

# Lecture 4

## Knowledge Base Queries & Linked Open Data

COMP 474/6741, Winter 2024

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

René Witte  
Department of Computer Science  
and Software Engineering  
Concordia University

## 1 Introduction

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

## 2 SPARQL Queries

## 3 SPARQL Protocol

## 4 Linked Open Data (LOD)

## 5 Notes and Further Reading

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

## Slides Credit

- Includes slides by Ivan Herman, W3C [Her]

## 1 Introduction

Review  
OWL  
Queries

## 2 SPARQL Queries

## 3 SPARQL Protocol

## 4 Linked Open Data (LOD)

## 5 Notes and Further Reading

### Introduction

Review  
OWL  
Queries  
  
SPARQL Queries  
Introduction  
Describe  
Select  
Construct  
Ask  
Other SPARQL Features

### SPARQL Protocol

Named Graphs  
Serving Knowledge Graphs  
Inferencing

### Linked Open Data (LOD)

The LOD Initiative  
DBpedia  
The LOD Cloud  
Linked Data Design Issues  
Freebase, DBpedia & Wikidata  
Publishing Options and Workflows

### Notes and Further Reading

## Introduction

[Review](#)

[OWL](#)

[Queries](#)

## SPARQL Queries

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

## SPARQL Protocol

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

## Linked Open Data (LOD)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

## Notes and Further Reading

# Vocabularies

# Vocabularies

- ▶ Data integration needs agreements on
  - terms
    - “translator”, “author”
  - categories used
    - “Person”, “literature”
  - relationships among those
    - “an author is also a Person...”, “historical fiction is a narrower term than fiction”
    - ie, new relationships can be deduced

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Vocabularies

---

- ▶ There is a need for “languages” to define such vocabularies
  - to define those vocabularies
  - to assign clear “semantics” on how new relationships can be deduced

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Classes, resources, ...

- 
- ▶ Think of well known traditional vocabularies:
    - use the term “novel”
    - “every novel is a fiction”
    - “«The Glass Palace» is a novel”
    - etc.
  - ▶ RDFS defines resources and classes:
    - everything in RDF is a “resource”
    - “classes” are also resources, but...
    - ...they are also a collection of possible resources (i.e., “individuals”)
      - “fiction”, “novel”, ...

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Classes, resources, ... (cont.)

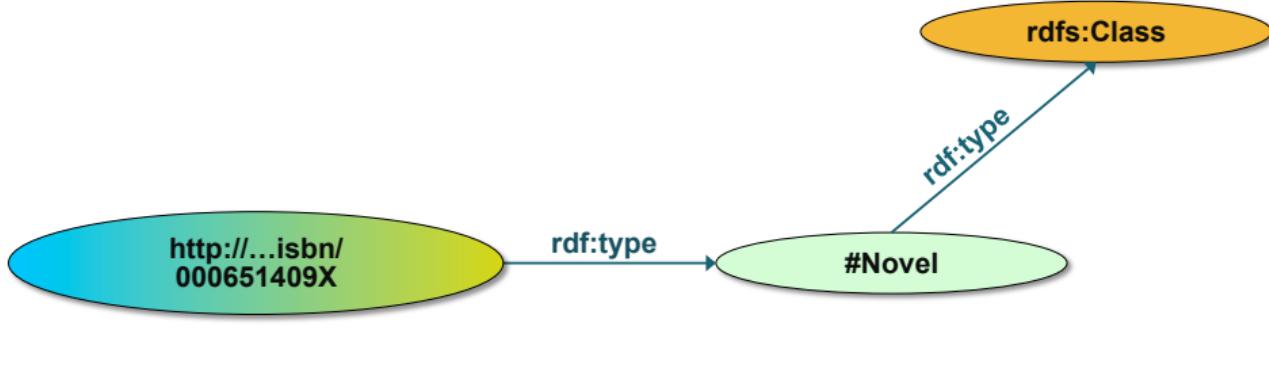
---

- ▶ Relationships are defined among resources:
  - “typing”: an individual belongs to a specific class
    - “«The Glass Palace» is a novel”
    - to be more precise: “<http://.../000651409X>” is a novel”
  - “subclassing”: all instances of one are also the instances of the other (“every novel is a fiction”)
- ▶ RDFS formalizes these notions in RDF

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Classes, resources in RDF(S)

René Witte



- ▶ RDFS defines the meaning of these terms
  - (these are all special URI-s, we just use the namespace abbreviation)

## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

# Outline

René Witte



## 1 Introduction

Review

OWL

Queries

## 2 SPARQL Queries

## 3 SPARQL Protocol

## 4 Linked Open Data (LOD)

## 5 Notes and Further Reading

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

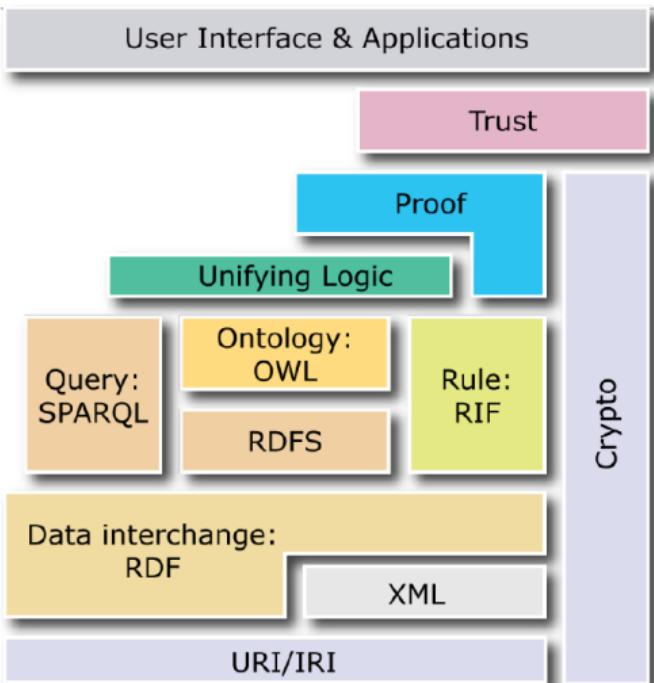
Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

## The Web Ontology Language (OWL)

- Current version OWL2 (2009)
- Different OWL2-Profiles (lite, full, etc.)
- Ontology language based on **Description Logics (DL)**
- Enables logic-based **reasoning**



<http://www.w3.org/TR/owl2-overview/>

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

# OWL Species

René Witte



[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

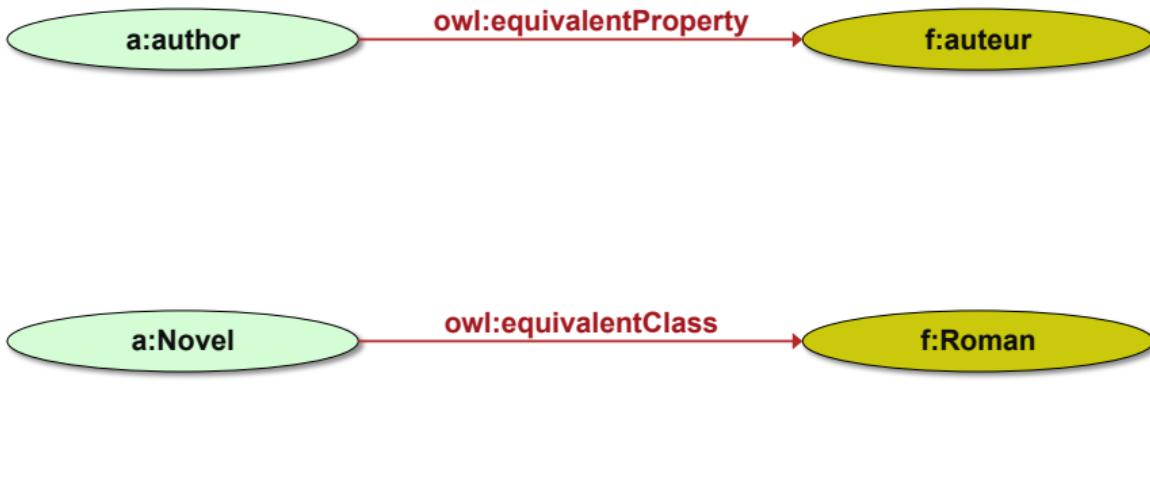
# Term equivalences

## ▶ For individuals:

- owl:sameAs: two URIs refer to the same concept (“individual”)
- owl:differentFrom: negation of owl:sameAs

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Other example: connecting to French

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Typical usage of owl:sameAs

- ▶ Linking our example of Amsterdam from one data set (DBpedia) to the other (Geonames):

```
<http://dbpedia.org/resource/Amsterdam>
owl:sameAs <http://sws.geonames.org/2759793>;
```

- ▶ This is the main mechanism of “Linking” in the Linked Open Data project

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

→ Worksheet #3: Task 1

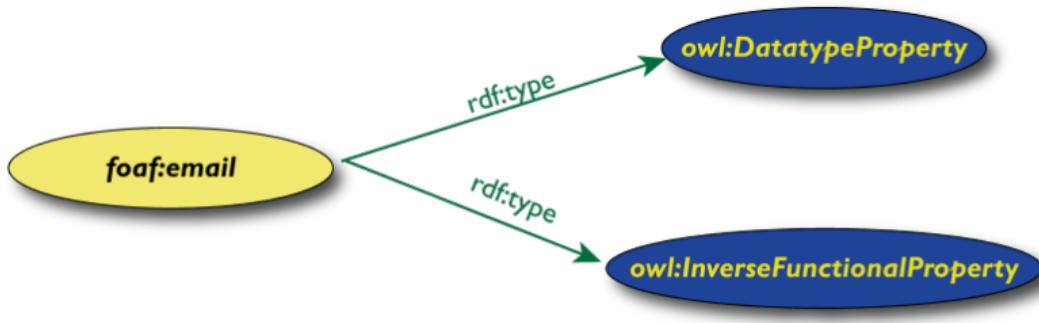
# Property characterization

- ▶ In OWL, one can characterize the behavior of properties (symmetric, transitive, functional, inverse functional, reflexive, irreflexive, ...)
- ▶ OWL also separates data and object properties
  - “datatype property” means that its range are typed literals

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Characterization example

- ▶ “foaf:email” may be defined as “inverse functional”
  - i.e., two different subjects cannot have identical objects

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# What this means is...

- ▶ If the following holds in our triples:

```
:email rdf:type owl:InverseFunctionalProperty.
```

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# What this means is...

- ▶ If the following holds in our triples:

```
:email rdf:type owl:InverseFunctionalProperty.  
<A> :email "mailto:a@b.c".  
<B> :email "mailto:a@b.c".
```

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# What this means is...

- ▶ If the following holds in our triples:

```
:email rdf:type owl:InverseFunctionalProperty.  
<A> :email "mailto:a@b.c".  
<B> :email "mailto:a@b.c".
```

then, processed through OWL, the following holds, too:

```
<A> owl:sameAs <B>.
```

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Inverse properties

- ▶ There may be an inverse relationship among properties, eg:

```
<somebook> ex:author <somebody>.  
ex:author owl:inverseOf ex:authorOf.
```

yields, in OWL:

```
<somebody> ex:authorOf <somebook>.
```

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Classes in OWL

- ▶ In RDFS, you can subclass existing classes... that's all
- ▶ In OWL, you can construct classes from existing ones:
  - enumerate its content
  - through intersection, union, complement
  - etc

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# OWL DL and Description Logic

---

René Witte



- ▶ OWL DL can be interpreted as a variant of Description Logic
  - for connoisseurs: OWL (2) DL  $\approx$  *SROIQ(D)*
- ▶ Hence the results of this particular area of logic are directly applicable

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

# Description Logic Formalism

- ▶ There is also a compact mathematical notation for axioms, assertions, etc:
  - Literature ≡ Novel ⊓ Short\_Story ⊓ Poetry
  - Listed\_Price ⊑ ∀ currency.Currencies
- ▶ You may see these in papers, books...

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Ontologies examples

---

- ▶ eClassOwl: eBusiness ontology for products and services, 75,000 classes and 5,500 properties
- ▶ National Cancer Institute's ontology: about 58,000 classes
- ▶ Open Biomedical Ontologies Foundry: a collection of ontologies, including the Gene Ontology to describe gene and gene product attributes in any organism or protein sequence and annotation terminology and data (UniProt)
- ▶ BioPAX: for biological pathway data

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Outline

René Witte



## 1 Introduction

Review

OWL

Queries

## 2 SPARQL Queries

## 3 SPARQL Protocol

## 4 Linked Open Data (LOD)

## 5 Notes and Further Reading

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

# Querying RDF graphs

- ▶ Remember the Python+RDFLib idiom:

```
for (s,p,o) in graph.triples((subject,None,None)) :  
    do_something(p,o);
```

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

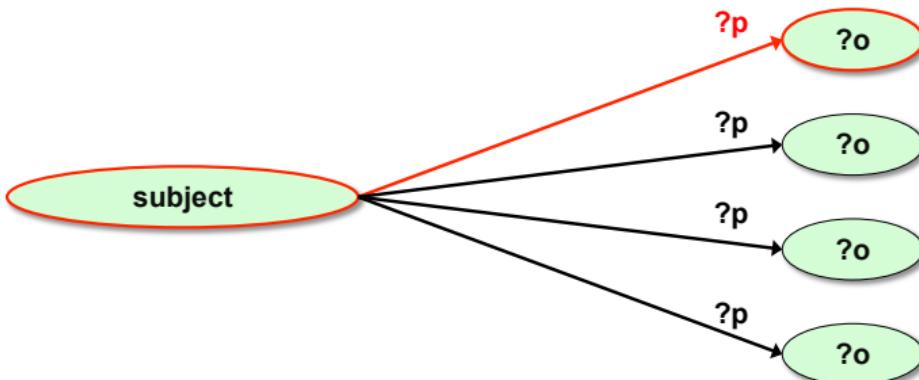
# Querying RDF graphs

- ▶ In practice, more complex queries into the RDF data are necessary
  - something like: “give me the (a,b) pair of resources, for which there is an x such that (x parent a) and (b brother x) holds” (ie, return the uncles)
    - these rules may become quite complex
- ▶ The goal of SPARQL (Query Language for RDF)

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Analyze the Python+RDFLib example

```
for (s,p,o) in graph.triples((subject,None,None)) :  
    do_something(p,o);
```



# General: graph patterns

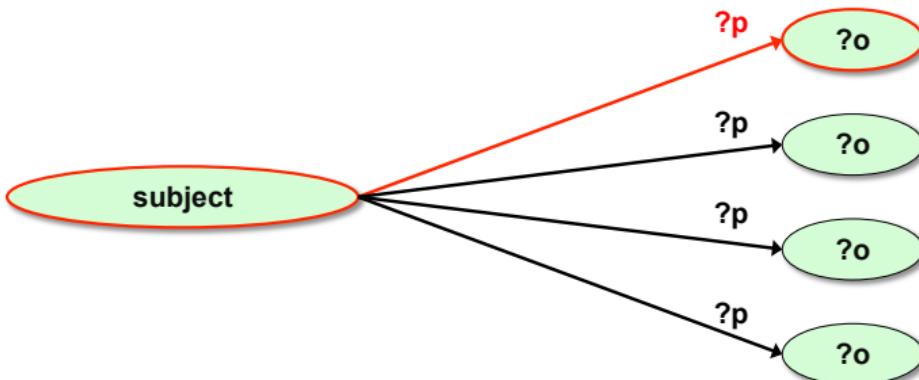
- ▶ The fundamental idea: use graph patterns
  - the pattern contains unbound symbols
  - by binding the symbols, subgraphs of the RDF graph are selected
  - if there is such a selection, the query returns the bound resources

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Our Python example in SPARQL

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

- ▶ The triples in WHERE define the graph pattern, with ?p and ?o “unbound” symbols
- ▶ The query returns all p,o pairs



## Introduction

Review  
OWL  
Queries

## SPARQL Queries

Introduction  
Describe  
Select  
Construct  
Ask  
Other SPARQL Features

## SPARQL Protocol

Named Graphs  
Serving Knowledge Graphs  
Inferencing

## Linked Open Data (LOD)

The LOD Initiative  
DBpedia  
The LOD Cloud  
Linked Data Design Issues  
Freebase, DBpedia & Wikidata  
Publishing Options and Workflows

## Notes and Further Reading

# Simple SPARQL example

René Witte



```
SELECT ?isbn ?price ?currency # note: not ?x!
WHERE {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

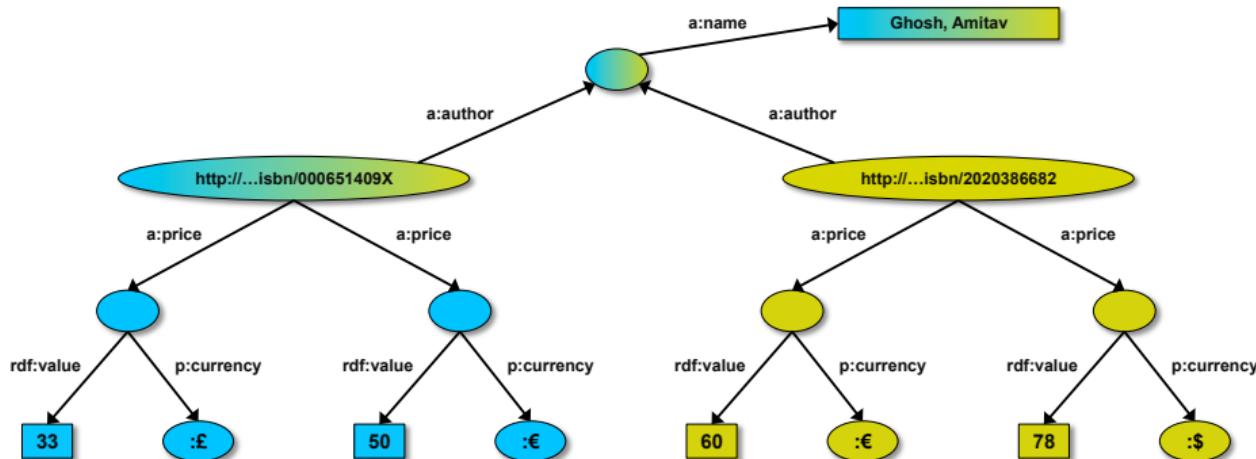
The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading



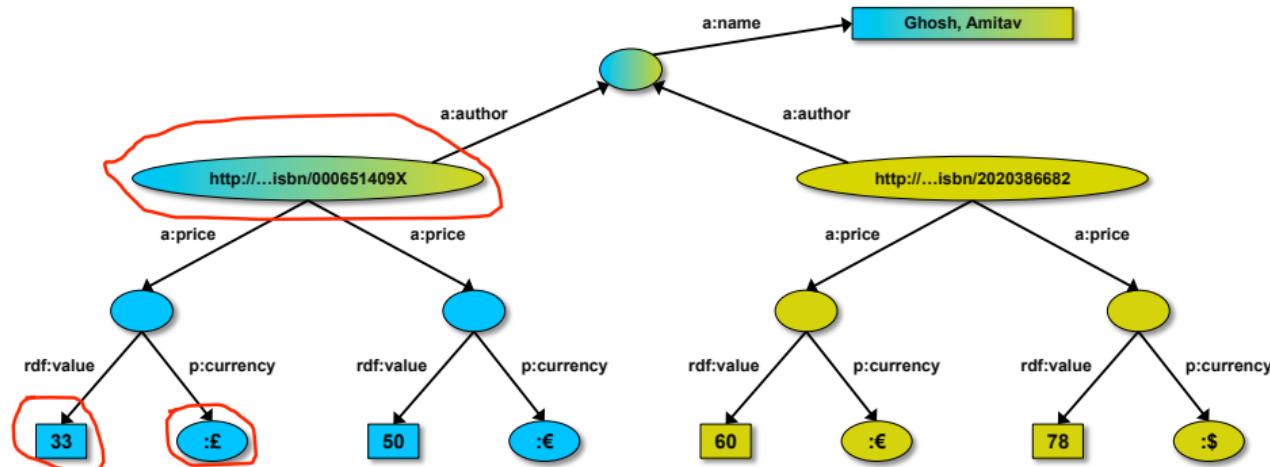
# Simple SPARQL example

René Witte



```
SELECT ?isbn ?price ?currency # note: not ?x!
WHERE {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```

Returns: [<...409X>,33,:£]



Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

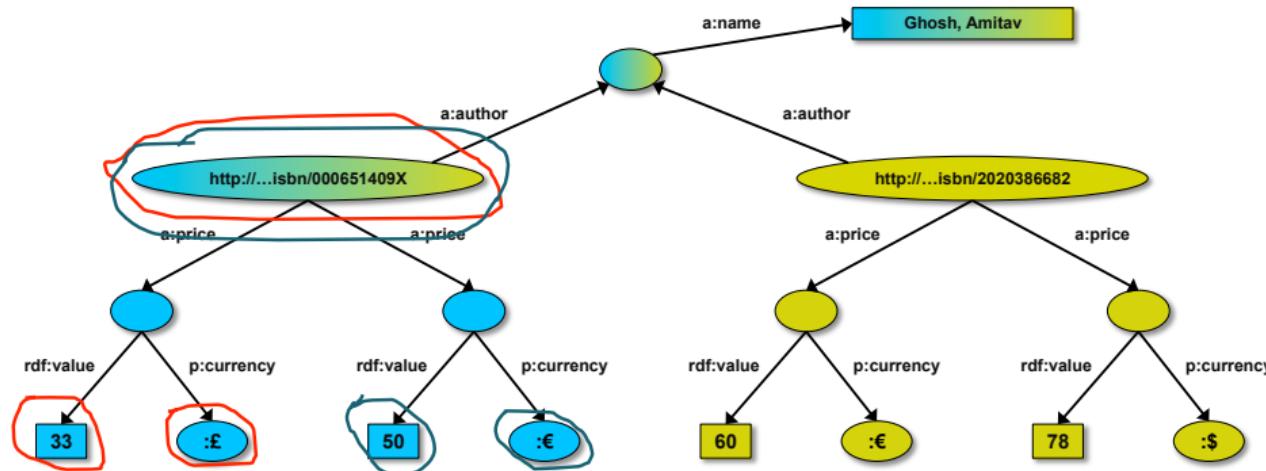
# Simple SPARQL example

René Witte



```
SELECT ?isbn ?price ?currency # note: not ?x!
WHERE {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```

Returns: [<...409X>,33,:£], [<...409X>,50,:€]



Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

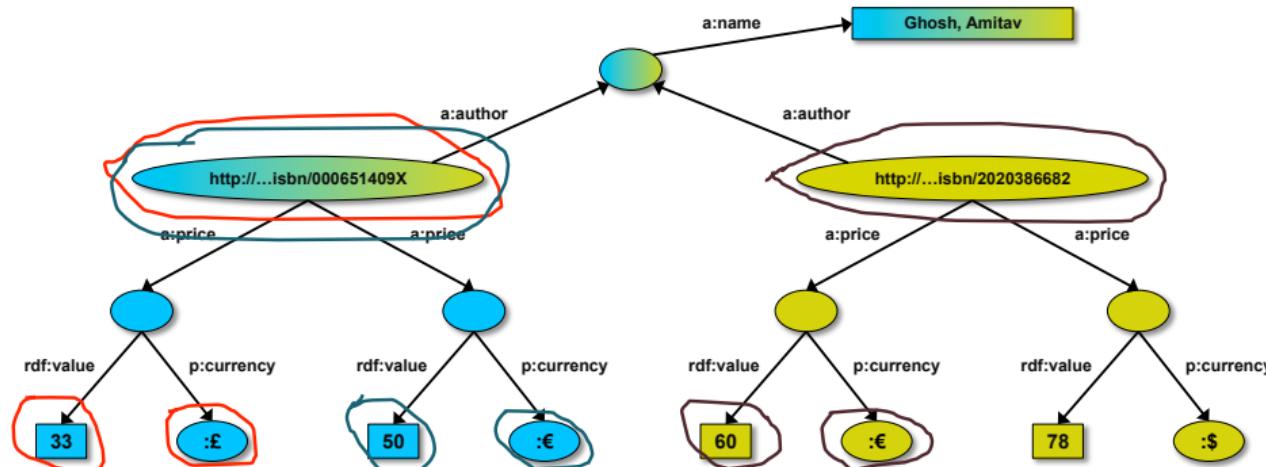
# Simple SPARQL example

René Witte



```
SELECT ?isbn ?price ?currency # note: not ?x!
WHERE {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```

Returns: [...409X,33,:£], [...409X,50,:€],  
[<...6682>,60,:€]



Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

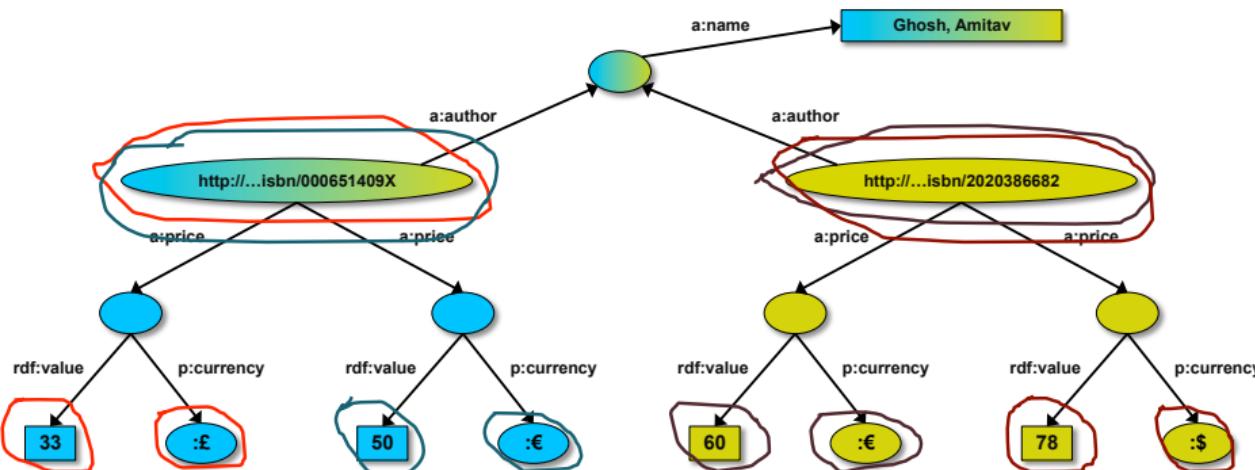
# Simple SPARQL example

René Witte



```
SELECT ?isbn ?price ?currency # note: not ?x!
WHERE {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```

Returns: [⟨...409X>,33,:£], [⟨...409X>,50,:€],  
[⟨...6682>,60,:€], [⟨...6682>,78,:\$]



→ Worksheet #3: Task 2

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

# Outline

René Witte



## 1 Introduction

Introduction

Review

OWL

Queries

## 2 SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

### SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

### SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

### Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

### Notes and Further Reading

## 3 SPARQL Protocol

## 4 Linked Open Data (LOD)

## 5 Notes and Further Reading



# Query RDF: (SPARQL)

Photo credit "reedster", Flickr

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

## SPARQL Queries

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

## SPARQL Protocol

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

## Linked Open Data (LOD)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

## Notes and Further Reading

# Introduction

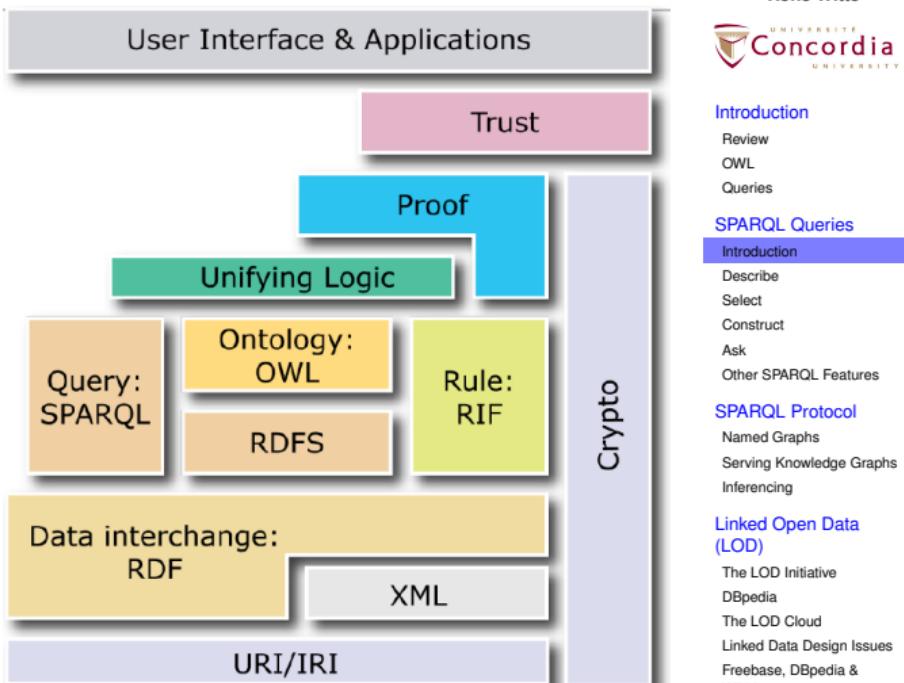
René Witte

## SPARQL W3C Standard

SPARQL stands for...

*"SPARQL Protocol And RDF Query Language"*

- Current version 1.1 (like RDF, RDFS, etc.)
- Language for querying graphs
- and a protocol for doing this over the web using a [SPARQL endpoint](#)
- Major difference between 1.0 and 1.1: modifying graphs via SPARQL (insert, delete etc.)



<https://www.w3.org/TR/sparql11-query/>

## Describing a resource

Simple query that can be used when no information about a graph's content is available.

### Example 1

```
DESCRIBE <http://dbpedia.org/resource/Concordia_University>
```

### Example 2

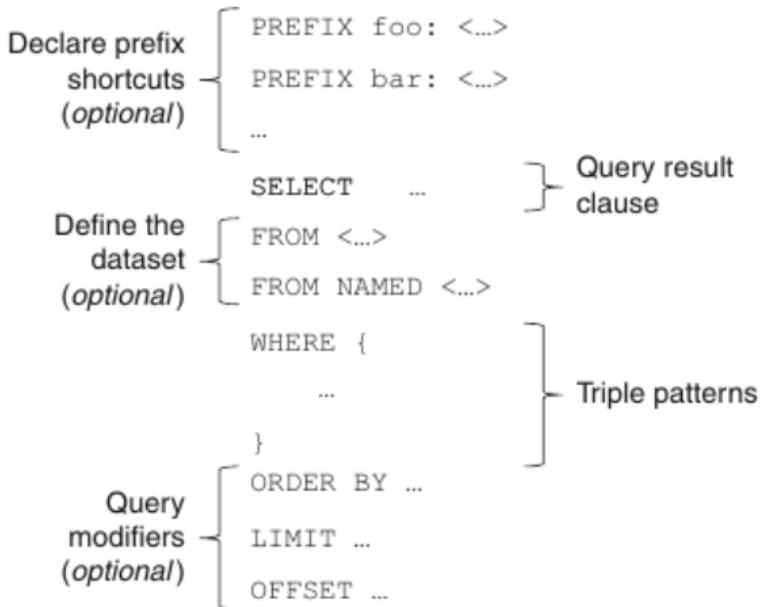
```
PREFIX geo: <http://www.w3.org/2003/01/geo/wgs84_pos#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
DESCRIBE ?s
WHERE { ?s geo:lat "45.497002"^^xsd:float .
      ?s geo:long "-73.578003"^^xsd:float . }
```

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)



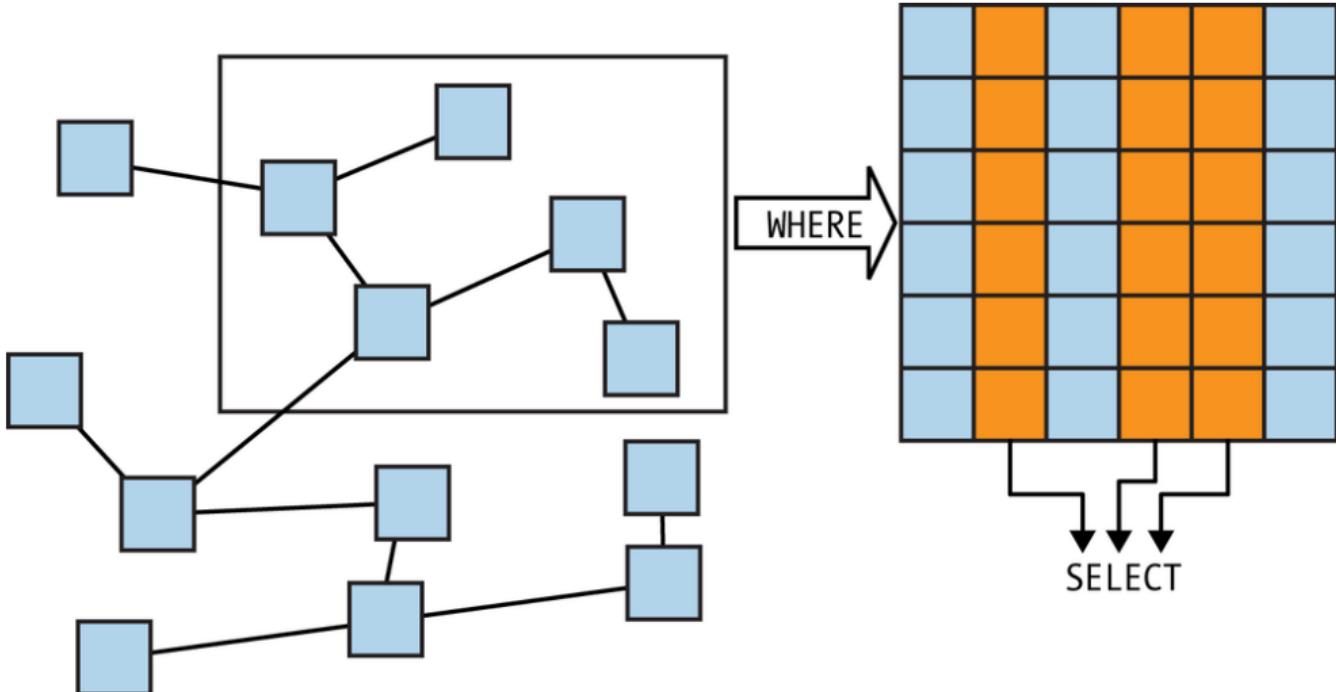
## Probably the most widely used type of SPARQL query

- Select triples from a graph that match a given triple pattern
- Like an RDF triple, except subject, predicate, and/or object may be a variable



# Select... where

René Witte



Copyright 2013 by O'Reilly Media, [DuC13]

## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

## Select: some details

René Witte



### DISTINCT

Use SELECT DISTINCT to remove redundant triples

### ORDER BY

Use ORDER BY to sort the result triples (e.g., ORDER BY ?amount)

### LIMIT

Use LIMIT to restrict the number of results (e.g., LIMIT 10)

### Functions

You can use functions like AVG(), MIN(), MAX(), COUNT(), SUM(), e.g.,

```
SELECT (MAX(?amount) as ?maxAmount)  
WHERE { ?meal e:amount ?amount . }
```

→ Worksheet #3: Task 4

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

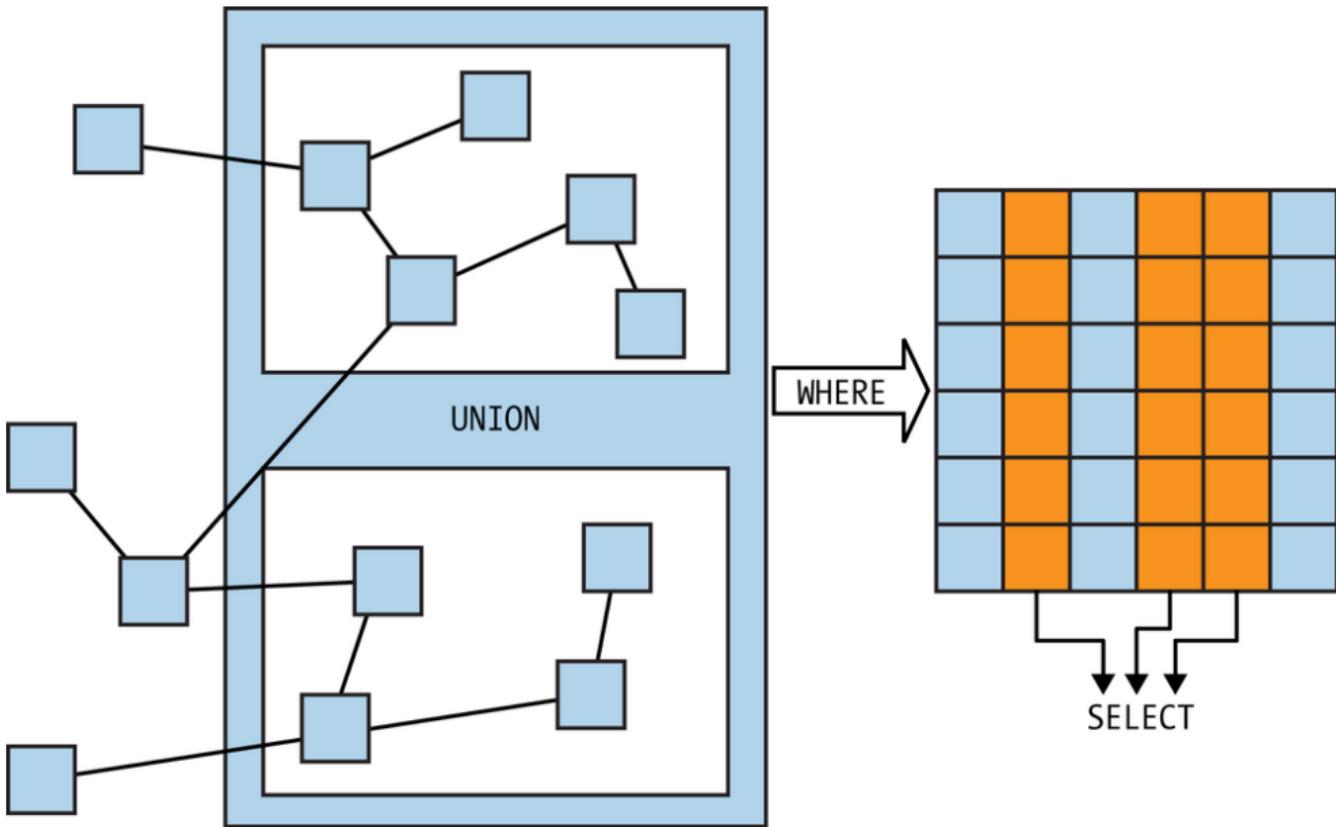
[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

# Union



Copyright 2013 by O'Reilly Media. [DuC13]

René Witte



## Introduction

Review  
OWL  
Queries

## SPARQL Queries

Introduction  
Describe  
**Select**  
Construct  
Ask  
Other SPARQL Features

## SPARQL Protocol

Named Graphs  
Serving Knowledge Graphs  
Inferencing

## Linked Open Data (LOD)

The LOD Initiative  
DBpedia  
The LOD Cloud  
Linked Data Design Issues  
Freebase, DBpedia & Wikidata  
Publishing Options and Workflows

## Notes and Further Reading

## Example (using the Gene Ontology)

*“Find me the cellular processes that are either integral to or a refinement of signal transduction.”*

```
PREFIX go: <http://purl.org/obo/owl/GO#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX obo: <http://www.obofoundry.org/ro/ro.owl#>

SELECT DISTINCT ?label ?process
WHERE {
  { ?process obo:part_of go:GO_0007165 }      # "integral to"
    UNION
  { ?process rdfs:subClassOf go:GO_0007165 } # "refinement of"
  ?process rdfs:label ?label
}
```

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia &](#)[Wikidata](#)[Publishing Options and](#)[Workflows](#)[Notes and Further Reading](#)

## Optional Information

Use the `OPTIONAL` keyword to match optional information, e.g.,

```
prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
prefix foaf: <http://xmlns.com/foaf/0.1/>
```

```
select ?name ?url
where {
    ?person foaf:name ?name .
    OPTIONAL { ?person rdfs:seeAlso ?url }
}
```

- This will return a person's URL, if there is one
- Without the `OPTIONAL`, persons without URLs would not have been matched

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

# Optional pattern

René Witte



```
SELECT ?isbn ?price ?currency ?wiki
WHERE { ?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.
        OPTIONAL ?wiki w:isbn ?isbn. }
```

## Introduction

Review  
OWL  
Queries

## SPARQL Queries

Introduction  
Describe  
**Select**  
Construct  
Ask  
Other SPARQL Features

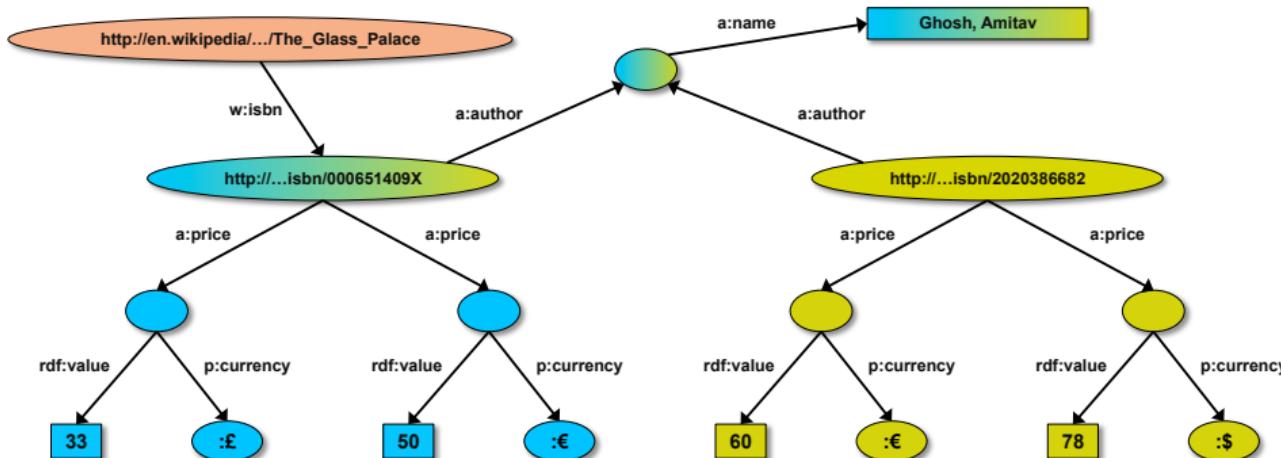
## SPARQL Protocol

Named Graphs  
Serving Knowledge Graphs  
Inferencing

## Linked Open Data (LOD)

The LOD Initiative  
DBpedia  
The LOD Cloud  
Linked Data Design Issues  
Freebase, DBpedia & Wikidata  
Publishing Options and Workflows

## Notes and Further Reading



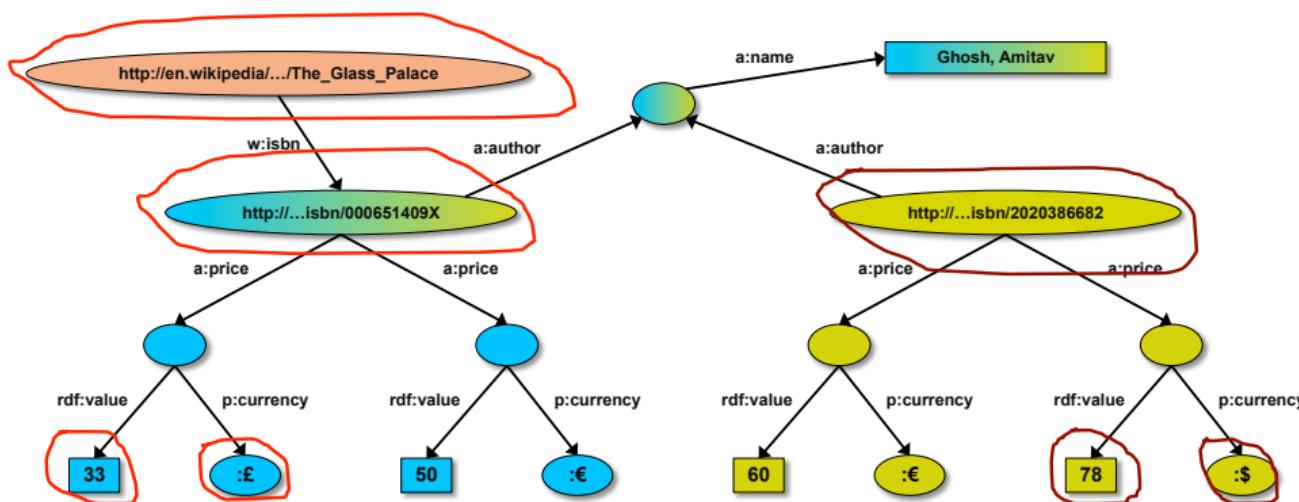
# Optional pattern

René Witte



```
SELECT ?isbn ?price ?currency ?wiki
WHERE { ?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency .
        OPTIONAL ?wiki w:isbn ?isbn. }
```

Returns: [[<..09X>,33,:£,<...Palace>], ... , [<..6682>,78,:\$, ]]



→ Worksheet #3: Task 5

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

## Filtering Information

Use a **FILTER** to remove results that were matched by WHERE, e.g.:

```
PREFIX dbr: <http://dbpedia.org/resource/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
```

```
SELECT ?comment
WHERE {
    dbr:Linked_data rdfs:comment ?comment .
    FILTER (lang(?comment) = "en")
}
```

- Here, we restrict all matched abstracts to those with an English language tag.
- **FILTERs** can operate on numbers, strings, dates, URIs, or other data types and support regular expressions.

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

**Select**

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

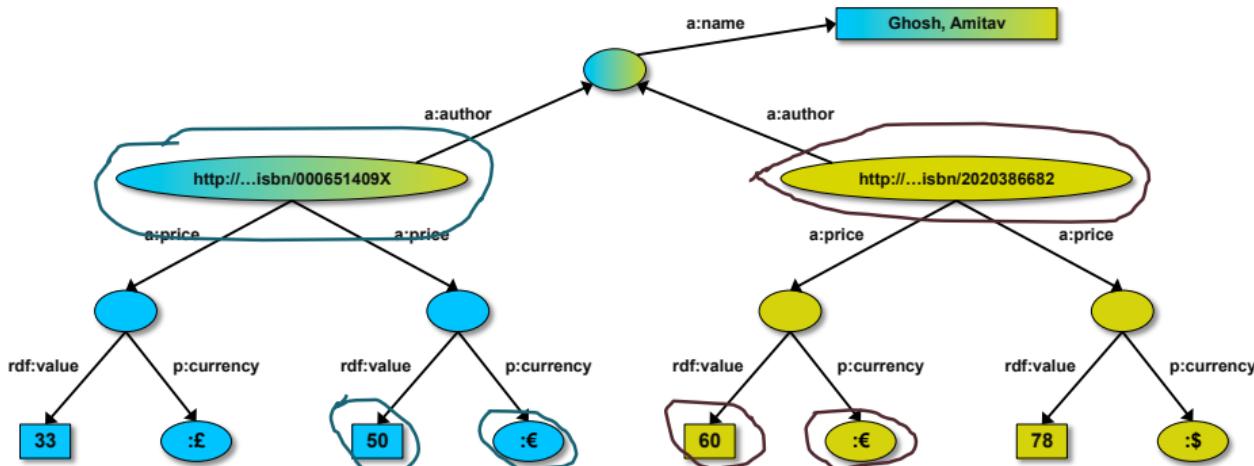
# Pattern constraints

René Witte



```
SELECT ?isbn ?price ?currency # note: not ?x!
WHERE { ?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency .
        FILTER(?currency == :€) }
```

Returns: [<...409X>,50,:€], [<...6682>,60,:€]



→ Worksheet #3: Task 6

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

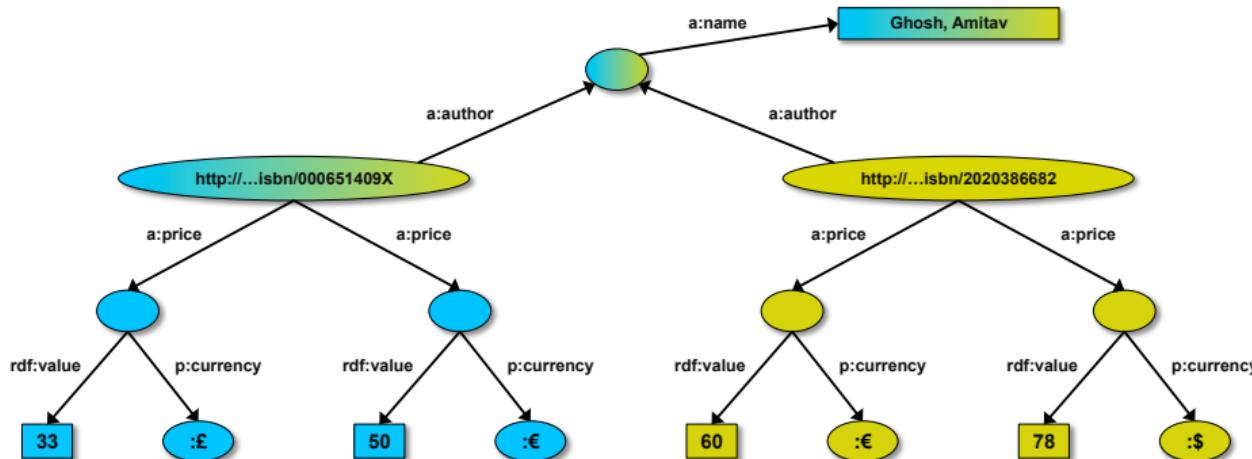
## Constructing a new graph

Can be used to re-construct a new graph from an existing one.

- For example, re-write triples from one vocabulary into another

# Construct a new graph

```
CONSTRUCT { ?isbn b:price ?price.
            ?isbn a:author ?y. ?y a:name ?name . }
WHERE { ?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency .
       ?isbn a:author ?y. ?y a:name ?name .
       FILTER(?currency == :€) }
```



## Introduction

[Review](#)
[OWL](#)
[Queries](#)

## SPARQL Queries

[Introduction](#)
[Describe](#)
[Select](#)
[Construct](#)
[Ask](#)
[Other SPARQL Features](#)

## SPARQL Protocol

[Named Graphs](#)
[Serving Knowledge Graphs](#)
[Inferencing](#)

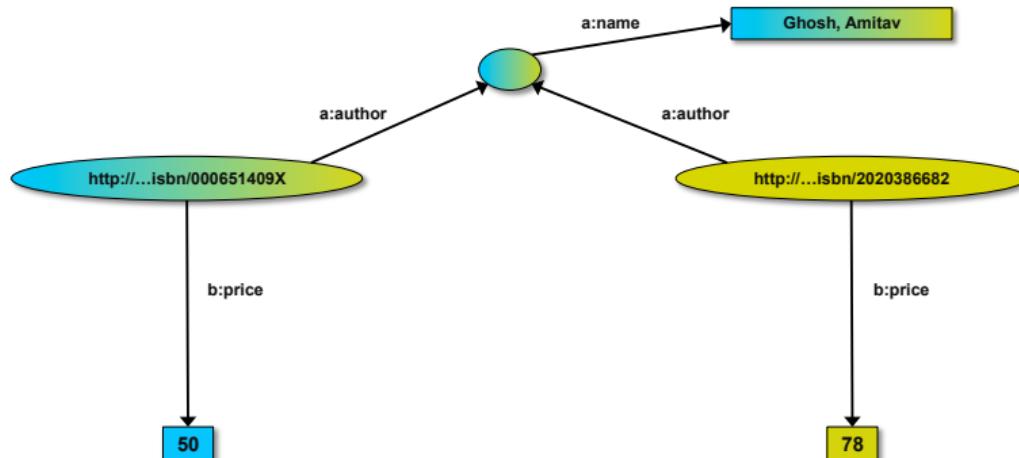
## Linked Open Data (LOD)

[The LOD Initiative](#)
[DBpedia](#)
[The LOD Cloud](#)
[Linked Data Design Issues](#)
[Freebase, DBpedia & Wikidata](#)
[Publishing Options and Workflows](#)

## Notes and Further Reading

# Construct a new graph

```
CONSTRUCT { ?isbn b:price ?price.
            ?isbn a:author ?y. ?y a:name ?name . }
WHERE { ?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency .
       ?isbn a:author ?y. ?y a:name ?name .
       FILTER(?currency == :€) }
```



## Introduction

- Review

- OWL

- Queries

## SPARQL Queries

- Introduction

- Describe

- Select

- Construct**

- Ask

- Other SPARQL Features

## SPARQL Protocol

- Named Graphs

- Serving Knowledge Graphs

- Inferencing

## Linked Open Data (LOD)

- The LOD Initiative

- DBpedia

- The LOD Cloud

- Linked Data Design Issues

- Freebase, DBpedia & Wikidata

- Publishing Options and Workflows

## Notes and Further Reading

## Asking a true/false question

```
ASK <graph pattern>
```

Returns `true` if the pattern can be matched in the graph, otherwise `false`

### Example

*Is Concordia University located in Mexico?*

```
ASK {  
    wd:Q326342 wdt:P17 wd:Q96  
}
```

→ Worksheet #3: Task 7

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Other SPARQL features

---

- ▶ Limit the number of returned results; remove duplicates, sort them, ...
- ▶ Specify several data sources (via URI-s) within the query
- ▶ Construct a graph combining a separate pattern and the query results
- ▶ Use datatypes and/or language tags when matching a pattern
- ▶ Aggregation of the results (min, max, average, etc.)
- ▶ Path expressions (a bit like regular expressions)

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# SPARQL usage in practice

---

René Witte



- ▶ SPARQL is usually used over the network
  - http request is sent to a SPARQL endpoint
  - result is the result of the SELECT, the CONSTRUCT,...
- ▶ Separate documents define the protocol and the result format
  - SPARQL Protocol for RDF with HTTP and SOAP bindings
  - SPARQL results in XML or JSON formats
- ▶ Big datasets usually offer “SPARQL endpoints” using this protocol

## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

## Other SPARQL Features

### SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

### Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

# Remote query/reply example

René Witte



```
GET /qps?&query=SELECT+...+WHERE+... HTTP/1.1
User-Agent: my-sparql-client/0.0
Host: my.example

HTTP/1.1 200 OK
Server: my-sparql-server/0.0
Content-Type: application/sparql-results+xml

<?xml version="1.0" encoding="UTF-8"?>
<sparql xmlns="http://www.w3.org/2005/sparql-results#>
  <head>
    <variable name="a"/>
    ...
  </head>
  <results>
    <result ordered="false" distinct="false">
      <binding name="a"><uri>http:...</uri></binding>
      ...
    </result>
    <result> ... </result>
  </results>
</sparql>
```

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

# SPARQL 1.1 Update

- 
- ▶ SPARQL CONSTRUCT returns a new, modified graph
    - the original data remains unchanged!
  - ▶ SPARQL 1.1 Update *modifies the original dataset!*

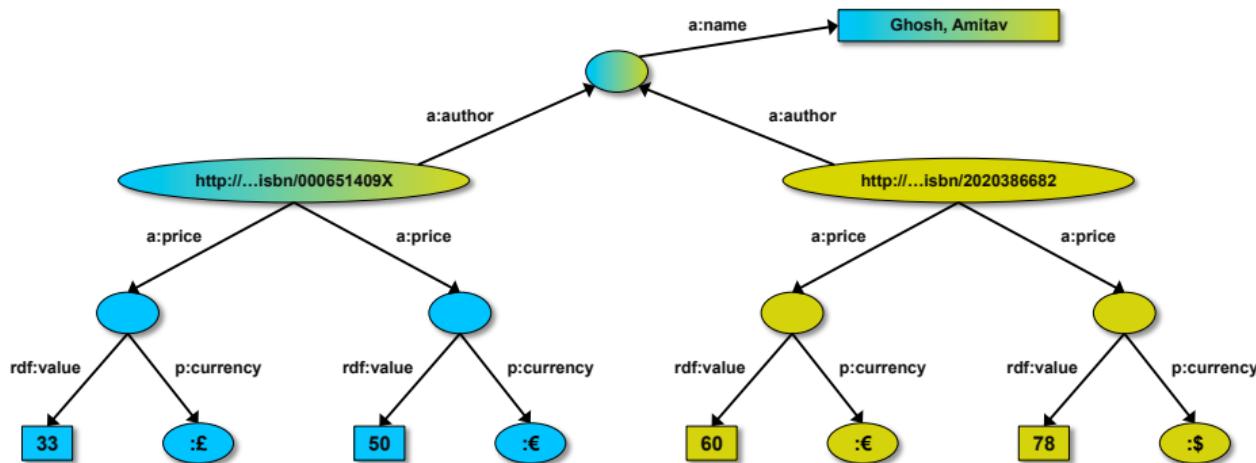
[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Update: insert

René Witte



```
INSERT {?isbn rdf:type frbr:Work}
WHERE  {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```



## Introduction

Review  
OWL  
Queries

## SPARQL Queries

Introduction  
Describe  
Select  
Construct  
Ask

## Other SPARQL Features

## SPARQL Protocol

Named Graphs  
Serving Knowledge Graphs  
Inferencing

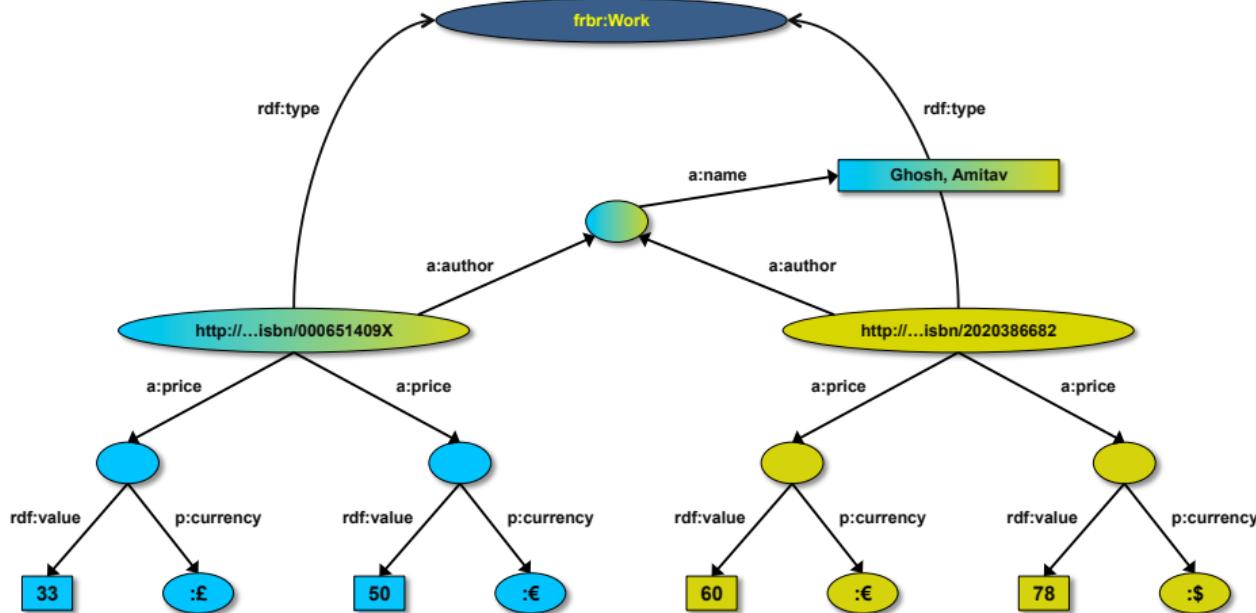
## Linked Open Data (LOD)

The LOD Initiative  
DBpedia  
The LOD Cloud  
Linked Data Design Issues  
Freebase, DBpedia & Wikidata  
Publishing Options and Workflows

## Notes and Further Reading

# Update: insert

```
INSERT {?isbn rdf:type frbr:Work}
WHERE  {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```



## Introduction

- Review
- OWL
- Queries

## SPARQL Queries

- Introduction
- Describe
- Select
- Construct
- Ask

## Other SPARQL Features

### SPARQL Protocol

- Named Graphs
- Serving Knowledge Graphs
- Inferencing

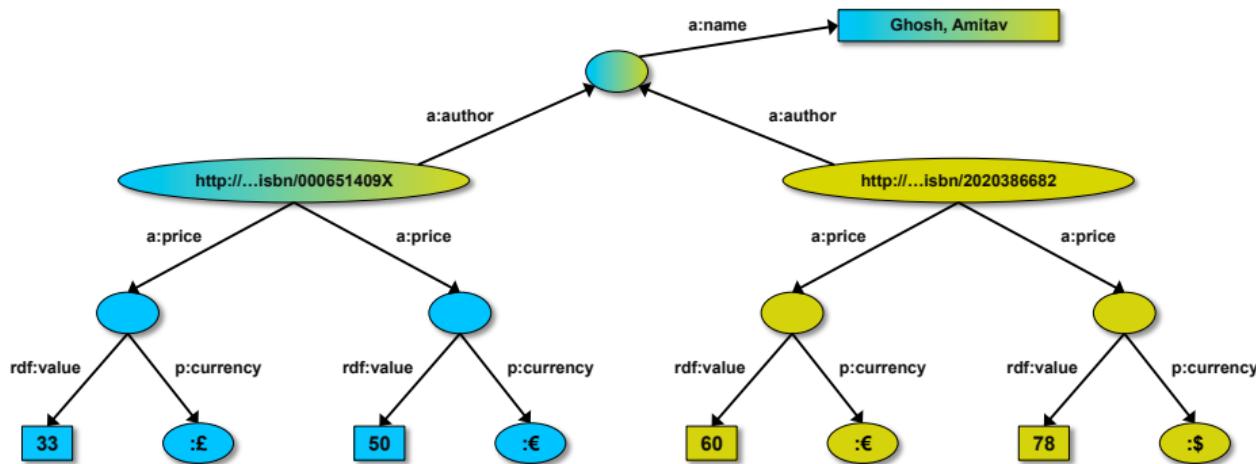
## Linked Open Data (LOD)

- The LOD Initiative
- DBpedia
- The LOD Cloud
- Linked Data Design Issues
- Freebase, DBpedia & Wikidata
- Publishing Options and Workflows

## Notes and Further Reading

# Update: delete

```
DELETE {?x p:currency ?currency}
WHERE  {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```



## Introduction

Review  
OWL  
Queries

## SPARQL Queries

Introduction  
Describe  
Select  
Construct  
Ask

## Other SPARQL Features

### SPARQL Protocol

Named Graphs  
Serving Knowledge Graphs  
Inferencing

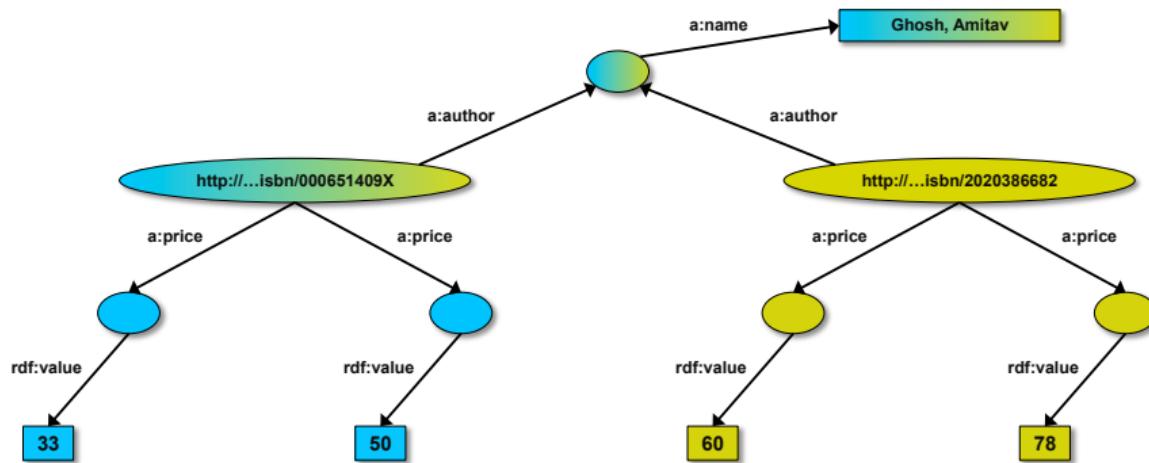
### Linked Open Data (LOD)

The LOD Initiative  
DBpedia  
The LOD Cloud  
Linked Data Design Issues  
Freebase, DBpedia & Wikidata  
Publishing Options and Workflows

### Notes and Further Reading

# Update: delete

```
DELETE {?x p:currency ?currency}
WHERE  {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```



## Introduction

Review  
OWL  
Queries

## SPARQL Queries

Introduction  
Describe  
Select  
Construct  
Ask

## Other SPARQL Features

## SPARQL Protocol

Named Graphs  
Serving Knowledge Graphs  
Inferencing

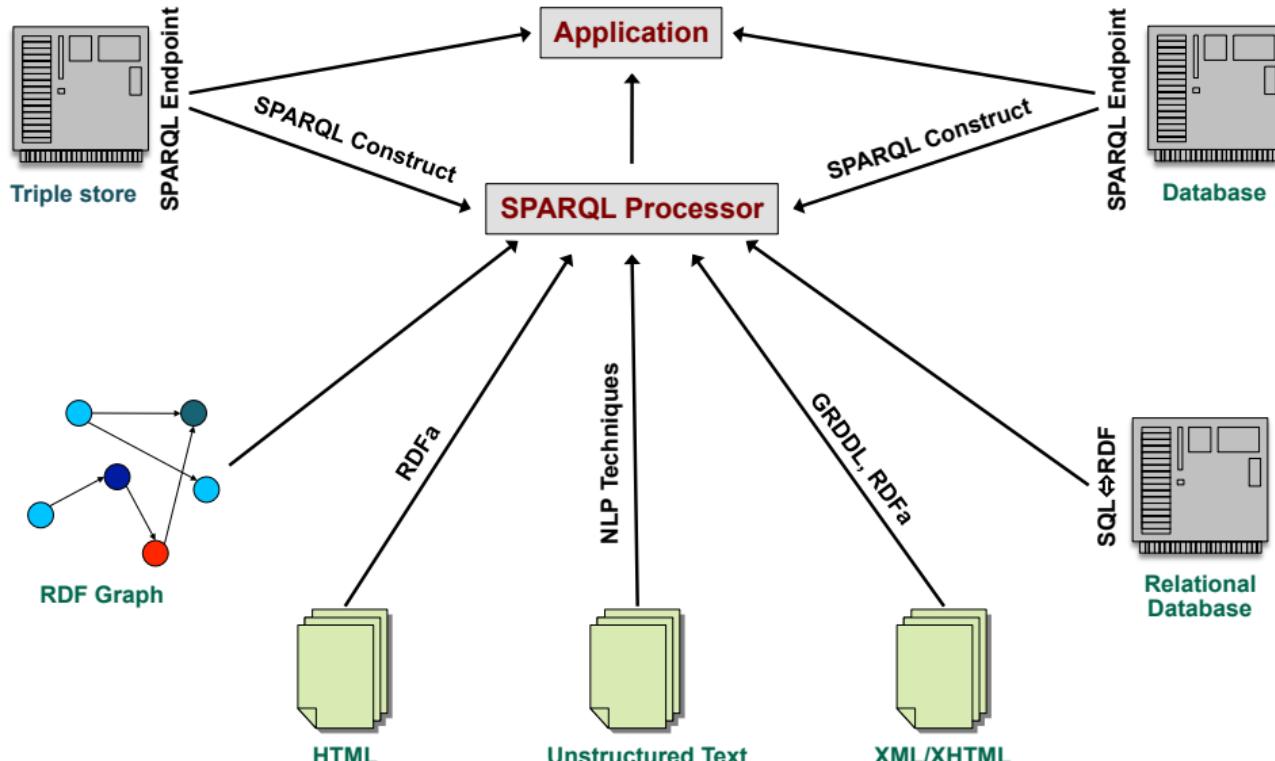
## Linked Open Data (LOD)

The LOD Initiative  
DBpedia  
The LOD Cloud  
Linked Data Design Issues  
Freebase, DBpedia & Wikidata  
Publishing Options and Workflows

## Notes and Further Reading

# SPARQL as a unifying point

René Witte



## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

## Other SPARQL Features

### SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

### Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

### Notes and Further Reading

# Outline

René Witte



## 1 Introduction

Introduction

Review

OWL

Queries

## 2 SPARQL Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## 3 SPARQL Protocol

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Named Graphs

Serving Knowledge Graphs

Inferencing

## 4 Linked Open Data (LOD)

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## 5 Notes and Further Reading

Notes and Further Reading

## RDF Dataset

An RDF dataset may have multiple [named graphs](#) and at most one unnamed ("default") graph.

## Serialization

TriG: Extension of [Turtle](#) for named graphs  
See <https://www.w3.org/TR/trig/>

N-Quads: Extension of [N-Triples](#) for named graphs  
See <https://www.w3.org/TR/n-quads/>

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# TriG Example

René Witte



```
BASE    <http://example.org/>
PREFIX ...  
  
GRAPH <http://example.org/bob>
{
    <bob#me>
        a foaf:Person ;
        foaf:knows <alice#me> ;
        schema:birthDate "1990-07-04"^^xsd:date ;
        foaf:topic_interest wd:Q12418 .
}  
  
GRAPH <https://www.wikidata.org/wiki/Special:EntityData/Q12418>
{
    wd:Q12418
        dcterms:title "Mona Lisa" ;
        dcterms:creator <http://dbpedia.org/resource/Leonardo_da_Vinci> .
        <http://data.europeana.eu/item/04802/243FA8618938F4117025F17A8B813C5F9AA4D619>
            dcterms:subject wd:Q12418 .
}  
  
<http://example.org/bob>
    dcterms:publisher <http://example.org> ;
    dcterms:rights <http://creativecommons.org/licenses/by/3.0/> .
```

See <https://www.w3.org/TR/rdf11-primer/>

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

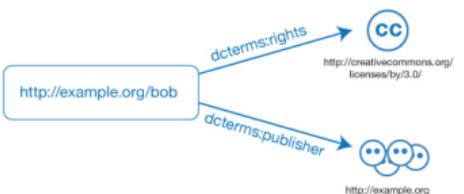
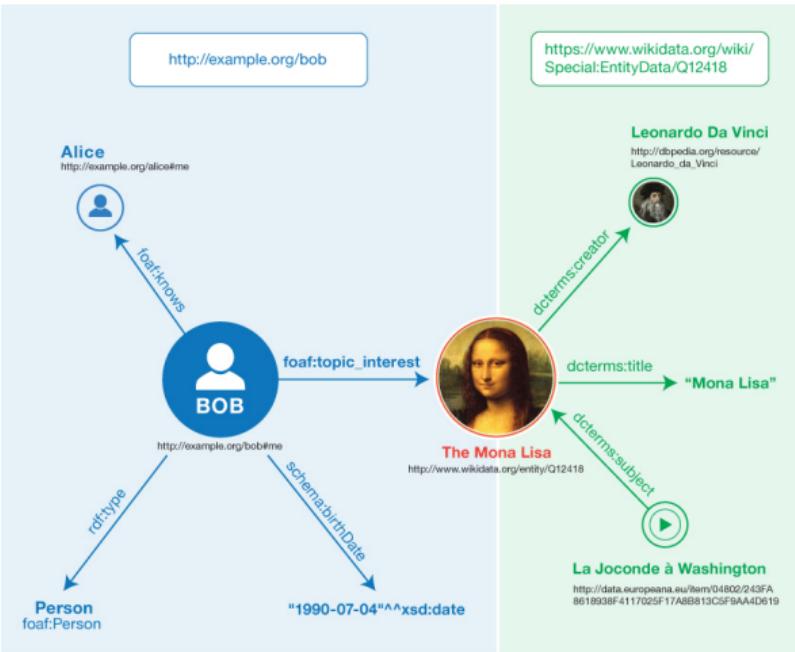
[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

# Named Graphs Example

René Witte



## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

### Named Graphs

Serving Knowledge Graphs  
Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

## N-Quads

N-Quads add a [fourth element](#) to a line, capturing the [graph IRI](#) of the triple described on that line

## Example

```
<http://example.org/bob#me> ←  
  <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> ←  
    <http://xmlns.com/foaf/0.1/Person> <http://example.org/bob> .  
...  
<http://www.wikidata.org/entity/Q12418> <http://purl.org/dc/terms/title> ←  
  "Mona Lisa" <https://www.wikidata.org/wiki/Special:EntityData/Q12418> .  
...  
<http://example.org/bob> <http://purl.org/dc/terms/rights> ←  
  <http://creativecommons.org/licenses/by/3.0/> .
```

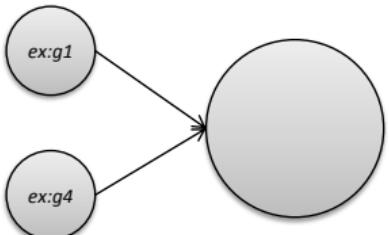
[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

A SPARQL queries a *default graph* (normally) and zero or more *named graphs* (when inside a **GRAPH** clause).

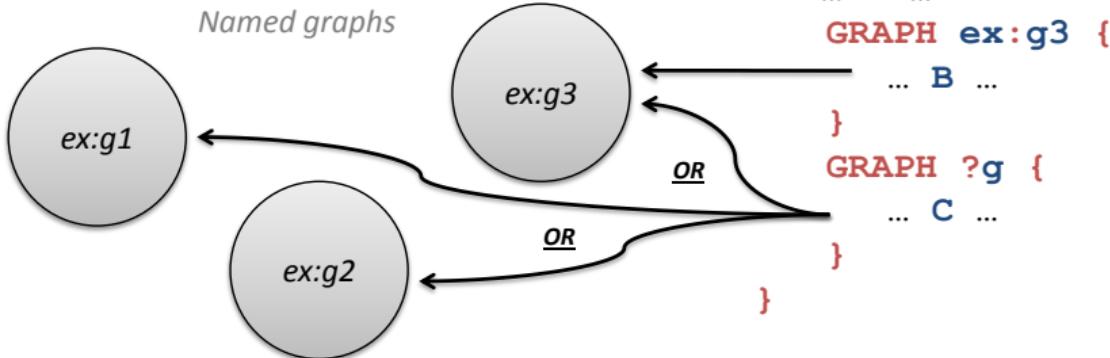
René Witte



Default graph  
(the merge of zero or more graphs)



```
PREFIX ex: <...>  
SELECT ...  
FROM ex:g1  
FROM ex:g4  
FROM NAMED ex:g1  
FROM NAMED ex:g2  
FROM NAMED ex:g3  
WHERE {
```



Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs  
Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

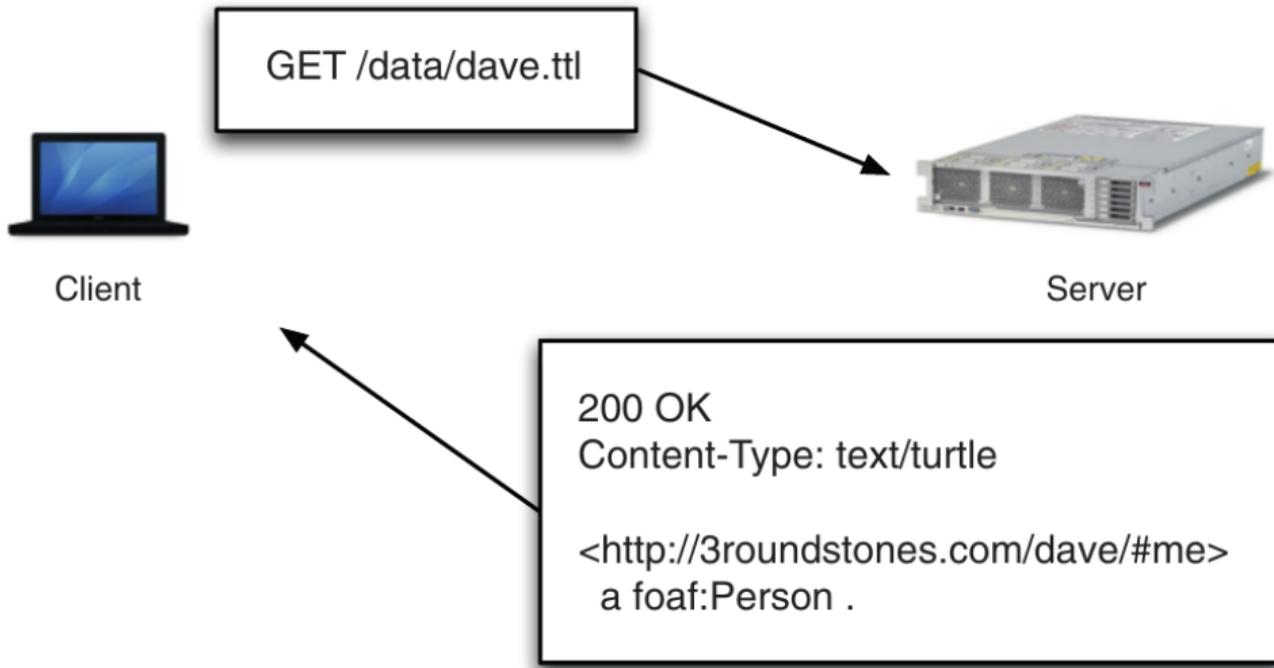
Linked Data Design Issues  
Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

# Simple HTTP Request

René Witte



## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

## Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Firebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

# SPARQL Over HTTP (the SPARQL Protocol)

René Witte



`http://host.domain.com/sparql/endpoint?<parameters>`

where `<parameters>` can include:

`query=<encoded query string>`

e.g. `SELECT+*%0DWHERE+{ ... }`

`default-graph-uri=<encoded graph URI>`

e.g. `http%3A%2F%2Fexmaple.com%2Ffoo...`

n.b. zero or more occurrences of `default-graph-uri`

`named-graph-uri=<encoded graph URI>`

e.g. `http%3A%2F%2Fexmaple.com%2Fbar...`

n.b. zero or more occurrences of `named-graph-uri`

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

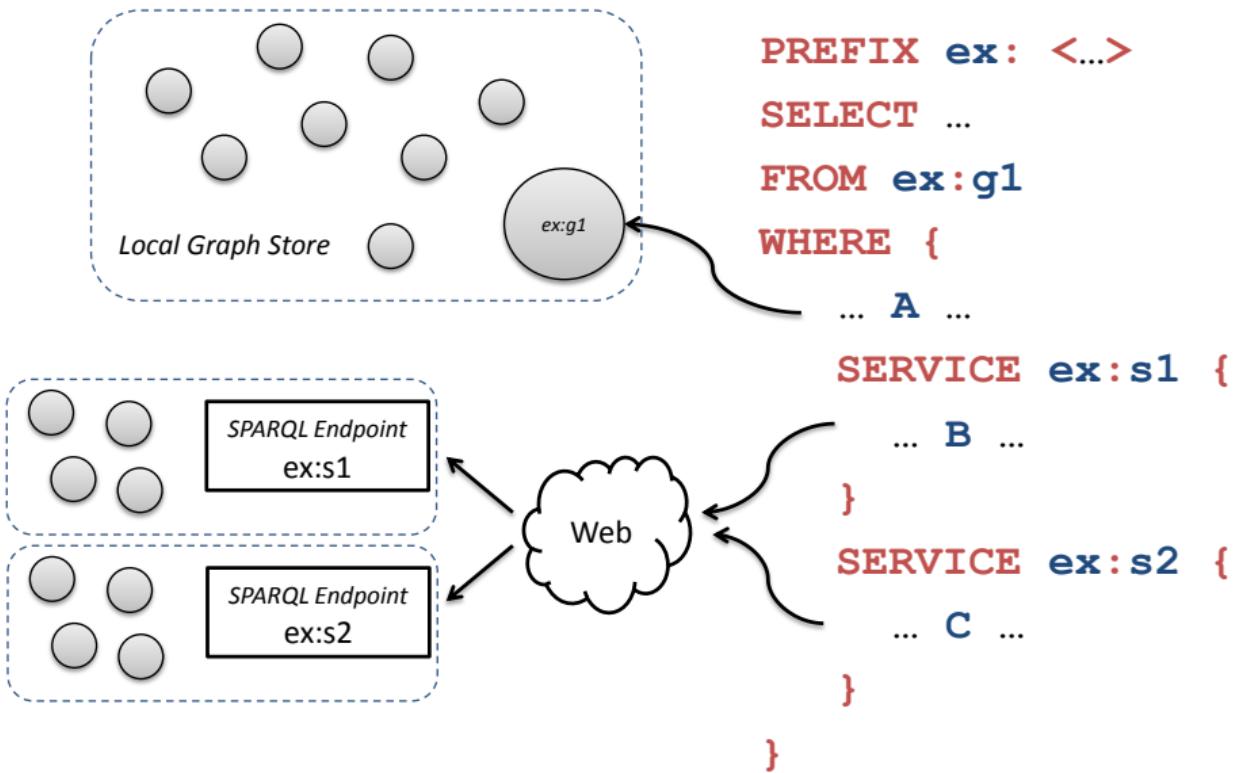
[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

HTTP GET or POST. Graphs given in the protocol override graphs given in the query.

# Federated Query (SPARQL 1.1)


[Introduction](#)
[Review](#)
[OWL](#)
[Queries](#)
[SPARQL Queries](#)
[Introduction](#)
[Describe](#)
[Select](#)
[Construct](#)
[Ask](#)
[Other SPARQL Features](#)
[SPARQL Protocol](#)
[Named Graphs](#)
[Serving Knowledge Graphs](#)
[Inferencing](#)
[Linked Open Data \(LOD\)](#)
[The LOD Initiative](#)
[DBpedia](#)
[The LOD Cloud](#)
[Linked Data Design Issues](#)
[Freebase, DBpedia & Wikidata](#)
[Publishing Options and Workflows](#)
[Notes and Further Reading](#)

## Examples

**Commercial:** Virtuoso (OpenLink Software); has “open source edition” at <https://github.com/openlink/virtuoso-opensource>

**Cloud:** Amazon AWS Neptune, see <https://aws.amazon.com/neptune/>

**Open Source:** Apache Jena, see <https://jena.apache.org/>



AWS re:Invent 2017 - Amazon Neptune: Fast, Reliable Graph Database Built for the Cloud

<https://www.youtube.com/watch?v=Rl6UwE7kLio>

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

# Apache Jena Fuseki

Apache Jena Fuseki is a SPARQL server. It can run as a operating system service, as a Java web application (WAR file), and as a standalone server. It provides security (using [Apache Shiro](#)) and has a user interface for server monitoring and administration.

It provides the SPARQL 1.1 [protocols for query and update](#) as well as the [SPARQL Graph Store protocol](#).

Fuseki is tightly integrated with [TDB](#) to provide a robust, transactional persistent storage layer, and incorporates [Jena text query](#). It can be used to provide the protocol engine for other RDF query and storage systems.

## Contents

- [Download](#)
- [Getting Started](#)
- [Security](#)
- [Running Fuseki](#)
  - [As a standalone server](#)
  - [As a service](#)
  - [As a web application](#)
  - [As an standalone SPARQL server](#)
- [Architecture](#)
  - [Server URI scheme : services and datasets](#)
  - [Server Admin Protocol](#)
- [Fuseki Configuration](#)
- [Logging](#)
- [How to Contribute](#)
- [Client access](#)
  - [Use from Java](#)
  - [SPARQL Over HTTP - scripts to help with data management.](#)
- [Links to Standards](#)

The Jena users mailing list is the place to get help with Fuseki.

See <https://jena.apache.org/documentation/fuseki2/index.html>

## Introduction

[Review](#)

[OWL](#)

[Queries](#)

## SPARQL Queries

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

## SPARQL Protocol

[Named Graphs](#)

## Serving Knowledge Graphs

[Inferencing](#)

## Linked Open Data (LOD)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

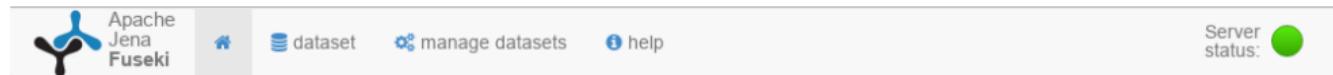
[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

## Notes and Further Reading

# Apache Fuseki (Standalone Server Mode)

René Witte



The screenshot shows the Apache Jena Fuseki web interface. At the top, there is a header bar with the Apache Jena Fuseki logo, a home icon, a dataset icon, a manage datasets icon, a help icon, and a green circular 'Server status' indicator. Below the header, the title 'Apache Jena Fuseki' is displayed, followed by the text 'Version 2.0.0. Uptime: 0m 12s'. The main content area is titled 'Datasets on this server' and contains the message 'There are no datasets on this server yet. [Add one.](#)'. A callout box provides instructions on how to perform actions on the server, listing three options: 'Dataset', 'Manage datasets', and 'Help'.

## Introduction

[Review](#)

[OWL](#)

[Queries](#)

## SPARQL Queries

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

## SPARQL Protocol

[Named Graphs](#)

## Serving Knowledge Graphs

[Inferencing](#)

## Linked Open Data (LOD)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

## Notes and Further Reading



Dataset: /foo

query

upload files

edit

info

## SPARQL query

To try out some SPARQL queries against the selected dataset, enter your query here.

EXAMPLE QUERIES

Selection of triples

Selection of classes

PREFIXES

rdf

rdfs

owl

xsd

SPARQL ENDPOINT

http://localhost:3030/foo/sparql

CONTENT TYPE (SELECT)

JSON

CONTENT TYPE (GRAPH)

Turtle



```
1
2
3 SELECT ?subject ?predicate ?object
4 WHERE {
5   ?subject ?predicate ?object
6 }
7 LIMIT 25
```

### Introduction

[Review](#)[OWL](#)[Queries](#)

### SPARQL Queries

[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)

### SPARQL Protocol

[Named Graphs](#)

### Serving Knowledge Graphs

[Inferencing](#)

### Linked Open Data (LOD)

[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)

### Notes and Further Reading

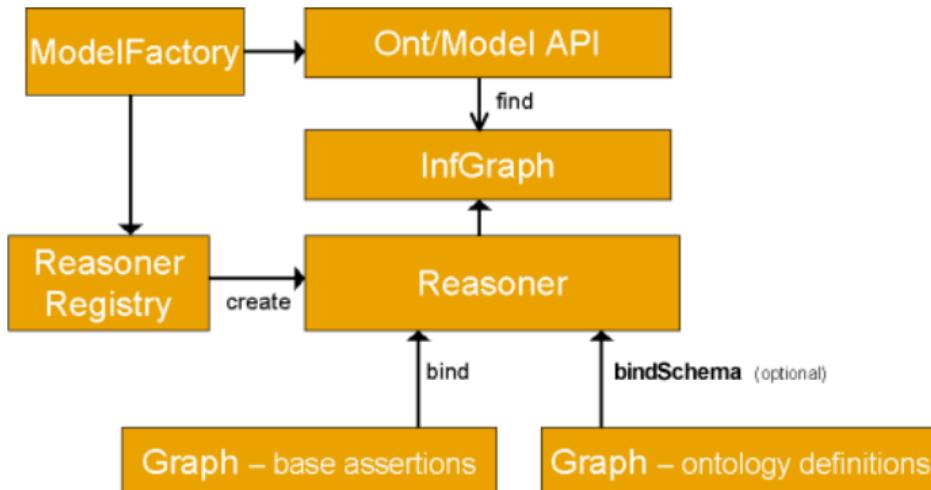
## Remember these...

```
ex:Student rdfs:subClassOf foaf:Person  
ex:Joe a ex:Student
```

What happens when you query for all foaf:Persons?

### Reasoning Engine

- RDFlib will return empty result
- Requires inference support (e.g., RDFS reasoner, OWL reasoner)



See <https://jena.apache.org/documentation/inference/>

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

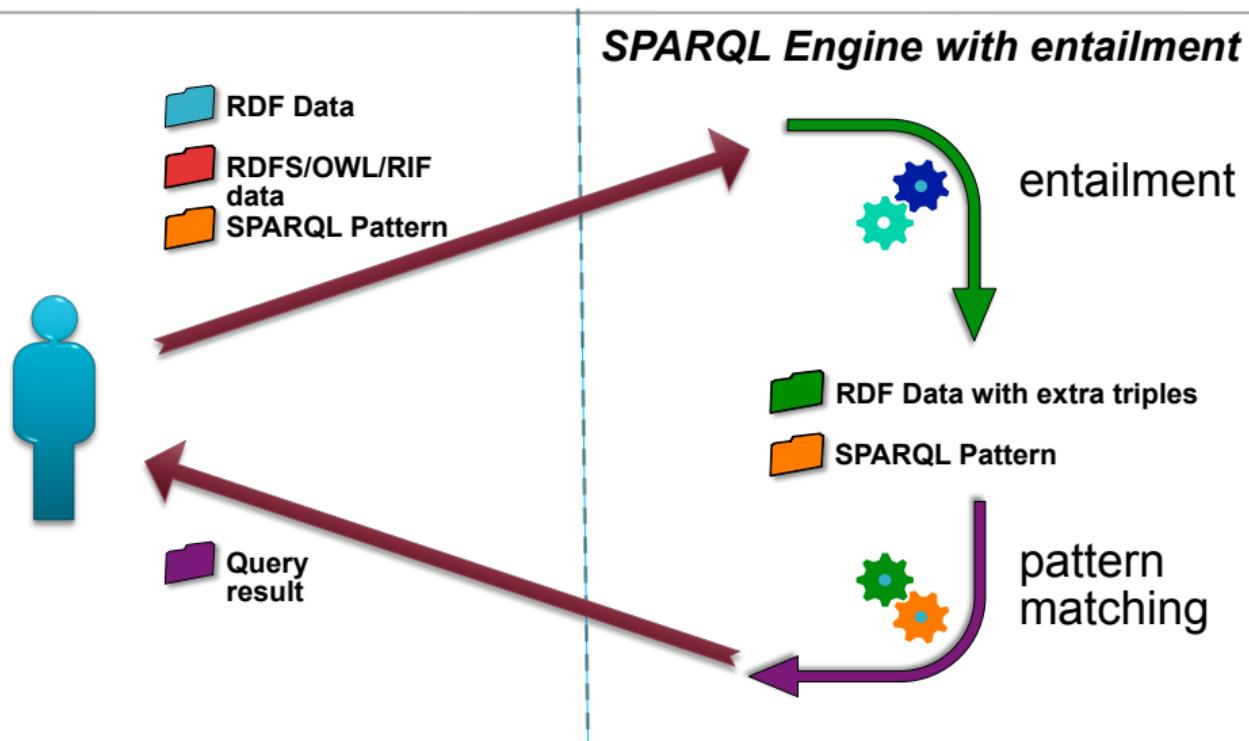
Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

# SPARQL 1.1 and RDFS/OWL/RIF

René Witte



## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

# Outline

René Witte



## 1 Introduction

Introduction

Review

OWL

Queries

## 2 SPARQL Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## 3 SPARQL Protocol

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## 4 Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

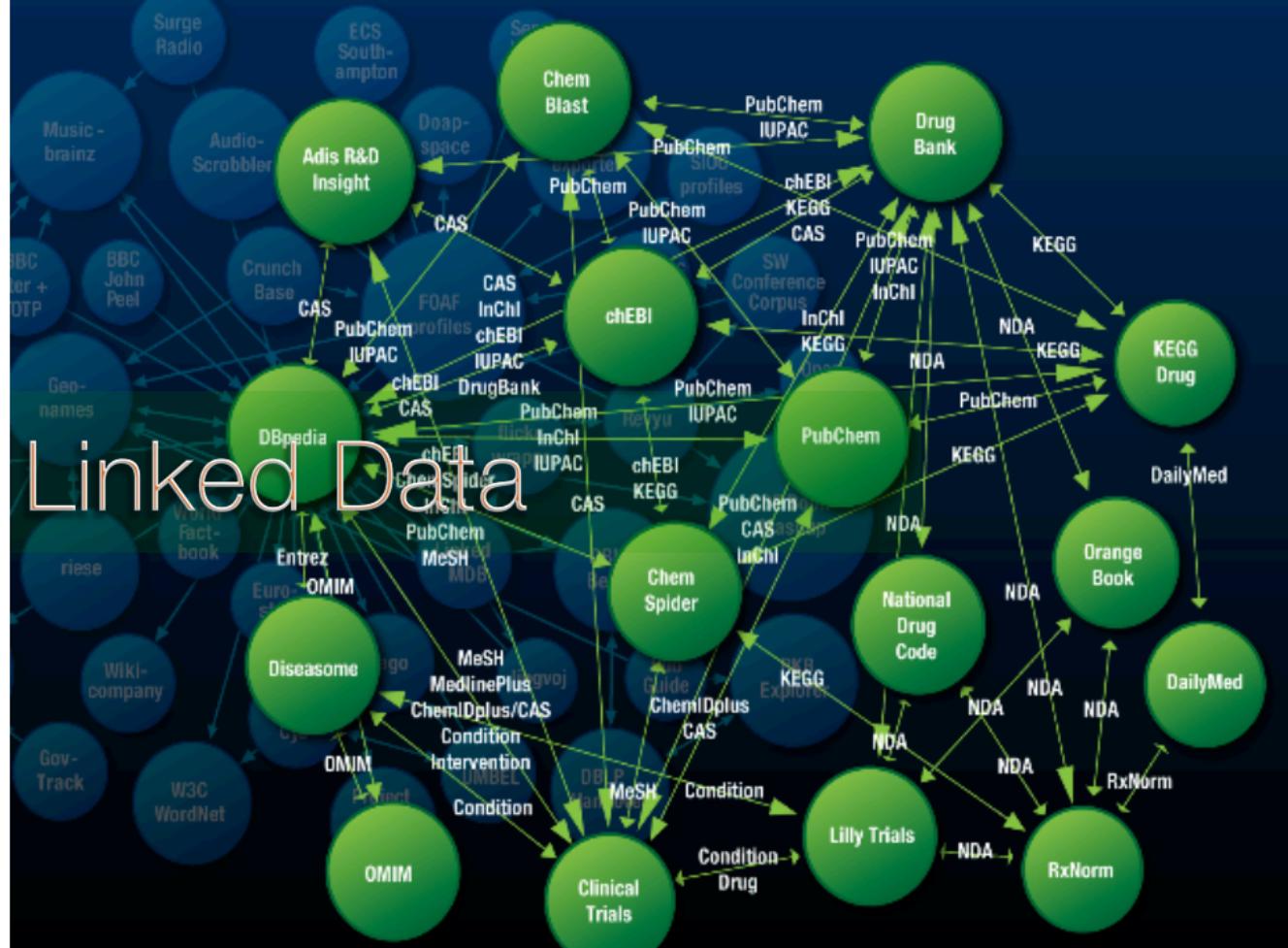
Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## 5 Notes and Further Reading

Notes and Further Reading



# Linked Data “Project”

- ▶ Goal: “expose” datasets on the Web
  - remember the importance of data!
- ▶ Set links among the data items from different datasets
  - we want to avoid the silo effects

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

# Is your data 5 Star?

René Witte



- 1 ★ Available on the web (whatever format), but with an open license
- 2 ★★ Available as machine-readable structured data (e.g., excel instead of an image scan)
- 3 ★★★ As before, but using a non-proprietary format (e.g., CSV instead of excel)
- 4 ★★★★ All the above, plus use open standards (RDF & Co.) to identify things, so that people could point at your stuff
- 5 ★★★★★ All the above, plus link your data to other people's data to provide context

## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

### The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

# Example data source: DBpedia

- ▶ DBpedia is a community effort to
  - extract structured (“infobox”) information from Wikipedia
  - provide a query endpoint to the dataset
  - interlink the DBpedia dataset with other datasets on the Web



UNIVERSITÄT LEIPZIG



[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

# Extracting structured data from Wikipedia

René Witte



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

dbpedia:**Amsterdam**

```
dbterm:officialName "Amsterdam" ;  
dbterm:longd "4" ;  
dbterm:longm "53" ;  
dbterm:longs "32" ;  
dbterm:website <http://www.amsterdam.nl> ;  
dbterm:populationUrban "1364422" ;  
dbterm:areaTotalKm "219" ;  
...  
...
```

dbpedia:**ABN\_AMRO**

```
dbterm:location dbpedia:Amsterdam ;  
...  
...
```

Amsterdam	
- Municipality / City -	
	
Coordinates:	52°22'23"N 4°53'32"E
Country	Netherlands
Province	North Holland
COROP	Amsterdam
Boroughs	Boroughs
Government	
- Mayor	Eberhard van der Laan (PvdA)
- Aldermen	Carolien Gijkels Hans Gerson Maarten van Poeleest Freek Ossel Marjke Vos
- Secretary	Henk de Jong
Area <sup>[1][2]</sup>	
- Municipality / City	219 km <sup>2</sup> (84.6 sq mi)
- Land	166 km <sup>2</sup> (64.1 sq mi)
- Water	53 km <sup>2</sup> (20.5 sq mi)
- Urban	1,003 km <sup>2</sup> (387.3 sq mi)
- Metro	1,815 km <sup>2</sup> (700.8 sq mi)
Elevation <sup>[3]</sup>	2 m (7 ft)
Population (June 2009) <sup>[4][5]</sup>	
- Municipality / City	762,057
- Density	4,459/km <sup>2</sup> (11,548.8/sq mi)
- Urban	1,364,422
- Metro	2,158,372
- Demonym	Amsterdammer
Time zone	CET (UTC+01)
- Summer (DST)	CEST (UTC+02) (UTC)
Postal codes	1011–1109
Area code(s)	020
Website	<a href="http://www.amsterdam.nl">www.amsterdam.nl</a>

## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

# Automatic links among open datasets

```
<http://dbpedia.org/resource/Amsterdam> ←  
owl:sameAs <http://rdf.freebase.com/ns/...> ;  
owl:sameAs <http://sws.geonames.org/2759793> ;  
...
```

```
<http://sws.geonames.org/2759793>  
owl:sameAs <http://dbpedia.org/resource/Amsterdam>  
wgs84_pos:lat "52.3666667" ;  
wgs84_pos:long "4.8833333" ;  
geo:inCountry <http://www.geonames.org/countries/#NL> ;  
...
```

## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia &

Wikidata

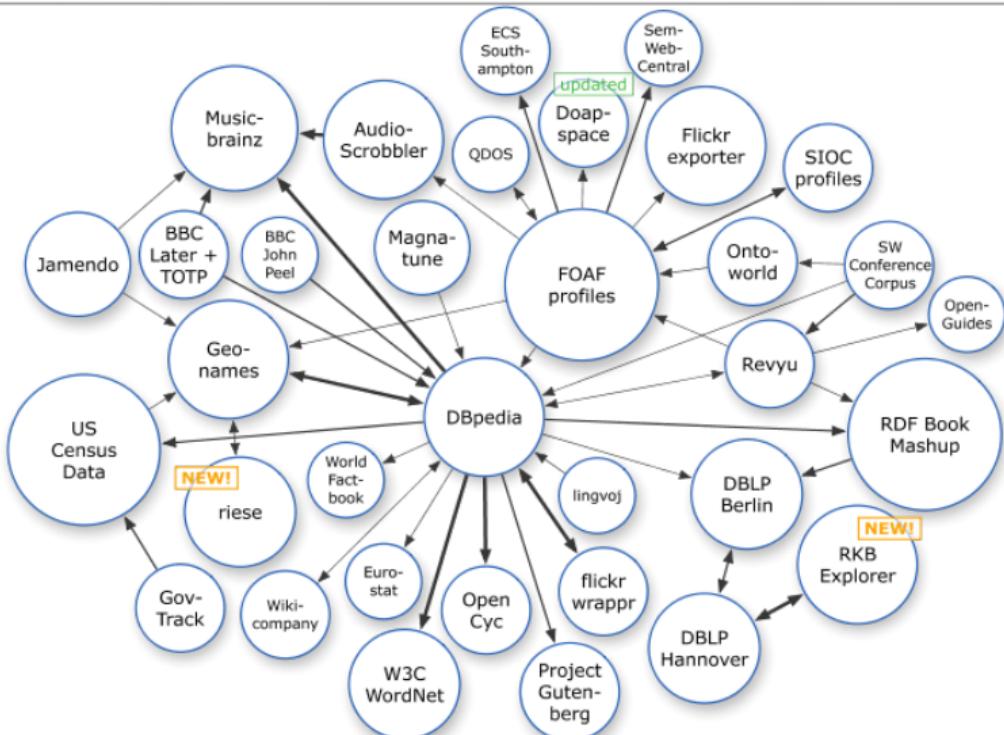
Publishing Options and

Workflows

## Notes and Further Reading

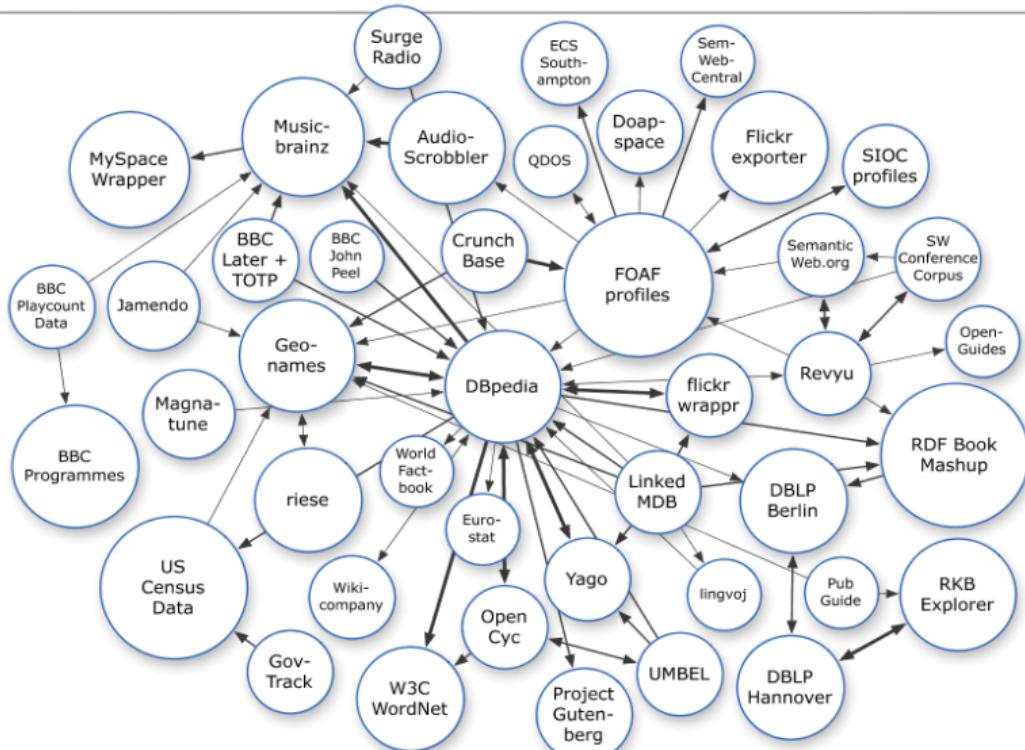
Processors can switch automatically from one to the other...

# The LOD “cloud”, March 2008



# The LOD “cloud”, September 2008

René Witte



As of September 2008

## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

### The LOD Cloud

Linked Data Design Issues

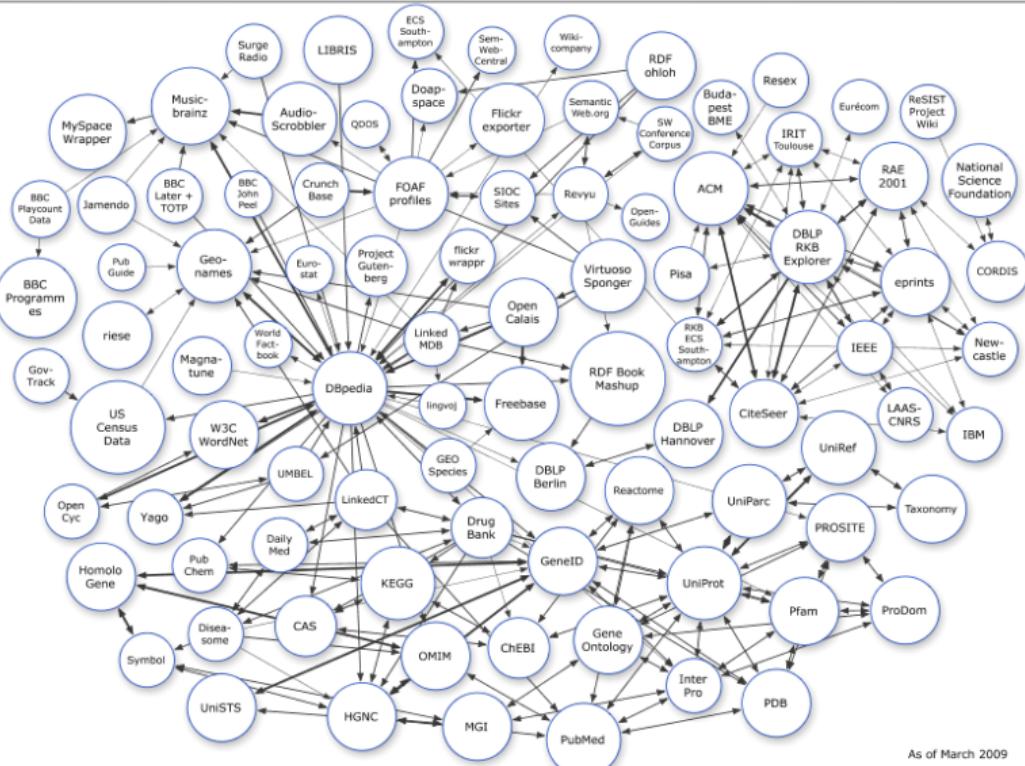
Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

# The LOD “cloud”, March 2009

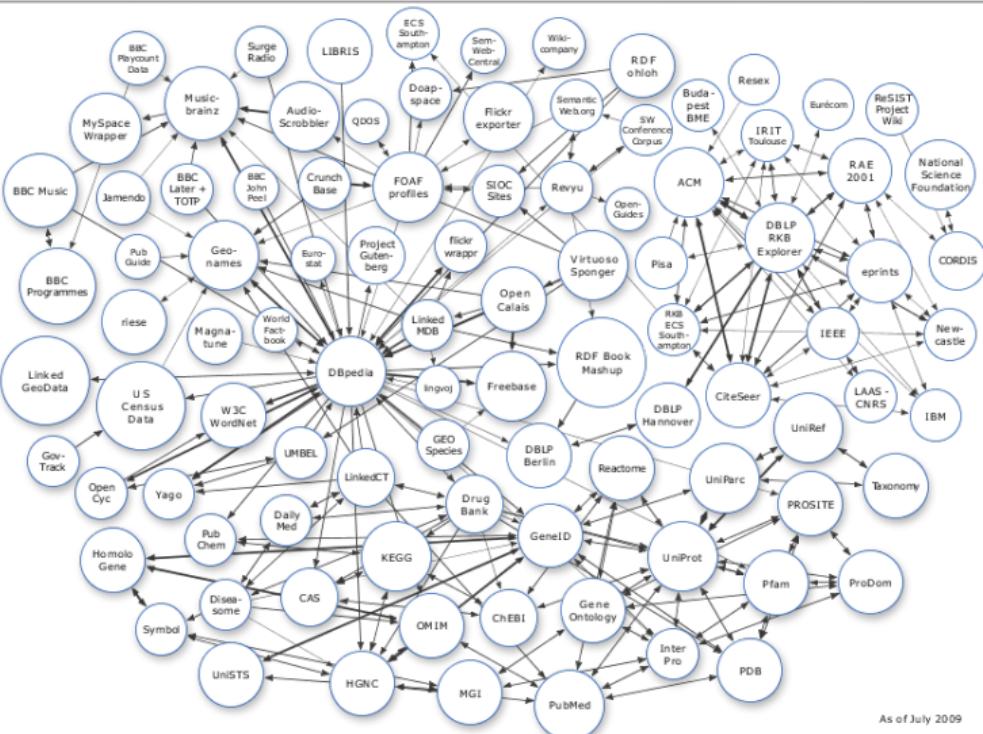
René Witte



As of March 2009

# The LOD “cloud”, June 2009

René Witte



## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

## The LOD Cloud

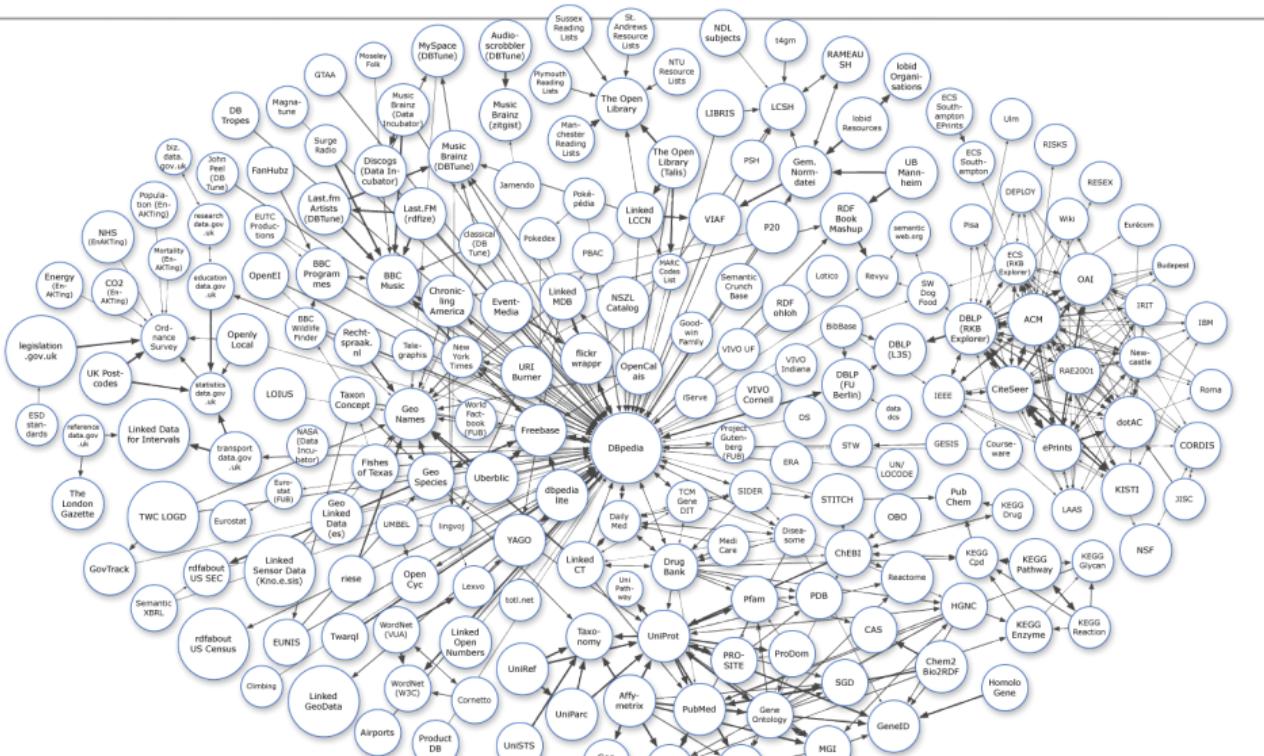
Linked Data Design Issues

Firebase, DBpedia & Wikidata

Publishing Options and Workflows

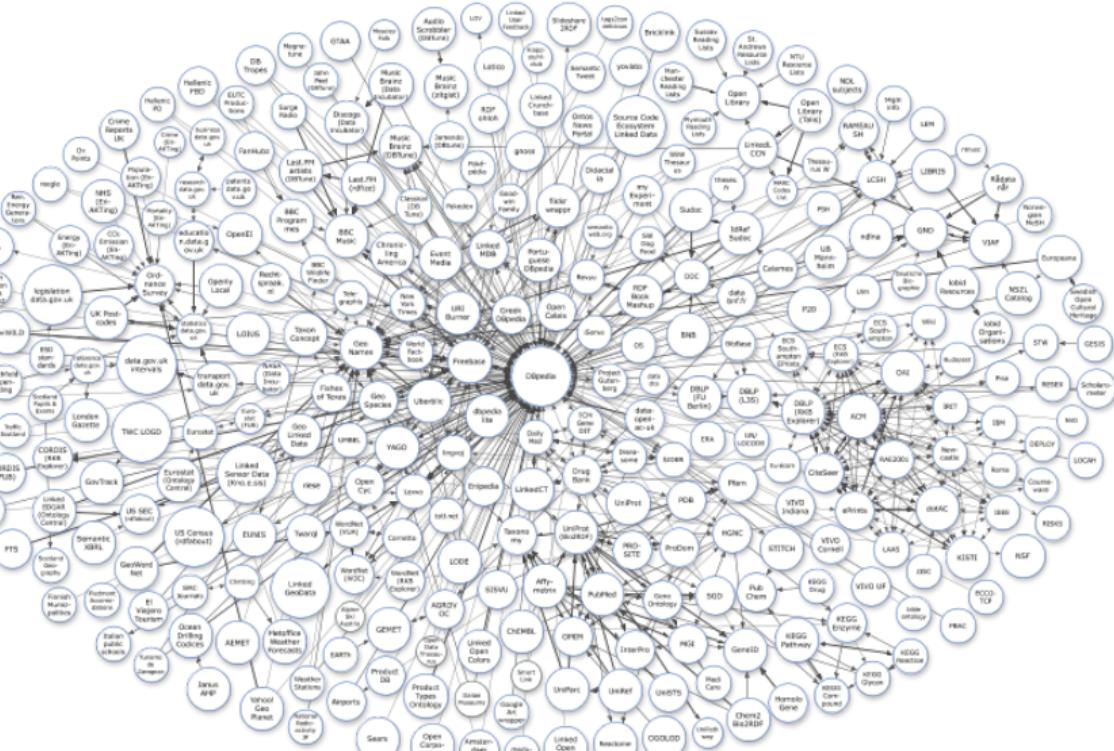
## Notes and Further Reading

# The LOD “cloud”, September 2010



As of September 2010 

# The LOD “cloud”, September 2011



Courtesy of Richard Cyganiak and Anja Jentzsch

As of September 2011



## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

## The LOD Cloud

Linked Data Design Issues

Firebase, DBpedia & Wikidata

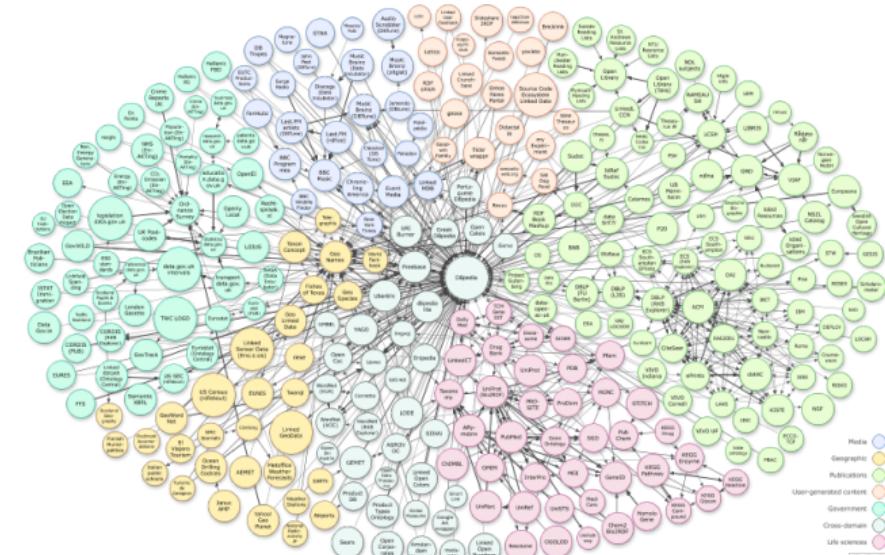
Publishing Options and Workflows

## Notes and Further Reading

# Application specific portions of the cloud

## ► Eg, “bio” related datasets

- done, partially, by the “Linking Open Drug Data” task force of the HCLS IG at W3C



Courtesy of Richard Cyganiak and Anja Jentzsch

## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

## The LOD Cloud

Linked Data Design Issues

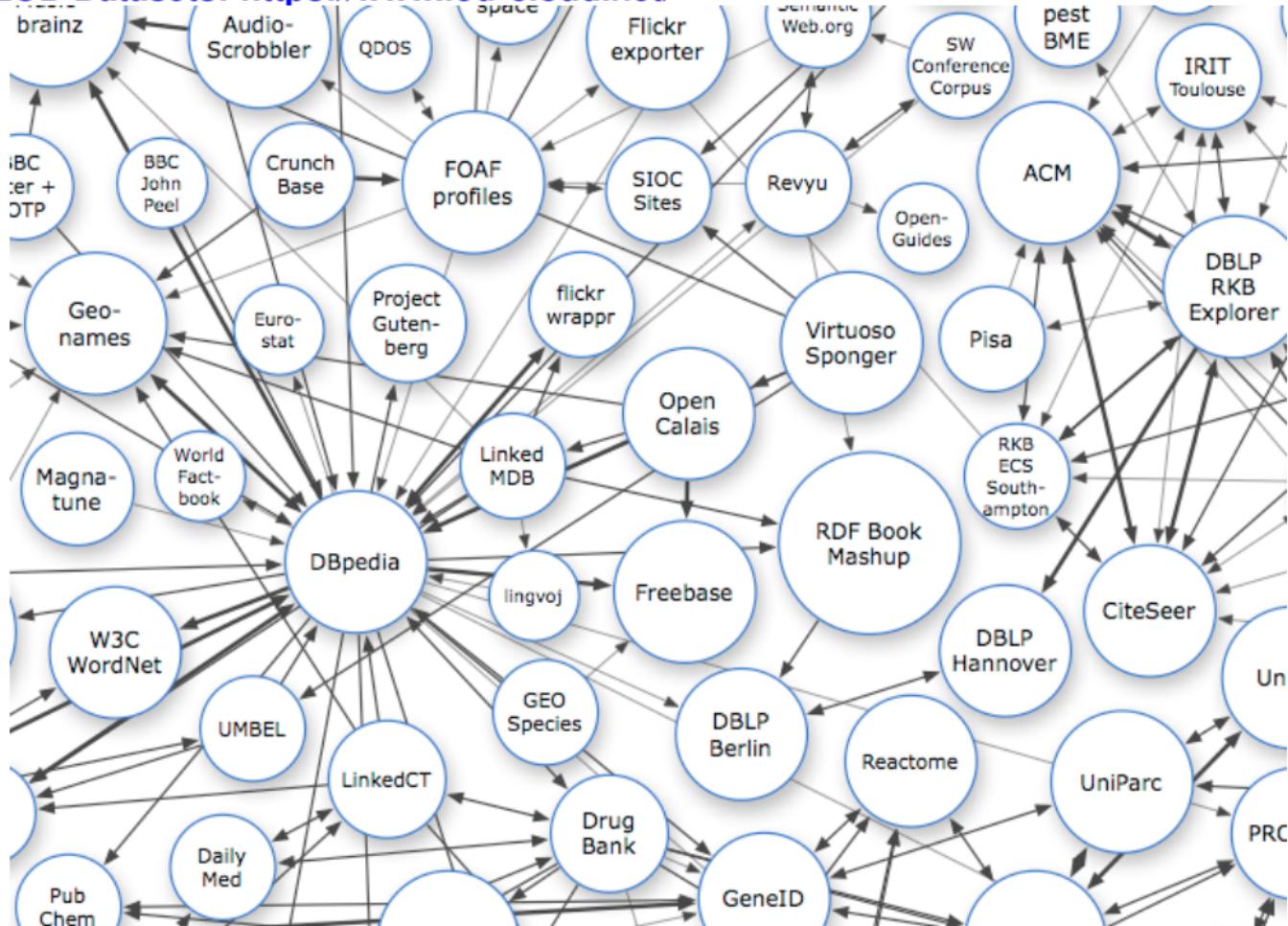
Firebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

# LOD Datasets: <https://www.lod-cloud.net/>

René Witte



## Introduction

Review  
OWL  
Queries

## SPARQL Queries

Introduction  
Describe  
Select  
Construct  
Ask  
Other SPARQL Features

## SPARQL Protocol

Named Graphs  
Serving Knowledge Graphs  
Inferencing

## Linked Open Data (LOD)

The LOD Initiative  
DBpedia  
**The LOD Cloud**  
Linked Data Design Issues  
Freebase, DBpedia & Wikidata  
Publishing Options and Workflows

## Notes and Further Reading

## Origin

First proposed by Tim Berners-Lee in 2006

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

## What's a "link"?

Technically, a **link** is a triple where

- the **subject** IRI is in one graph (namespace) and
- the **predicate** and/or **object** are in a different graph (namespace)

## Types of Links

**Identity Link:** points to the same object or concept in another knowledge graph  
(e.g., Canada in DBpedia and Wikidata)

**Relationship Link:** points to other objects related to a given one (e.g., from a person to the city they live in)

**Vocabulary Link:** between data and their vocabulary term  
(e.g., IRI is a `foaf:Person`) or between vocabulary terms  
(e.g., `ex:Student rdfs:subClassOf foaf:Person`)

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

## Instance Level

Creating links on the **instance level** (IRIs):

`owl:sameAs` Most widely used, but makes strong assumptions about both IRIs being identical (it is *symmetric* and *transitive*)

`rdfs:seeAlso` Just a reference, makes no claim about the IRIs being identical (no specific semantics)

using vocabularies e.g., `skos:exactMatch`, `foaf:knows`

## Schema Level

Two graphs can also be linked on the **schema level**:

- Using `owl:equivalentClass` and `owl:equivalentProperty`
- Using `rdfs:subClassOf` and `rdfs:subPropertyOf`
- Using vocabularies, e.g., `skos:broadMatch` or `skos:narrowMatch`

[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

[Introduction](#)[Review](#)[OWL](#)[Queries](#)[SPARQL Queries](#)[Introduction](#)[Describe](#)[Select](#)[Construct](#)[Ask](#)[Other SPARQL Features](#)[SPARQL Protocol](#)[Named Graphs](#)[Serving Knowledge Graphs](#)[Inferencing](#)[Linked Open Data \(LOD\)](#)[The LOD Initiative](#)[DBpedia](#)[The LOD Cloud](#)[Linked Data Design Issues](#)[Freebase, DBpedia & Wikidata](#)[Publishing Options and Workflows](#)[Notes and Further Reading](#)

## The “four rules”

- 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.

# How to create your own URIs

René Witte



## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

## Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading

Follow these best practices when creating sets of URIs.



Name things using HTTP URIs.

Adopt generally accepted guidance about designing URI sets.

### URI naming guidelines

A Proposal For Governmental Data URIs

Designing Uri Sets Uk Public Sector

Use a domain that you control.

Do not use someone else's domain.

Use natural keys.

Avoid: `http://.../984d6a`

Use instead: `http://.../baked_goods/bread/rye-12`

Use neutral URIs.

Do not include implementation details in your names.

Do not include version numbers or technology names.

Use fragment identifiers with caution.

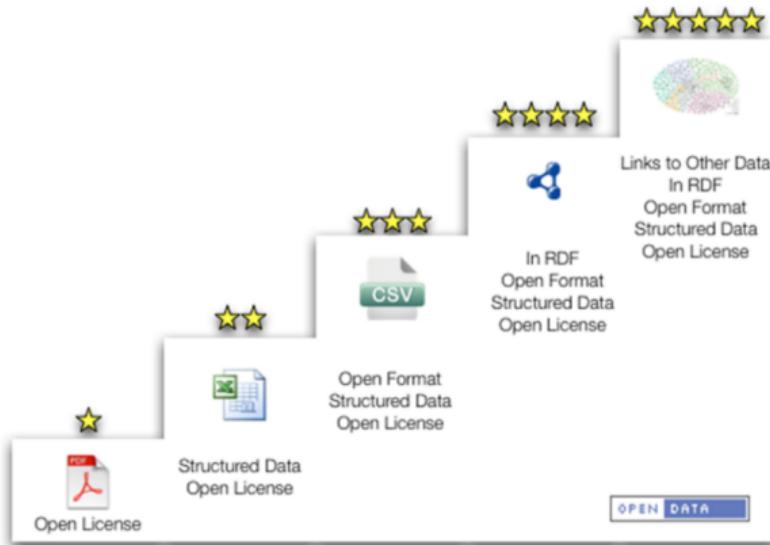
Avoid: `http://example.com/id/vocabulary#linked_data`

Use instead: `http://example.com/id/vocabulary/linked_data/`

## Major Points

To create a knowledge base in LOD-compliant format:

- ① Make your data “5-star”
- ② Create URIs following the guidelines
- ③ Select appropriate vocabularies
- ④ Extend existing vocabularies if necessary
- ⑤ Link your data to other knowledge graphs
- ⑥ Publish your knowledge graph on the web



### Introduction

Review

OWL

Queries

### SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

### SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

### Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

### Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

### Notes and Further Reading

# Knowledge Bases: Timeline

René Witte



## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

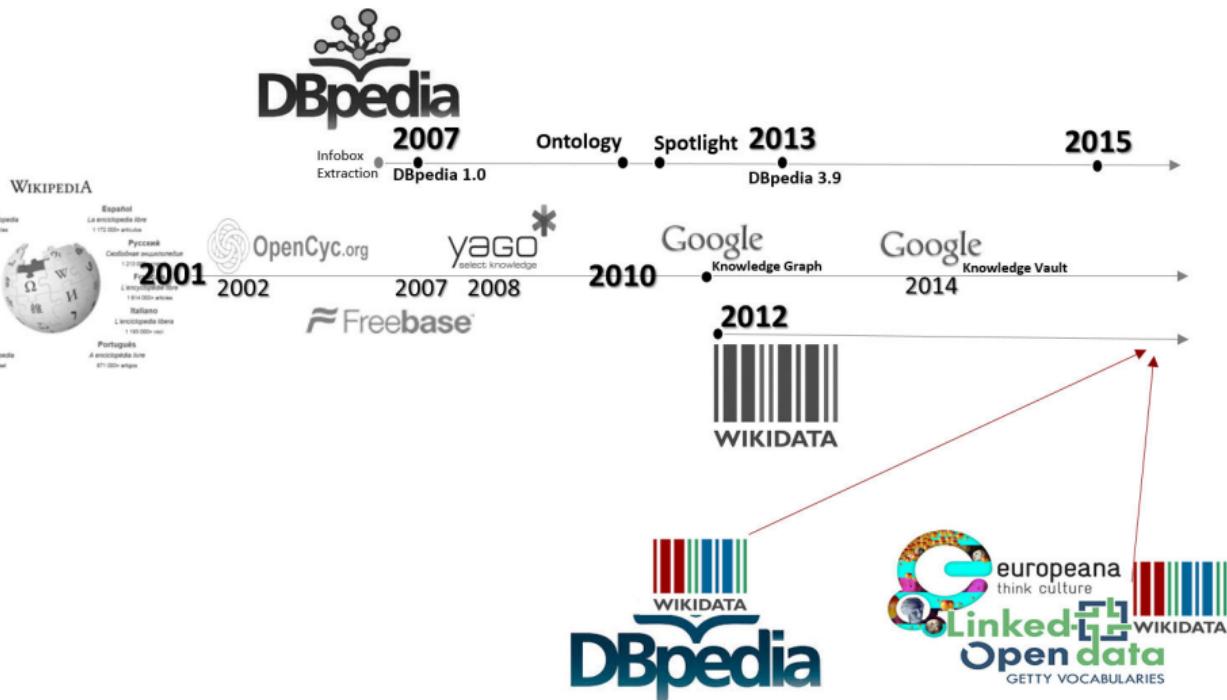
The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading



## Freebase

- One of the first major public knowledge graphs, started in 2007
- Startup *Metaweb* bought by Google in 2010
- Shutdown in 2016...
- ...but data was donated to [Wikidata](#)

	<b>Freebase™</b>
<b>Type of site</b>	Online database
<b>Available in</b>	English
<b>Owner</b>	Metaweb Technologies ( <a href="#">Google</a> )
<b>URL</b>	<a href="http://www.freebase.com">www.freebase.com</a> ↗
<b>Commercial</b>	No
<b>Registration</b>	Optional
<b>Launched</b>	3 March 2007; 13 years ago
<b>Current status</b>	Offline (since 2 May 2016), succeeded by <a href="#">Wikidata</a> <sup>[1][2]</sup>
<b>Content license</b>	Creative Commons Attribution License

 [Browse using](#) ↘ [Formats](#) ↘

<a href="#">rdfs:label</a>	■ Kobe Bryant (en)
<a href="#">rdfs:seeAlso</a>	■ <a href="#">dbr&gt;List_of_career_achievements_by_Kobe_Bryant</a>
<a href="#">owl:sameAs</a>	■ <a href="http://data.europa.eu/euodp/jrc-names/Kobe_Bryant">http://data.europa.eu/euodp/jrc-names/Kobe_Bryant</a> ■ <a href="#">dbpedia-sq:Kobe Bryant</a> ■ <a href="#">dbpedia-ka:Kobe Bryant</a> ■ <a href="#">freebase:Kobe Bryant</a>

[Introduction](#)
[Review](#)
[OWL](#)
[Queries](#)
[SPARQL Queries](#)
[Introduction](#)
[Describe](#)
[Select](#)
[Construct](#)
[Ask](#)
[Other SPARQL Features](#)
[SPARQL Protocol](#)
[Named Graphs](#)
[Serving Knowledge Graphs](#)
[Inferencing](#)
[Linked Open Data \(LOD\)](#)
[The LOD Initiative](#)
[DBpedia](#)
[The LOD Cloud](#)
[Linked Data Design Issues](#)
[Freebase, DBpedia & Wikidata](#)
[Publishing Options and Workflows](#)
[Notes and Further Reading](#)

[RESOURCES](#) [MEMBERS](#) [COMMUNITY](#)

# Global and Unified Access to Knowledge Graphs

[DBPEDIA BLOG](#)

Tutorial at September 1, 2021

## DBpedia Tutorial at LDK 2021

January 14, 2021 by Julia Holze

We are happy to announce that we will organize a DBpedia Tutorial on September 1, 2021 in Zaragoza, Spain. This DBpedia tutorial will be part of the Language, Data and Knowledge conference 2021. Building upon the success of the previous events held in Galway, Ireland in 2017, and in Leipzig, Germany in 2019, this conference will bring together researchers from across disciplines concerned with the acquisition, curation and use of language data in the context of data science and knowledge-based applications.

[Read more](#)

## DBpedia Tutorial at LDK 2021

# DBpedia: Part of Watson's brain

René Witte



## Introduction

[Review](#)

[OWL](#)

[Queries](#)

## SPARQL Queries

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

## SPARQL Protocol

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

## Linked Open Data (LOD)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

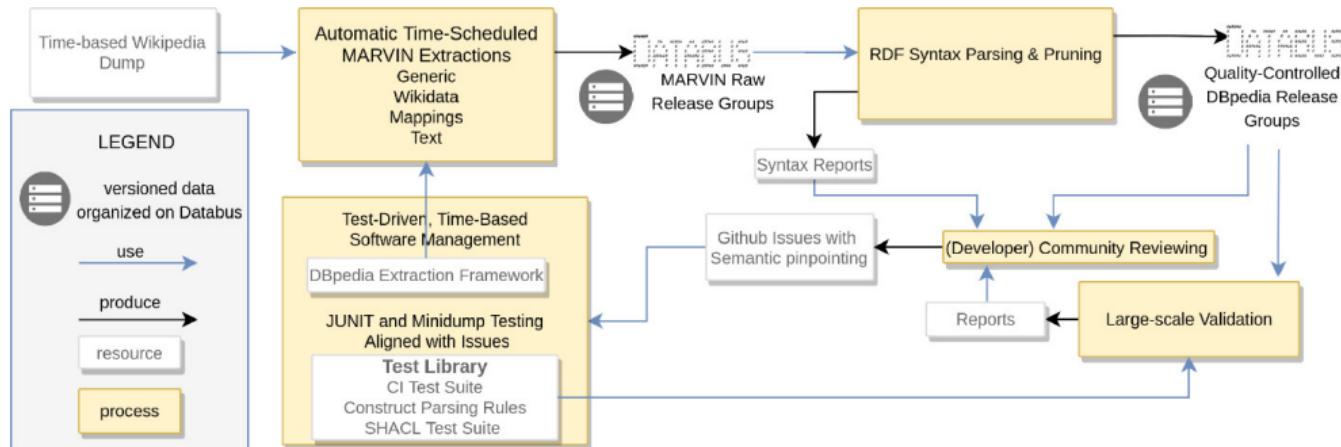
[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

## Notes and Further Reading

# DBpedia Release Cycle

René Witte



"The New DBpedia Release Cycle: Increasing Agility and Efficiency in Knowledge Extraction Workflows" (IHDE20)

## Introduction

Review

OWL

Queries

## SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

## SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

## Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

## Notes and Further Reading



Main page  
Community portal  
Project chat  
Create a new item  
Recent changes  
Random item  
Query Service  
Nearby  
Help  
Donate

Lexicographical data  
Create a new Lexeme  
Recent changes  
Random Lexeme

Tools

What links here  
Related changes  
Special pages  
Permanent link  
Page information  
Wikidata item

In other projects

Wikimedia Commons

MediaWiki

Meta-Wiki

Wikispecies

Wikibooks

Wikimania

Wikinews

Wikidata

Wikiquette

Wikisource

Wikiversity

Wikivoyage

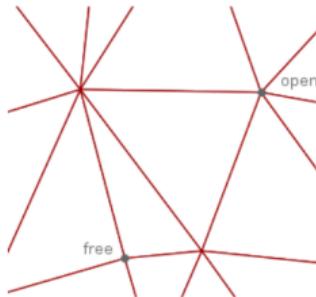
Wiktionary

In Pictures

Atikamekw

Néhiyawewin /  
ᓈᐎᐤ

Deutsch



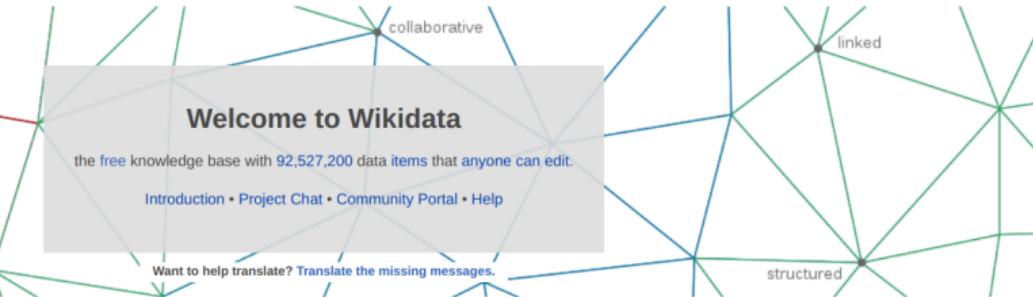
Join the consultation about the Universal Code of Conduct and take the online survey!

# Welcome to Wikidata

the free knowledge base with 92,527,200 data items that anyone can edit.

Introduction • Project Chat • Community Portal • Help

Want to help translate? Translate the missing messages.



## Welcome!

Wikidata is a free and open knowledge base that can be read and edited by both humans and machines.

Wikidata acts as central storage for the **structured data** of its Wikimedia sister projects including Wikipedia, Wikivoyage, Wiktionary, Wikisource, and others.

Wikidata also provides support to many other sites and services beyond just Wikimedia projects! The content of Wikidata is available under a free license, exported using standard formats, and can be interlinked to other open data sets on the linked data web.

## Get involved

For a complete starters' guide, visit the [community portal](#).

### Learn about Wikidata

- What is Wikidata? Read the [Wikidata introduction](#).
- Explore Wikidata by looking at a featured showcase item for author [Douglas Adams](#) (Q42).
- Get started with Wikidata's [SPARQL query service](#).

### Contribute to Wikidata

- Learn to edit Wikidata: follow the [tutorials](#).
- Work with other volunteers on a subject that interests you: [join a WikiProject](#).
- Individuals and organizations can also [donate data](#).

## Learn about data

New to the wonderful world of data? Develop and improve your data literacy through content designed to get you up to speed and feeling comfortable with the fundamentals in no time.



Item: [Earth](#) (Qz)



Property: [highest point](#) (P610)



custom value:  
[Mount Everest](#) (Q513)

## Current highlights

- 2021 Clásica de Almería (Q103950409)
- Tour de la Provence 2021 (Q101085154)
- 2021 Grand Prix Gazipaşa (Q105321988)
- Britten-Norman BN-2 Islander (Q921019) (pictured)
- Mary Wilson (Q2302368)



# Wikidata: Wiki principle applied to structured data

English

Item Discussion

Read View history

Search Wikidata

## Concordia University (Q326342)

university in Montreal, Quebec, Canada

edit

Sir George Williams University | Loyola College, Montreal | Concordia university (Montréal, Canada) | Concordia

▼ In more languages

Configure

Language	Label	Description	Also known as
English	Concordia University	university in Montreal, Quebec, Canada	Sir George Williams University Loyola College, Montreal Concordia university (Montréal, ... Concordia
German	Concordia University	Universität in Kanada	Concordia-Universität
French	Université Concordia	université québécoise née de la fusion de l'Université Sir George Williams et du Collège Loyola à Montréal, en août 1974	Université Sir George Williams Université Concordia (Montréal, ...
Italian	Università Concordia	No description defined	Concordia University

All entered languages

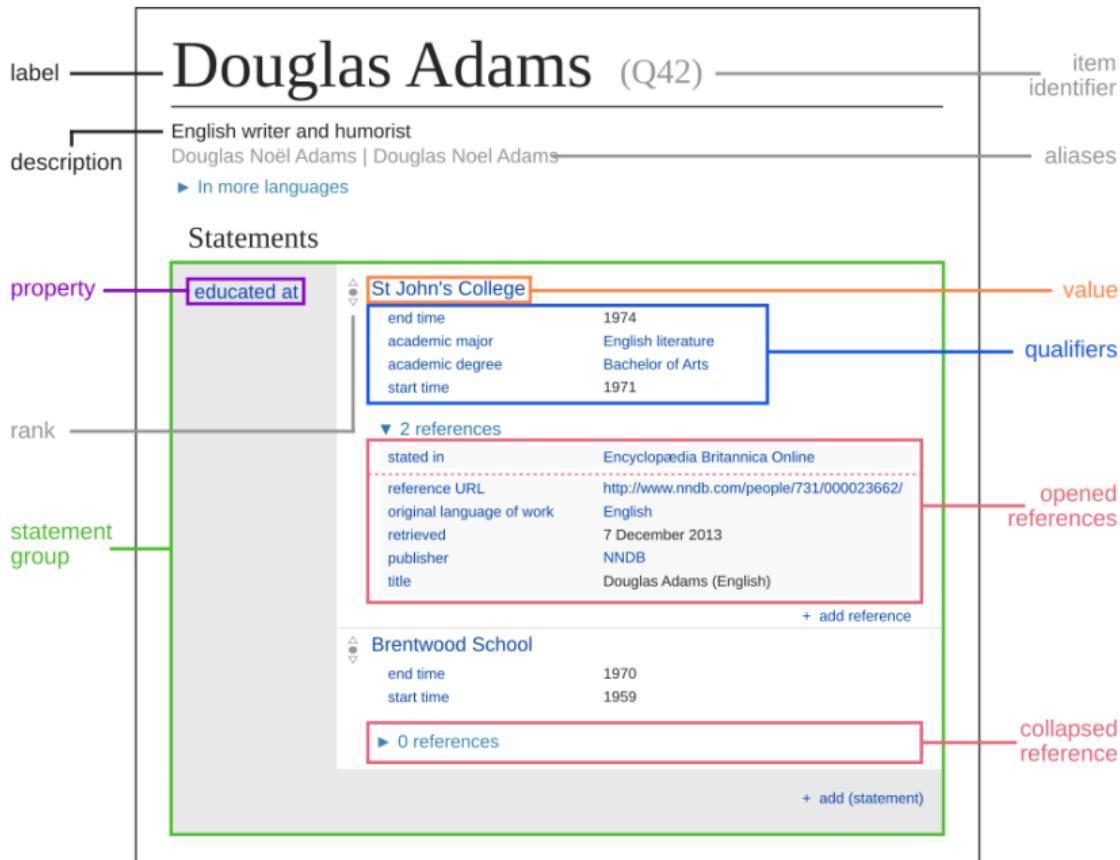
## Statements

instance of	university	edit
	▼ 0 references	+ add reference

+ add value

Wikipedia (25 entries) edit

ar	جامعة كونكورديا
ast	Universidá Concordia
atj	Université Concordia
azb	کونکوردیا سیلیم بوردو
de	Concordia University
el	Πανεπιστήμιο Κονκόρδια
en	Concordia University
eo	Universitato Concordia
es	Universidad Concordia
et	Concordia ülikool (Kanada)
fa	دانشگاه کنکوردیا
fi	Concordia-yliopisto
fr	Université Concordia
he	אוניברסיטת קונקורדייה
it	Università Concordia
ja	コンコルディア大学
ko	콘코디아 대학교
nl	Concordia-universiteit (Montreal)
pl	Uniwersytet Concordia
pt	Universidade Concórdia
ru	Университет Конкордия
sv	Concordia University
tl	Pamantasan ng Concordia


[Introduction](#)
[Review](#)
[OWL](#)
[Queries](#)
[SPARQL Queries](#)
[Introduction](#)
[Describe](#)
[Select](#)
[Construct](#)
[Ask](#)
[Other SPARQL Features](#)
[SPARQL Protocol](#)
[Named Graphs](#)
[Serving Knowledge Graphs](#)
[Inferencing](#)
[Linked Open Data \(LOD\)](#)
[The LOD Initiative](#)
[DBpedia](#)
[The LOD Cloud](#)
[Linked Data Design Issues](#)
[Freebase, DBpedia & Wikidata](#)
[Publishing Options and Workflows](#)
[Notes and Further Reading](#)

## Approaches

- Community-constructed (e.g., Freebase, Wikidata)
- (Semi-)Automatically constructed (e.g., DBpedia, BabelNet)
- Exported from other data sources (e.g., MusicBrainz)



[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

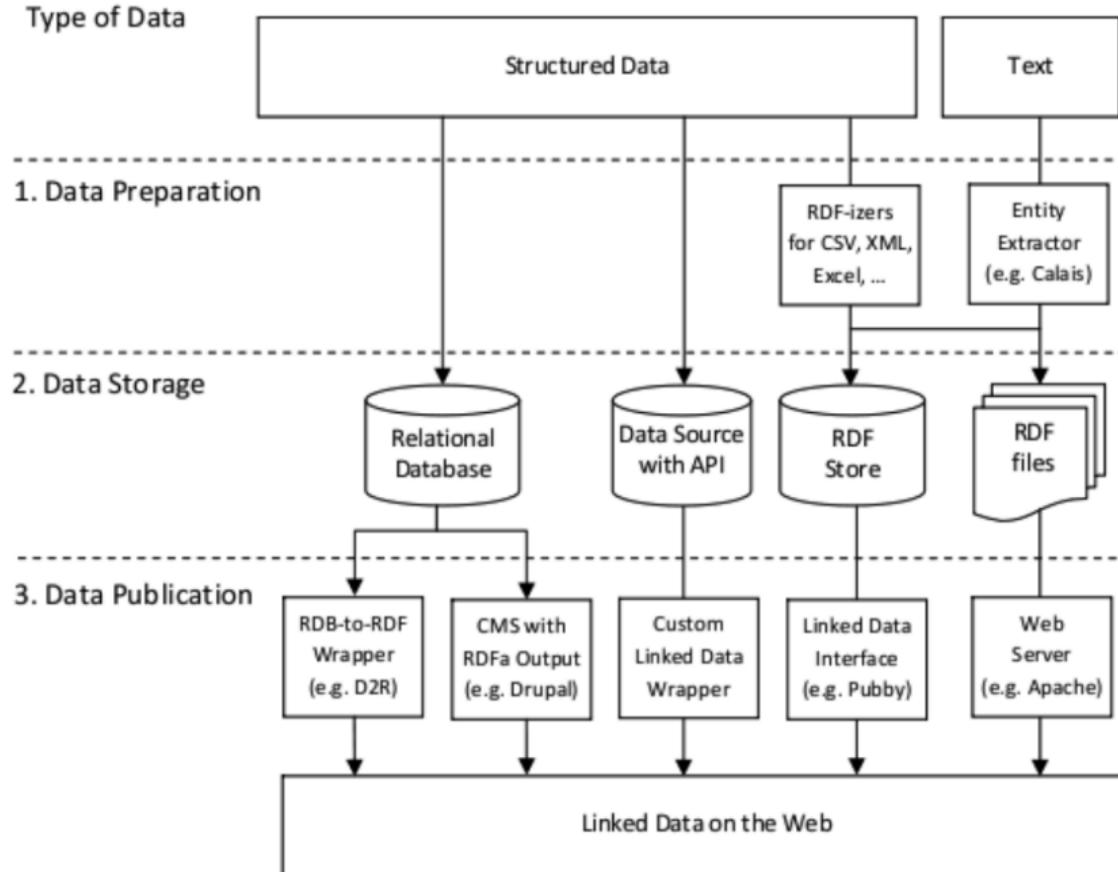
[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

# Linked Data Publishing Options and Workflows

René Witte



[Introduction](#)

[Review](#)

[OWL](#)

[Queries](#)

[SPARQL Queries](#)

[Introduction](#)

[Describe](#)

[Select](#)

[Construct](#)

[Ask](#)

[Other SPARQL Features](#)

[SPARQL Protocol](#)

[Named Graphs](#)

[Serving Knowledge Graphs](#)

[Inferencing](#)

[Linked Open Data \(LOD\)](#)

[The LOD Initiative](#)

[DBpedia](#)

[The LOD Cloud](#)

[Linked Data Design Issues](#)

[Freebase, DBpedia & Wikidata](#)

[Publishing Options and Workflows](#)

[Notes and Further Reading](#)

## 1 Introduction

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

## 2 SPARQL Queries

## 3 SPARQL Protocol

## 4 Linked Open Data (LOD)

## 5 Notes and Further Reading

## Required

- [Yu14, Chapter 6] (SPARQL)
- [Yu14, Chapter 9] (Linked Open Data)

## Supplemental

- [DuC13] (Learning SPARQL)
- [WZRH14, Chapter 5] (SPARQL)
- SPARQL 1.1 Overview, <https://www.w3.org/TR/sparql11-overview/>
- [Yu14, Chapter 8] (DBpedia)
- [Yu14, Chapter 12] (Wikidata)

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

## References I

René Witte



- [DFH11] John Domingue, Dieter Fensel, and James A. Hendler, editors. *Handbook of Semantic Web Technologies*. Springer, 2011.  
<https://concordiauniversity.on.worldcat.org/oclc/769756125>.
- [DuC13] Bob DuCharme. *Learning SPARQL: Querying and Updating with SPARQL 1.1*. O'Reilly, 2nd edition, 2013.  
<https://concordiauniversity.on.worldcat.org/oclc/853679890>.
- [HB11] Tom Heath and Christian Bizer. *Linked Data: Evolving the Web into a Global Data Space*. Morgan & Claypool, 2011.  
<https://concordiauniversity.on.worldcat.org/oclc/704257552>.
- [Her] Ivan Herman. Tutorial on Semantic Web Technologies.  
<http://www.w3.org/People/Ivan/CorePresentations/RDFTutorial/>.

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading

## References II

René Witte



- [HHDF20] Marvin Hofer, Sebastian Hellmann, Milan Dojchinovski, and Johannes Frey.  
The New DBpedia Release Cycle: Increasing Agility and Efficiency in Knowledge Extraction Workflows.  
In *Semantic Systems. In the Era of Knowledge Graphs*, pages 1–18, Cham, 2020. Springer International Publishing.  
[https://link.springer.com/chapter/10.1007/978-3-030-59833-4\\_1](https://link.springer.com/chapter/10.1007/978-3-030-59833-4_1).
- [WZRH14] David Wood, Marsha Zaidman, Luke Ruth, and Michael Hausenblas.  
*Linked Data: Structured Data on the Web*.  
Manning, 2014.  
<https://concordiauniversity.on.worldcat.org/oclc/871683907>.
- [Yu14] Liyang Yu.  
*A Developer's Guide to the Semantic Web*.  
Springer-Verlag Berlin Heidelberg, 2nd edition, 2014.  
<https://concordiauniversity.on.worldcat.org/oclc/897466408>.

Introduction

Review

OWL

Queries

SPARQL Queries

Introduction

Describe

Select

Construct

Ask

Other SPARQL Features

SPARQL Protocol

Named Graphs

Serving Knowledge Graphs

Inferencing

Linked Open Data (LOD)

The LOD Initiative

DBpedia

The LOD Cloud

Linked Data Design Issues

Freebase, DBpedia & Wikidata

Publishing Options and Workflows

Notes and Further Reading