Web

3b - RDF/S in use

GEIST Research Group
<http://geist.agh.edu.pl>



AGH University of Science and Technology, POLAND

Using slides according to license from:

- P. Hitzler – “Knowledge Representation for the Semantic Web” *course based on*
- P. Hitzler, M. Krötzsch, S. Rudolph – Foundations of Semantic Web Technologies
- e-Lite: 01LHVIU - Semantic Web: Technologies, Tools, Applications



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- 2 Getting it
- 3 Querying it
- 4 Storing it
- 5 RDF/S Tools
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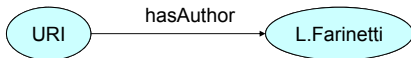
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Common language for describing resources

Author =
L. Farinetti

- Diagram:



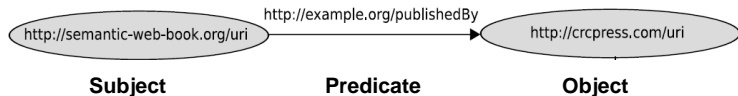
- Simple RDF assertion (triple):

```
triple (hasAuthor, URI, L.Farinetti)
```


RDF triples



- An RDF triple consists of



(borrowed from linguistics)

- allowed are:
 - In the subject : URIs and empty nodes
 - In the predicate: URIs (usually called *properties*)
 - In the object: URIs and empty nodes and literals
- Note that the graph can be reconstructed from the list of triples.

Example



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“Triple” or “Turtle” notation

```

<http://www.w3.org/People/EM/contact#me>
<http://www.w3.org/2000/10/swap/pim/contact#fullName>
"Eric Miller" .

<http://www.w3.org/People/EM/contact#me>
<http://www.w3.org/2000/10/swap/pim/contact#mailbox>
<mailto:em@w3.org> .

<http://www.w3.org/People/EM/contact#me>
<http://www.w3.org/2000/10/swap/pim/contact#personalTitle>
"Dr." .

<http://www.w3.org/People/EM/contact#me>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.w3.org/2000/10/swap/pim/contact#Person> .

```

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RDF/XML Syntax

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
          xmlns:contact="http://www.w3.org/2000/10/swap/pim/contact#">

  <contact:Person rdf:about="http://www.w3.org/People/EM/contact#me">
    <contact:fullName>Eric Miller</contact:fullName>
    <contact:mailbox rdf:resource="mailto:em@w3.org"/>
    <contact:personalTitle>Dr.</contact:personalTitle>
  </contact:Person>

</rdf:RDF>
```

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```

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<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:contact="http://www.w3.org/2000/10/swap/pim/contact#"
  >
  <contact:Person rdf:about="http://www.w3.org/People/EM/contact#me" >
    <contact:fullName>Eric Miller</contact:fullName>
    <contact:mailbox rdf:resource="mailto:em@w3.org"/>
    <contact:personalTitle>Dr.</contact:personalTitle>
  </contact:Person>
</rdf:RDF>

```

Subject

Predicate

Object

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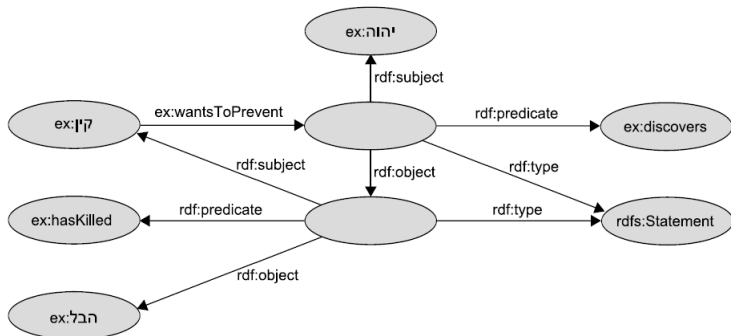
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A reification puzzle

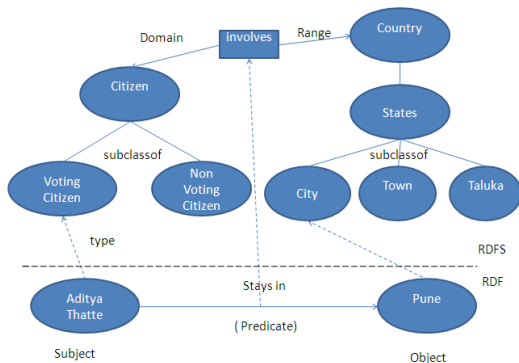


You know that story? It's in the old testament :)

RDF and RDFS (RDF Schema)

■ RDFS extends RDF with "schema vocabulary" such as:

- Class, Property
- subclassOf, subPropertyOf
- range, domain



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RDF/S: abstract data representation layer

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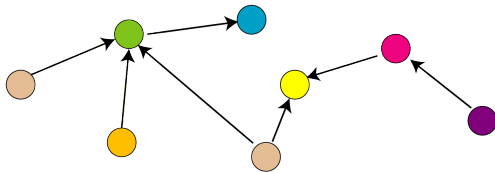
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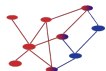
Applications



SPARQL,
OWL inferences,
etc.

Data represented in RDF, possibly with extra knowledge (RDFS, OWL, SKOS, Rules, ...)

SQL \Leftrightarrow RDF,
GRDDL, RDFa
etc.



Data in various formats

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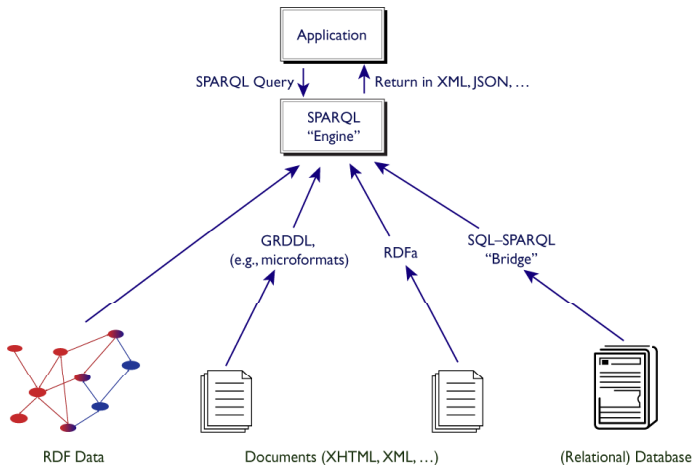
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The Linked Data Project

- A fundamental prerequisite of the Semantic Web is the existence of **large amounts of meaningfully interlinked RDF data** on the Web.
- Linked Data is about using the Web to **connect related data** that wasn't previously linked, or using the Web to lower the barriers to linking data currently linked using other methods
- It is a **recommended best practice** for exposing, sharing, and connecting pieces of data, information, and knowledge on the Semantic Web using URIs and RDF

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The Linked Data Project

- **Community effort** to make various open datasets available on the Web as RDF and to set RDF links between data items from different datasets
- The datasets are published according to the **Linked Data principles** and can therefore be crawled by Semantic Web search engines and navigated using Semantic Web browsers
- Supported by W3C
- Began early 2007
 - <http://linkeddata.org/home>

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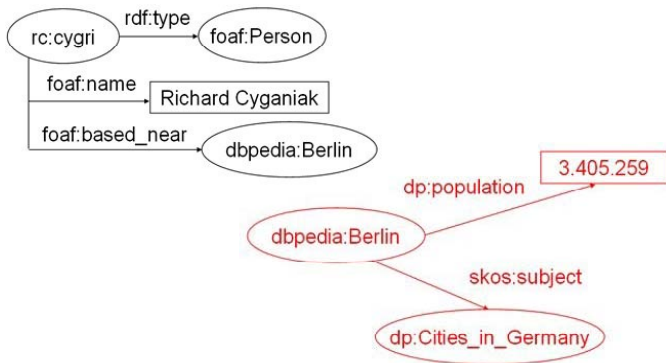
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Linked Data example



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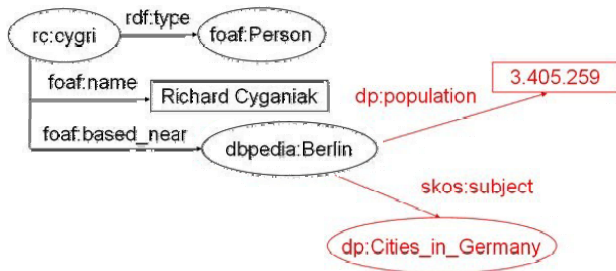
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Why publish Linked Data?

- Ease of discovery
- Ease of consumption
 - Standards-based data sharing
- Reduced redundancy
- Added value
 - Build ecosystems around your data/content

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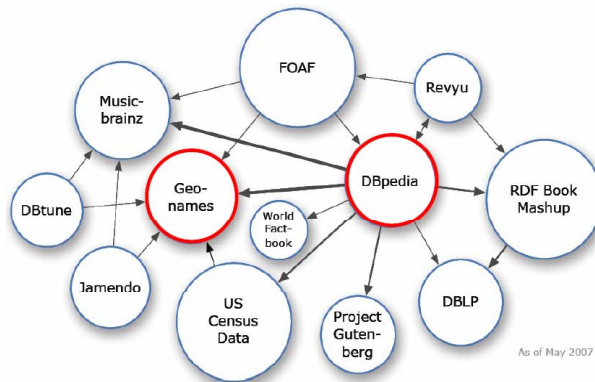
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Linked Open Data cloud

May 2007



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DBpedia



- DBpedia is a community effort to extract structured information from Wikipedia and to make this information available on the Web
- DBpedia allows to ask sophisticated queries against Wikipedia, and to link other data sets on the Web to Wikipedia data

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GeoNames



- GeoNames is a geographical database that contains over eight million geographical names
- Available for download free of charge under a creative commons attribution license

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Main contributors

- **DBLP** Computer science bibliography
 - Richard Cyganiak, Chris Bizer (FU Berlin)
- **DBpedia** Structured information from Wikipedia
 - Universität Leipzig, FU Berlin, OpenLink
- **DBtune, Jamendo** Creative Commons music repositories
 - Yves Raimond (University of London)
- **Geonames** World-wide geographical database
 - Bernard Vatant (Mondeca), Marc Wick (Geonames)
- **Musicbrainz** Music and artist database
 - Frederick Giasson, Kingsley Idehen (Zitgist)
- **Project Gutenberg** Literary works in the public domain
 - Piet Hensel, Hans Butschalowsky (FU Berlin)
- **Revyu** Community reviews about anything
 - Tom Heath, Enrico Motta (Open University)
- **RDF Book Mashup** Books from the Amazon API
 - Tobias Gauß, Chris Bizer (FU Berlin)
- **US Census Data** Statistical information about the U.S.
 - Josh Tauberer (University of Pennsylvania), OpenLink
- **World Factbook** Country statistics, compiled by CIA
 - Piet Hensel, Hans Butschalowsky (FU Berlin)

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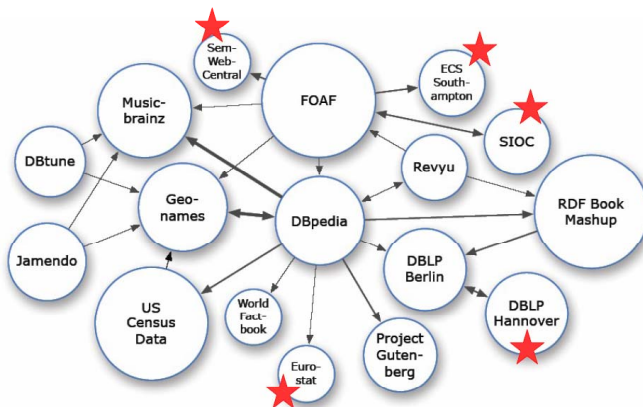
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July 2007



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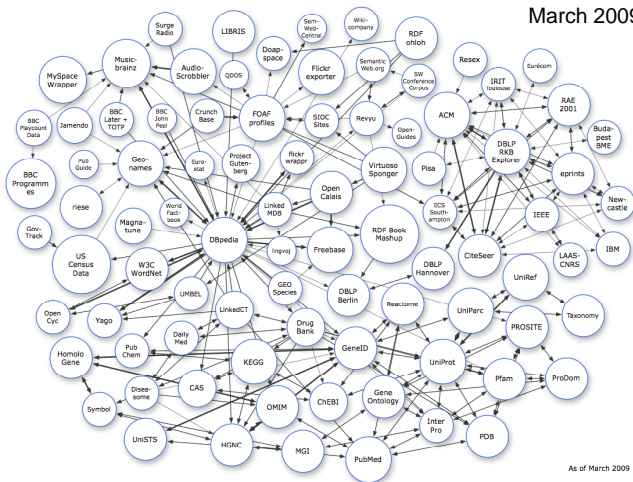
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March 2009



F. Corno, L. Farinetti - Politecnico di Torino

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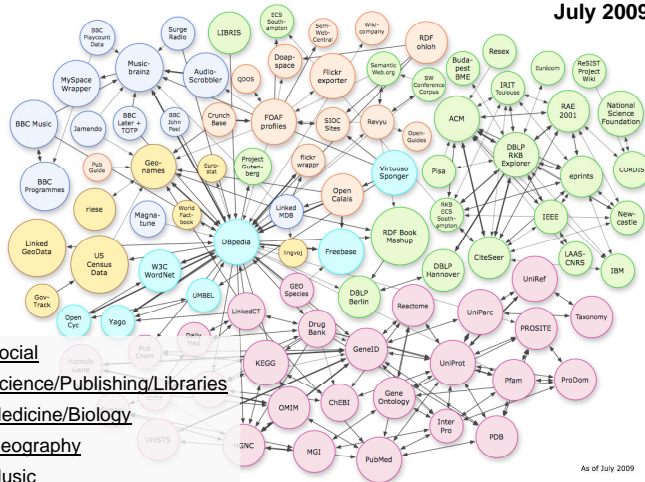
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July 2009



As of July 2009

Social**Science/Publishing/Libraries****Medicine/Biology****Geography****Music****Dictionary/Encyclopedia** di Torino

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Linked Open Data 2014

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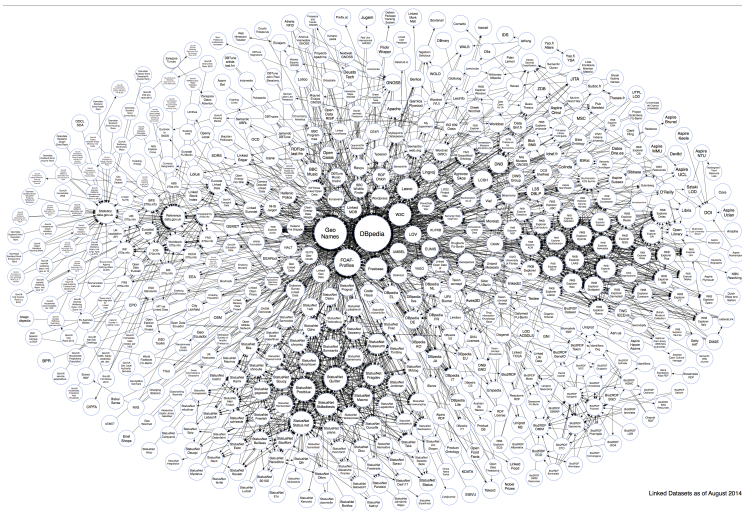
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Linked Datasets as of August 2014 

Picture from: <http://lod-cloud.net/versions/2014-08-30/lod-cloud.png>

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Statistics on datasets

- <http://esw.w3.org/topic/TaskForces/CommunityProjects/LinkingOpenData/DataSets/Statistics>

Data set	Size of the data set (number of triples)	Wrapper?	endpoint?	RDF dump?
ACM (RKB)	12,644,052	N	Y	Y
AudioScrobbler	600,000,000	Y	Y	N
BBC John Peel	277,000	N	Y	Y
BBC Later + TOTP (link not responding - 2009-04-01)	10,000	N	Y	Y
BBC Music	>10,000,000	N	N	N
BBC Playcount Data	10,000	N	Y	Y
BBC Programmes	10,000,000	N	N	N
Budapest BME (RKB)	42,064	N	Y	Y
Bio2RDF:Affymetrix	45,560,115	N	Y	Y
Bio2RDF:BioCYC	18,699,622	N	Y	Y
Bio2RDF:EBI:ChEBI	7,376,253	N	Y	Y
Bio2RDF:DBpedia	190,790	N	Y	Y
Bio2RDF:GO	8,188,649	N	Y	Y
Bio2RDF:HGNC	1,208,802	N	Y	Y
Bio2RDF:KEGG:Compound	177,199	N	Y	Y
Bio2RDF:KEGG:Drug	116,822	N	Y	Y

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Statistics on links between datasets

- <http://esw.w3.org/topic/TaskForces/CommunityProjects/LinkingOpenData/DataSets/LinkStatistics>

Source data set	Type	Target data set	Link count (range)	Link count (actual)
ACM (RKB)	Data Set	DBLP (RKB)	> 100,000	834,923
ACM (RKB)	Data Set	LAAS CNRS (RKB)	> 100	173
ACM (RKB)	Data Set	Newcastle (RKB)	> 100	684
ACM (RKB)	Data Set	eprints (RKB)	> 10,000	59,081
ACM (RKB)	Data Set	IRIT Toulouse (RKB)	> 100	729
ACM (RKB)	Data Set	CiteSeer (RKB)	> 1,000,000	1,768,94
ACM (RKB)	Data Set	Pisa (RKB)	> 100	
ACM (RKB)	Data Set	R o c c x (RKB)	> 100	
ACM (RKB)	Data Set	IBM (RKB)	> 100	116
ACM (RKB)	Data Set	IEEE (RKB)	> 1,000	2,267
ACM (RKB)	Data Set	RAE 2001 (RKB)	> 1,000	4,534
ACM (RKB)	Data Set	ECS Southampton (RKB)	> 1,000	1,358
AudioScrobbler	Wrapper	Musicbrainz	> 100	
AudioScrobbler	Wrapper	FOAF profiles	> 100,000	
BBC John Peel	Data Set	DBpedia	> 1,000	
BBC Later + TOTP	Data Set	DBpedia	> 1,000	

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Linked Data shopping list

- List of sites/datasets that the “community” would like to see published as Linked Data
 - This list may form the basis for some campaign/action to encourage these data publishers to embrace Linked Data
- <http://community.linkeddata.org/MediaWiki/index.php?ShoppingList>

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The Linked Data principles ("expectations of behavior")

- 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
- It is the **unexpected re-use of information** which is the value added by the web

(Tim Berners-Lee)

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The Linked Data principles ("expectations of behavior")

- Use **URIs** as names for things
 - Anything, not just documents
 - You are not your homepage
 - Information resources and non-information resources
- Use **HTTP URIs**
 - Globally unique names, distributed ownership
 - Allows people to look up those names

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The Linked Data principles ("expectations of behavior")

- Provide **useful information** in RDF
 - When someone looks up a URI
- Include **RDF links to other URIs**
 - To enable discovery of related information

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Link to other datasets

■ Popular predicates for linking

- owl:sameAs
- foaf:homepage
- foaf:topic
- foaf:based_near
- foaf:maker/foaf:made
- foaf:page
- foaf:primaryTopic
- rdfs:seeAlso

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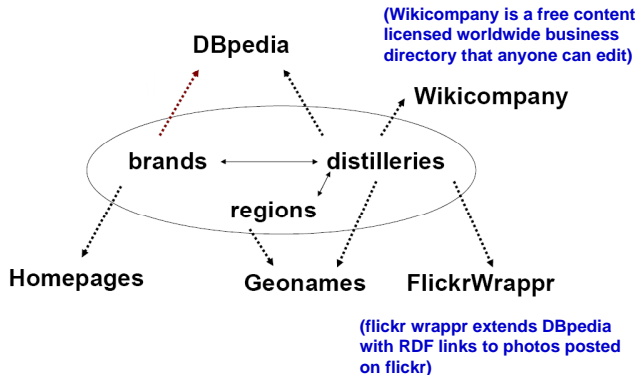
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Link to other Data Sets



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Tools for conversion

- **GRDDL** (Gleaning Resource Descriptions from Dialects of Languages)
 - W3C Recommendation (Sep 11th, 2007)
 - Enables users to obtain **RDF triples out of XML documents**
- **RDFa** (Resource Description Framework-in-attributes)
 - W3C Recommendation (October, 2008)
 - Set of extensions to XHTML that allows to **annotate XHTML markup with semantics**
 - Uses attributes from XHTML's meta and link elements, and generalizes them so that they are usable on all elements
 - A simple mapping is defined so that RDF triples may be extracted

XHTML + RDFa example

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML+RDFa 1.0//EN"
  "http://www.w3.org/Markup/DTD/xhtml-rdfa-1.dtd">
<html xmlns="http://www.w3.org/1999/xhtml"
  xmlns:foaf="http://xmlns.com/foaf/0.1/"
  xmlns:dc="http://purl.org/dc/elements/1.1/"
  version="XHTML+RDFa 1.0" xml:lang="en">
<head>
  <title>John's Home Page</title>
  <base href="http://example.org/john-d/" />
  <meta property="dc:creator" content="Jonathan Doe" />
</head>
<body>
  <h1>John's Home Page</h1>
  <p>My name is <span property="foaf:nick">John D</span> and I like
    <a href="http://www.neubauten.org/" rel="foaf:interest"
      xml:lang="de">Einstürzende Neubauten</a>. </p>
  <p>My <span rel="foaf:interest" resource="urn:ISBN:0752820907">
    favorite book</span> is the inspiring
    <span about="urn:ISBN:0752820907"><cite property="dc:title">
      Weaving the Web</cite> by <span property="dc:creator">Tim
      Berners-Lee</span></span> </p>
</body>
</html>
```

F. Corno, L. Farinetti - Politecnico di Torino

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Automatic conversion to RDF/XML

```

<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:foaf="http://xmlns.com/foaf/0.1/"
  xmlns:dc="http://purl.org/dc/elements/1.1/">
  <rdf:Description rdf:about="http://example.org/john-d/">
    <dc:creator xml:lang="en">Jonathan Doe</dc:creator>
    <foaf:nick xml:lang="en">John D</foaf:nick>
    <foaf:interest rdf:resource="http://www.neubauten.org/">
    <foaf:interest>
      <rdf:Description rdf:about="urn:ISBN:0752820907">
        <dc:creator xml:lang="en">Tim Berners-Lee</dc:creator>
        <dc:title xml:lang="en">Weaving the Web</dc:title>
      </rdf:Description>
    </foaf:interest>
  </rdf:Description>
</rdf:RDF>

```

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Semantic Web and RDB

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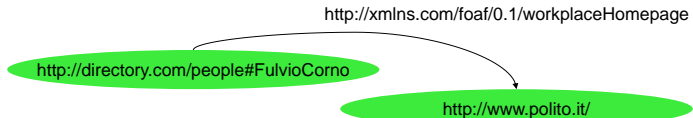
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Semantic Web vs. Relational Databases

- a record is an RDF node;
- the field (column) name is RDF propertyType; and
- the record field (table cell) is a value.

-(*T.Berners-Lee: Design Issues, 1999*)

Information in triples



RDF

CompanyHomePage

PersonID	Homepage
FulvioCorno	http://www.polito.it/

Relational database

**First order
logic predicate**

```
HasCompanyHomePage(
  'FulvioCorno',
  'http://www.polito.it/');
```

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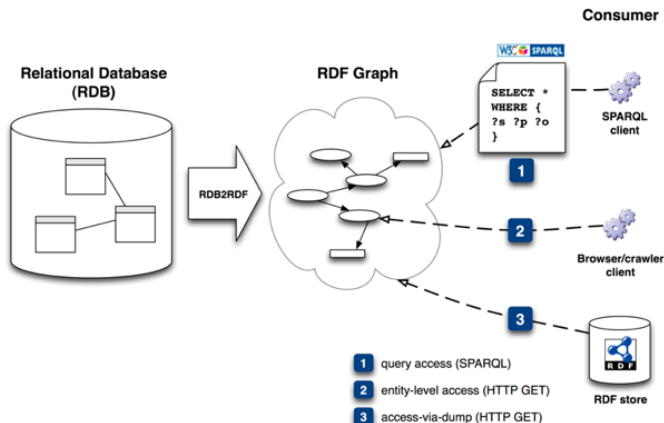
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RDB2RDF Principle



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Exporting data from RDB to RDF

- **D2R Server** – provides a mapping from a SQL server (tested with several brands), producing both linked virtual RDF data files and a SPARQL service.
- **dbview.py** – provides a mapping from a SQL server (tested with mySQL), producing linked virtual RDF data files.
- **OpenLink Virtuoso's Metaschema Language** – enables the creation of RDF Instance Data for associated RDF Ontologies via RDF VIEWS of ODBC, JDBC, ADO.NET, and OLE-DB accessible SQL Data.
- **Triplify** – a plugin for Web applications, which reveals the semantic structures encoded in relational databases by making database content available as RDF, JSON or Linked Data.
- **RDBToOnto** – a conversion tool that can produce accurate RDF/OWL models from various types of relational databases and Excel spreadsheets.

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RDB2RDF Working Group

- W3C Working Group (2007)
- Goal: standarize existing RDB2RDF mapping approaches
- Approach:
 - direct mapping, or
 - mapping definition in RDB2RDF Mapping Language (R2RML)
 - R2RML: W3C Recommendation 27 September 2012 – <http://www.w3.org/TR/r2rml/>

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RDB2RDF Direct Mapping

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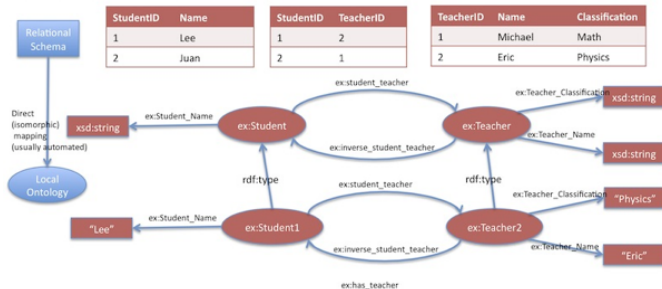
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RDB2RDF R2RML Mapping

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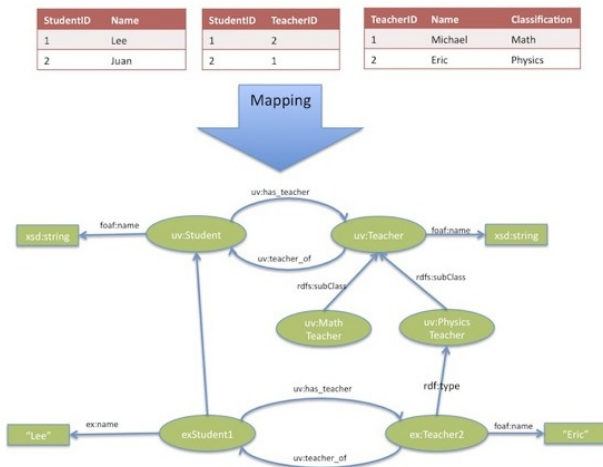
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Resources

- Relational Databases on the Semantic Web, Tim Berners-Lee, Design Issue Note:
<http://www.w3.org/DesignIssues/RDB-RDF.html>
- Linked Data Aspects of R2RML: <http://www.w3.org/2001/sw/rdb2rdf/wiki/LinkedDataAspects>
- Presentation of several existing RDB2RDF implementations:
http://www.w3.org/2001/sw/rdb2rdf/wiki/Initial_Round_of_Presentations
- From Relational Databases to the Semantic Web: New W3C Standards and Directions (videos):
<http://www.vimeo.com/13998744>,
<http://www.vimeo.com/13984398>
- Relational Database and the Semantic Web:
<http://www.semanticuniverse.com/blogs-relational-database-and-semantic-web.html>
- My first mapping from RDB to RDF using R2RML:
<http://ivan-herman.name/2010/11/02/my-first-mapping-from-rdb-to-rdf-using-r2rml/>

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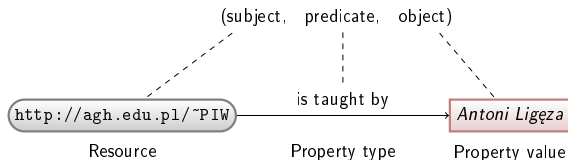
SPARQL



- W3C Recommendation: January 15th, 2008
- SPARQL queries RDF graphs
 - An RDF graph is a set of *triples*
- SPARQL can be used to express queries across *diverse data sources*, whether the data is stored natively as RDF or viewed as RDF via middleware

Query language for triples

- **SPARQL Protocol and RDF Query Language**
- Designed by the W3C RDF Data Access Working Group.
- No inference.
- Matching graph patterns:
 - combination of triple patterns:
 - ?x agh:taughtBy ?y
 - ?x, ?y – variables



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SPARQL

■ Uses SQL-like syntax

```

PREFIX dc: <http://purl.org/dc/elements/1.1/>
SELECT ?title
WHERE { <http://example.org/book/book1> dc:title
?title }

```

Prefix mechanism to abbreviate URIs

Query pattern (list of triple patterns)

Variables to be returned

FROM → Name of the graph

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SELECT

- Variables selection
- Variables: `?string`

```
?x
?title
?name
```

- Syntax: `SELECT var1, ..., varn`

```
SELECT ?name
SELECT ?x, ?title
```

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WHERE

- **Graph patterns** to match
- **Set of triples**
 $\{ (\text{subject predicate object } .)^* \}$
- **Subject:** URI, QName, Blank node, Literal, Variable
- **Predicate:** URI, QName, Blank node, Variable
- **Object:** URI, QName, Blank node, Literal, Variable

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Graph patterns

- The pattern contains **unbound symbols**
- By binding the symbols (if possible), **subgraphs of the RDF graph are selected**
- If there is such a selection, the query **returns** the bound resources

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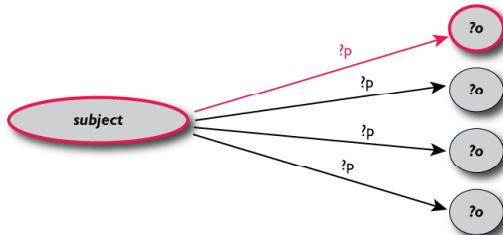
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Graph patterns

- E.g.: (subject, ?p, ?o)
 - ?p and ?o are “unknowns”



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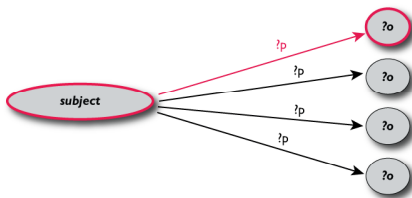
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Graph patterns

```
SELECT ?p ?o
WHERE {subject ?p ?o}
```

- The triplets in *WHERE* define the graph pattern, with ?p and ?o “unbound” symbols
- The query returns a list of matching p,o pairs



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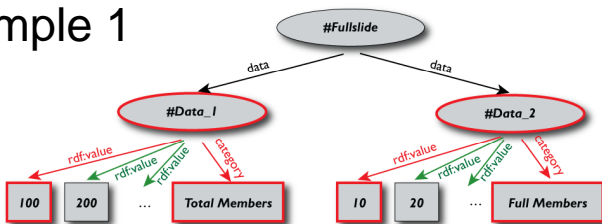
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Example 1



```
SELECT ?cat ?val
WHERE { ?x rdf:value ?val.
        ?x category ?cat }
```

■ Returns:

```
[["Total Members",100],[ "Total Members",200],...,
["Full Members",10],...]
```

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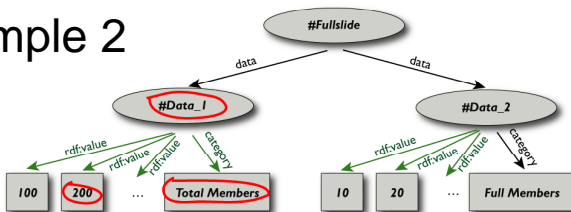
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Example 2



```

SELECT ?cat ?val
WHERE { ?x rdf:value ?val.
        ?x category ?cat.
        FILTER(?val>=200). }
  
```

■ Returns:

```
[[ "Total Members", 200 ], ... ]
```

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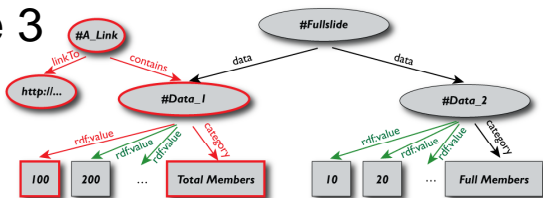
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Example 3



```

SELECT ?cat ?val ?uri
WHERE { ?x rdf:value ?val.
        ?x category ?cat.
        ?al contains ?x.
        ?al linkTo ?uri }

```

■ Returns:

```
[[["Total Members", 100, http://...]], ..., ]
```

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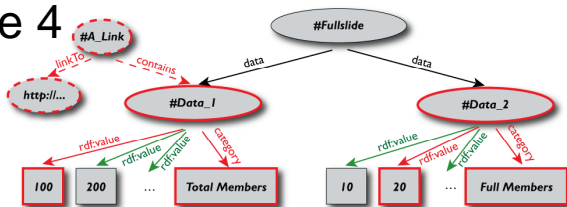
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Example 4



```

SELECT ?cat ?val ?uri
WHERE { ?x rdf:value ?val.
        ?x category ?cat.
OPTIONAL ?al contains ?x.
        ?al linkTo ?uri }

```

- Returns:

```

[[ ["Total Members", 100, http://...], ...,
  ["Full Members", 20, ], ..., ]

```

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Other SPARQL Features

- Limit the number of returned results
- Remove duplicates, sort them,...
- Specify several data sources (via URI-s) within the query (essentially, a merge)
- Construct a graph combining a separate pattern and the query results
- Use datatypes and/or language tags when matching a pattern

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SPARQL use in practice

- **Locally**, i.e., bound to a programming environments like Jena
 - Jena is a Java framework for building Semantic Web applications; provides an environment for RDF, RDFS and OWL, SPARQL and includes a rule-based inference engine
- **Remotely**, e.g., over the network or into a database

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SPARQL query structure

- A SPARQL query includes, in order
 - Prefix declarations, for abbreviating URIs
 - A result clause, identifying what information to return from the query
 - The query pattern, specifying what to query for in the underlying dataset
 - Query modifiers: slicing, ordering, and otherwise rearranging query results

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SPARQL query structure

- A SPARQL query includes, in order

```
# prefix declarations
PREFIX foo: <http://example.com/resources/>
...
# result clause
SELECT ...
# query pattern
WHERE {
    ...
}
# query modifiers
ORDER BY ...
```

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Dataset: Friend of a Friend (FOAF)

- FOAF is a standard RDF vocabulary for describing people and relationships
- Tim Berners-Lee's FOAF information available at <http://www.w3.org/People/Berners-Lee/card>

```
@prefix card: <http://www.w3.org/People/Berners-Lee/card#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
card:i foaf:name "Timothy Berners-Lee" .
<http://bblfish.net/people/henry/card#me>
foaf:name "Henry Story" .
<http://www.cambridgesemantics.com/people/about/lee>
foaf:name "Lee Feigenbaum" .
card:amy foaf:name "Amy van der Hiel" .
...
```

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Example 1 – simple triple pattern

- In the graph <http://www.w3.org/People/Berners-Lee/card>, find all subjects (?person) and objects (?name) linked with the foaf:name predicate.
- Then return all the values of ?name.
- In other words, find all names mentioned in Tim Berners-Lee's FOAF file

```
PREFIX foaf:  
<http://xmlns.com/foaf/0.1/>  
SELECT ?name  
WHERE {  
    ?person foaf:name ?name .  
}
```

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SPARQL endpoints

- **Accept queries** and returns results via HTTP
 - Generic endpoints queries any Web-accessible RDF data
 - Specific endpoints are hardwired to query against particular datasets
- The **results of SPARQL queries** can be returned in a variety of formats:
 - XML, JSON, RDF, HTML
 - JSON (JavaScript Object Notation): lightweight computer data interchange format; text-based, human-readable format for representing simple data structures and associative arrays

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SPARQL endpoints

- This query is for an arbitrary bit of RDF data (Tim Berners-Lee's FOAF file)
- => **generic endpoint** to run it
- Possible choices
 - SPARQLer - General purpose processor - sparql.org
 - <http://sparql.org/sparql.html>
 - [OpenLink's Virtuoso](http://bbc.openlinksw.com/sparql/) (Make sure to choose "Retrieve remote RDF data for all missing source graphs")
 - <http://bbc.openlinksw.com/sparql/>
 - [Redland's Rasqal](http://librdf.org/rasqal/)
 - <http://librdf.org/rasqal/>

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SPARQLer

SPARQLer - General purpose processor

General SPARQL query : input query, set any options and press "Get Results"

```

PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name
WHERE {
  ?person foaf:name ?name .
}

```

SPARQL query

Dataset

Target graph URI (or use FROM in the query) Output XML: with XSLT style sheet (leave blank for none): or JSON output: or text output: Force the accept header to text/plain regardless

Get Results

OpenLink's Virtuoso

OpenLink Virtuoso SPARQL Query

This query page is designed to help you test OpenLink Virtuoso SPARQL protocol endpoint.
Consult the [Virtuoso Wiki page](#) describing the service or the [Online Virtuoso Documentation](#) section [RDF Database and SPARQL](#).

There is also a rich Web based user interface with sample queries. [View the sample queries](#) [@sparql](#).

Query

Default Graph URI
 Dataset

Retrieve remote RDF data for all missing source graphs

Query text

```
SELECT ?name
WHERE {
  ?person foaf:name ?name .
}
```

SPARQL query

Display Results As: Rigorous check of the query

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Example 1 - simple triple pattern

```

PREFIX foaf:
<http://xmlns.com/foaf/0.1/>
SELECT ?name
WHERE {
    ?person foaf:name ?name .
}

```

name
Dan Connolly
Henry Story
Timothy Berners-Lee
Norman Walsh
World Wide Web Consortium
Ralph R. Swick
Daniel Krech
Christoph Bussler
Nicholas Gibbins
Wendy Hall
Nigel Shadbolt
Les Carr
Charles McMathieNevile
Håkon Wium Lie
Peter Szolovits

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Example 2 – multiple triple pattern

- Find all people in Tim Berners-Lee's FOAF file that have names and email addresses
- Return each person's URI, name, and email address
- Multiple triple patterns retrieve **multiple properties** about a particular resource
- SELECT *** selects all variables mentioned in the query

```
PREFIX foaf:
<http://xmlns.com/foaf/0.1/>
SELECT *
WHERE {
    ?person foaf:name ?name .
    ?person foaf:mbox ?email .
}
```

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Example 2 - multiple triple pattern

person	name	email
http://www.w3.org/People/Connolly/#me	Dan Connolly	mailto:connolly@w3.org
http://www.w3.org/People/Berners-Lee/card#i	Timothy Berners-Lee	mailto:timbl@w3.org
http://www.aaronsw.com/about.xrdf#aaronsw	Aaron Swartz	mailto:me@aaronsw.com
http://www.dajobe.org/foaf.rdf#i	Dave Beckett	mailto:dave@dajobe.org
http://www.w3.org/People/Berners-Lee/card#amy	Amy van der Hiel	mailto:amy@w3.org
http://www.w3.org/People/EM/contact#me	Eric Miller	mailto:em@w3.org
http://www.w3.org/People/karl/karl-foaf.xrdf#me	Karl Dubost	mailto:karl@w3.org
http://www.w3.org/People/Berners-Lee/card#cm	Coralie Mercier	mailto:coralie@w3.org
http://www.w3.org/People/Berners-Lee/card#dj	Dean Jackson	mailto:dean@w3.org
http://www.w3.org/People/Berners-Lee/card#dj	Dean Jackson	mailto:dino@grorg.org
http://www.w3.org/People/Berners-Lee/card#edd	Edd Dumbill	mailto:edd@usefulinc.com
http://www.w3.org/People/Berners-Lee/card#edd	Edd Dumbill	mailto:edd@xml.com
http://www.w3.org/People/Berners-Lee/card#edd	Edd Dumbill	mailto:edd@xmlhack.com
http://swordfish.rdfweb.org/people/libby/rdfweb/webwho.xrdf#me	Libby Miller	mailto:libby.miller@bristol.ac.uk
http://people.csail.mit.edu/lkagal/foaf.rdf#me	Lalana Kagal	mailto:lalana@csail.mit.edu
nodeID://1003907694	Susie Stephens	mailto:susie.stephens@gmail.com

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Example 3 – traversing a graph

- Find the homepage of anyone known by Tim Berners-Lee



homepage
http://purl.org/net/eric/
http://www.johnseelybrown.com/
http://www.grog.org/dean/
http://heddley.com/edd/
http://www.mellon.org/about_foundation/staff/program_area_staff/rafuchs

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Example 3 – traversing a graph

```

PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX card: <http://www.w3.org/People/Berners-Lee/card#>
SELECT ?homepage
FROM <http://www.w3.org/People/Berners-Lee/card>
WHERE {
    card:i foaf:knows ?known .
    ?known foaf:homepage ?homepage .
}

```

- The FROM keyword specifies the target graph in the query
- By using ?known as an object of one triple and the subject of another, it is possible to traverse multiple links in the graph

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Example 4 – exploring DBPedia

- Find 15 example concepts in the DBPedia dataset

```
SELECT DISTINCT ?concept
WHERE {
  ?s a ?concept .
} LIMIT 15
```

concept
http://www.w3.org/2004/02/skos/core#Concept
http://dbpedia.org/ontology/MusicalWork
http://dbpedia.org/ontology/Resource
http://dbpedia.org/ontology/Work
http://dbpedia.org/ontology/Album
http://dbpedia.org/ontology/Musical
http://umbel.org/umbel/sc/Product
http://umbel.org/umbel/ac/Artifact
http://dbpedia.org/class/yago/1982Novels
http://dbpedia.org/ontology/Book
http://dbpedia.org/class/yago/EnglishAstronomers
http://dbpedia.org/class/yago/EnglishPoliticians
http://umbel.org/umbel/sc/Astronomer
http://dbpedia.org/class/yago/LivingPeople
http://dbpedia.org/class/yago/AmericanCompetitiveEaters

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Example 4 – exploring DBPedia

- LIMIT is a **solution modifier** that limits the number of rows returned from a query
- SPARQL has two other solution modifiers
 - ORDER BY for **sorting** query solutions on the value of one or more variables
 - OFFSET, used in conjunction with LIMIT and ORDER BY to take a slice of a sorted solution set (e.g. for paging)
- The SPARQL keyword **a** is a shortcut for the common predicate **rdf:type** (class of a resource)
- The DISTINCT modifier **eliminates duplicate rows** from the query results

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Example 5 – basic SPARQL filters

- Find all landlocked countries with a population greater than 15 million

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX type: <http://dbpedia.org/class/yago/>
PREFIX prop: <http://dbpedia.org/property/>
SELECT ?country_name ?population
WHERE {
  ?country a type:LandlockedCountries ;
    rdfs:label ?country_name ;
    prop:populationEstimate ?population .
  FILTER (?population > 15000000) .
}
```

- FILTER** constraints use boolean conditions to **filter out** unwanted query results
- A semicolon (;) can be used to separate two triple patterns that **share the same subject**

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SPARQL filters

- Conditions on literal values
- Syntax

```
FILTER expression
```

- Examples

```
FILTER (?age > 30)
FILTER isIRI(?x)
FILTER !BOUND(?y)
```


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SPARQL filters

- `BOUND (var)`
 - true if `var` is bound in query answer
 - false, otherwise
 - `!BOUND (var)` enables negation-as-failure
- Testing types
 - `isIRI (A)`: `A` is an “Internationalized Resource Identifier”
 - `isBLANK (A)`: `A` is a blank node
 - `isLITERAL (A)`: `A` is a literal

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SPARQL filters

- Comparison between RDF terms

A = B
A != B

- Comparison between Numeric and Date types

A = B
A != B
A <= B
A >= B
A < B
A > B

- Boolean AND/OR

A && B
A || B

- Basic arithmetic

A + B
A - B
A * B
A / B

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Example 5 – basic SPARQL filters

- Note all the **translated duplicates** in the results
- How can we deal with that?

country_name	population
Afghanistan	31889923
Afghanistan	31889923
□□□□□□	31889923
Afghanistan	31889923
Afganistan	31889923
Афганистан	31889923
Afghanistan	31889923
Afganistán	31889923
Afganistan	31889923
Afganistan	31889923
Afeganistão	31889923
□□□	31889923
Afghanistan	31889923
Afghanistan	31889923
Afghanistan	31889923
Ethiopia	78254090
Éthiopie	78254090

Example 6 – SPARQL filters

- Find me all landlocked countries with a population greater than 15 million (revisited), with the highest population country first

```
PREFIX type: <http://dbpedia.org/class/yago/>
PREFIX prop: <http://dbpedia.org/property/>
SELECT ?country_name ?population
WHERE {
    ?country a type:LandlockedCountries ;
             rdfs:label ?country_name ;
             prop:populationEstimate ?population .
    FILTER (?population > 15000000 &&
           langMatches(lang(?country_name), "EN")) .
} ORDER BY DESC(?population)
```

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Example 6 – SPARQL filters

- `lang` extracts a literal's language tag, if any
- `langMatches` matches a language tag against a language range

country_name	population
Ethiopia	78254090
Afghanistan	31889923
Uganda	30900000
Nepal	29519114
Uzbekistan	27372000
Kazakhstan	15217711

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Dataset: Jamendo

- Jamendo is a community collection of music all freely licensed under Creative Commons licenses
 - <http://www.jamendo.com/it/>
- DBTune.org hosts a queryable RDF version of information about Jamendo's music collection
 - Data on thousands of artists, tens of thousands of albums, and nearly 100,000 tracks
 - <http://dbtune.org/>

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Example 7 – the wrong way

- Find all Jamendo artists along with their image, home page, and the location they're near

```

PREFIX mo: <http://purl.org/ontology/mo/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name ?img ?hp ?loc
WHERE {
  ?a a mo:MusicArtist ;
    foaf:name ?name ;
    foaf:img ?img ;
    foaf:homepage ?hp ;
    foaf:based_near ?loc .
}

```

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Example 7 – DBTune SPARQL endpoint

Interactive query

```

PREFIX mo: <http://purl.org/ontology/mo/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name ?img ?hp ?loc
WHERE {
  ?a a mo:MusicArtist ;
    foaf:name ?name ;
    foaf:img ?img ;
    foaf:homepage ?hp ;
    foaf:based_near ?loc .
}
  
```

<http://dbtune.org/jamendo/store/>

Result format: Resource: Entailment:

- Jamendo has information on about 3,500 artists
- Trying the query we **only get 2,667** results. What's wrong?

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Example 7 – the right way

- Not every artist has an image, homepage, or location!
- OPTIONAL tries to match a graph pattern, but **doesn't fail the whole query** if the optional match fails
- If an OPTIONAL pattern fails to match for a particular solution, any variables in that pattern remain **unbound** (no value) for that solution

```

PREFIX mo: <http://purl.org/ontology/mo/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name ?img ?hp ?loc
WHERE {
  ?a a mo:MusicArtist ;
     foaf:name ?name .
  OPTIONAL { ?a foaf:img ?img }
  OPTIONAL { ?a foaf:homepage ?hp }
  OPTIONAL { ?a foaf:based_near ?loc }
}

```

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Dataset: GovTrack

- GovTrack provides SPARQL access to data on the U.S. Congress
- Contains over 13,000,000 triples about legislators, bills, and votes
- <http://www.govtrack.us/>

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Example 8 – querying alternatives

- Find Senate bills that either John McCain or Barack Obama sponsored and the other cosponsored

```

PREFIX bill: <http://www.rdfabout.com/rdf/schema/usbill/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?title ?sponsor ?status
WHERE {
  { ?bill bill:sponsor ?mccain ; bill:cosponsor ?obama . }
  UNION
  { ?bill bill:sponsor ?obama ; bill:cosponsor ?mccain . }
  ?bill a bill:SenateBill ;
    bill:status ?status ;
    bill:sponsor ?sponsor ;
    dc:title ?title .
  ?obama foaf:name "Barack Obama" .
  ?mccain foaf:name "John McCain" .
}

```

Example 8 – GovTrack specific endpoint

```
PREFIX bill: <http://www.rdfabout.com/rdf/schema/usbill/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?title ?sponsor ?status
WHERE {
  { ?bill bill:sponsor ?mccain ; bill:cosponsor ?obama . }
  UNION
  { ?bill bill:sponsor ?obama ; bill:cosponsor ?mccain . }
```

Run Query

Display As:

SPARQL XML

<http://www.govtrack.us/developers/rdf.xpd>

- The UNION keyword forms a **disjunction of two graph patterns**: solutions to both sides of the UNION are included in the results

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RDF datasets

- All queries so far have been against a single graph
- In SPARQL this is known as the **default graph**
- RDF datasets are composed of a single default graph and **zero or more named graphs**, identified by a URI
- Named graphs can be specified with one or more **FROM NAMED clauses**, or they can be hardwired into a particular SPARQL endpoint
- The SPARQL **GRAPH keyword** allows portions of a query to match against the named graphs in the RDF dataset
- Anything outside a GRAPH clause matches against the default graph

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Dataset: semanticweb.org

- data.semanticweb.org hosts RDF data regarding workshops, schedules, and presenters for the International Semantic Web (ISWC) and European Semantic Web Conference (ESWC) series of events
- Presents data via FOAF, SWRC, and iCal ontologies
- The data for each individual ISWC or ESWC event is stored in its own named graph
 - i.e., there is **one named graph per conference event** contained in this dataset
- <http://data.semanticweb.org/>

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Example 9 – querying named graphs

- Find people who have been involved with at least three ISWC or ESWC conference events

```

PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT DISTINCT ?person
WHERE {
  GRAPH ?g1 { ?person a foaf:Person }
  GRAPH ?g2 { ?person a foaf:Person }
  GRAPH ?g3 { ?person a foaf:Person }
  FILTER(?g1 != ?g2 && ?g1 != ?g3 && ?g2 != ?g3) .
}

```

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Example 9 – querying named graphs

- The GRAPH ?g construct allows a pattern to match against **one of the named graphs** in the RDF dataset
- The URI of the matching graph is bound to ?g (or whatever variable was actually used)
- The FILTER assures that we're finding a person who occurs in three distinct graphs
- The Web interface used for this SPARQL query defines the foaf: prefix, which is why it is omitted here

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Data.semanticweb.org specific SPARQL endpoint

<http://data.semanticweb.org/snorql/>

Snorql: Exploring <http://data.semanticweb.org/sparql>

GRAPH:Default graph. [List named graphs](#)

GRAPH:Named graph goes here. [Switch back to default graph](#)

Browse:

- [Classes](#)
- [Properties](#)
- [Named Graphs](#)

SPARQL:

```
SELECT DISTINCT ?person
WHERE {
  GRAPH ?g1 { ?person a foaf:Person }
  GRAPH ?g2 { ?person a foaf:Person }
  GRAPH ?g3 { ?person a foaf:Person }
  FILTER(?g1 != ?g2 && ?g1 != ?g3 && ?g2 != ?g3) .
}
```

Results: XSLT stylesheet URL:

Powered by [Sesame](#)

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Exercises - RDF

```

@prefix : <http://example.org/data#> .
@prefix ont: <http://example.org/myOntology#> .
@prefix vcard: <http://www.w3.org/2001/vcard-rdf/3.0#> .

:john
  vcard:FN "John Smith" ;
  vcard:N [
    vcard:Given "John" ;
    vcard:Family "Smith" ] ;
  ont:hasAge 32 ;
  ont:marriedTo :mary .
:mary
  vcard:FN "Mary Smith" ;
  vcard:N [
    vcard:Given "Mary" ;
    vcard:Family "Smith" ] ;
  ont:hasAge 29 .

```

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SPARQL query – exercise 1

- Return the full names of all people in the graph

```

PREFIX vCard:
<http://www.w3.org/2001/vcardrdf/3.0#>
SELECT ?fullName
WHERE {?x vCard:FN ?fullName}

```

- Result

```

fullName
=====
"John Smith"
"Mary Smith"

```

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SPARQL query – exercise 2

- Return the relation between John and Mary

```
PREFIX : <http://example.org/data#>
SELECT ?p
WHERE { :john ?p :mary }
```

- Result

```
p
=====
<http://example.org/myOntology#marriedTo>
```

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SPARQL query – exercise 3

- Return the spouse of a person whose name is John Smith

```

PREFIX vCard:
<http://www.w3.org/2001/vcard-rdf/3.0#>
PREFIX ont: <http://example.org/myOntology#>
SELECT ?y
WHERE {?x vCard:FN "John Smith".
       ?x ont:marriedTo ?y}
  
```

- Result

```

y
=====
<http://example.org/data#mary>
  
```

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SPARQL query – exercise 4

- Return the name and the first name of all people in the knowledge base

```
PREFIX vCard:
<http://www.w3.org/2001/vcard-rdf/3.0#>
SELECT ?name, ?firstName
WHERE {?x vCard:N ?name .
       ?name vCard:Given ?firstName}
```

Result

name	firstName
"John Smith"	"John"
"Mary Smith"	"Mary"

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SPARQL query – exercise 5

- Return all people over 30 in the knowledge base

```
PREFIX ont: <http://example.org/myOntology#>
SELECT ?x
WHERE {?x ont:hasAge ?age .
       FILTER(?age > 30)}
```

- Result

```
x
=====
<http://example.org/data#john>
```


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FROM

- Select RDF graph (= dataset) to be queried
- In case of multiple FROM clauses, graphs are merged
- Example

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name
FROM <http://example.org/foaf/aliceFoaf>
WHERE { ?x foaf:name ?name }
```

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SPARQL query – exercise 6

- Graph `http://example.org/bob`

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .  
_:a foaf:name "Bob" .  
_:a foaf:mbox <mailto:bob@oldcorp.example.org> .
```

- Graph `http://example.org/alice`

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .  
_:a foaf:name "Alice" .  
_:a foaf:mbox <mailto:alice@work.example> .
```

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SPARQL query – exercise 6

- Return the names of people in both graphs

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?src ?name
FROM NAMED <http://example.org/alice>
FROM NAMED <http://example.org/bob>
WHERE
{ GRAPH ?src { ?x foaf:name ?name } }
```

- Result

src	name
<http://example.org/bob>	"Bob"
<http://example.org/alice>	"Alice"

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 - <http://www.w3.org/2006/Talks/0524-Edinburgh-IH/>
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 - <http://tomheath.com/slides/2009-02-austin-linkeddata-tutorial.pdf>

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Example: Twinkle

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The screenshot shows the Twinkle SPARQL Tools application. The main window displays a SPARQL query named 'heaviest-ten-elements.rq [Periodic Table]'. The query is as follows:

```

PREFIX table: <http://www.daml.org/2003/01/periodictable/PeriodicTable#>
SELECT ?name ?weight
WHERE {
  ?element table:name ?name;
           table:atomicWeight ?weight.
}
ORDER BY DESC(?weight)
LIMIT 10
  
```

The results are displayed in a table format:

name	weight
ununquadium^^http://www.w3.org/2001/XMLSchema#float	289^^http://www.w3.org/2001/XMLSchema#float
ununbium^^http://www.w3.org/2001/XMLSchema#float	285^^http://www.w3.org/2001/XMLSchema#float
unununium^^http://www.w3.org/2001/XMLSchema#float	272^^http://www.w3.org/2001/XMLSchema#float
ununnilium^^http://www.w3.org/2001/XMLSchema#float	271^^http://www.w3.org/2001/XMLSchema#float
hassium^^http://www.w3.org/2001/XMLSchema#float	269^^http://www.w3.org/2001/XMLSchema#float
meitnerium^^http://www.w3.org/2001/XMLSchema#float	268^^http://www.w3.org/2001/XMLSchema#float
seaborgium^^http://www.w3.org/2001/XMLSchema#float	266^^http://www.w3.org/2001/XMLSchema#float
bohrium^^http://www.w3.org/2001/XMLSchema#float	264^^http://www.w3.org/2001/XMLSchema#float

The interface also includes a sidebar with navigation options: General (Write Simple Query), In Memory (Planet RDF Feed & Blogroll, Periodic Table), Inferencing (Planet Feed (RDFS)), Persistent Stores, and Remote Services (Reyvu.com, GovTrack.us, DBpedia.org).

Example: DBpedia SPARQL Endpoint

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SPARQL Explorer for http://dbpedia.org/sparql

SPARQL:

```

PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX do: <http://purl.org/dc/elements/1.1/>
PREFIX : <http://dbpedia.org/resource/>
PREFIX dbpedia2: <http://dbpedia.org/property/>
PREFIX dbpedia: <http://dbpedia.org/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>

```

```
PREFIX dbo: <http://dbpedia.org/ontology/>
```

```

SELECT ?name ?birth ?death ?person WHERE {
  ?person dbo:birthPlace .Berlin .
  ?person dbo:birthDate ?birth .
  ?person foaf:name ?name .
  ?person dbo:deathDate ?death .
  FILTER (?birth < "1900-01-01"^^xsd:date) .
}

```

Results:

SPARQL results:

name	birth	death	person
"()@en	"1811-10-29"^^xsd:date	"1873-06-06"^^xsd:date	:Prince_Adalbert_of_Prussia_%281811%E2%80%931873%29 ↗
"(Carl Heinrich) Eduard Knoblauch Knoblauch"@en	"1801-09-25"^^xsd:date	"1865-05-29"^^xsd:date	:Eduard_Knoblauch ↗
"Achim von Arnim"@en	"1781-01-26"^^xsd:date	"1831-01-21"^^xsd:date	:Ludwig_Achim_von_Arnim ↗
"Adalbert Of Prussia"@en	"1811-10-29"^^xsd:date	"1873-06-06"^^xsd:date	:Prince_Adalbert_of_Prussia_%281811%E2%80%931873%29 ↗
"Adam Muller"@en	"1779-06-30"^^xsd:date	"1829-01-17"^^xsd:date	:Adam_M%C3%BCler ↗

<http://wiki.dbpedia.org/OnlineAccess#h28-3>

Relational, Tree and Graph DB Models

- **Relational DB:** tables related by Primary Key
- **Hierarchical DB:** parent nodes – more intrinsic importance
- **Graph DB:** arbitrary object relations, no intrinsic importance

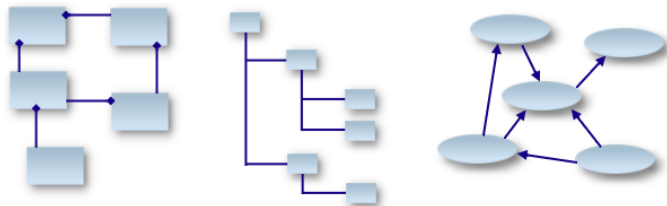


Figure: Comparison of the DB (<http://LinkedDataTools.com>)

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RDF Store (Triple store)

- System for **storing and managing** RDF data.
- Optimized for the storage and retrieval of statements.
- On top of RDB or built from scratch.
- Examples:
 - Jena (toolkit),
 - RedStore,
 - Bigdata.

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Popular RDF Stores

Name	Programming Language	Storing	Interface
3store	C	MySQL, Berkeley DB	RDQL and SPARQL (<u>HTTP server</u>) <u>C API</u>
Redland	C	Berkeley DB, MySQL PostgreSQL, SQLite files, URIs	SPARQL and RDQL <u>Perl</u> <u>PHP</u> Python Ruby
ARC	<u>PHP</u>	MySQL	SPARQL <u>PHP</u>
RAP	<u>PHP</u>	Memory, Database	SPARQL RDQL <u>PHP</u>
AllegroGraph	Java	SPARQL Prolog	
Jena	Java	Memory, Database	SPARQL
Mulgara	Java	Memory, Database	SPARQL
Sesame	Java	Memory, MySQL PostgreSQL, Oracle	SeRQL <u>API</u>
ClioPatria	Prolog	Memory	SeRQL SPARQL

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Benchmark: loading triples

System under test	1M	25M	100M
Sesame	00:02:59	12:17:05	3:06:27:35
Jena TDB	00:00:49	00:16:53	01:34:14
Jena SDB	00:02:09	04:04:38	1:14:53:08
Virtuoso TS	00:00:23	00:39:24	07:56:47
Virtuoso RV	00:00:34	00:17:15	01:03:53
D2R Server	00:00:06	00:02:03	00:11:45

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Benchmark: Query Mixes per Hour

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Dataset Size 1M	Number of clients				
	1	2	4	8	64
Sesame	18,094	19,057	16,460	18,295	16,517
Jena TDB	4,450	6,752	9,429	8,453	8,664
Jena SDB	10,421	17,280	23,433	24,959	23,478
Virtuoso TS	12,360	21,356	32,513	29,448	29,483
Virtuoso RV	17,424	28,985	34,836	32,668	33,339
D2R Server	2,828	3,861	3,140	2,960	2,938

Resources

- <http://esw.w3.org/LargeTripleStores>
- <http://esw.w3.org/RdfStoreBenchmarking>
- <http://www4.wiwiss.fu-berlin.de/bizer/BerlinSPARQLBenchmark/>
- http://semanticweb.org/wiki/Category:RDF_store

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Linked Data tools

- Tools for Publishing Linked Data
 - [D2R Server](#): a tool for publishing relational databases as Linked Data
 - [Talis Platform](#): the Talis Platform provides Linked Data-compliant hosting for content and RDF data
 - [Pubby](#): a Linked Data frontend for SPARQL endpoints
- Linked Data/RDF Editors and Validators
 - [Hyena](#): RDF Editor
 - [Vapour](#): Linked Data Validator
- Tools for consuming Linked Data
 - [Semantic Web Browsers and Client Libraries](#)
 - [Semantic Web Search Engines](#)
- Linked Data applications for end users
 - [Semantic Web Browsers and Client Libraries](#)
 - [Other Linked Data Applications](#)

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Pubby



- Many triple stores and other **SPARQL endpoints** can be accessed only by SPARQL client applications that use the SPARQL protocol
 - It cannot be accessed by the growing variety of Linked Data clients
- Pubby is designed to provide a **Linked Data interface** to those RDF data sources
- <http://www4.wiwiss.fu-berlin.de/pubby/>

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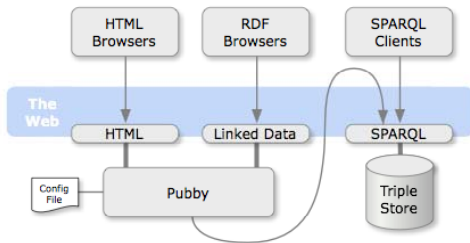
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The Tabulator Project

- Generic **data browser** and editor
 - Provides a way to browse RDF data on the web
- Open source under the W3C software license
 - <http://www.w3.org/2005/ajar/tab>

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The End

The Tabulator Project

Developer

▼ Iliaria Liccardi  

Type

- ▼ <http://xmlns.com/foaf/0.1/Person>   
- Is domain of  member_of
- Is range of  reported by
- ▼ **developer**
 - Type  Property
 -  ObjectProperty
 - Comment Desarrollador de software para el proyecto.
Developer of software for the project.
Développeur pour le projet.
 - Domain  Project
 - IsDefinedBy  Description of a Project (DOAP) vocabulary
 - Label desarrollador
developer
développeur
 - Range  <http://xmlns.com/foaf/0.1/Person>
 -  documenter
 -  helper
 -  maintainer
 -  tester
 -  translator
- Is subclassOf of
 - ▼ **SoloMusicArtist**  
 - Level 1
 - Type  Class
 - Comment Single person whose musical creative work shows sensitivity and imagination.
 - IsDefinedBy  The Music Ontology

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Marbles

- Linked Data browser
 - Colored dots are used to correlate the origin of displayed data with a list of data sources (hence the name)
- source code is available in the SourceForge project
 - <http://marbles.sourceforge.net/>

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Marbles

Open



DBpedia project



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

- Project  
- Open Linked Data project  



seeAlso

- <http://dbpedia.org/resource/DBpedia>  
- <http://dig.csail.mit.edu/2007/wiki/Projects.rdf> 
- <http://dig.csail.mit.edu/2007/wiki/projects.rdf> 

name

- DBpedia project  



comment

- A collection of the data from wikipedia  



homepage

- DBpedia  

name

- DBpedia project  

<http://www.w3.org/2007/ont/od#example>

- [John Seely Brown](#)  

Sources

-  <http://dbpedia.org/resource/DBpedia> redirect (303), retrieved Sun, 18 Apr 2010 14:26:04 GMT (clear)
-  <http://api.sindice.com/v2/search?q=term&page=1&q=http%3A%2F%2Fdig.csail.mit.edu/2007/wiki/projects.rdf> success (200), retrieved Sun, 18 Apr 2010 14:26:04 GMT (clear)
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-  <http://revyu.com/spargl?query=PREFIX+rev%3A+%3Chttp%3A%2F%2Fpurl.org%2Fstuf...> success (200), retrieved Sun, 18 Apr 2010 14:26:04 GMT (clear)
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Thank you

Thank you for your attention!

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