



Data Culture with Culture Data

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- * Funded by the Andrew W. Mellon Foundation
- * Hosted by the Curatorial Directorate, British Museum

Culture Data

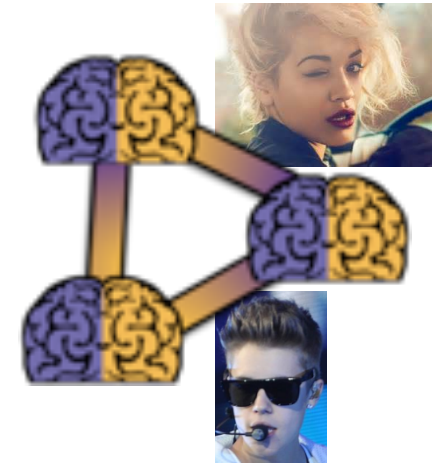


collection.britishmuseum.org

>2M objects described

RDF & public SPARQL

researchspace.org



musicbrainz.org

>1M albums described

RDF & public SPARQL

linkedbrainz.org

Not the Starting Point



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.

Tim Berners-Lee
Date: 2006-07-27

Not the Starting Point

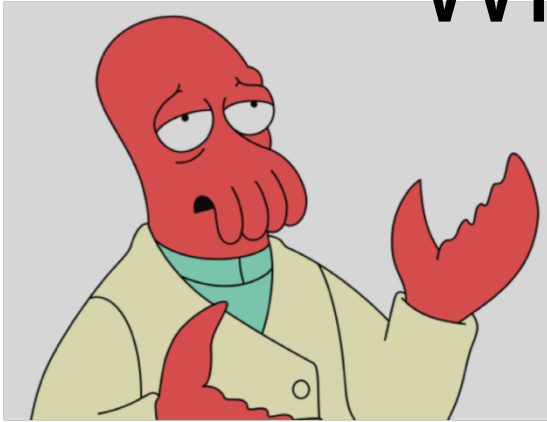


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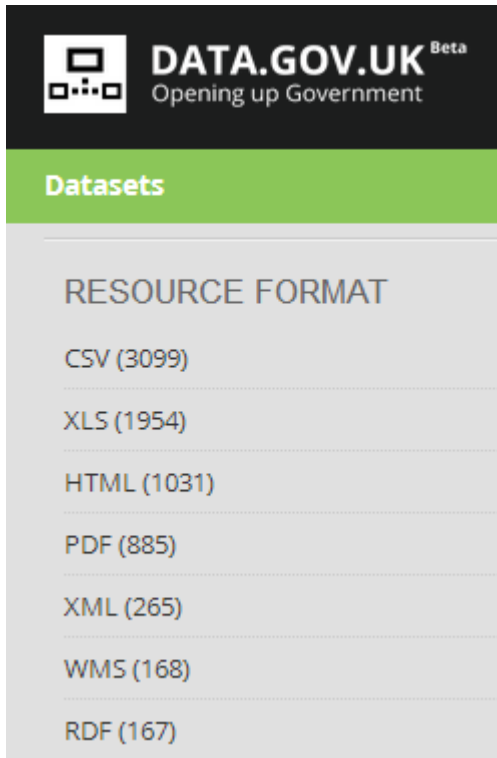
Why?

Tim Berners-Lee
Date: 2006-07-27

Why not CSVs?



- There are many of them
- They're easy to import into a spreadsheet (if they ever left)
- They're line-by-line processable
 - resurgence of GNU tools
 - powerful scripting languages
 - chunkable for Hadoop
- W3C CSV on the Web



DATA.GOV.UK Beta
Opening up Government

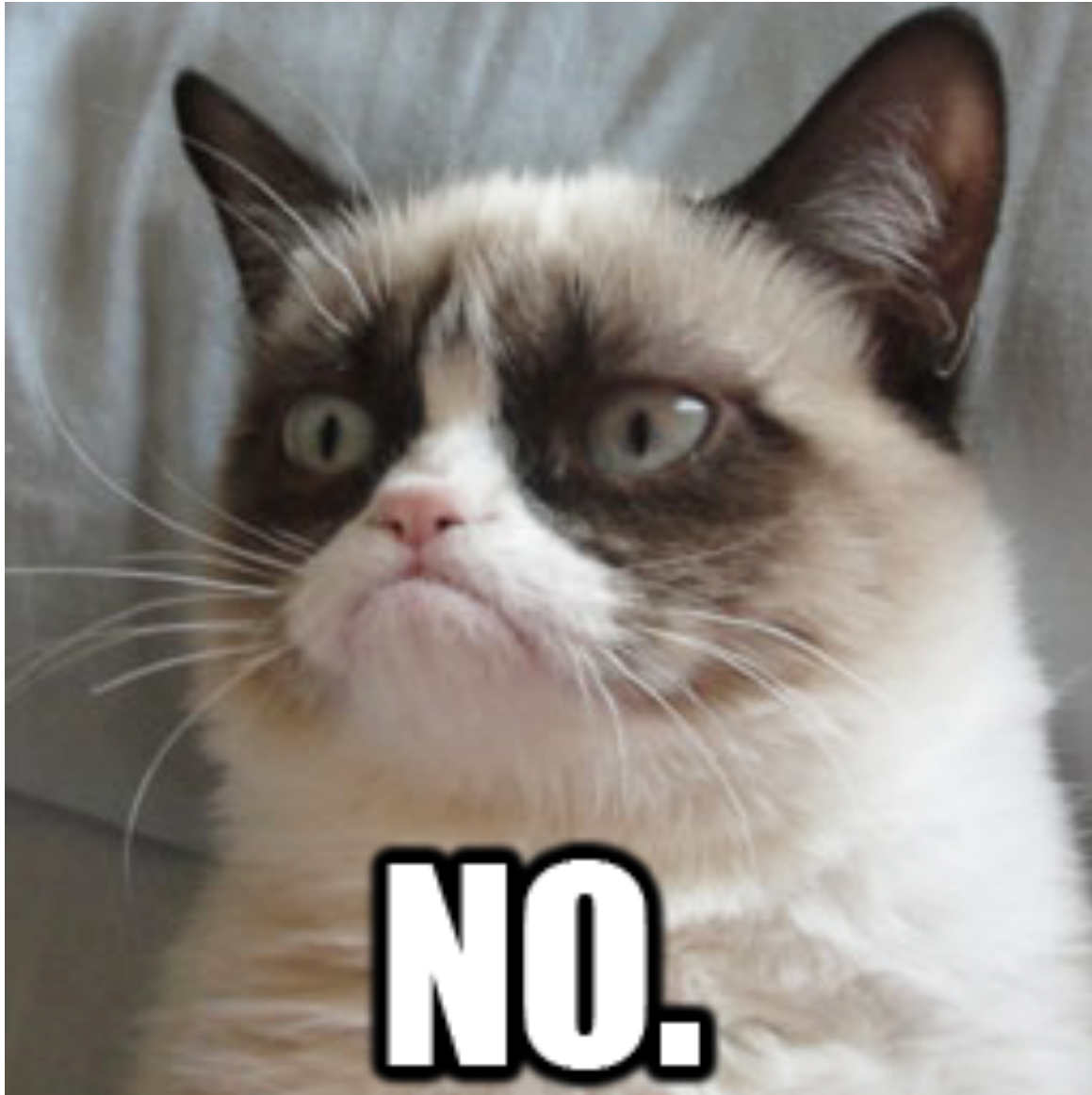
Datasets

RESOURCE FORMAT

CSV (3099)
XLS (1954)
HTML (1031)
PDF (885)
XML (265)
WMS (168)
RDF (167)



The British
Museum





CSV Simple Music

Artist	Album
The Beatles	Rubber Soul
The Beatles	Revolver
The Beatles	Sgt. Pepper's Lonely Hearts Club Band
The Rolling Stones	Their Satanic Majesties Request
The Rolling Stones	Beggars Banquet
The Rolling Stones	Let It Bleed



CSV Simple Denormalisation

Artist	Album	Track
The Beatles	Rubber Soul	Drive My Car
The Beatles	Rubber Soul	Norwegian Wood
The Beatles	Rubber Soul	...
The Beatles	Revolver	...
The Beatles	Sgt. Pepper's
The Rolling Stones	Their Satanic Majesties
The Rolling Stones	Beggars Banquet	...

- Redundant but feasible because this is a hierarchy



CSV Denormalisation

Artist	Member	Album	Track
The Beatles	John	Rubber Soul	?
The Beatles	Paul	Rubber Soul	?
The Beatles	George	Rubber Soul	?
The Beatles	Ringo	Rubber Soul	?
The Beatles		Sgt. Pepper's ...	?
The Rolling Stones		Their Satanic Majesties
The Rolling Stones		Beggars Banquet	...

- Orthogonal (arguably) hierarchies – either deeply redundant or very sparse...

Spreadsheets

	A	B	C
1	The Beatles	John Lennon	
2	The Beatles	Paul McCartney	
3	The Beatles	George Harrison	
4	The Beatles	Ringo Starr	
5	The Rolling Stones	Mick Jagger	
6	The Rolling Stones	Keith Richards	
7	The Rolling Stones	Charlie Watts	
8	The Rolling Stones	Ronnie Wood	
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

	A	B
1	Rubber Soul	Drive My Car
2	Rubber Soul	Norwegian Wood
3	Rubber Soul	You Won't See Me
4	Rubber Soul	Nowhere Man
5	Rubber Soul	Think for Yourself
6	Rubber Soul	The Word
7	Rubber Soul	Michelle
8	Revolver	Taxman
9	Revolver	Eleanor Rigby
10	Revolver	I'm Only Sleeping
11	Revolver	Love You To
12	Revolver	Here, There and Everywhere
13	Revolver	Yellow Submarine
14	Revolver	She Said She Said
15		
16		
17		
18		

- But this is just a relational database without the rigour...

Why not RDBMS?



- Not as unlikely as you might think

https://musicbrainz.org/doc/MusicBrainz_Database



MusicBrainz Database

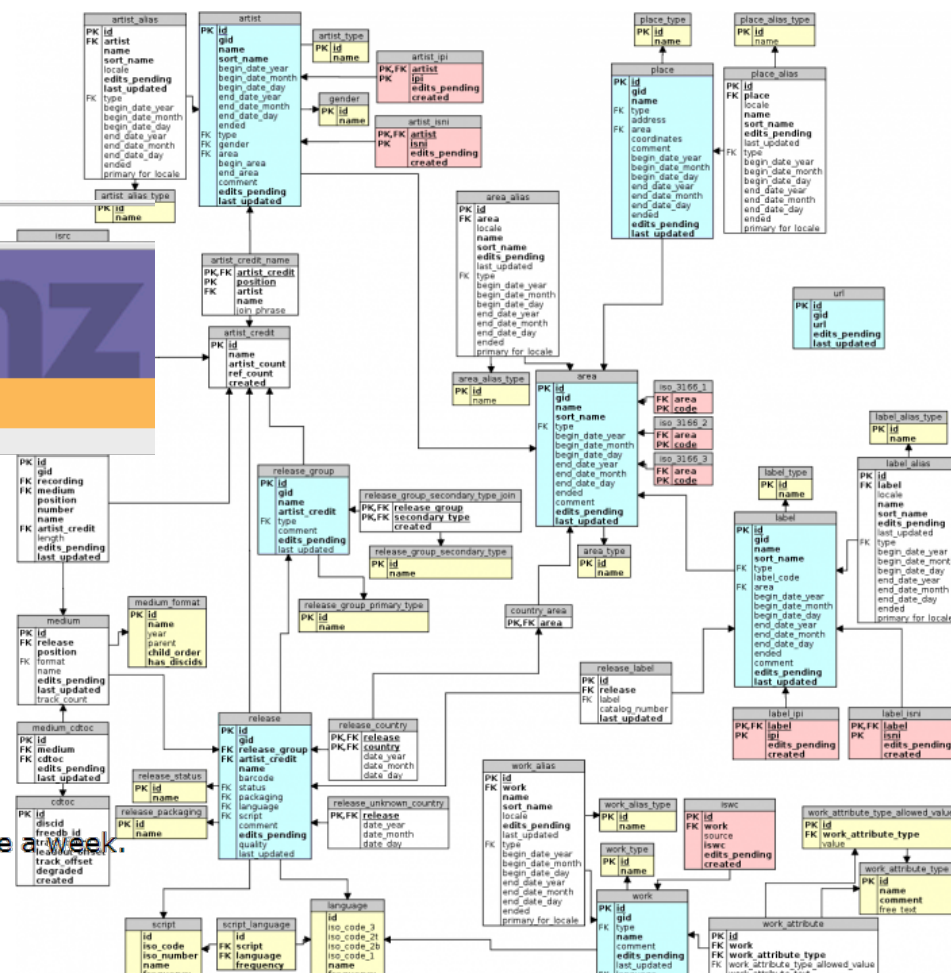
Products > MusicBrainz Database

Schema

Schema details are in the process of being written.

Download

A complete data snapshot of the entire database is generated twice a week.



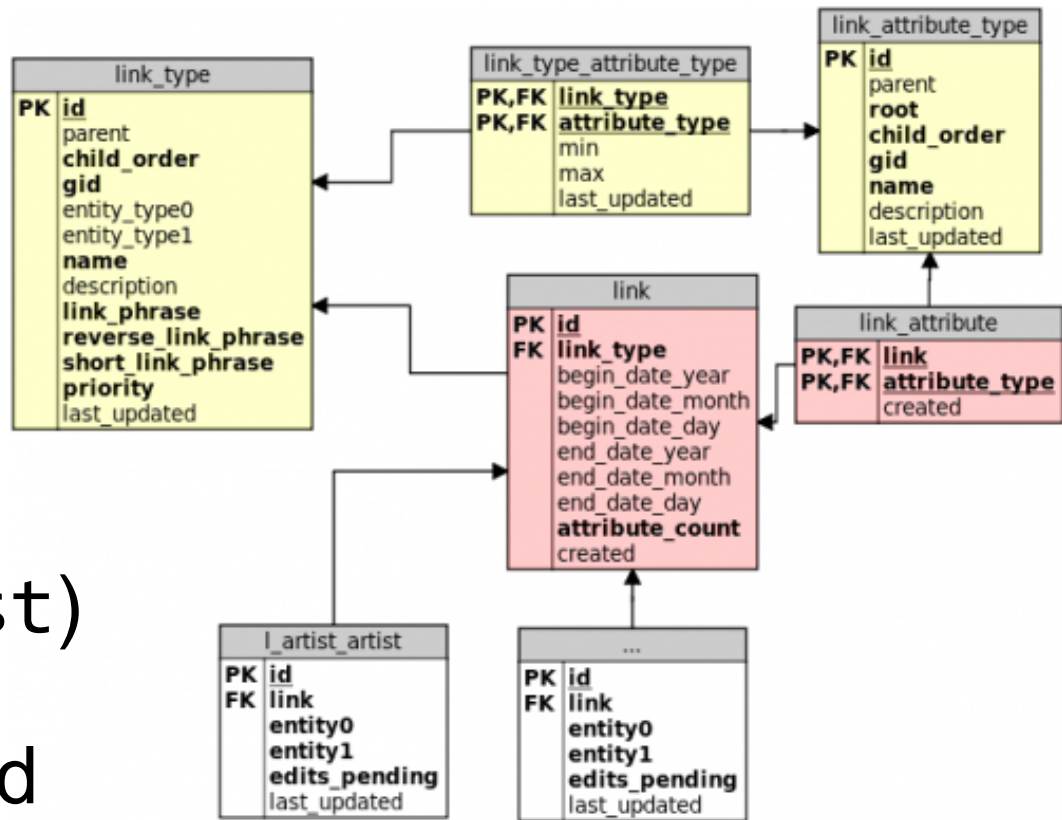


RDBMS on Web?

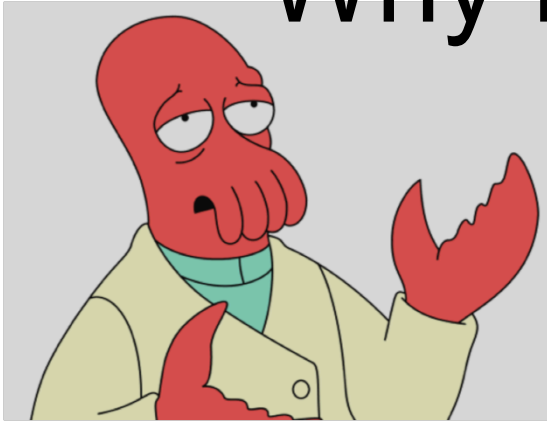
- Tricky to install and update, but feasible
 - MusicBrainz, for instance, distributes the postgresql index, but also a VM and postgresql replication
- Actually the basis of most CSV
 - project and denormalise
 - equally feasible with SPARQL (see later)
- Difficult to extend and integrate new data...

'Advanced Relationships'

- link_types (rows) are extensible binary relationships
- Each pair of entities (e.g. artist_artist) are paired and then links typed



Why not XML/SOAP?

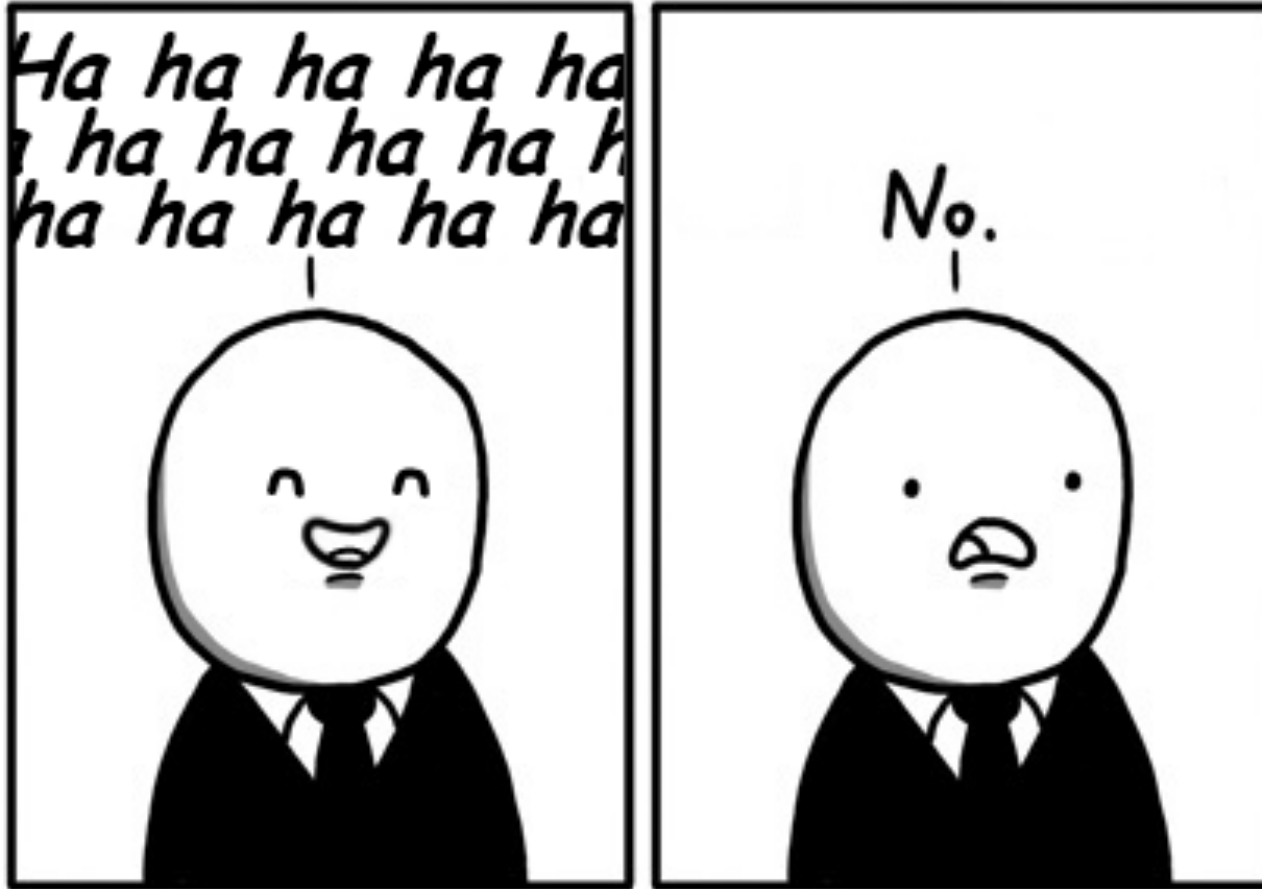


- XML is the 'data equivalent' to HTML Web documents
- XML is communicable via the Web protocol, HTTP, in SOAP
- So didn't we solve all this in the 90s?

```

<metadata xmlns="http://musicbrainz.org/ns/mmd-2.0#">
  <artist-list>
    <artist id="a16d1433-ba99-4ff2-a10a-000000000000">
      <user-tag-list>
        <user-tag><name>noise</name></user-tag>
        <user-tag><name>korean</name></user-tag>
        <user-tag><name>jpop</name></user-tag>
      </user-tag-list>
    </artist>
  </artist-list>
  <recording-list>
    <recording id="047ea202-b98d-46ae-97f7-0180a20ee5cf">
      <user-tag-list>
        <user-tag><name>noise</name></user-tag>
      </user-tag-list>
    </recording>
  </recording-list>
</metadata>

```





HTML versus XML

HTML:

```
<html>
  <body>
    <h1>title</h1>
    <p>Some text
referring to:</p>
    
    <ul>
      <li>one</li>
      <li>two</li>
      <li>three</li>
    </ul>
  </body>
</html>
```

XML (example):

```
<artists>
  <artist
    name="The Beatles">
    <member>John</member>
    <member>Paul</member> ...
    <album name="Rubber Soul">
      <track>Drive My Car</track>
      <track>Norwegian Wood ...
    </album>
    <album name="Revolver"> ...
  </artist>
  <artist
    name="The Rolling Stones">
    ...
```




HTTP versus Services

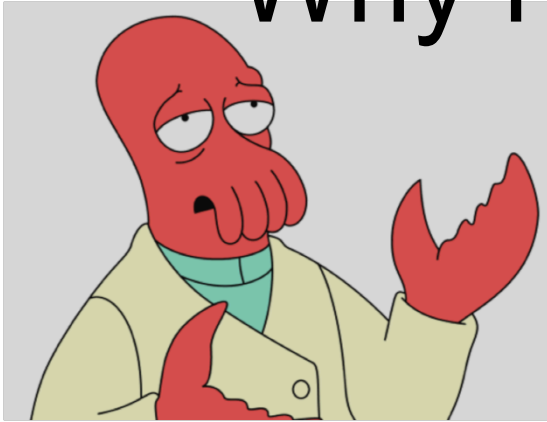
HTTP:

```
GET /artist/b10bbbfc-  
cf9e-42e0-be17-  
e2c3e1d2600d HTTP/1.1  
Host: musicbrainz.org
```

SOAP:

```
POST /ws  
Host: www.example.com
```

Why not JSON/REST?



- JSON removes a lot of the ambiguous structure of XML
- JSON is a lot more flexible in terms of schema (expectations)
- REST argues that resources have URIs and all representations be resolved there



The British
Museum

NO.





JSON

```
{
  "id": "fcbcdc39-8851-4efc-a02a-ab0e13be224f",
  "title": "LAST ANGEL",
  "disambiguation": "video",
  "artist-credit": [
    {
      "name": "倅田來未",
      "joinphrase": " feat. ",
      "artist": {
        "id": "455641ea-fff4-49f6-8fb4-49f961d8f1ac",
        "name": "倅田來未",
        "sort-name": "Koda, Kumi",
        "disambiguation": null
      }
    },
    {
      "name": "東方神起",
      "artist": {
        "id": "05cbaf37-6dc2-4f71-a0ce-d633447d90c3",
        "name": "東方神起",
        "sort-name": "TVXQ",
        "disambiguation": null
      },
      "joinphrase": ""
    }
  ],
  "isrcs": [ "JPB600760301" ],
  "length": 228106,
  "releases": [
    {
      "id": "abcd76db-7d5f-3eb7-b386-051c97bfe2e4",
      "title": "Kingdom",
```

Usage of **Linked Data**

Introduction and Application Scenarios

Presented by:
Barry Norton



Agenda

- 1. Motivation Scenario**
- 2. Linked Data Foundations**
- 3. Introduction to Linked Data**
- 4. Linked Data use case scenarios**

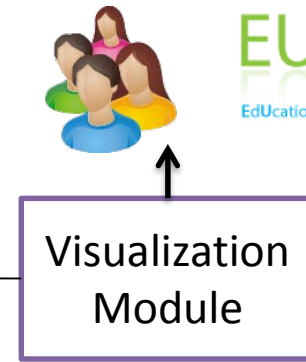
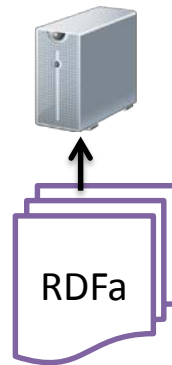
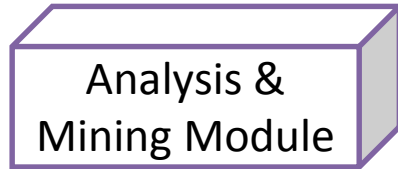
MOTIVATION SCENARIO

Music!

- Provision of a music-based portal.
- Bring together a number of disparate components of data-oriented content:
 1. **Musical content** (streaming data & downloads)
 2. **Music and artist metadata**
 3. **Review content**
 4. **Visual content** (pictures of artists & albums)

Music!

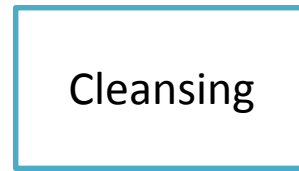
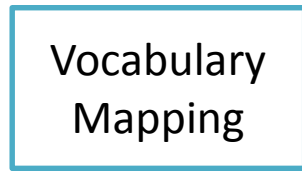
Application



Access

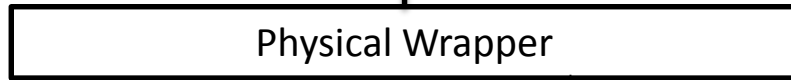


LD Dataset



Publishing

Data acquisition



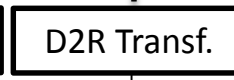
Musical Content



Downloads



Metadata



Other content



Music!

Expected Results

- The developer will contribute back the aggregated and interlinked content to the Linked Open Data Cloud.
- Linking of artists will be improved.
- Metadata, visual content and reviews will be improved.
- Links to emerging Web technologies that inherit from semantics: Google RichSnippets, Facebook OpenGraph and schema.org annotation.

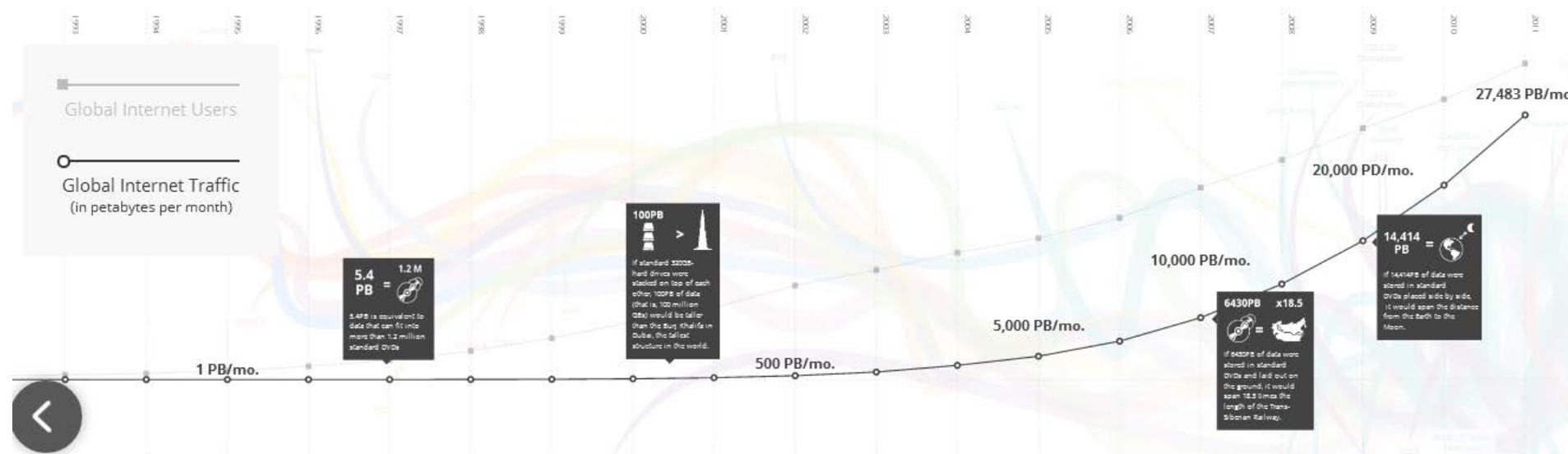
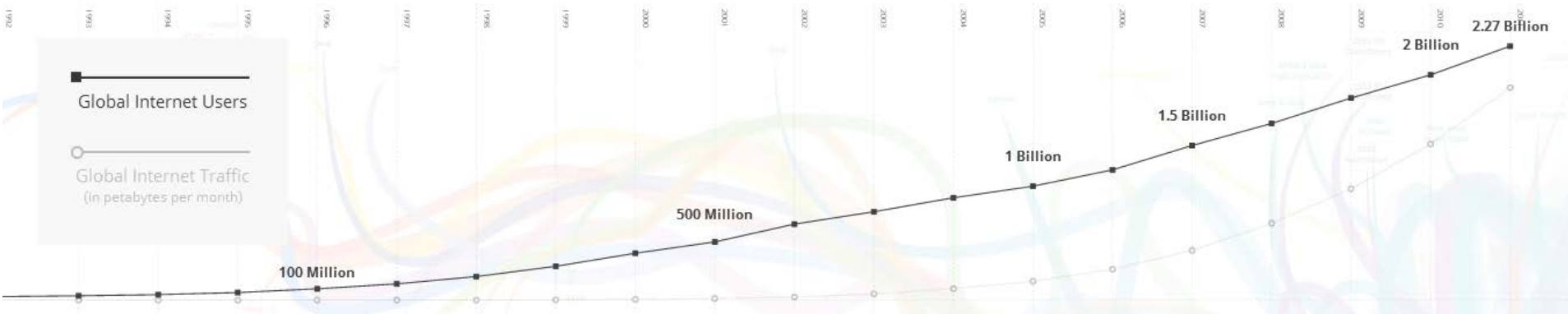
LINKED DATA FOUNDATIONS

Internet

- Extension of the technology of **computer networks**.
- The technology supporting the Internet includes the **Internet Protocol (IP)** .
- Each computer on the Internet is assigned an **IP number**.
- Messages can be **routed** from one computer to another.

Internet

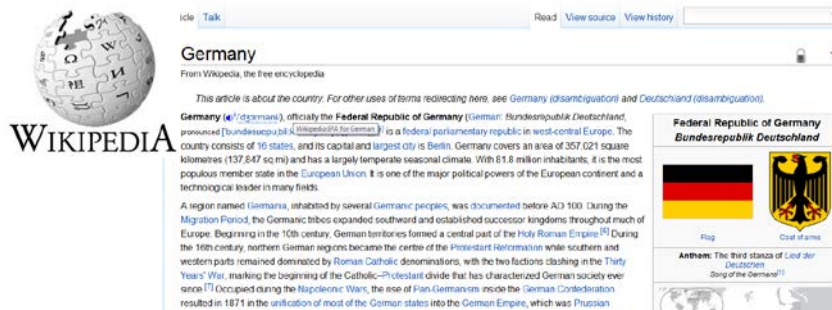
The growth of the Internet



Source: <http://www.evolutionoftheweb.com>

The Web

- There is a wealth of information on the Web.
- It is aimed mostly towards consumption by **humans as end-users**:
 - Recognize the meaning behind content and draw conclusions,
 - Infer new knowledge using context and
 - Understand background information.



The image shows a screenshot of the Wikipedia article for Germany. At the top left is the Wikipedia logo, a globe with letters. Below it is the word "WIKIPEDIA". The article title "Germany" is prominently displayed. Below the title is a search bar and navigation links like "Read", "View source", and "View history". The main text of the article is visible, starting with "Germany (officially the Federal Republic of Germany)". To the right of the text are two small images: the German flag and the German coat of arms. Below these images is the German national anthem text: "Anthem: The third stanza of 'Lied der Deutschen' (Song of the Germans)".



[Germany – Wikipedia](#)

[de.wikipedia.org/wiki/Germany](#)

Germany ist: die englische Bezeichnung für Deutschland. **Germany** (Mondkrater), ein Mondkrater; **Germany** (Rapper), deutscher Rapper. Zudem steht der Name ...

[Germany - Wikipedia, the free encyclopedia](#)

[en.wikipedia.org/wiki/Germany](#) - Diese Seite übersetzen

Song of the Germans. Location of **Germany** (dark green)–in Europe (green & dark grey). Location of **Germany** (dark green). – in Europe (green & dark grey) ...

Flag of Germany - History of Germany - Geography of Germany - German cuisine

[Tourism in Germany – travel, breaks, holidays](#)

[www.germany.travel/](#) - Diese Seite übersetzen

Tourism in **Germany** – travel, breaks, holidays. ... BMWi Logo **Germany**, the travel destination. Towns, cities & culture Towns, cities & culture; Leisure and ...

[Startseite: Das Deutschland-Portal](#)

[www.deutschland.de/](#)

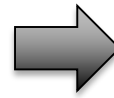
deutschland.de ist das offizielle und unabhängige Portal der Bundesrepublik Deutschland im Internet. Es bietet in fünf Sprachen eine Sammlung wichtiger ...

The Web

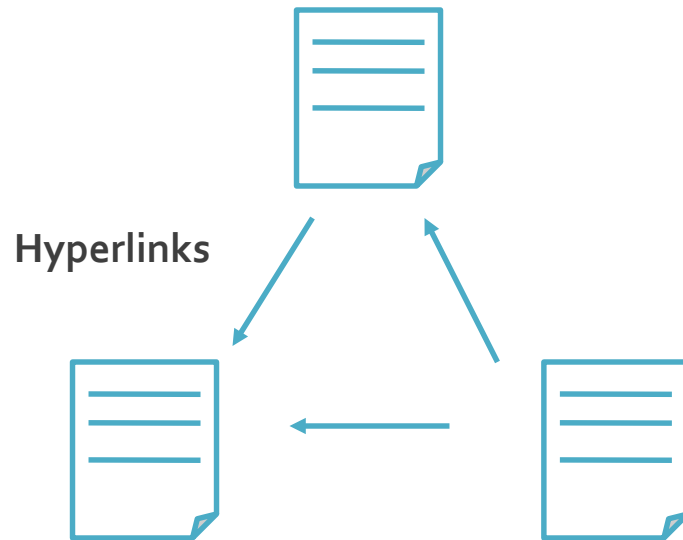
- Billions of diverse documents online, but it is not easily possible to automatically:
 - Retrieve relevant documents.
 - Extract information.
 - Combine information in a meaningful way.
- Idea:
 - Also publish machine processable data on the web.
 - Formulate questions in terms understandable for a machine.
 - Do this in a standardized way so machines can interoperate.
- The Web becomes a **Web of Data**
 - This provides a common framework to share knowledge on the Web across application boundaries.

The Web: Evolution

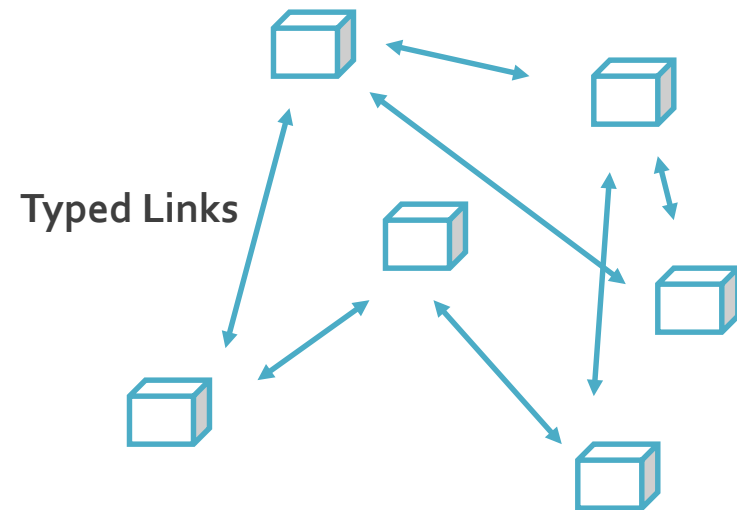
Web of Documents



Web of Data



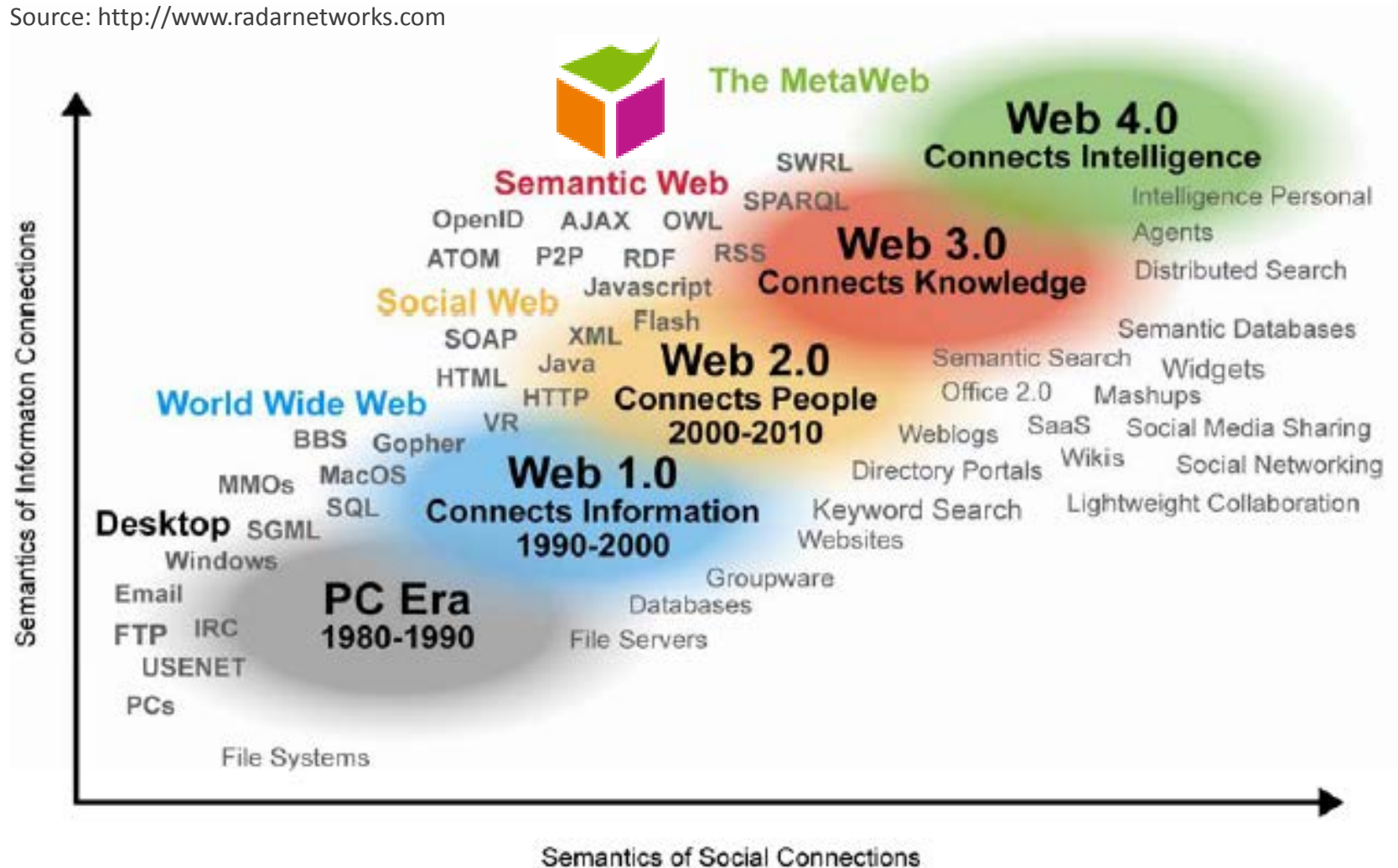
"Documents"



"Things"

The Web: Evolution

Source: <http://www.radarnetworks.com>



HTML – HyperText Markup Language

- Language for displaying web pages and other information in a web browser.
- HTML elements consist of **tags** (enclosed in angle brackets), **attributes** and **content**.

HTTP – Hypertext Transfer Protocol

- Foundation of data communication for the WWW.
- Client-server protocol.
- Every interaction is based on: **request** and **response**.

Uniform Resource Identifier (URI)

- Compact sequence of characters that identifies an abstract or physical resource.

- **Examples:**

`ldap://[2001:db8::7]/c=GB?objectClass?one`

`mailto:John.Doe@example.com`

`news:comp.infosystems.www.servers.unix`

`tel:+1-816-555-1212`

`telnet://192.0.2.16:80/`

`urn:oasis:names:specification:docbook:dtd:xml:4.1.2`

`http://dbpedia.org/resource/Karlsruhe`

Describing Data

Vocabularies

- Collections of defined **relationships** and **classes** of resources.
 - Classes group together similar resources.
- Terms from well-known vocabularies should be **reused** wherever possible.
- New terms should be define only if you can not find required terms in existing vocabularies.

Describing Data

Vocabularies

A set of well-known vocabularies has evolved in the Semantic Web community. **Some** of them are:

Vocabulary	Description	Classes and Relationships
Friend-of-a-Friend (FOAF)	Vocabulary for describing people.	foaf:Person, foaf:Agent, foaf:name, foaf:knows, foaf:member
Dublin Core (DC)	Defines general metadata attributes.	dc:FileFormat, dc:MediaType, dc:creator, dc:description
Semantically-Interlinked Online Communities (SIOC)	Vocabulary for representing online communities.	sioc:Community, sioc:Forum, sioc:Post, sioc:follows, sioc:topic
Music Ontology (MO)	Provides terms for describing artists, albums and tracks.	mo:MusicArtist, mo:MusicGroup, mo:Signal, mo:member, mo:record
Simple Knowledge Organization System (SKOS)	Vocabulary for representing taxonomies and loosely structured knowledge.	skos:Concept, skos:inScheme, skos:definition, skos:example

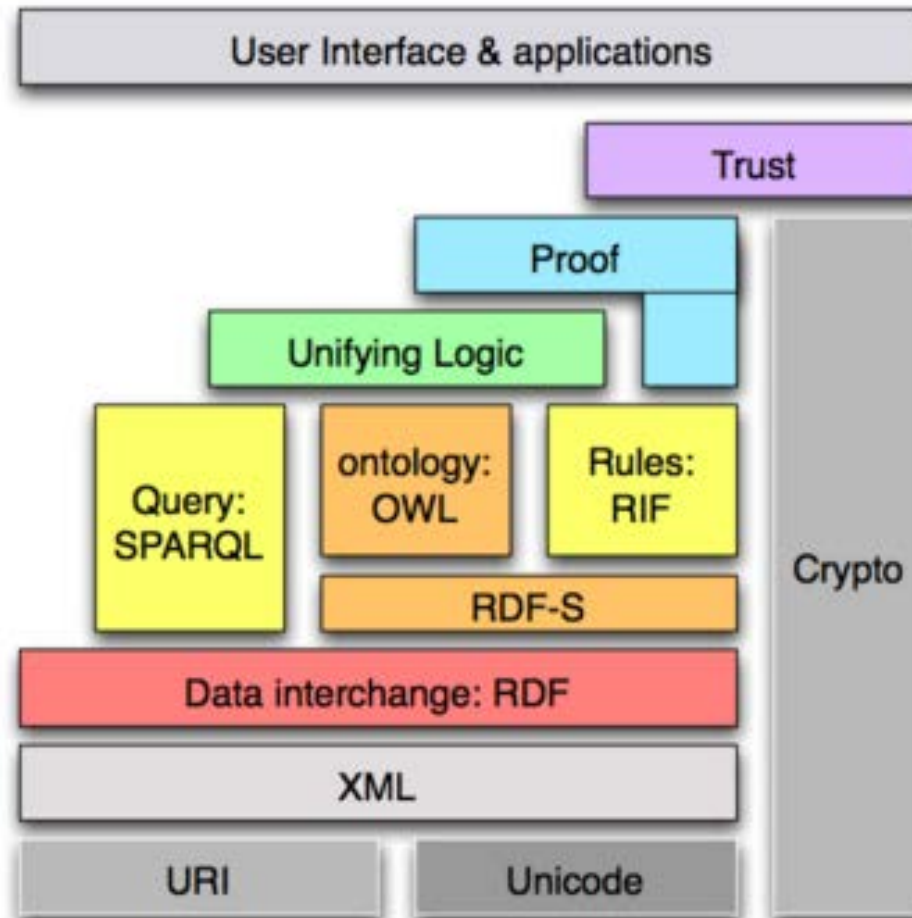
Describing Data

Vocabularies

More extensive lists of well-known vocabularies are maintained by:

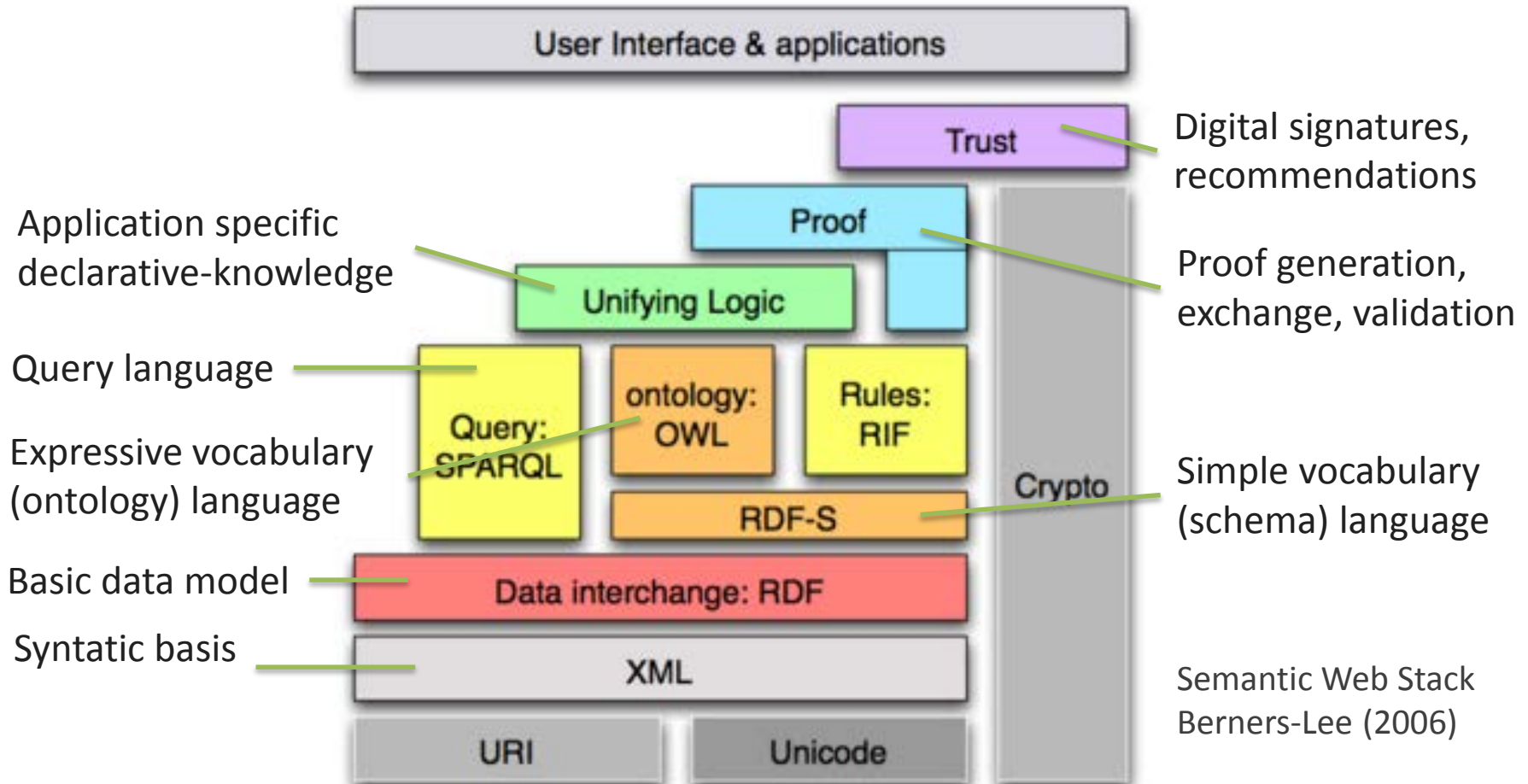
- W3C SWEO Linking Open Data community project
<http://www.w3.org/wiki/TaskForces/CommunityProjects/LinkingOpenData/CommonVocabularies>
- Mondeca: Linked Open Vocabularies
<http://labs.mondeca.com/dataset/lov>
- Library Linked Data Incubator Group: Vocabularies in the library domain
<http://www.w3.org/2005/Incubator/Ild/XGR-Ild-vocabdataset-20111025>

Semantics on the Web

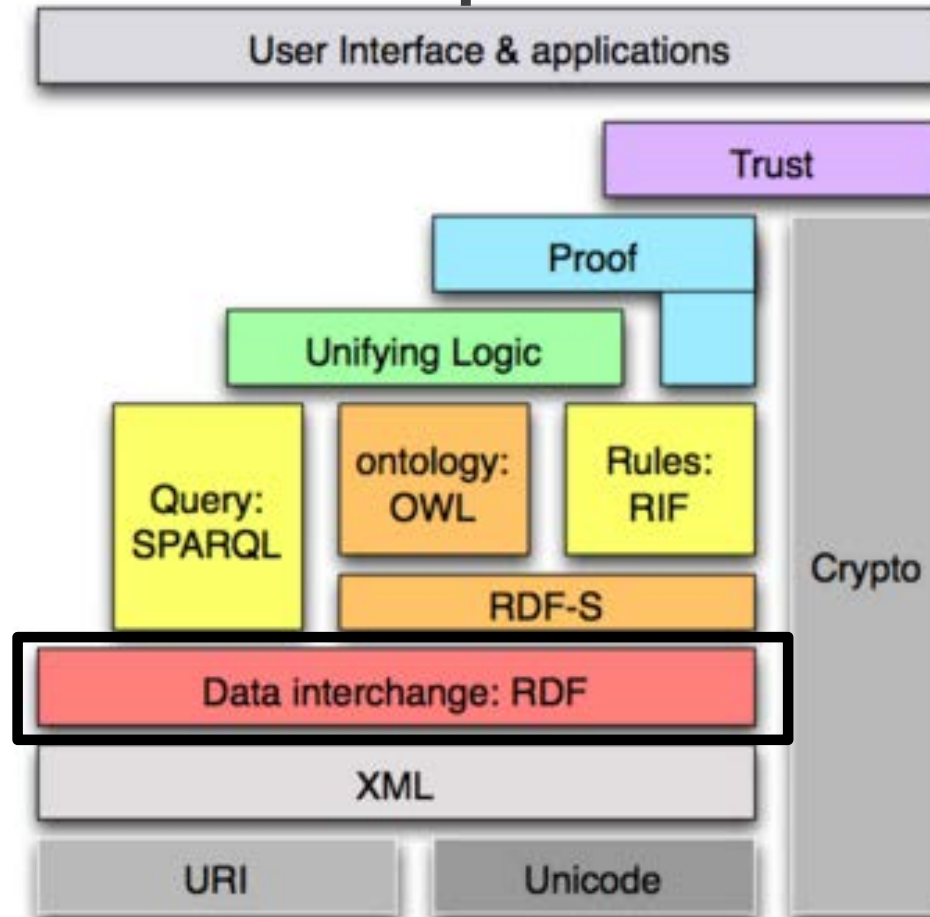


Semantic Web Stack
Berners-Lee (2006)

Semantics on the Web



RDF – Resource Description Framework



Semantic Web Stack
Berners-Lee (2006)

RDF – Resource Description Framework

- RDF is the basis layer of the Semantic Web stack ‘layer cake’.
- Basic building block: RDF triple.
 - **Subject** – a resource, which may be identified with a URI.
 - **Predicate** – a URI-identified reused specification of the relationship.
 - **Object** – a resource or literal to which the subject is related.

RDF – Resource Description Framework (Example)

`<http://musicbrainz.org/artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#_>`

`<http://www.w3.org/2002/07/owl#sameAs>`

`<http://dbpedia.org/resource/The_Beatles>.`

URIs are given in angle brackets in N-Triples.

`<http://musicbrainz.org/artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#_>`

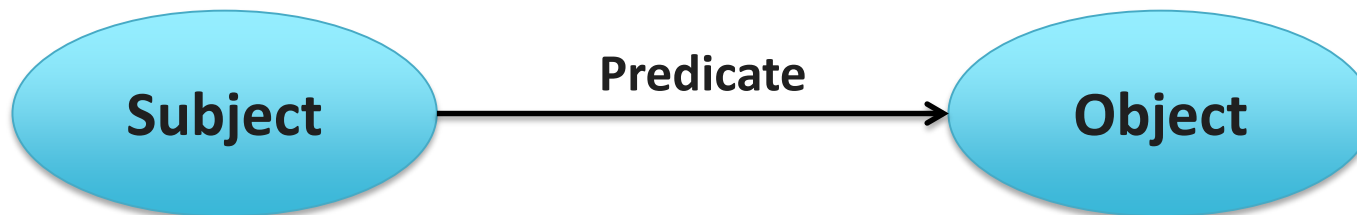
`<http://xmlns.com/foaf/0.1/name>`

`"The Beatles" .` Literals are given in quotes in N-Triples.

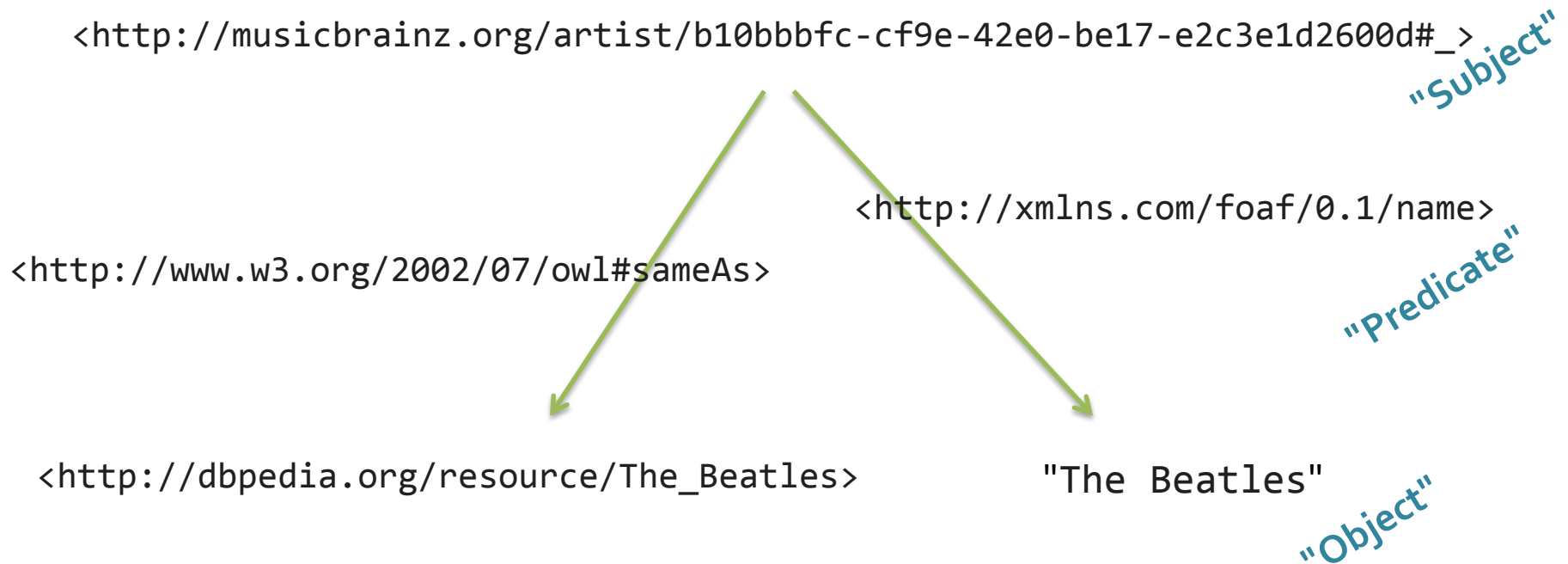
In N-Triples every statement is terminated with a full stop.

RDF Graphs

- Every set of RDF assertions can then be drawn and manipulated as a (labelled directed) graph:
 - **Resources** – the subjects and objects are nodes of the graph.
 - **Predicates** – each predicate use becomes a label for an arc, connecting the subject to the object.

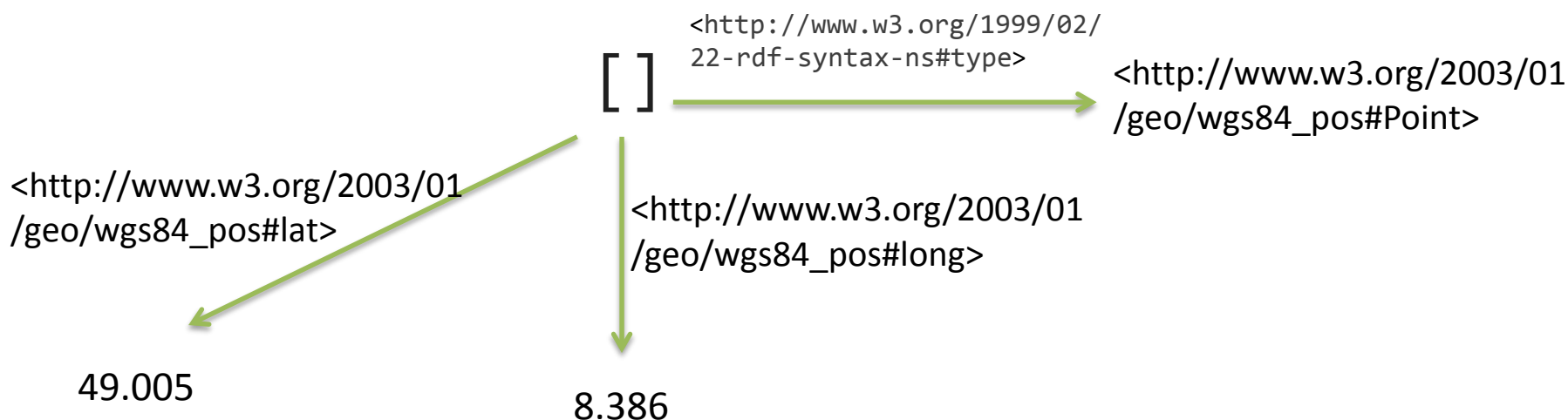


RDF Graphs (Example)



RDF Blank Nodes

- RDF graphs can also contain unidentified resources, called *blank nodes*:



- Blank nodes can group related information, but their use in Linked Data is discouraged.

RDF Turtle

- Turtle is a syntax for RDF more readable.
- Since many URIs share same basis we use **prefixes**:

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

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

```
@prefix owl:<http://www.w3.org/2002/07/owl#>.
```

```
@prefix mo:<http://purl.org/ontology/mo/>.
```

```
@prefix dbpedia:<http://dbpedia.org/resource/>.
```

And (sometimes) a unique base:

```
@base <http://musicbrainz.org/>.
```

RDF Turtle

- Also has a simple *shorthand* for class membership:

```
@base <http://musicbrainz.org/>.
```

```
@prefix mo:<http://purl.org/ontology/mo/>.
```

```
<artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#_> a mo:MusicGroup.
```

Is equivalent to:

```
<http://musicbrainz.org/artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#_>  
  <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>  
  <http://purl.org/ontology/mo/MusicGroup>.
```



RDF Turtle

- When multiple statements apply to **same subject** they can be abbreviated as follows:

```
<artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#_>
```

```
  rdfs:label "The Beatles"; _____ Same subject
```

```
  owl:sameAs dbpedia:The_Beatles , _____ Same subject &  
  <http://www.bbc.co.uk/music/artists/      predicate  
    b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#artist> .
```

RDF Turtle

- Turtle also provides a simple syntax for **datatypes** and **language tags** for literals, respectively:

```
<recording/5098d0a8-d3c3-424e-9367-1f2610724410#_> a mo:Signal;  
    rdfs:label "All You Need Is Love" ;  
    mo:duration "PT3M48S"^^xsd:duration .
```

```
dbpedia:The_Beatles dbpedia-owl:abstract  
    "The Beatles were an English rock band formed (...) "@en,  
    "The Beatles waren eine britische Rockband in den (...) "@de .
```

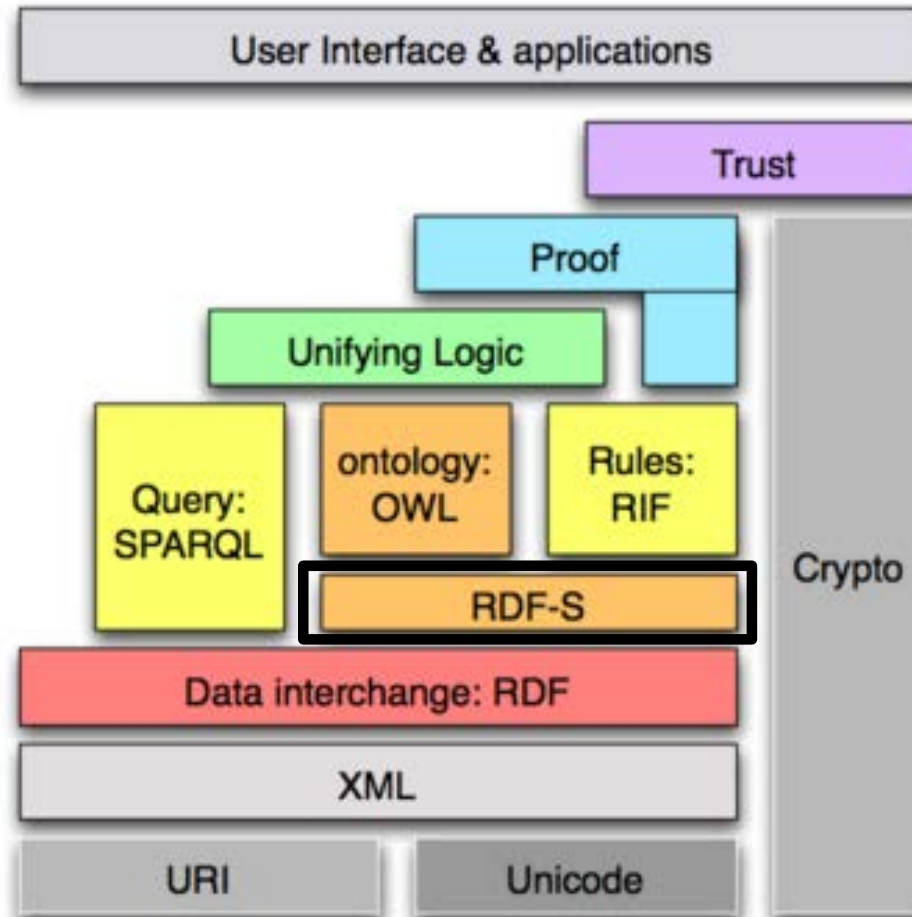
RDF/XML

- This is most useful for inter-machine communication.
- The primary (recurring) element in encoding assertions (thereby triples) is `rdf:Description`, e.g.:

```
<rdf:Description
  rdf:about="http://musicbrainz.org/artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#_">
  <foaf:name>The Beatles</foaf:name>
  <owl:sameAs rdf:resource="http://dbpedia.org/resource/The_Beatles">
</rdf:Description>
<rdf:Description
  rdf:about="http://musicbrainz.org/artist/4d5447d7-c61c-4120-ba1b-d7f471d385b9#_">
  <foaf:name>John Lennon</foaf:name>
</rdf:Description>
```

Semantics on the Web

RDF-S – RDF Schema



Semantic Web Stack
Berners-Lee (2006)

RDF-S – RDF Schema

Language for two tasks w.r.t. the RDF data model:

- **Expectation** – nominate:
 - the ‘types’, i.e., *classes*, of things we might make assertions about, and
 - the *properties* we might apply, as predicates in these assertions, to capture their relationships.
- **Inference** – given a set of assertions, using these classes and properties, specify what should be inferred about assertions that are *implicitly* made.

RDF-S – RDF Schema

- **rdf:Property** - Class of RDF properties. Example:
mo:member - Indicates a member of a musical group.
- **rdfs:domain** - States that any resource that has a given property is an instance of one or more classes.
`mo:member rdfs:domain mo:MusicGroup .`
- **rdfs:range** - States that the values of a property are instances of one or more classes.
`mo:member rdfs:range foaf:Agent .`

RDF-S – RDF Schema

Schema `mo:MusicGroup`
`rdfs:subClassOf`
`foaf:Group` .

Existing fact
`<artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#_>`
`rdf:type`
`mo:MusicGroup` .

Inferred
fact

`<artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#_>`
`rdf:type`
`foaf:Group` .

We *expect* to use this vocabulary to make assertions about music groups.

Having made such an assertion...

Inferences can be drawn that we did not explicitly make

RDF-S – RDF Schema

Resources and predicates with (limited) **inferences**:

`rdfs:Resource`

`rdfs:Literal`, `rdfs:Datatype`

`rdfs:Class`, `rdfs:subClassOf`

`rdfs:subPropertyOf`

`rdfs:range`, `rdfs:domain`

`rdf:Property` (an instance of `rdfs:Class`)

Some predicates with **NO inferences**:

`rdfs:comment`

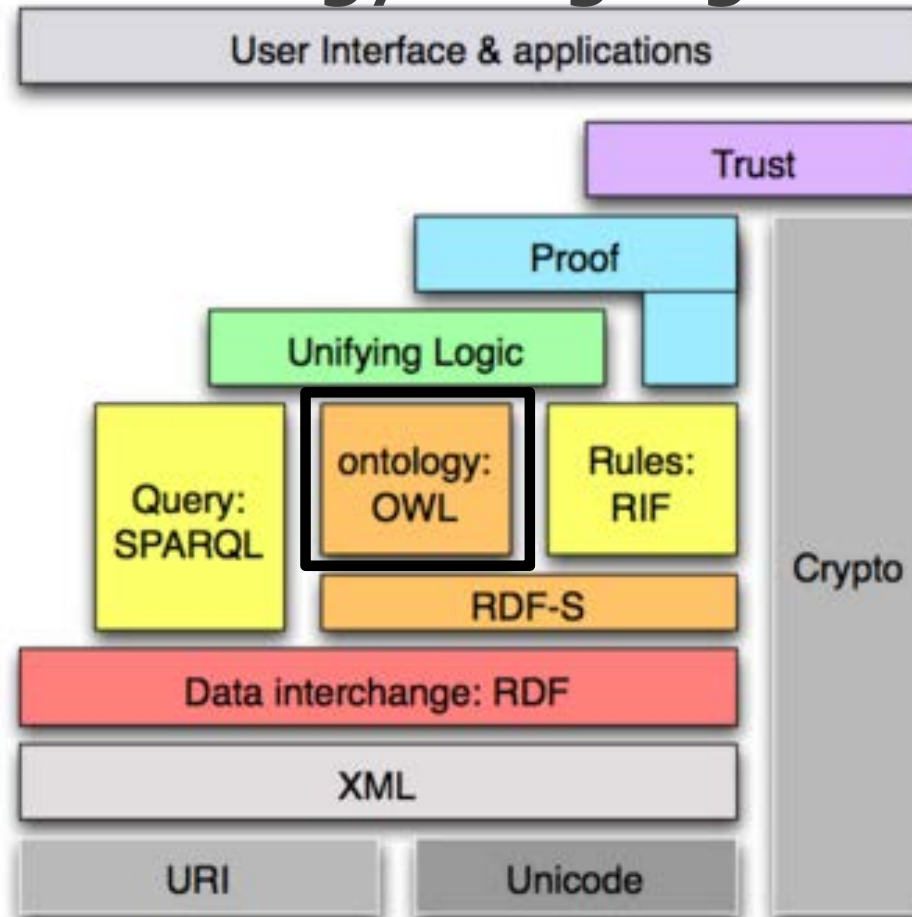
`rdfs:label`

`rdfs:seeAlso`

`rdfs:isDefinedBy`

Semantics on the Web

OWL – Web Ontology Language



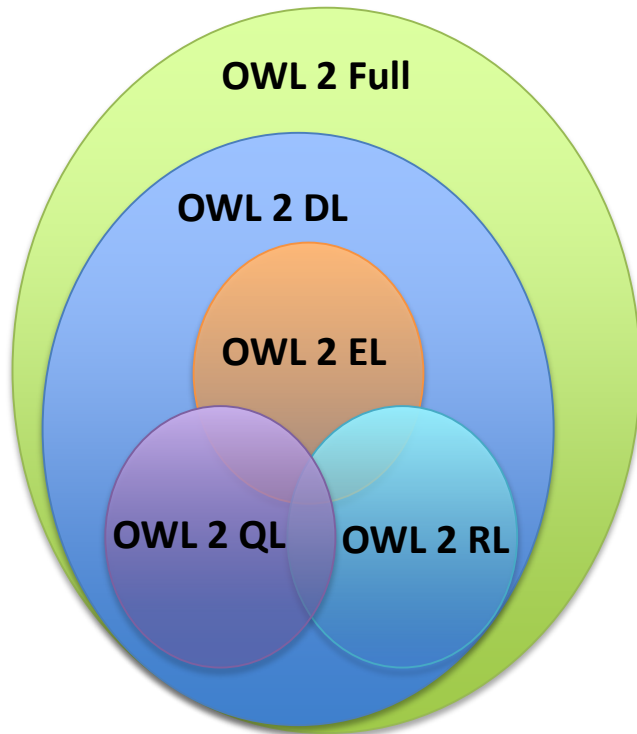
Semantic Web Stack
Berners-Lee (2006)

OWL – Web Ontology Language

- RDFS provides a simplified ontological language for defining vocabularies about specific domains.
- Sometimes it is necessary to have access to a wider range of ontological constructs.
- **Web Ontology Language (OWL)** provides more ontological constructs and avoids some of the potential confusion in RDF-S.

OWL 2.0 – Web Ontology Language 2.0

Extends the DL further, but has three more computable fragments (profiles).



OWL 2 Full

- Used informally to refer to RDF graphs considered as OWL 2 ontologies and interpreted using the RDF-Based Semantics.

OWL 2 DL

- Used informally to refer to OWL 2 DL ontologies interpreted using the Direct Semantics.

OWL 2 EL

- Limited to basic classification, but with polynomial-time reasoning.

OWL 2 QL

- Designed to be translatable to relational database querying.

OWL 2 RL

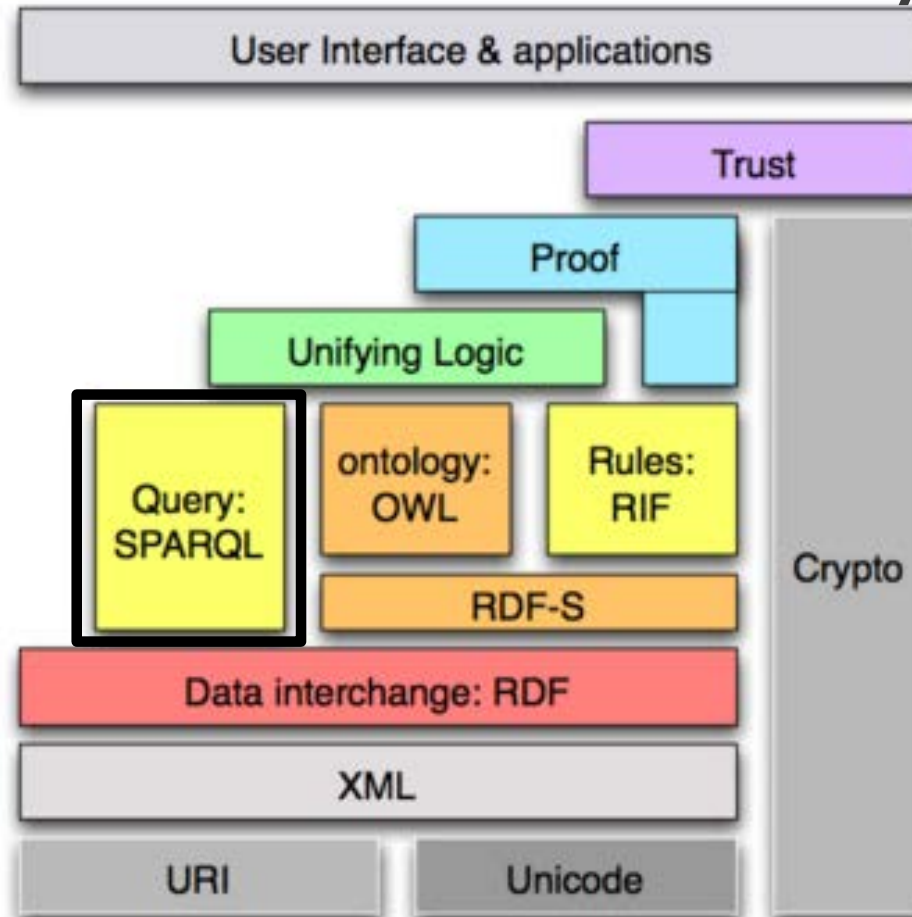
- Designed to be efficiently implementable in rule-based systems.

OWL – Web Ontology Language

OWL is made up of **terms** which provide for:

- **Class construction:** forming new classes from membership of existing ones (e.g., unionOf, intersectionOf, etc.).
- **Property construction:** distinction between OWL ObjectProperties (resources as values) and OWL DatatypeProperties (literals as values).
- **Class axioms:** sub-class, equivalence and disjointness relationships.
- **Property axioms:** sub-property relationship, equivalence and disjointness, and relationships between properties.
- **Individual axioms:** statements about individuals (sameIndividual, differentIndividuals).

SPARQL – * Protocol and RDF Query Language



Semantic Web Stack
Berners-Lee (2006)

SPARQL – * Protocol and RDF Query Language

- Query language designed to use a syntax similar to SQL for retrieving data from relational databases.
- Different query forms:
 - **SELECT** returns variables and their bindings directly.
 - **CONSTRUCT** returns a single RDF graph specified by a graph template.
 - **ASK** test whether or not a query pattern has a solution. Returns yes/no.
 - **DESCRIBE** returns a single RDF graph containing RDF data about resources.

SPARQL – * Protocol and RDF Query Language

- The syntax of a **SELECT** query is as follows:
 - **SELECT** nominates which components of the matches made against the data should be returned.
 - **FROM** (optional) indicates the sources for the data against which to find matches.
 - **WHERE** defines patterns to match against the data.
 - **ORDER BY** defines a means to order the selected matches.

SPARQL – * Protocol and RDF Query Language

Retrieve the names of the albums and tracks recorded by The Beatles.

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>
```

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
```

```
PREFIX music-ont: <http://purl.org/ontology/mo/>
```

```
SELECT ?album_name ?track_title
```

```
WHERE {
```

```
  <http://musicbrainz.org/artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d# >
```

```
    foaf:made ?album .
```

```
    ?album dc:title ?album_name ;
```

```
        music-ont:track ?track .
```

```
    ?track dc:title ?track_title . }
```


SPARQL – * Protocol and RDF Query Language

SQL

Based on relations (tables).

The relations (tables) to be matched over should be indicated.

(Retrieval) queries produce a relation from a relation.

SPARQL

Based on labelled directed graphs.

Assumes a default graph.
(The FROM clause populates this with specific identified subgraphs).

SPARQL SELECT queries produce a relation from a graph.
CONSTRUCT queries (considered later) produce a graph from a graph.

SPARQL – * Protocol and RDF Query Language

- SPARQL 1.1 provides graph update operations:
 - **INSERT DATA:** adds explicit triples, given inline.
 - **DELETE DATA:** removes explicit triples, given inline.
 - **DELETE/INSERT WHERE:** updates based on triples calculated from WHERE clause (as in SELECT and CONSTRUCT).
 - **LOAD:** reads the content of a document into a graph.
 - **COPY/MOVE/APPEND:** manipulates at named graph level.
 - **CLEAR/DROP:** removes all triples in one or more graph.

SPARQL – * Protocol and RDF Query Language

Insert the following albums recorded by The Beatles into the graph
http://myFavGroups/The_Beatles

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>
```

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
```

```
INSERT DATA { GRAPH <http://myFavGroups/The\_Beatles> {  
<http://musicbrainz.org/artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d#>  
  foaf:made <http://musicbrainz.org/release/3a685770-7326-34fc-9f18-e5f5626f3dc5#> ,  
  <http://musicbrainz.org/release/cb6f8798-d51e-4fa5-a4d1-2c0602bfe1b6#> .  
  
<http://musicbrainz.org/release/3a685770-7326-34fc-9f18-e5f5626f3dc5#>  
  dc:title "Please Please Me".  
  
<http://musicbrainz.org/release/cb6f8798-d51e-4fa5-a4d1-2c0602bfe1b6#>  
  dc:title "Something New". } }
```

SPARQL – * Protocol and RDF Query Language

Delete all the information about the album Casualties of The Beatles.

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>
```

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
```

```
DELETE { ?album ?predicate ?object . }
```

```
WHERE {
```

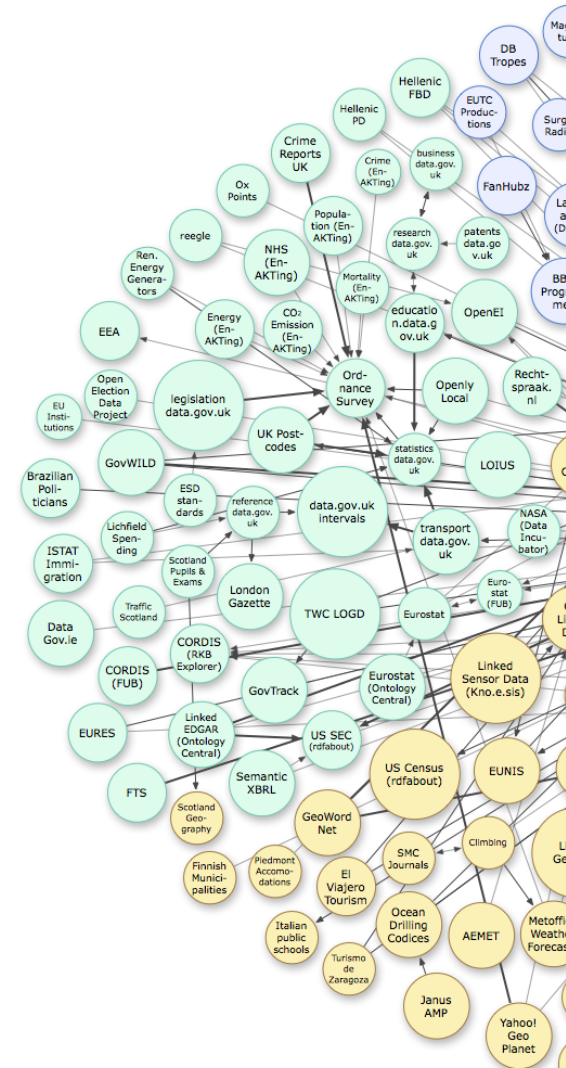
```
<http://musicbrainz.org/artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d>
```

```
    foaf:made ?album .
```

```
?album dc:title "Casualties";
```

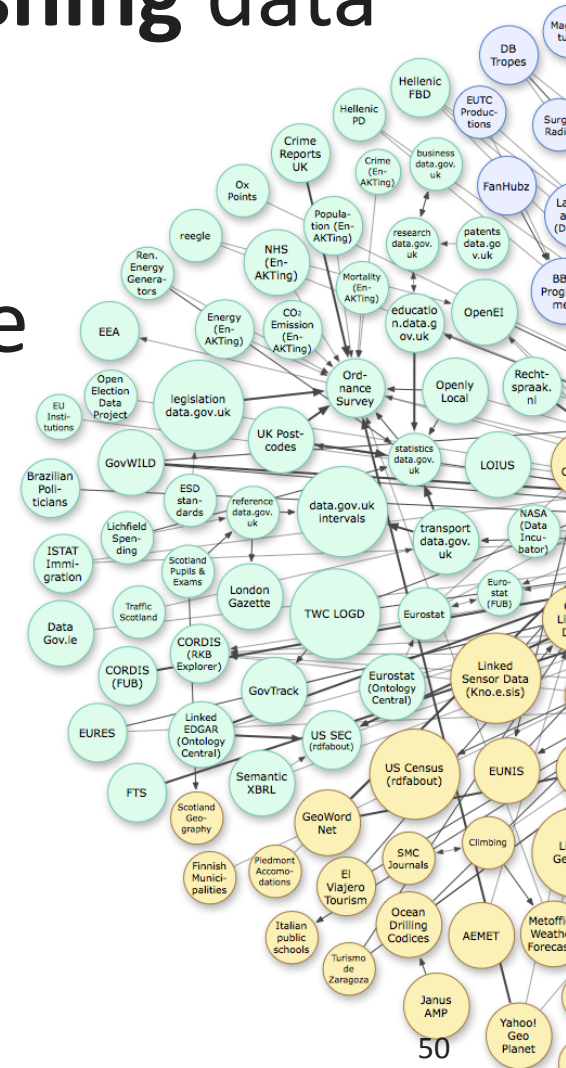
```
    ?predicate ?object .}
```

INTRODUCTION TO: LINKED DATA



Linked Data

- Set of best practices for **publishing** data on the Web.
- Data from different knowledge domains, self-described, linked and accessible.
- Follows 4 simple principles...



Linked Data Principles

1. Use URIs as **names** for things.
2. Use HTTP URIs so that users 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 users can **discover** more things.

Linked Data Principles

1. Use URIs as **names** for things.

- A foundational issue in Linked Data was the distinction of URIs for **object documents** that might describe them.

Linked Data Principles

2. Use HTTP URIs so user can **look up** those names.

- HTTP allows a second way to distinguish real-world objects from documents.
- Best practice says HTTP 303 and Location header should be used.

3. When someone looks up a URI, **provide useful information**, using the standards (RDF*, SPARQL, Turtle¹).

- While RDF/XML should be the default for look-up.
 - RDFa annotations in HTML are now also standard.
- SPARQL endpoint for queries are encouraged, or a dump of the whole dataset.

¹ To become a standard.

3. When someone looks up a URI, **provide useful information**, using the standards (RDF*, SPARQL, Turtle¹).

What to return for a URI?

- **Immediate description:** triples where the URI is the subject.
- **Backlinks:** triples where the URI is the object.
- **Related descriptions:** information of interest in typical usage scenarios.
- **Metadata:** information as author and licensing information.
- **Syntax:** RDF descriptions as RDF/XML and human-readable formats.

Source: *How to Publish Linked Data on The Web* - Chris Bizer, Richard Cyganiak, Tom Heath.

Linked Data Principles

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

There are several ways to reuse URIs:

- direct **reuse**
 - (OWL) **sameAs**
 - (RDFS) **seeAlso**
- } Instance Level
- direct **reuse** of class/property
 - (RDFS) **sub-class/-property**
 - (OWL) **equivalent** class/property
 - SKOS **broad match**
- } Schema Level

Linked Data 5 Star


- ★ Data is available on the Web.
- ★★ Data is available as machine-readable structured data.
- ★★★ Non-proprietary formats are used.
- ★★★★ Individual data identified with open standards.
- ★★★★★ Data is linked to other data provider.

Linked Data 5 Star

Example:

My Data

THE BEATLES



"John Lennon"

"Paul McCartney"

"George Harrison"

"Ringo Starr"

Please Please Me - 1963 • With The Beatles - 1963
A Hard Day's Night - 1964 • Beatles For Sale - 1964
Help! - 1965 • Rubber Soul - 1965
Revolver - 1966
Sgt. Pepper's Lonely Hearts Club Band - 1967
White Album - 1968
Abbey Road - 1969
Magical Mystery Tour - 1967
Yellow Submarine - 1969
Let It Be - 1970
Past Masters - 1988


Linked Data 5 Star



Data is available on the Web

My Data

THE BEATLES



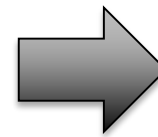
"John Lennon"

"Paul McCartney"

"George Harrison"

"Ringo Starr"

Please Please Me - 1963 • With The Beatles - 1963
A Hard Day's Night - 1964 • Beatles For Sale - 1964
Help! - 1965 • Rubber Soul - 1965
Revolver - 1966
Sgt. Pepper's Lonely Hearts Club Band - 1967
White Album - 1968
Abbey Road - 1969
Magical Mystery Tour - 1967
Yellow Submarine - 1969
Let It Be - 1970
Past Masters - 1988



It can be retrieved using HTTP.

Linked Data 5 Star



Data is available as machine-readable structured data

My Data

"The Beatles"	http://upload.wikimedia.org/wikipedia/commons/thumb/d/df/The_Fabs.JPG/600px-The_Fabs.JPG
"John Lennon"	
"Paul McCartney"	Please Please Me – 1963 A Hard Day's Night – 1964
"George Harrison"	Help! – 1965 Revolver – 1966
"Ringo Starr"	...

Machine-readable data:



Images



Scanned Information



Plain text or ...

(to continue on the next slide)

Linked Data 5 Star



Non-proprietary formats are used

My Data

```
<schema "http://www.example.com/2012/XMLMyMusic"
version= "1.0" >
<band>
  <name>The Beatles</name>
  <member>John Lennon</member>
  <member>Paul McCartney</member>
  <member>George Harrison</member>
  <member>Ringo Starr</member>
  <picture>http://upload.wikimedia.org/wikipedia/common
s/thumb/d/df/The_Fabs.JPG/600px-
The_Fabs.JPG</picture>
  <album year=1963>Please Please Me</album>
  <album year=1964>A Hard Day's Night</album>
  <album year=1965>Help!</album>
  <album year=1966>Revolver</album>
  ...
</band>
```

Linked Data 5 Star



Individual data identified with open standards

My Data

```
<schema
"http://www.example.com/2012/XMLMyMusic"
version="1.0" >
<band>
  <name>http://musicbrainz.org/artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d</name>
  <member>http://musicbrainz.org/artist/4d5447d7-c61c-4120-ba1b-d7f471d385b9</member>
  ...

  <album
year=1963>http://musicbrainz.org/release/5f3ba07b-4a24-4cd5-b8ad-95ba0fcebec1</album>
  ...
</band>
```

URI: Uniform Resource Identifier

- Data is uniquely identified

→ The Beatles

→ John Lennon

→ Revolver

- Dissambiguation

In this context, "Revolver" is an album! Not a gun.



Linked Data 5 Star



Data is linked to other data provider

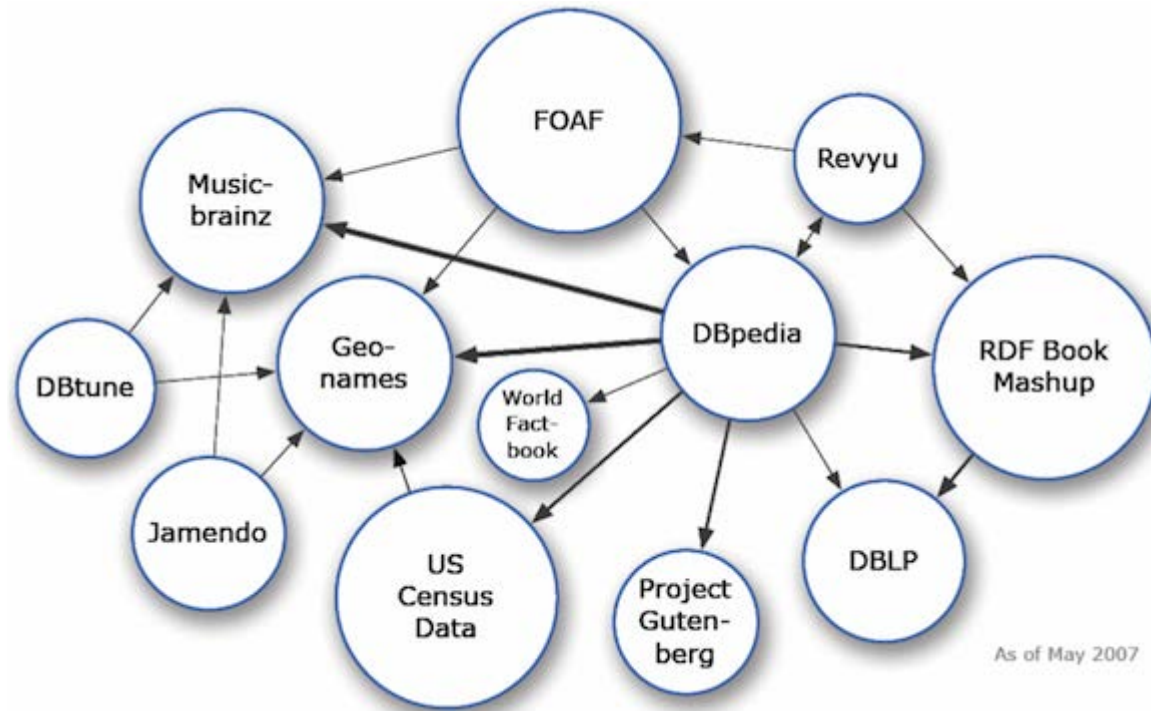
```
<schema
"http://www.example.com/2012/XMLMyMusic"
version="1.0" >
<band>
  <name>http://musicbrainz.org/artist/b10bbbfc-cf9e-42e0-be17-e2c3e1d2600d</name>
  <member>http://musicbrainz.org/artist/4d5447d7-c61c-4120-ba1b-d7f471d385b9</member>
  ...
  <album
year=1963>http://musicbrainz.org/release/5f3ba07b-4a24-4cd5-b8ad-95ba0fcebec1</album>
  ...
  <seeAlso>http://dbpedia.org/resource/The\_Beatles
  </seeAlso>
</band>
```

http://dbpedia.org/resource/The_Beatles



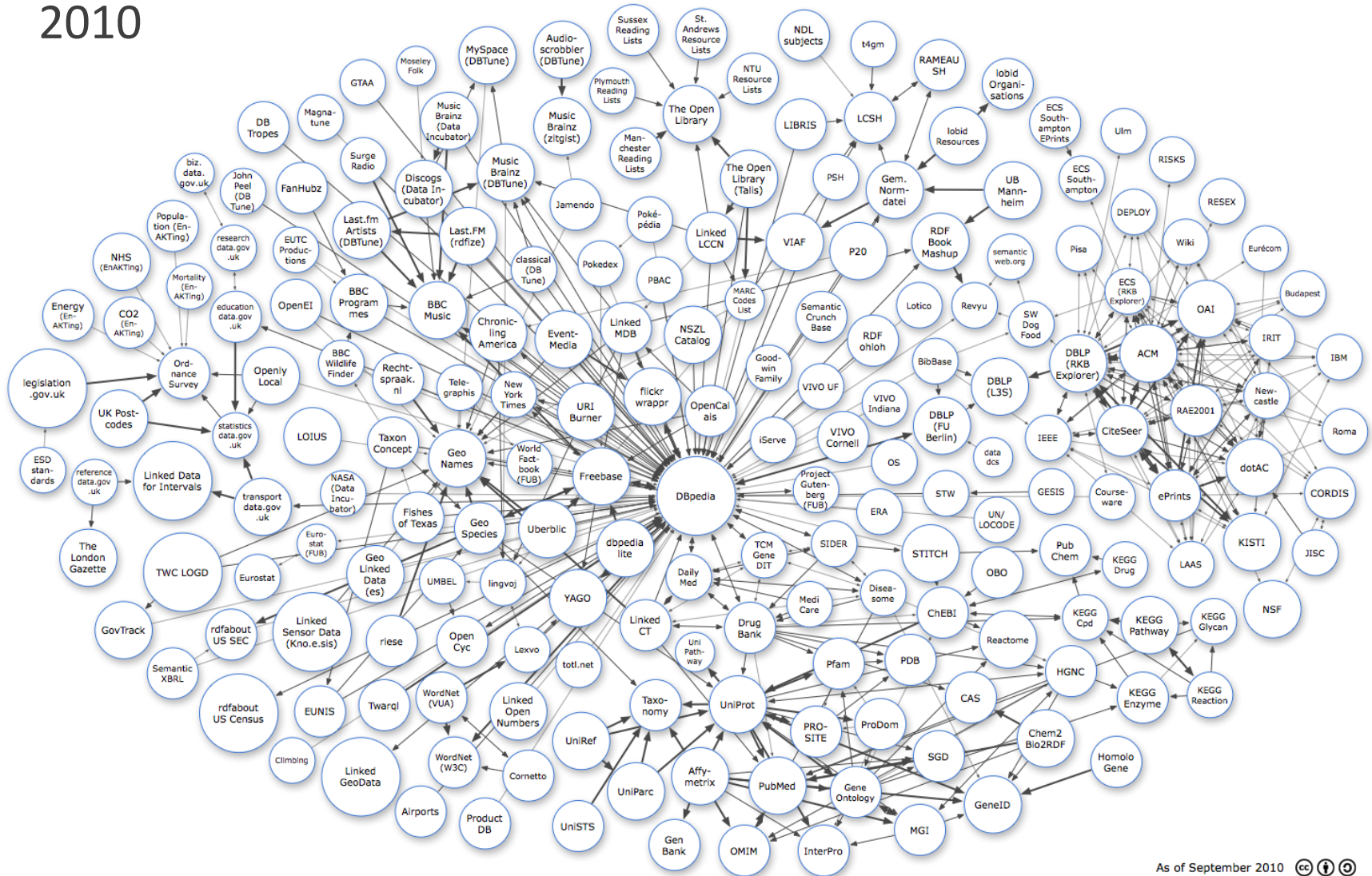
Linked Data Cloud

2007



Linked Data Cloud

2010



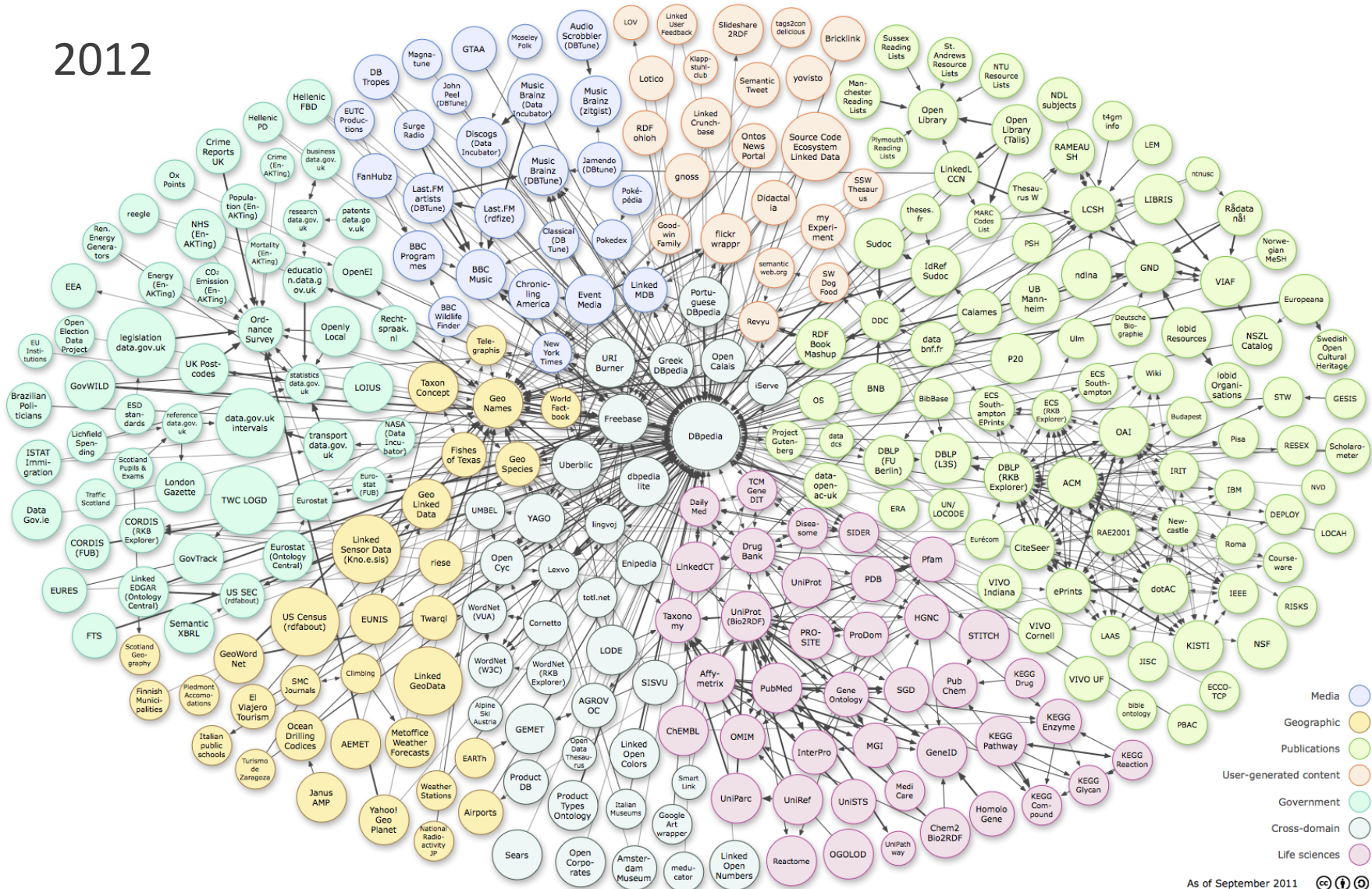
As of September 2010 © ⓘ



Linked Data Cloud



2012



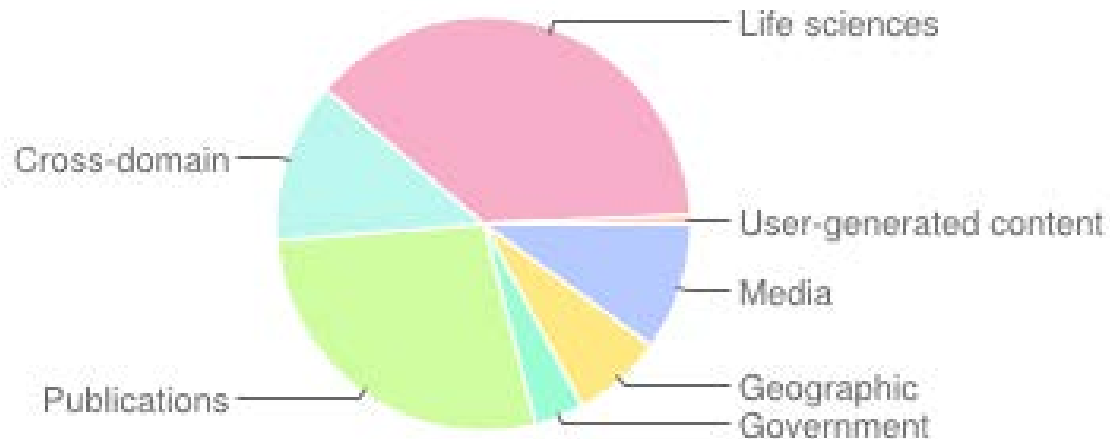
As of September 2011



State of the LOD Cloud¹

- Total Datasets:
295

- Total Triples:
31,634,213,770



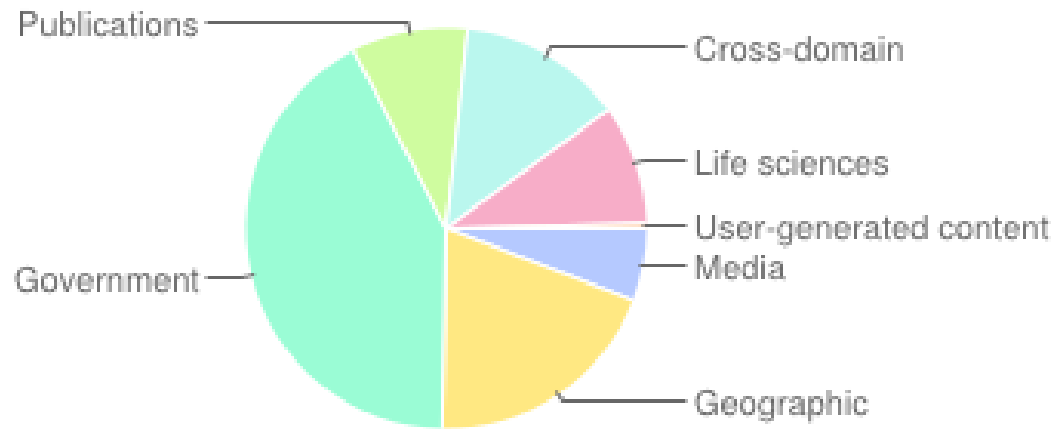
Distribution of triples by domain

¹ Version 0.3, 09/19/2011

<http://www4.wiwiss.fu-berlin.de/lodcloud/state>

State of the LOD Cloud¹

- Total (Out-)Links:
503,998,829



Distribution of links by domain

¹ Version 0.3, 09/19/2011

<http://www4.wiwiss.fu-berlin.de/lodcloud/state>

Exploring the Web of Data

- **Linked Data browsers**
- **Linked Data mashups**
- **Search engines**

Linked Data Browsers

Marbles

The screenshot shows the Marbles browser interface for the profile of Tim Berners-Lee. The browser address bar displays the URL `http://www.w3.org/People/Berners-Lee/card#`. The profile page includes a title "Tim Berners-Lee", a URL `http://www.w3.org/1999/02/22/rdf-syntax-ns#type`, and a list of related entities such as "Paris", "Tim Berners-Lee", and "Tim Berners-Lee (who at www.wissia.fr.bedsu.jp)". A central image shows Tim Berners-Lee sitting at a desk. Below the image, there are sections for "Web sites", "cats", "Open cats", and "Webb. card". At the bottom, a "Sources" section lists various URLs and their retrieval status, such as "http://www.wissia.fr.bedsu.jp/bookmarks/bookmarks/0002011887X" and "http://www.wissia.fr.bedsu.jp/bookmarks/bookmarks/0002011887X".

<http://marbles.sourceforge.net>

Linked Data Mashup

Revyu.com

ReVYU.COM
ReView ANYTHING

[Home](#) | [Browse Things](#) | [Search Things](#) | [Browse People](#)
[Login/Register](#) | [New Review](#)

Broken Flowers

Links
Homepage: <http://www.brokenflowersmovie.com/>
See Also: http://en.wikipedia.org/wiki/Broken_flowers


Tags
[bill-murray](#) [film](#) [jessica-lange](#) [jim-jarmusch](#) [julie-delpy](#) [movie](#) [sharon-stone](#)

Reviews (1)
★★★★★ [by tom on 30 Jan 2007](#)


Broken Flowers provides a fantastic vehicle for a classic deadpan Bill Murray performance. The film centers around his character Don, who one day receives a letter from an ex-girlfriend, telling him he has a teenage son. The letter is unsigned, so (with encouragement from his neighbour) he sets off round the country, visiting each the exes who could be the mother of his son. Predictably they're all different in personality and life situation, giving plenty of raw material for awkward silences and dubious encounters. This is great viewing for any Bill Murray fans, or anyone who likes their humour intelligent and a little bit quirky. The soundtrack is also excellent, and deserves a separate review.

What do you think of **Broken Flowers**? [Write Your Own Review...](#)


Broken Flowers



directed by [Jim Jarmusch](#)

[RDF Metadata About Broken Flowers](#)


[Write a Review of Broken Flowers](#)

 [Add to del.icio.us](#)

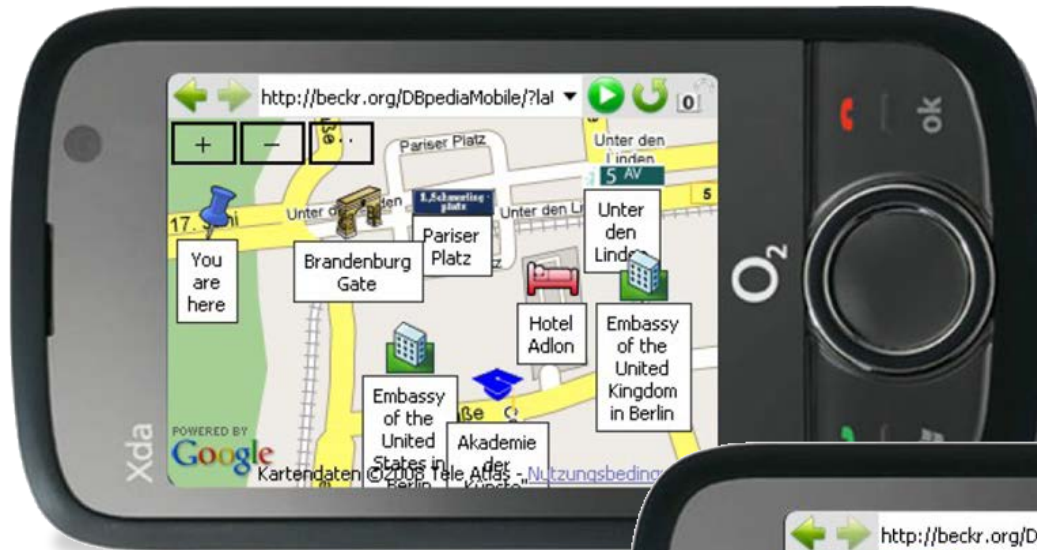
Revyu.com: [Contact](#) | [Credits](#) | [Privacy Policy](#) | [Disclaimer](#)

<http://revyu.com>



Linked Data Mashup

DBPedia Mobile



Pictures from revyu.com



<http://wiki.dbpedia.org/DBpediaMobile>

Linked Data Mashup

SIGMA

SIGMA
SEMANTIC INFORMATION MASHUP

Help About Forum

Version: 1.1.33

tim berners-lee [Add More Info](#) [Start New](#) [Order](#) [Options](#) [Use it](#)

Tim Berners-Lee

picture:  [9,11,12,14,15,17,18,19,20] [9,10,13]

given name: Tim [1,11,12,14,15,17,18,19,20]

family name: Berners-Lee [1,11,12,14,15,17,18,19,20]

comment: Sir Timothy John "Tim" Berners-Lee, OM, KBE, FRS, FEng, FRSA (born 8 June 1955, also known as "TimBL"), is a British engineer and computer scientist and MIT professor credited with inventing the World Wide Web, making the first proposal for it in March 1989. On 25 December 1990, with the help of Robert Cailliau and a young student at CERN, he implemented the first successful communication between an HTTP client and server via the Internet.

[hide value](#) [just this value](#) [which sources](#) [reject sources](#)

Sir Timothy John Berners-Lee, OM, KBE, FRS ist ein britischer Informatiker. Er ist der Erfinder der HTML (Hypertext Markup Language) und der Begründer des World Wide Web. Heute steht er dem World Wide Web Consortium (W3C) vor und ist Professor am Massachusetts Institute of Technology (MIT). [9,13,10]

蒂莫西·约翰·蒂姆·伯纳斯-李爵士，OM，KBE，FRS，FEng，FRSA（Sir Timothy John "Tim" Berners-Lee，1955年6月8日 - ），生於英國倫敦，是万维网的发明者，現任麻省理工學院正教授。1990年12月25日，在罗伯特·卡里奥与CERN的一名年轻学生的帮助下，他成功地通过Internet实现了HTTP代理与服务器的第一次通讯。他是监视万维网发展的万维网联盟（總部位於麻省理工學院）的主席。2009年4月，他在华盛顿成为美国国家科学院院士。 [9,13,10]

is creator of: [Tabulator](#) [9,10,11,12,13,14,15,17,18,19,20]

alternate: http://rdf.freebase.com/rdf/en.tim_berners-lee [6]

author name: vicente181096 [5]

author url: <http://www.slideshare.net/vicente181096> [5]

admins: 1124331582,500054654,220400,512158401,808970553,1502271052,695398126 [3]

birth year: 1955-01-01 00:00:00 [9]

Sources (20) Approved (0) Rejected (0)

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http://en.wikipedia.org/wiki/Tim_Berners-...
- 2 [Tim Berners-Lee: Biograp...](#) 9 facts | 2011-05-19
<http://www.answers.com/topic/tim-berners-...>
- 3 [Untitled document](#) 10 facts | 2011-05-24
<http://www.time.com/time/magazine/article...>
- 4 [Tim Berners-Lee](#) 2 facts | 2011-05-19
http://schools-wikipedia.org/wp/t/Tim_Ber...
- 5 [Untitled document](#) 14 facts | 2011-01-13
<http://www.slideshare.net/api/oembed/1?format=xml&su...>
- 6 [Tim Berners-Lee facts - ...](#) 4 facts | 2011-02-23
http://www.freebase.com/view/en/tim_berne...
- 7 [SIOC profile for "http://...](#) 2016 facts | 2011-02-10
<http://ws.sioc-project.org/mediawiki/mediawiki.php?...>
- 8 [Untitled document](#) 4 facts | 2011-02-03
<http://linkeddata.uribumer.com/sparql?default-grap...>
- 9 [About: Tim Berners-Lee](#) 130 facts | 2011-05-18
http://dbpedia.org/page/Tim_Berners-Lee
- 10 [Untitled document](#) 218 facts | 2011-01-10
<http://linkeddata.uribumer.com/sparql?default-grap...>
- 11 [Tim Berners-Lee](#) 130 facts | 2011-05-23
http://dbpedia.org/8890/resource/Tim_Berners-Lee
- 12 [Timothy Berners-Lee](#) 137 facts | 2011-05-18
http://dbpedia.org/resource/Tim_Berners-Lee
- 13 [About: Timothy Berners-L...](#) 224 facts | 2011-02-03
<http://linkeddata.uribumer.com/about/html/http://d...>
- 14 [Untitled document](#) 137 facts | 2011-05-18
http://dbpedia.org/data/Tim_Berners-Lee.xml
- 15 [Untitled document](#) 136 facts | 2011-05-19
http://dbpedia.org/data/Tim_Berners-Lee.n3
- 16 [Berners-Lee, Tim: bibli...](#) 42 facts | 2011-01-14

<http://sig.ma>



Linked Data Search Engines

NYTimes

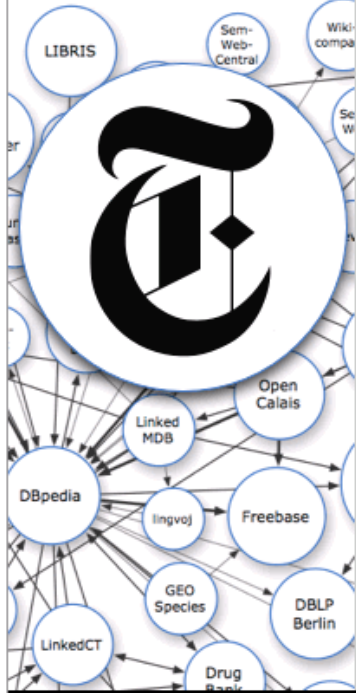

The New York Times

Linked Open Data BETA


[View Application Source](#)

Alumni In The News

Enter a school name below and see our coverage of that school's alumni.



San Francisco State University



George Miller
Attorney
Born: May 17, 1945

- [Congress Considers Concussion Protections](#) - September 24, 2010
- [EDITORIAL; Fairness for Older Workers](#) - September 14, 2010
- [EDITORIAL; Saving the Teachers](#) - May 06, 2010
- [House Bill Would Assure Workers Paid Sick Days](#) - November 04, 2009
- [EDITORIAL; Preventing Age Discrimination](#) - October 13, 2009
- [OP-ED COLUMNIST; Someday, a Bill Will Pass](#) - September 17, 2009
- [Obama Plan to End Role of Banks in Federal Student Loans Wins Support](#) - July 11, 2009
- [House Unveils Health Bill, Minus Key Details](#) - June 20, 2009
- [Democrats Nearing Consensus on Health](#) - June 10, 2009
- [U.S. Charges 7 Accused of Ties To Bonannos](#) - August 29, 2008

Please note that portions of this application rely on user generated data from external sources. It is hoped but not guaranteed that this data is accurate.

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<http://data.nytimes.com/schools/schools.html>

Some Application Scenarios

BBC

The screenshot shows the BBC Music website interface. At the top, there is a navigation bar with the BBC logo, a 'Sign in' button, and links for News, Sport, Weather, iPlayer, TV, Radio, and More... There is also a search bar and a 'London 2012' logo. Below the navigation bar, the 'MUSIC' section is highlighted. A search bar with the placeholder 'Search By Artist...' is present. The main content area features a large header for 'The Beatles' with the text 'Formed 1957. Disbanded 10 April 1970.' To the right of this header, there is a badge that says 'PLAYED MOST ON BBC RADIO 2' with a large number '2' and a graphic of leaves. Below the header is a video player showing a black and white photograph of The Beatles performing on stage. The video player has a 'BBC TWO' logo and a play button. Below the video player, there is a section titled 'Brian Epstein Finds The Beatles' with a sub-header 'ARENA | BBC TWO'. The text below reads: 'Brian Epstein, Paul McCartney and John Lennon talk about the early days of The Beatles in the Arena documentary, The Brian Epstein Story (1998)'. Below this text, there is a carousel of related content with the title 'THE BEATLES 1-4 OF 15' and 'Featured on BBC MUSIC SHOWCASE'. The carousel contains four items: 'RINGO STARR ON THE BEATLES...', 'RINGO STARR ON PLAYING WITH THE...', 'THE BEATLES AND BRIAN...', and 'BRIAN EPSTEIN FINDS THE...'. To the right of the main content area, there is a 'Share This Page' section with '15 so far' and buttons for 'Share', 'facebook', and 'twitter'. Below this is a 'BBC Music Showcase' section with a large button that says 'BBC MUSIC SHOWCASE' and the text 'Watch and listen to exclusive music clips'. At the bottom right, there is a 'Latest Tracks Played On The BBC' section with a list of tracks: 'Twist & Shout' (BBC RADIO 2 | ZOE BALL AND RICHARD BACON GO FOR GOLD 01/08/2012), 'Tomorrow Never Knows' (BBC 6 MUSIC | RADCLIFFE AND MACONIE WEDNESDAY - JOHNNY SHARP), 'She Loves You' (BBC RADIO 2 | KEN BRUCE CLAUDIA WINKLEMAN SITS IN), and 'Sgt Pepper's Lonely Hearts/With A Little Help' (BBC RADIO 2 | STEVE WRIGHT IN THE AFTERNOON PATRICK KIELTY SITS IN).

Some Application Scenarios

LinkedGeoData.org

This faceted Linked Geo Data browser is based on data obtained from the [OpenStreetMap project](#) (released under [CC-BY-SA](#)) and was developed by [AKSW research group](#).

LinkedGeoData.org

Search results Search: berlin powered by Nominatim [Link](#) [RDF-Export](#)

Your search was: 'berlin'

1. **Berlin**
2. **Berlin**
Deutschland, Europe
3. **Berlin**
Coos, New Hampshire, United States of America
4. **Berlin**
Berlin, Stadt, Mitte, Berlin, Deutschland, Europe
5. **Berlin**
Worcester County, Maryland, United States of America
6. **Berlin**
Hartford, Connecticut, United States of America
7. **Berlin**
LaMoure, North Dakota, United States of America
8. **Berlin**
Coos, New Hampshire, United States of America
9. **Berlin**
Camden, New Jersey, United States of America
10. **Berlin**

View
[node:697335603](#)
[Edit on OpenStreetMap](#)

Name	
Description	
Image	
Source_ref	
natural	stone
historic	monument

Some Application Scenarios

Linked Government Data: USA

An Official Web Site of the United States Government Tuesday, May 24, 2011 Text: A+ A- A Share

DATA.GOV
EMPOWERING PEOPLE

HOME DATA APPS COMMUNITY METRICS OPEN DATA SITES GALLERY WHAT'S NEW

Earthquake and Tsunami Datasets and Information

- Worldwide M1+ Earthquakes, Past 7 Days
- RadNet Map Interface for Near-Real-Time Radiation Monitoring Data
- Search other related datasets
- World Earthquake Interactive Map Demo

WORLDWIDE M1+ EARTHQUAKES, PAST 7 DAYS
Real-time, worldwide earthquake list for the past 7 days

SEARCH OUR CATALOGS
Search our catalogs.. SEARCH

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OPEN GOVERNMENT

Latest News: Japanese Earthquake and Radiation Data

Some Application Scenarios

Linked Government Data: UK

The screenshot shows the data.gov.uk website. At the top, there is a black navigation bar with the HM Government logo on the left and a 'Log in or sign up' link on the right. Below this is the main header area with the text 'data.gov.uk BETA' and 'Opening up government'. A search bar is present with the placeholder text 'What are you looking for?' and a green 'Search' button. A horizontal menu contains links for 'Data', 'Apps', 'Ideas', 'Forum', 'Wiki', 'Blogs', 'Linked Data', 'Resources', and 'About'. The main content area is divided into several sections. On the left, there are four vertical tiles: 'Call for dataset requests', 'Instructions for data publishers', 'Public Data Corporation', and 'Met office data'. The 'Instructions for data publishers' tile is highlighted with a green background and contains the text 'Calling all data publishers - new guide to publishing to data.gov.uk'. To the right of these tiles is a large image of a data table with a green overlay at the bottom that reads 'Instructions for data publishers'. Further right, there is a section titled 'Over 6,900 datasets to view' with a sub-section 'Inside Government Data'. This section contains a paragraph of text and three expandable links: 'Government spend over £25,000, by department', 'Who does what in Whitehall - and how much are they paid?', and 'Hospitality, gifts and expenses'. Below this is a 'Share this' section with social media icons for Twitter, Facebook, and LinkedIn. At the bottom of the page, there is a dark grey bar with the text 'Facts, figures, apps and more'. This bar contains three columns: 'Find data of interest' with a description and a green image, 'Apps' with a description and a blue image, and 'Tags' with a list of tags: 'health (2,328)', 'care (1,646)', 'transparency (1,594)', and 'communities (1,318)'.

HM Government Log in or sign up

data.gov.uk ^{BETA}
Opening up government

What are you looking for? Search

↑ Data Apps Ideas Forum Wiki Blogs Linked Data Resources About

Call for dataset requests

Instructions for data publishers

Public Data Corporation

Met office data

Instructions for data publishers
Calling all data publishers - new guide to publishing to data.gov.uk

PAUSE

Over 6,900 datasets to view

Inside Government Data

Who's who in Government and where does the money go? Follow these links to find the data that opens it all up.

- Government spend over £25,000, by department
- Who does what in Whitehall - and how much are they paid?
- Hospitality, gifts and expenses

Share this Twitter Facebook LinkedIn

Facts, figures, apps and more

Find data of interest
Looking for something specific, or just want to know more about how Government spends your money? You'll find datasets here to help you get answers.

Apps
Want your phone to wake you when you get to your train station? Discover over 100 apps harnessing public data to make your life easier.

Tags
Can't decide where to start? You can browse the data by clicking on popular topics. Try one of the tags here to find what you're most interested in.

health (2,328) care (1,646)
transparency (1,594) communities (1,318)

Summary

In this chapter we studied:

- **The Web** and its evolution.
- Web technology basics: **HTTP, HTML, URI**.
- **Vocabularies** to describe data.
- The **Semantic Web stack**: RDF, RDF-S, OWL, SPARQL.
- **Linked Data** concept and principles.
- Evolution of the **LOD cloud**.
- Browsers, mashups and search engines to **explore the Web of Data**.
- Some **application** scenarios.

For exercises, quiz and further material visit our website:



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