



WEB SÉMANTIQUE ET ONTOLOGIES
WEB DES DONNÉES
DONNÉES LIÉES (LINKED DATA)

3 – LE MODÈLE DE DONNEES RDF (RESOURCE DESCRIPTION FRAMEWORK)

Philippe GENOUD – Danielle ZIEBELIN - LIG-Steamer

Prénom.Nom@imag.fr



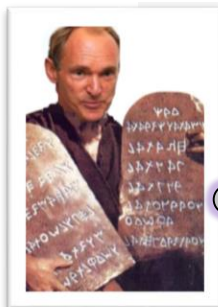
Outline

- “Theoretical” Session (morning)
 - Introduction
 - Distributing Data on the web with RDF
 - Naming the Data : URIs (Uniform Resources Identifiers)
 - The RDF Data model
 - Querying Linked Data with SPARQL
 - Semantic modelling
 - RDFS
 - OWL
 - Conclusion

Resource Description Framework (RDF)

Linked Data: 3rd Principle

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



Most apps use only a subset of the stack

Querying allows fine-grained data access

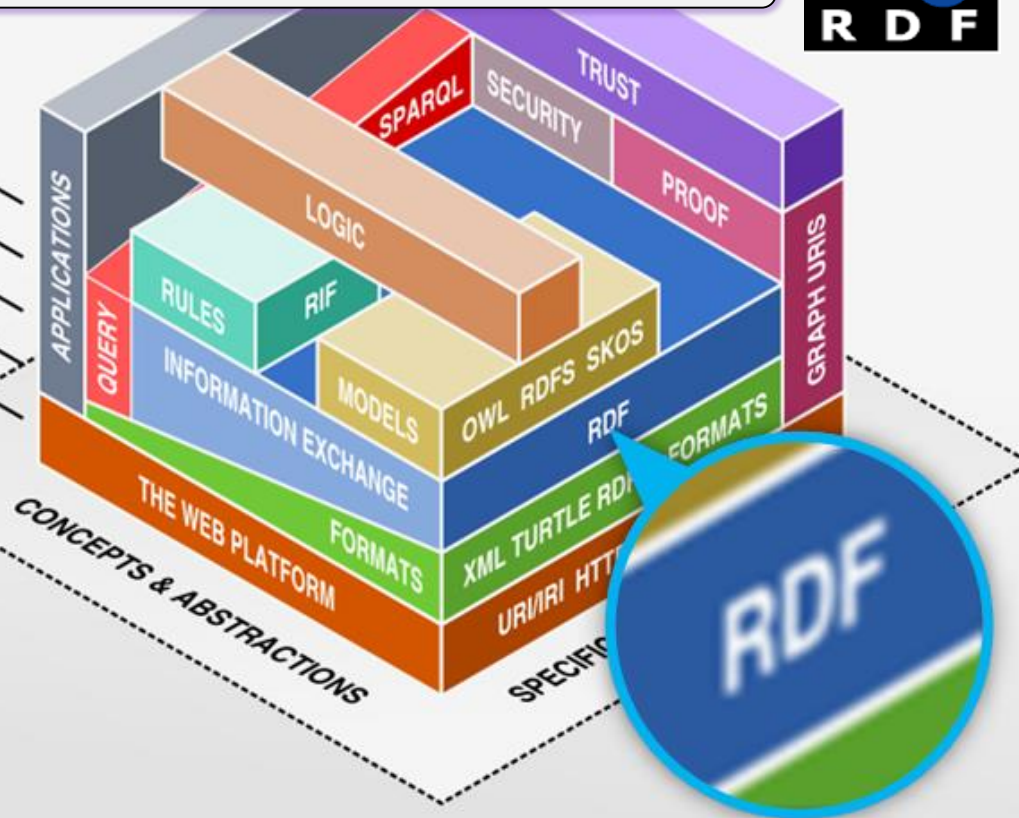
Standardized information exchange is key

Formats are necessary, but not too important

The Semantic Web is based on the Web

Linked Data uses a small selection of technologies

LINKED DATA



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

Resource Description Framework

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

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

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

Resource ?

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

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

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

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

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



RDF outline

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

RDF Data Model

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

the thing described	property	value
Georges Brassens	was born in	Sète

RDF Data Model

- RDF Statements are *triples*

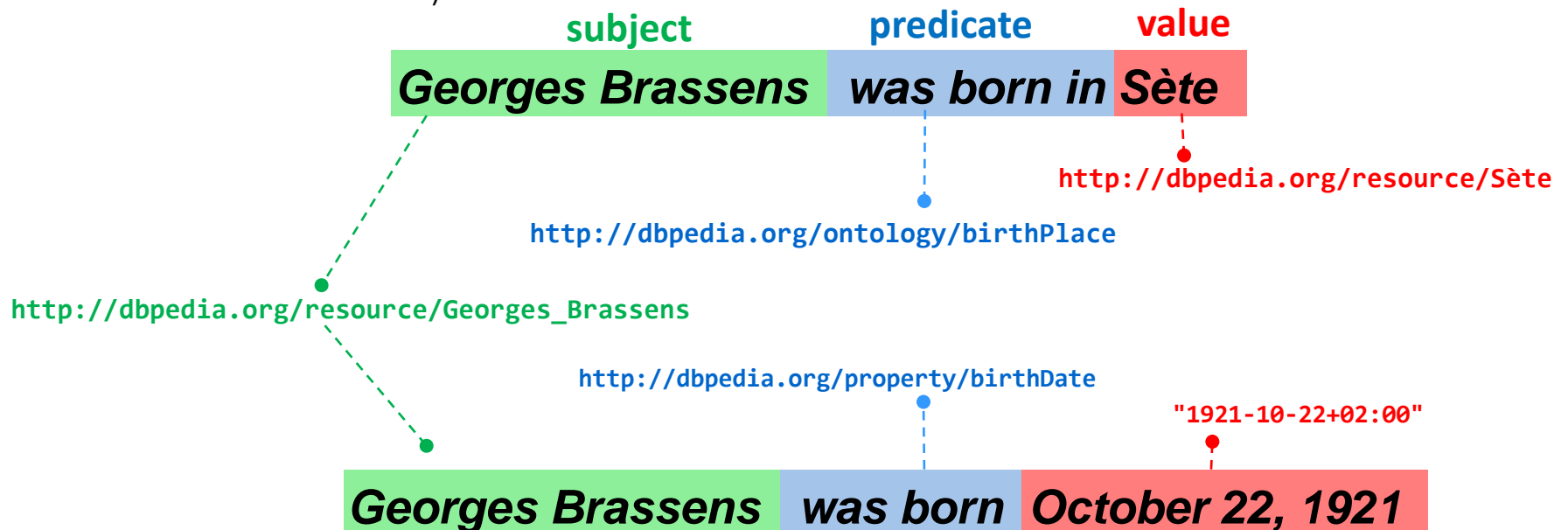
Subject **Predicate** **Object**

URI

URI

URI/Literal

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



RDF Data Model

- RDF Statements are *triples*

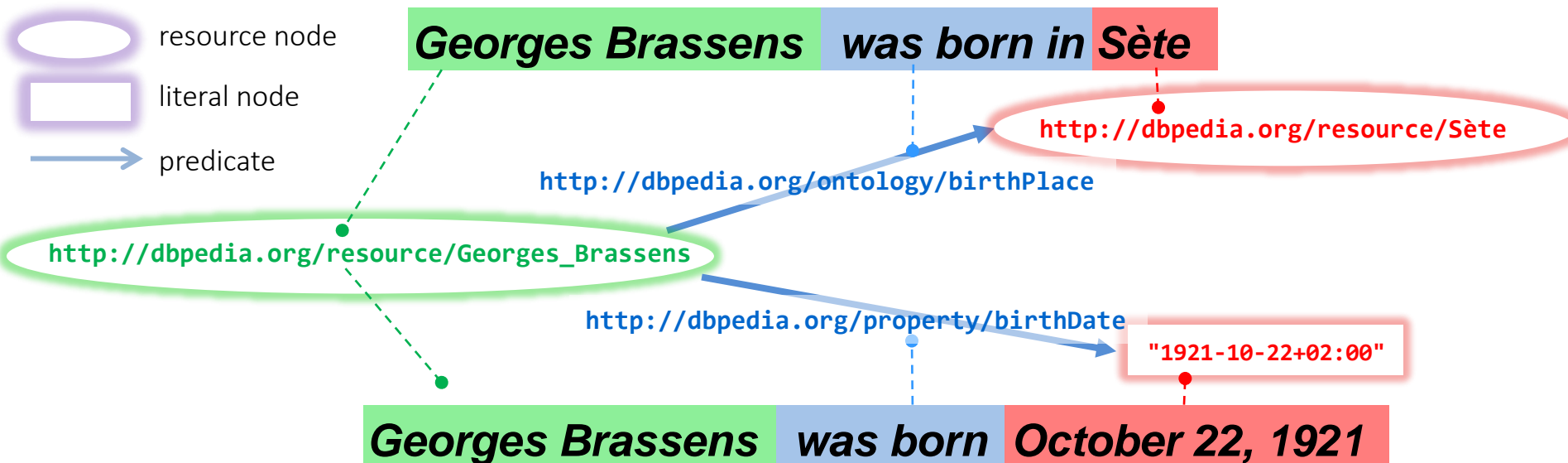
Subject **Predicate** **Object**

URI

URI

URI/Literal

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



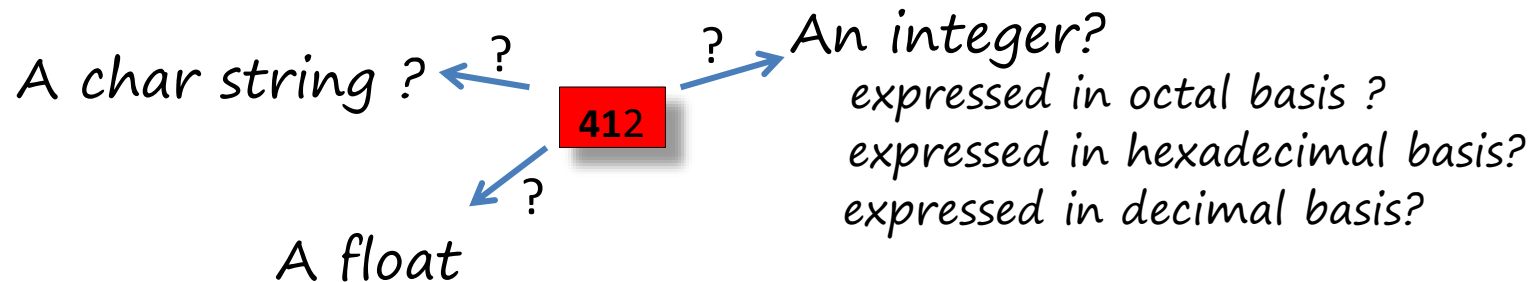
Typed Literals

- Literal are not resources : they are values



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

But what about a computer program ?



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

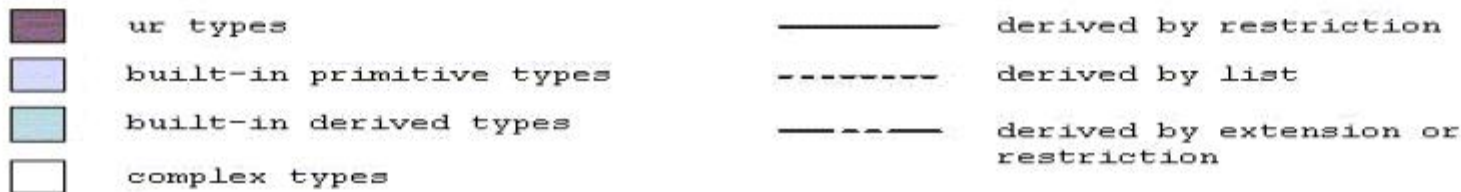
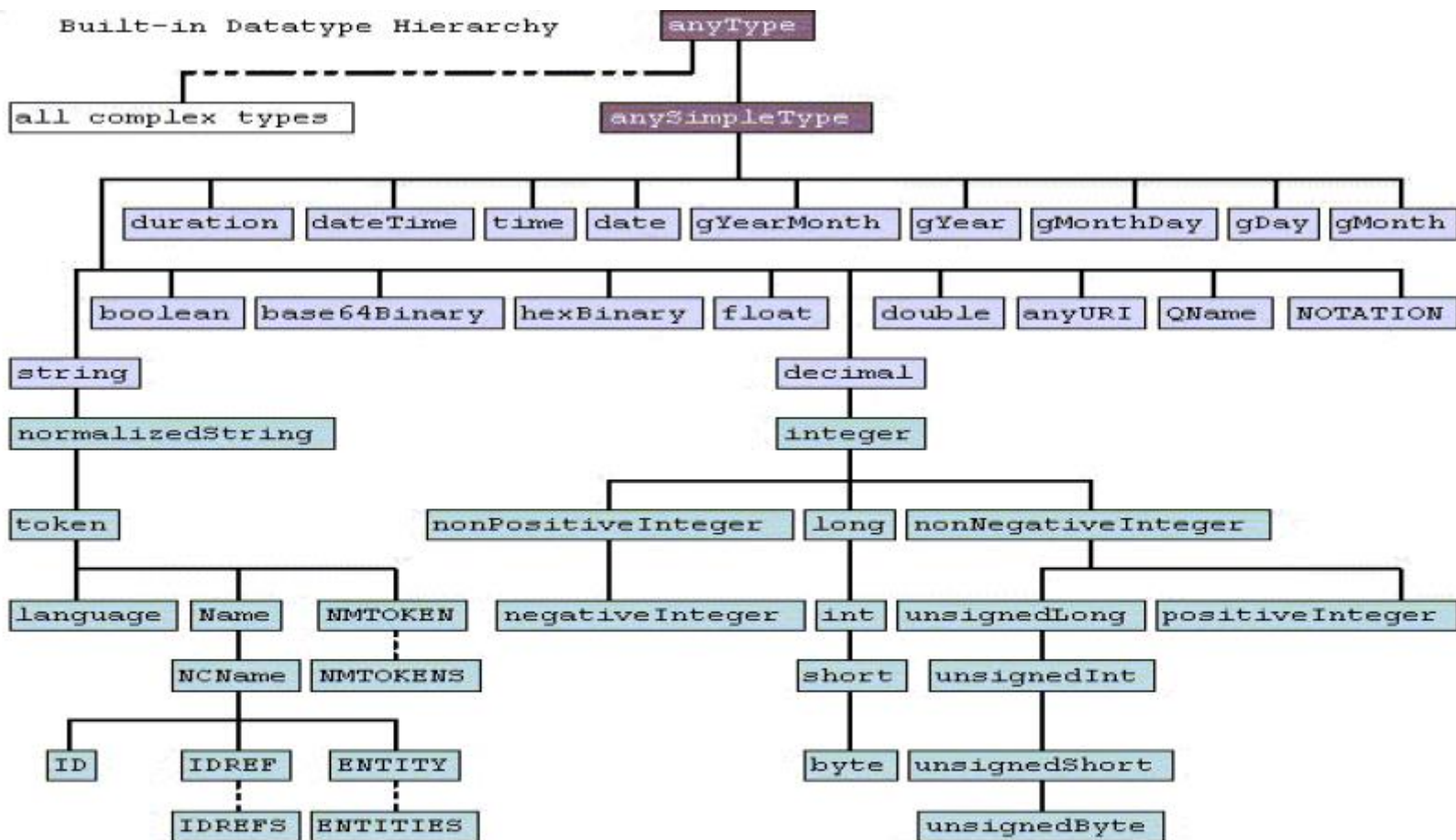
Typed Literals

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

Typed Literals : XSD

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

Typed Literals: XSD



Typed Literals: XSD

- examples of definition of new data types

new type derived by restrictions

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

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

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

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

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

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

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

```
  ...
```

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

the "super" type

} constraints to express the restriction

new type derived by list

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

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

```
</simpleType>
```

type of the list elements

+ constraints about the list length, maxLength, minLength

Typed Literals : XSD

new type derived by union and extension

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

type defined
by union

type defined by
restrictions

type defined
by extension

fontsize : 8-72 or small, medium, large

Typed Literals

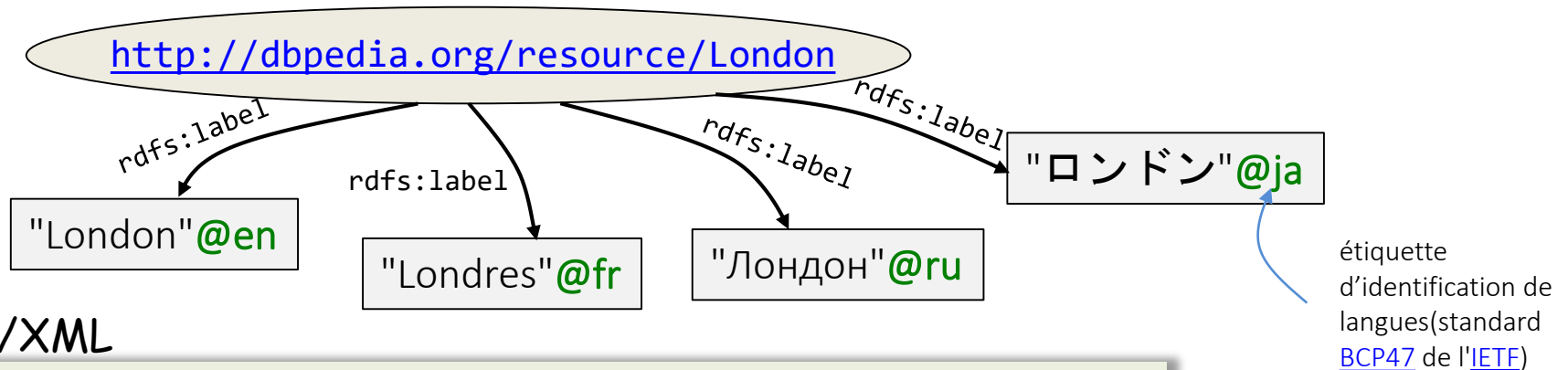
- Turtle : **literalvalue^^dataTypeURI**

```
@prefix dbo:    <http://dbpedia.org/ontology/> .
@prefix dbr:    <http://dbpedia.org/resource/> .
@prefix ns9:    <http://dbpedia.org/ontology/PopulatedPlace/> .
@prefix rdf:    <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix xsd:    <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs:   <http://www.w3.org/2000/01/rdf-schema#> .
```

```
dbr:Grenoble a          dbo:Place , <http://schema.org/Place> ,
  rdfs:comment          "Grenoble (IPA: ɡʁə.'nɔbl ; Grenoblo in ..."
  rdfs:label            "Grenoble"@fr , "Grenoble"@pl , "
  dbo:abstract          "Grenoble (prononcé [ɡʁə.'nɔbl ] ,...)"
  ns9:area              "18.44"^^<http://dbpedia.org/datatype/squareKilometre> ;
  dbo:country           dbr:France ;
  dbo:department        dbr:Isère ;
  dbo:elevation          "398.0"^^xsd:double ;
  dbo:inseeCode         "38185" ;
  dbo:intercommunality  dbr:Grenoble-Alpes_Métropole ;
  dbo:maximumElevation  "500.0"^^xsd:double ;
  dbo:mayor             dbr:Éric_Piolle ;
  dbo:minimumElevation  "212.0"^^xsd:double ;
  dbo:populationTotal   "156659"^^xsd:nonNegativeInteger ;
  dbo:postalCode        "38000, 38100" ;
  dbo:region            dbr:Rhône-Alpes ;
  ...
```


Localized textual literals

- A language can be associated to textual literals



RDF/XML

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

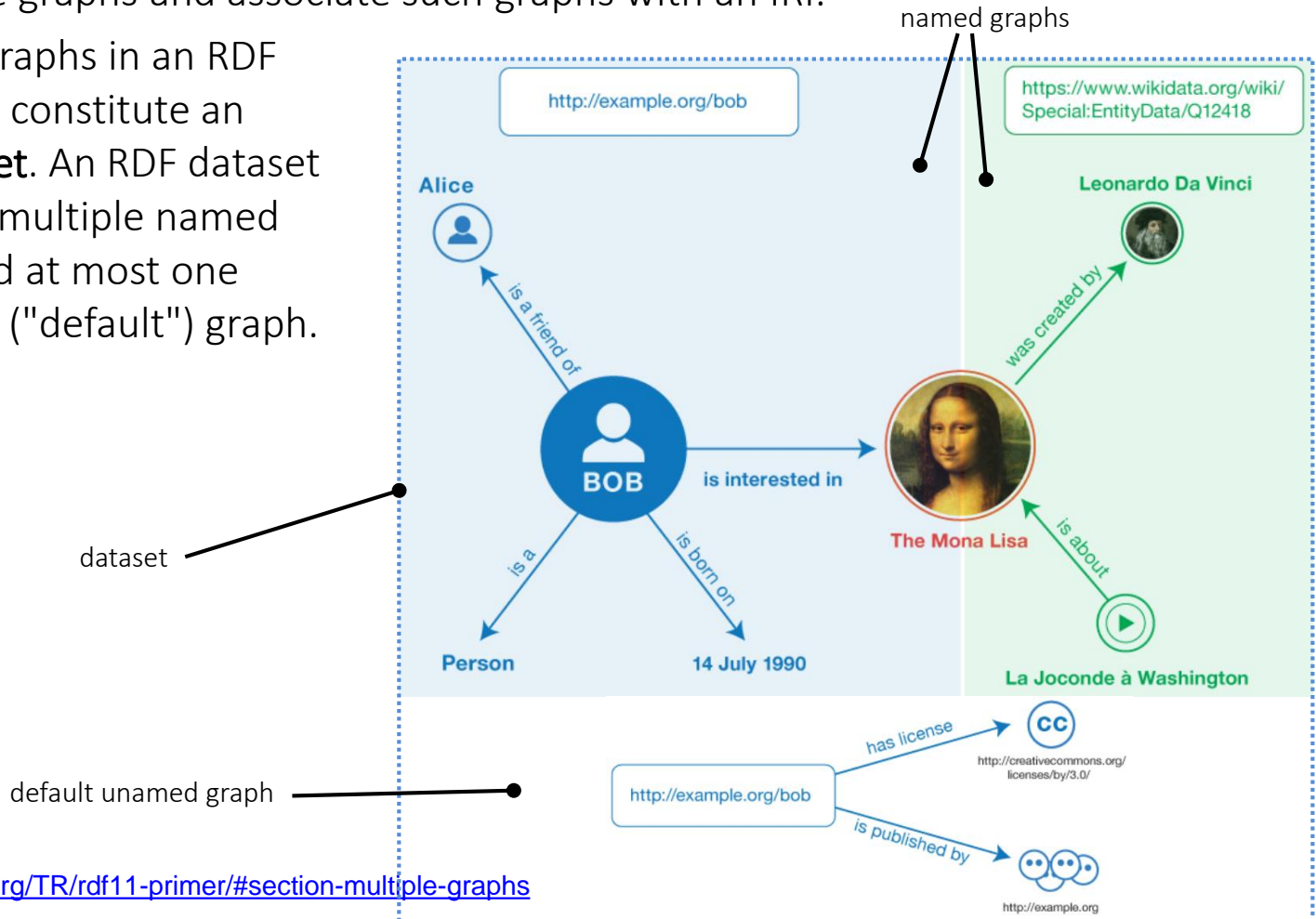
Turtle

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

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

RDF Datasets

- In practice, RDF tool builders and data managers needed a mechanism to talk about subsets of a collection of triples → RDF 1.1 a mechanism to group RDF statements in multiple graphs and associate such graphs with an IRI.
- Multiple graphs in an RDF document constitute an **RDF dataset**. An RDF dataset may have multiple named graphs and at most one unnamed ("default") graph.



<https://www.w3.org/TR/rdf11-primer/#section-multiple-graphs>

RDF outline

- RDF Model
- **Typed and localized literals**
- RDF serialization formats
- Blank nodes
- Resources definition
- RDF and data integration
- Persisting RDF
- References

RDF outline

- RDF Model
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RDF Serializations

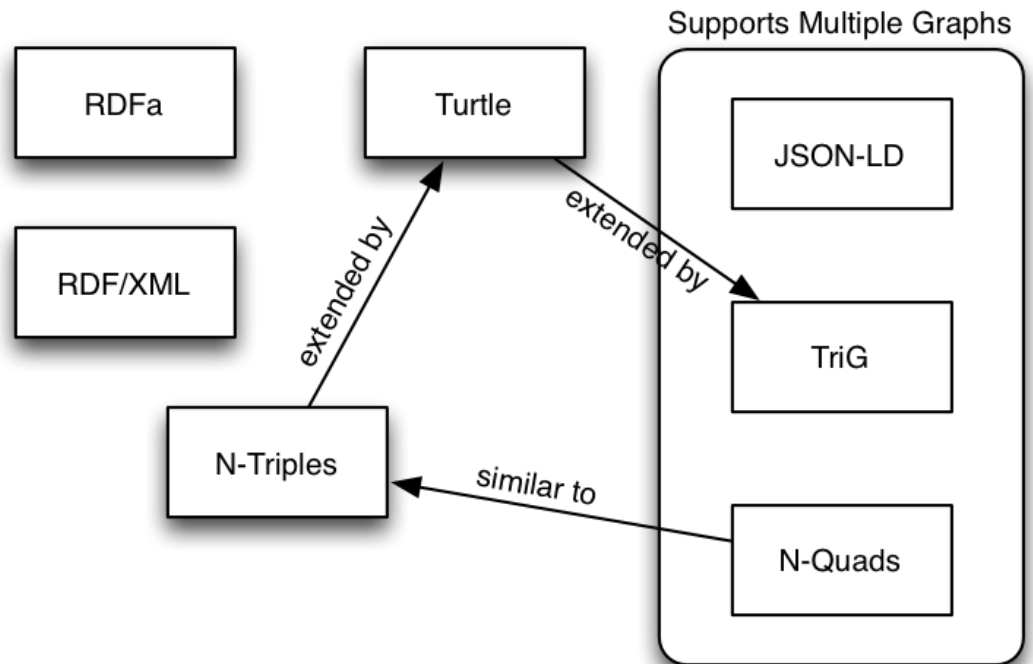
- RDF Graphs
 - good for human analysis but unsuitable for application exchange
- RDF serialization
 - provides a way to convert between the abstract model and a concrete syntax (format for files or other byte stream)
 - several equally expressive serialization formats
 - XML/RDF (normative (standard)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

RDF Serializations

RDF 1.0



RDF 1.1



<https://www.w3.org/TR/rdf11-new/#section-serializations>

RDF Serializations - N-Triples

media type*: `application/n-triples`

*media type (formerly known as MIME, Multipurpose Internet Mail Extensions, type) : a two-part identifier for file formats and format contents transmitted on the Internet <https://www.iana.org/assignments/media-types/media-types.xhtml>

RDF 1.0

RDF/XML

N-Triples

RDF 1.1

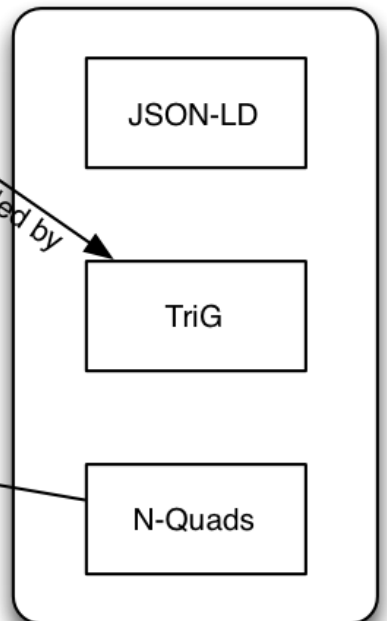
RDFa

RDF/XML

Turtle

N-Triples

Supports Multiple Graphs



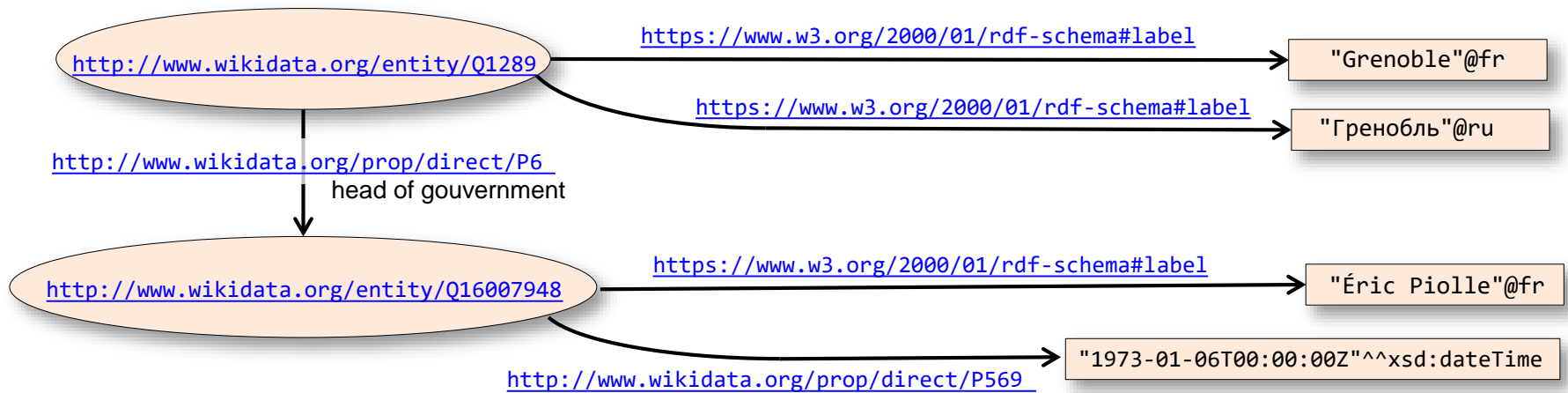
extended by

extended by

similar to

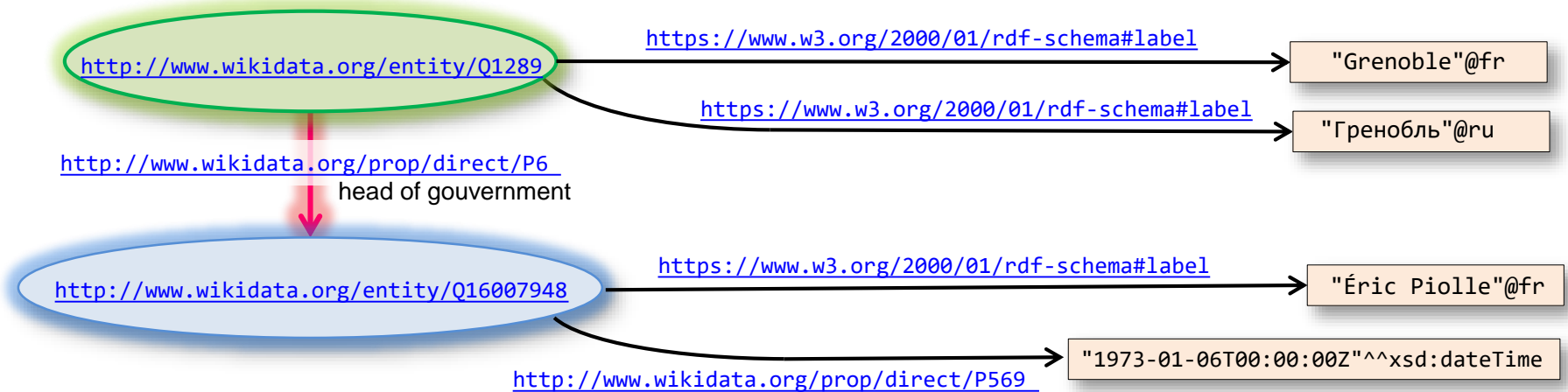
<https://www.w3.org/TR/rdf11-new/#section-serializations>

RDF Serialization - N-Triples



- the simplest notation
 - each line of output represents a single statement followed by '.'

RDF Serialization - N-Triples



- the simplest notation

- each line of output represents a single statement followed by '.'
- resources (subject, predicate, resource object) expressed as absolute URI enclosed in angle brackets

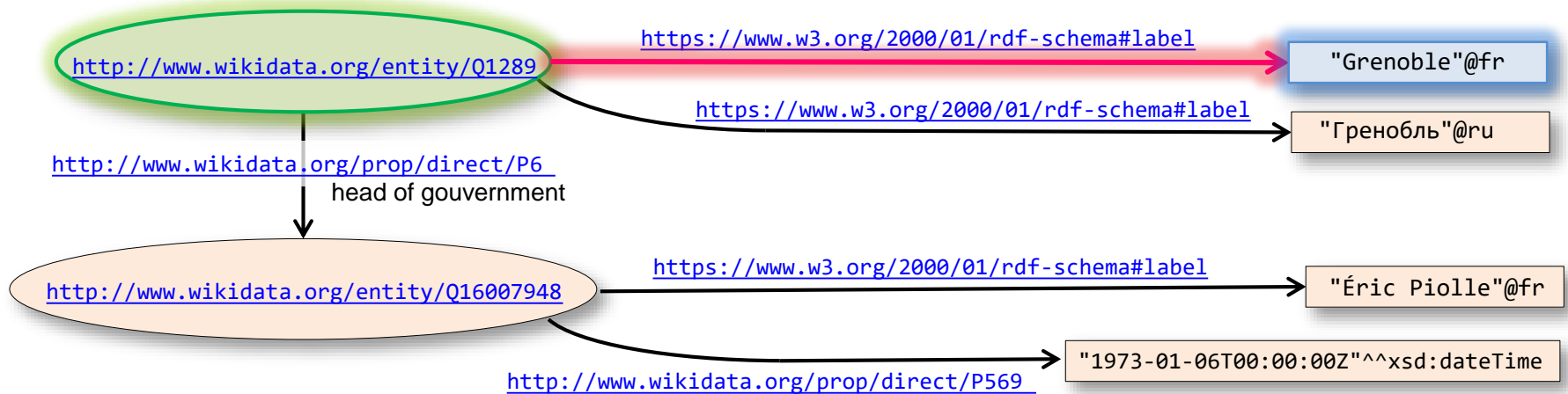
subject

predicate

object

<<http://www.wikidata.org/entity/Q1289>> <<http://www.wikidata.org/prop/direct/P6>> <<http://www.wikidata.org/entity/Q16007948>> .

RDF Serialization - N-Triples



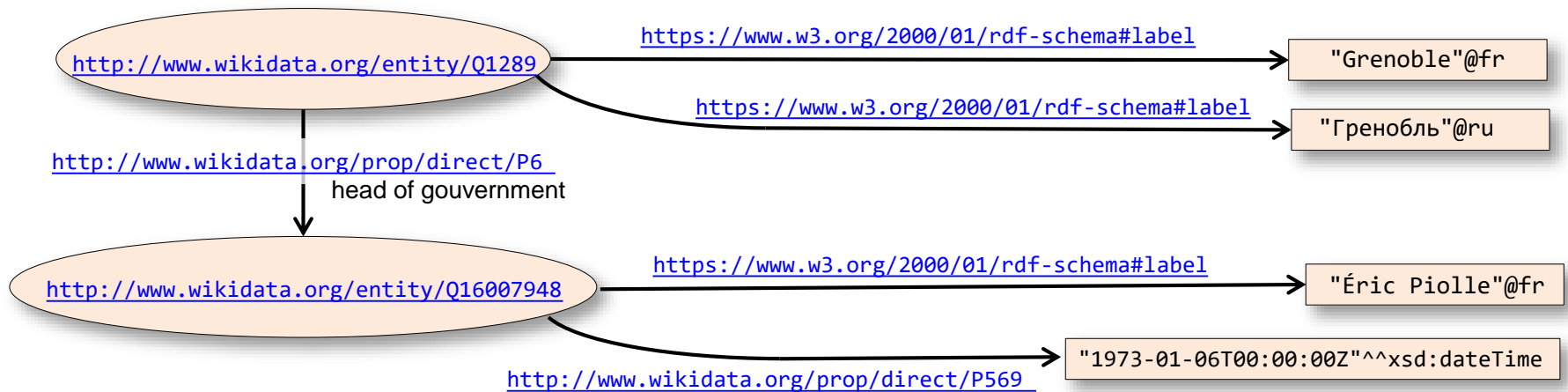
- the simplest notation

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

```
<http://www.wikidata.org/entity/Q1289> <http://www.wikidata.org/prop/direct/P6> <http://www.wikidata.org/entity/Q16007948>.
```

```
<http://www.wikidata.org/entity/Q1289> <https://www.w3.org/2000/01/rdf-schema#label> "Grenoble"@fr .
```

RDF Serialization - N-Triples

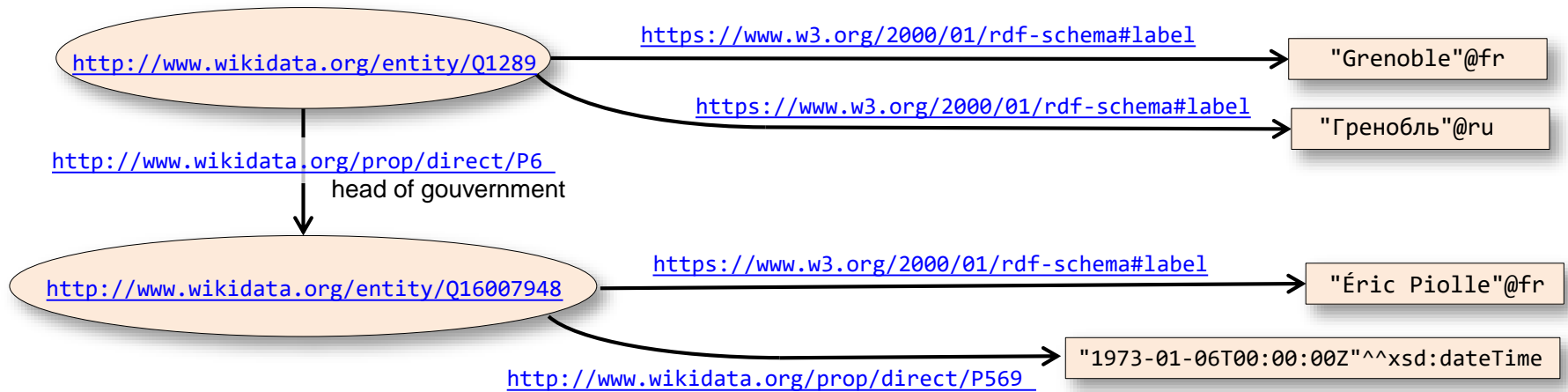


- the simplest notation

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

```
<http://www.wikidata.org/entity/Q1289> <http://www.wikidata.org/prop/direct/P6> <http://www.wikidata.org/entity/Q16007948> .  
<http://www.wikidata.org/entity/Q1289> <https://www.w3.org/2000/01/rdf-schema#label> "Grenoble"@fr .  
<http://www.wikidata.org/entity/Q1289> <https://www.w3.org/2000/01/rdf-schema#label> "Гренобль"@ru .  
<http://www.wikidata.org/entity/Q16007948> <https://www.w3.org/2000/01/rdf-schema#label> "Éric Piolle"@fr .  
<http://www.wikidata.org/entity/Q16007948> <http://www.wikidata.org/prop/direct/P569>  
"1973-01-06T00:00:00Z"^^<http://www.w3.org/2001/XMLSchema#dateTime> .
```

RDF Serialization - N-Triples



- the simplest notation

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

```
<http://www.wikidata.org/entity/Q1289> <http://www.wikidata.org/prop/direct/P6> <http://www.wikidata.org/entity/Q16007948> .
<http://www.wikidata.org/entity/Q1289> <https://www.w3.org/2000/01/rdf-schema#label> "Grenoble"@fr .
<http://www.wikidata.org/entity/Q1289> <https://www.w3.org/2000/01/rdf-schema#label> "Гренобль"@ru .
<http://www.wikidata.org/entity/Q16007948> <https://www.w3.org/2000/01/rdf-schema#label> "Éric Piolle"@fr .
<http://www.wikidata.org/entity/Q16007948> <http://www.wikidata.org/prop/direct/P569> <http://www.w3.org/2001/XMLSchema#dateTime> "1973-01-06T00:00:00Z"^^<http://www.w3.org/2001/XMLSchema#dateTime> .
```

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

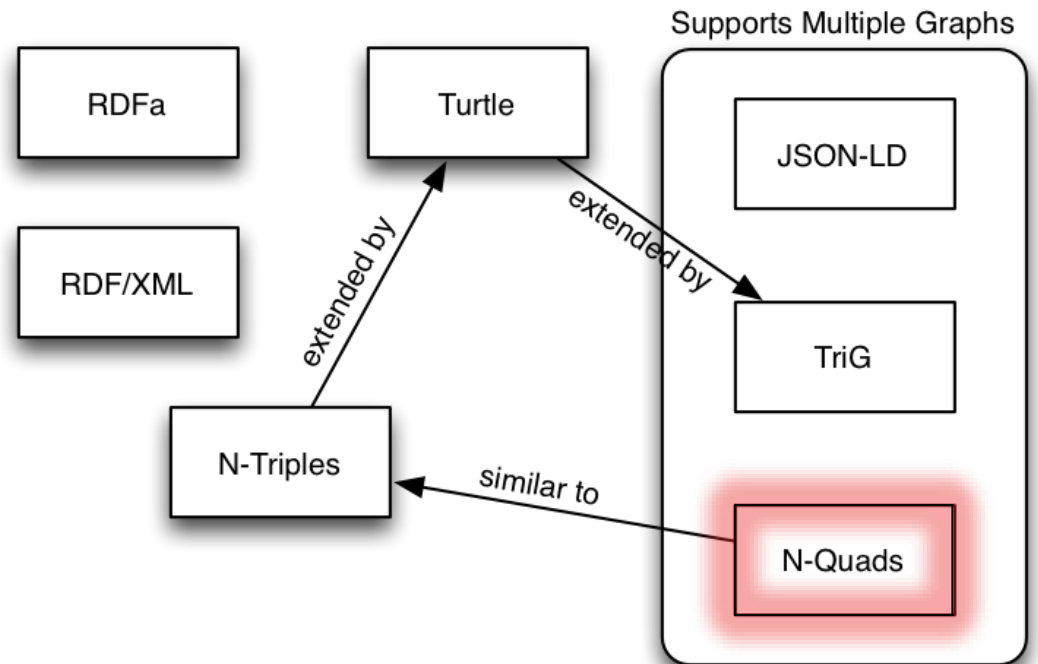
RDF Serializations - N-Quads

MIME type: application/n-quads

RDF 1.0



RDF 1.1

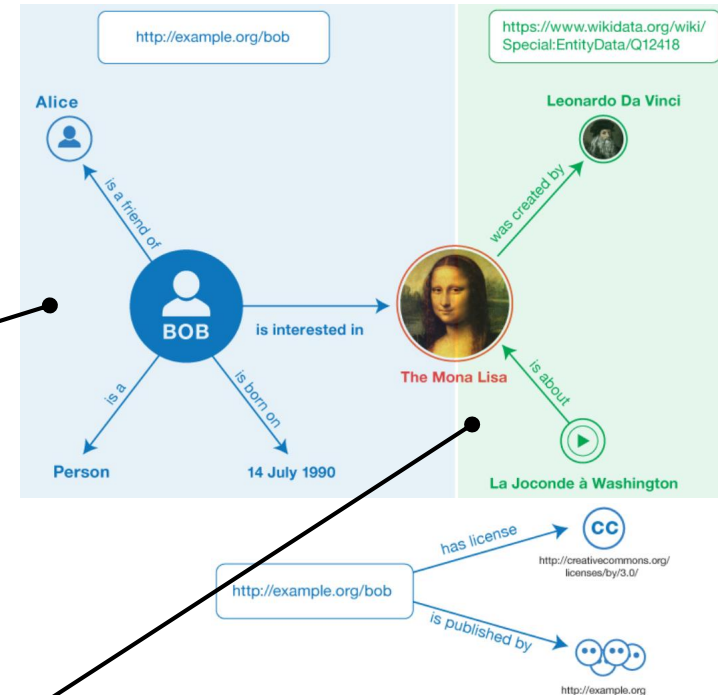


<https://www.w3.org/TR/rdf11-new/#section-serializations>

RDF Serializations - N-Quads

- support RDF datasets

```
01 <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> .
02 <http://example.org/bob#me>
  <http://xmlns.com/foaf/0.1/knows>
  <http://example.org/alice#me>
  <http://example.org/bob> .
03 <http://example.org/bob#me> <http://schema.org/birthDate>
  "1990-07-04"^^<http://www.w3.org/2001/XMLSchema#date>
  <http://example.org/bob> .
04 <http://example.org/bob#me>
  <http://xmlns.com/foaf/0.1/topic_interest>
  <http://www.wikidata.org/entity/Q12418>
  <http://example.org/bob> .
05 <http://www.wikidata.org/entity/Q12418> <http://purl.org/dc/terms/title>
  "Mona Lisa" <https://www.wikidata.org/wiki/Special:EntityData/Q12418> .
06 <http://www.wikidata.org/entity/Q12418> <http://purl.org/dc/terms/creator>
  <http://dbpedia.org/resource/Leonardo_da_Vinci>
  <https://www.wikidata.org/wiki/Special:EntityData/Q12418> .
07 <http://data.europeana.eu/item/04802/243FA8618938F4117025F17A8B813C5F9AA4D619>
  <http://purl.org/dc/terms/subject> <http://www.wikidata.org/entity/Q12418>
  <https://www.wikidata.org/wiki/Special:EntityData/Q12418> .
08 <http://example.org/bob> <http://purl.org/dc/terms/publisher> <http://example.org> .
09 <http://example.org/bob> <http://purl.org/dc/terms/rights>
  <http://creativecommons.org/licenses/by/3.0/> .
```



default graph

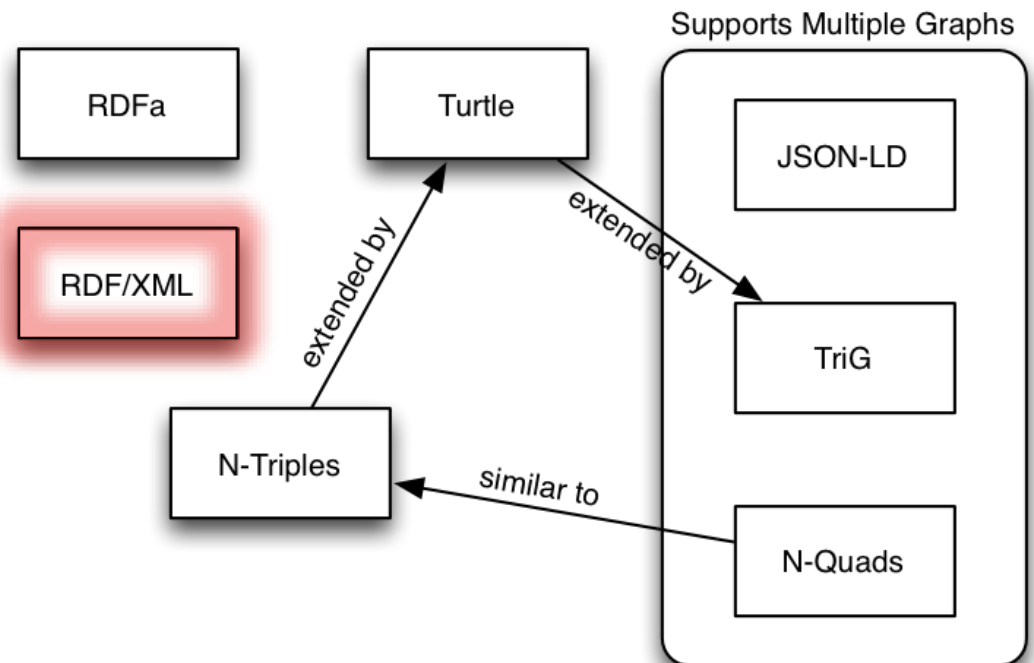
RDF Serializations - RDF/XML

media (MIME) type: application/rdf+xml

RDF 1.0



RDF 1.1



<https://www.w3.org/TR/rdf11-new/#section-serializations>

RDF Serializations : RDF/XML

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

gives the subject of all statement within the description

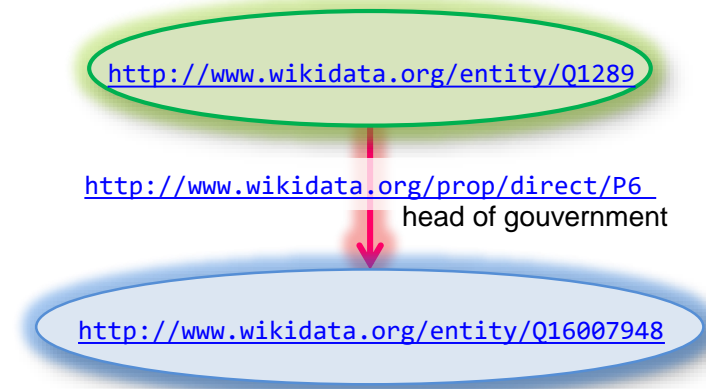
```
<rdf:Description rdf:about="subjectURI">  
  <predicate rdf:resource="objectURI" />  
  <predicate>literal value</predicate>  
</rdf:Description>
```

name of the internal tags represent a predicate

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

RDF Serializations : RDF/XML

- Example



XML declaration (states that's an XML document)

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

```
<rdf:RDF
```

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

```
  <rdf:Description
```

```
    rdf:about="http://www.wikidata.org/entity/Q1289">
```

```
    <wdt:P6
```

```
      rdf:resource="http://www.wikidata.org/entity/Q16007948" />
```

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

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

XML namespaces

Resources URIs

rdf:DescriptionElement for statements about a resource

opening
and
closing
root tag

RDF Serializations : RDF/XML

"Grenoble"@fr

②

<http://www.wikidata.org/entity/Q1289>

<http://www.wikidata.org/prop/direct/P6>

①

<http://www.wikidata.org/entity/Q16007948>

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

```
<rdf:RDF
```

```
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:wdt="http://www.wikidata.org/prop/direct/"
  xmlns:rdfs="https://www.w3.org/2000/01/rdf-schema#"
  >
```

```
① <rdf:Description
    rdf:about="http://www.wikidata.org/entity/Q1289">
    <wdt:P6
      rdf:resource="http://me.jtpollock.us/foaf.rdf#me" />
  </rdf:Description>
```

```
② <rdf:Description
    rdf:about="http://www.wikidata.org/entity/Q1289">
    <rdfs:label xml:lang="fr">Grenoble<rdfs:label>
  </rdf:Description>
```

```
<rdf:Description
  rdf:about=" http://www.wikidata.org/entity/Q1289">
  ...
</rdf:Description>
```

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

RDF Serializations : RDF/XML

"Grenoble"@fr

②

<http://www.wikidata.org/entity/Q1289>

<http://www.wikidata.org/prop/direct/P6>

①

<http://www.wikidata.org/entity/Q16007948>

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

```
<rdf:RDF
```

```
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:wdt="http://www.wikidata.org/prop/direct/"
  xmlns:rdfs="https://www.w3.org/2000/01/rdf-schema#"
  >
```

```
<rdf:Description
```

```
  rdf:about="http://www.wikidata.org/entity/Q1289">
```

```
  <wdt:P6
```

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

```
  <rdfs:label xml:lng="fr">Grenoble</rdfs:label>
```

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

```
<rdf:Description
```

```
  rdf:about="http://www.wikidata.org/entity/Q1289">
```

```
  ...
```

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

```
...
```

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

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

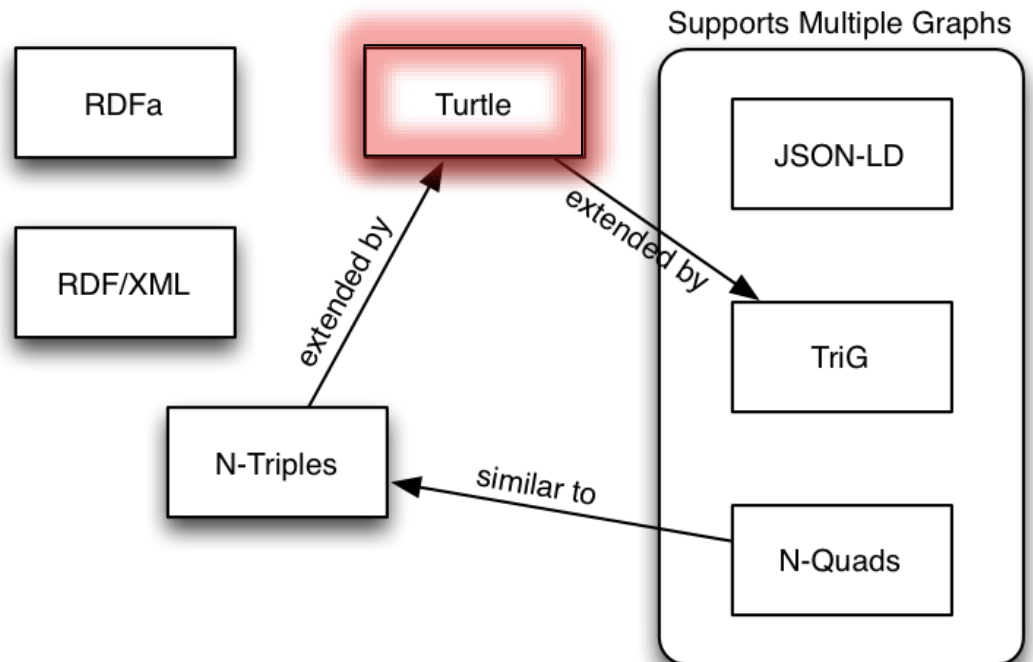
RDF Serializations - Turtle

media (MIME) type: text/turtle

RDF 1.0



RDF 1.1



<https://www.w3.org/TR/rdf11-new/#section-serializations>

RDF Serialization - N3 - Turtle

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

```
<http://www.wikidata.org/entity/Q1289> <http://www.wikidata.org/prop/direct/P6>
                                     <http://www.wikidata.org/entity/Q16007948> .
<http://www.wikidata.org/entity/Q1289> <https://www.w3.org/2000/01/rdf-schema#label> "Grenoble"@fr .
```



```
@prefix wd: <http://www.wikidata.org/entity/> .
@prefix wdt: <http://www.wikidata.org/prop/direct/>
@prefix rdfs: <https://www.w3.org/2000/01/rdf-schema#>
```

```
wd:Q1289 wdt:P6 wd:Q16007948 .
wd:Q1289 rdfs:label "Grenoble"@fr .
```

RDF Serialization - N3 - Turtle

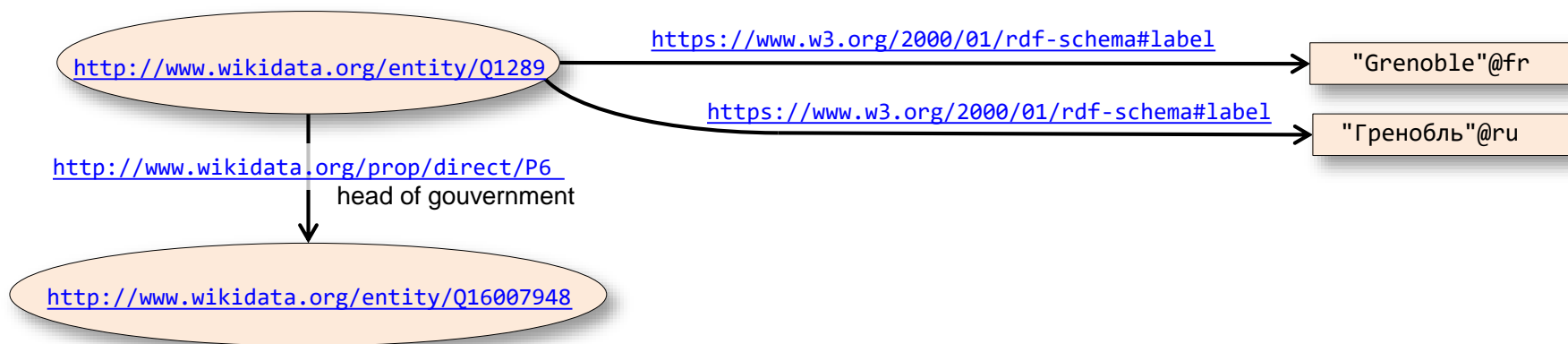


- possibility to combine multiple statements about the same subject using a semicolon (;)

```
@prefix wd: <http://www.wikidata.org/entity/> .
@prefix wdt: <http://www.wikidata.org/prop/direct/> .
@prefix rdfs: <https://www.w3.org/2000/01/rdf-schema#> .

wd:Q1289 wdt:P6 wd:Q16007948 ;
        rdfs:label "Grenoble"@fr .
```

RDF Serialization - N3 - Turtle

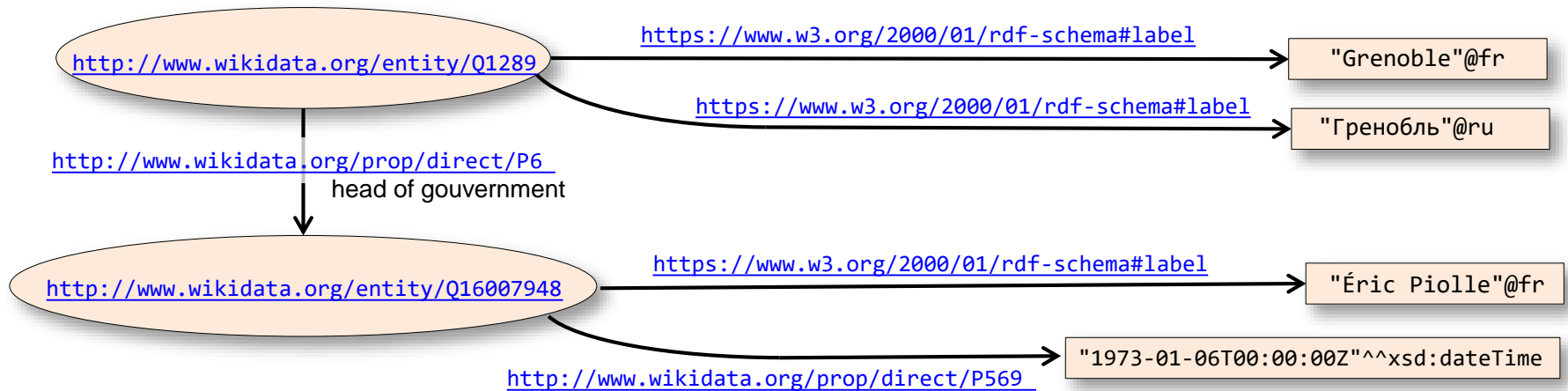


- possibility to combine multiple statements involving the same subject and predicate using a coma (',')

```
@prefix wd: <http://www.wikidata.org/entity/> .  
@prefix wdt: <http://www.wikidata.org/prop/direct/> .  
@prefix rdfs: <https://www.w3.org/2000/01/rdf-schema#> .  
  
wd:Q1289 wdt:P6 wd:Q16007948 ;  
    rdfs:label "Grenoble"@fr , "Гренобль"@ru .
```

ne pas oublier le
point terminal

RDF Serialization - N3 - Turtle



```
@prefix wd: <http://www.wikidata.org/entity/> .
@prefix wdt: <http://www.wikidata.org/prop/direct/> .
@prefix rdfs: <https://www.w3.org/2000/01/rdf-schema#> .

wd:Q1289 wdt:P6 wd:Q16007948 ;
        rdfs:label "Grenoble"@fr , "Гренобль"@ru .

wd:Q16007948 rdfs:label "Éric Piolle"@fr ;
            wdt:P569 "1973-01-06T00:00:00Z"^^xsd:dateTime .
```

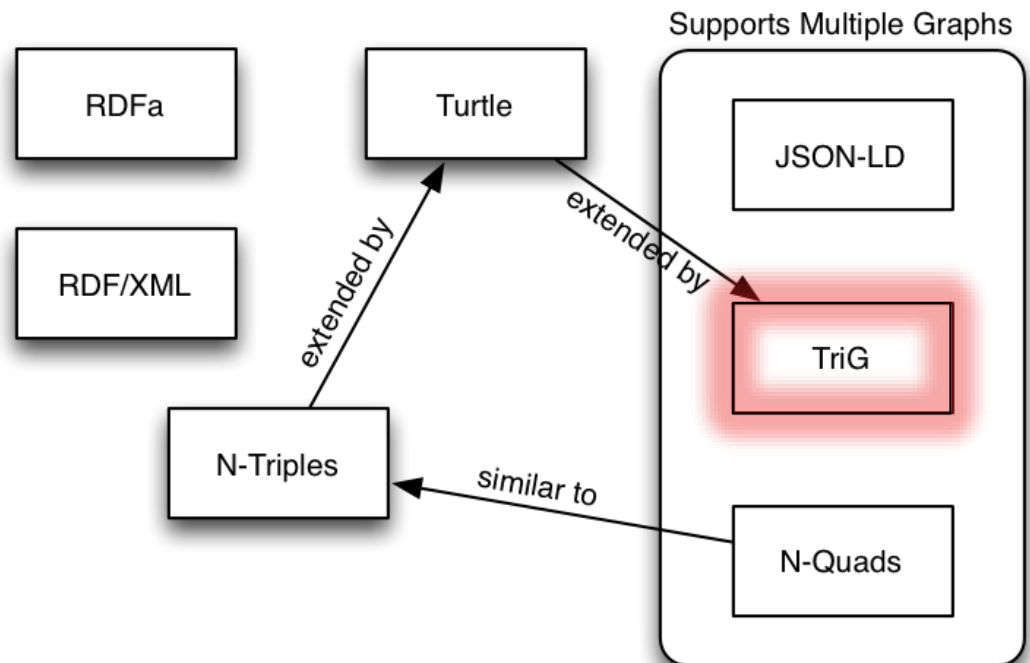

RDF Serialization - TriG

media (MIME) type: `application/trig`

RDF 1.0



RDF 1.1



Turtle syntax supports only the specification of single graphs without a means for "naming" them
TriG is an extension of Turtle enabling the specification of multiple graphs in the form of an RDF dataset.

RDF Serialization - TriG

- support RDF datasets

```

01 BASE <http://example.org/>
02 PREFIX foaf: <http://xmlns.com/foaf/0.1/>
03 PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
04 PREFIX schema: <http://schema.org/>
05 PREFIX dcterms: <http://purl.org/dc/terms/>
06 PREFIX wd: <http://www.wikidata.org/entity/>

```

```

07
08 GRAPH <http://example.org/bob>
09 {
10   <bob#me>
11     a foaf:Person ;
12     foaf:knows <alice#me> ;
13     schema:birthDate "1990-07-04"^^xsd:date ;
14     foaf:topic_interest wd:Q12418 .
15 }

```

```

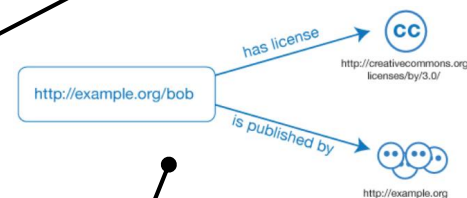
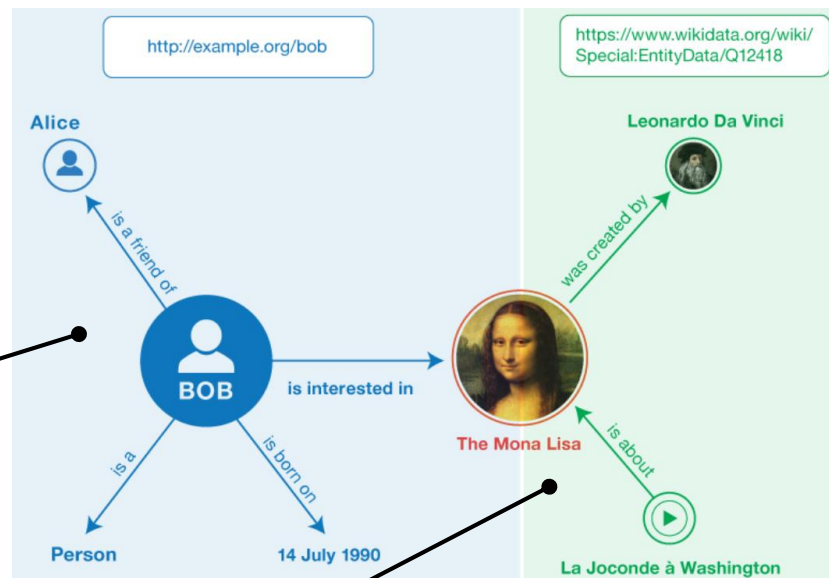
16
17 GRAPH <https://www.wikidata.org/wiki/Special:EntityData/Q12418>
18 {
19   wd:Q12418
20     dcterms:title "Mona Lisa" ;
21     dcterms:creator <http://dbpedia.org/resource/Leonardo_da_Vinci> .
22
23   <http://data.europeana.eu/item/04802/243FA8618938F4117025F17A8B813C5F9AA4D619>
24     dcterms:subject wd:Q12418 .
25 }

```

```

26
27 <http://example.org/bob>
28   dcterms:publisher <http://example.org> ;
29   dcterms:rights <http://creativecommons.org/licenses/by/3.0/> .

```



default graph

RDF Serialization - RDFa

RDFa = RDF in attributes

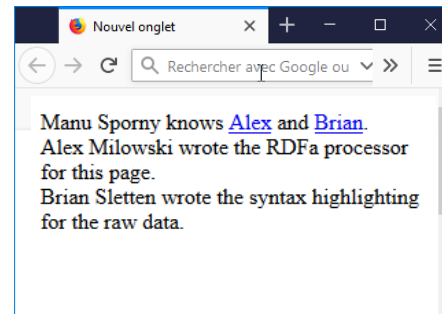
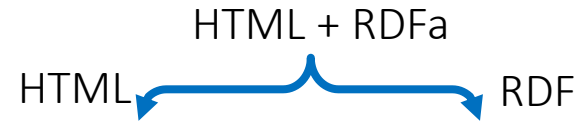
- to add metadata (RDF annotations) in (X)HTML documents
- use existing attributes (e.g. href, src) and introduce new ones (vocab, typeof, property, resource, prefix)

```
<div vocab="http://xmlns.com/foaf/0.1/">
  <div resource="#manu" typeof="Person">
    <span property="name">Manu Sporny</span> knows
    <a property="knows" href="#alex">Alex</a> and
    <a property="knows" href="#brian">Brian</a>.
  </div>
  <div resource="#alex" typeof="Person">
    <span property="name">Alex Milowski</span> wrote the RDFa processor for this page.
  </div>
  <div resource="#brian" typeof="Person">
    <span property="name">Brian Sletten</span> wrote the syntax highlighting for the raw data.
  </div>
</div>
```

<https://rdfa.info/play/>

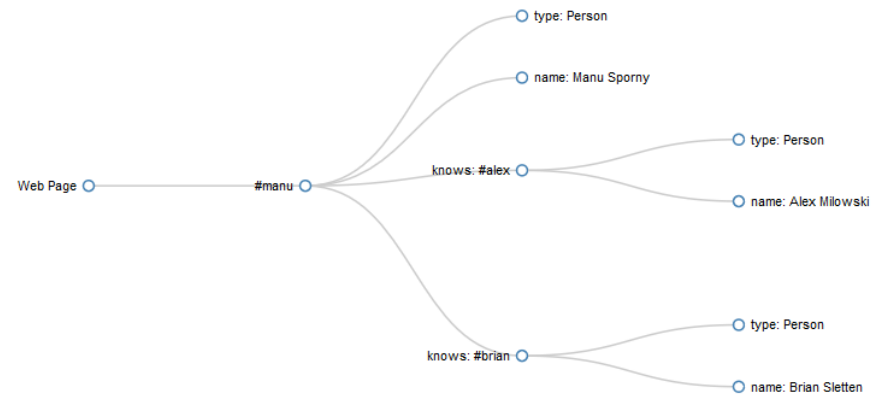
<https://rdfa.info/>

The screenshot shows the RDFa website with a navigation bar (RDFa, Play, Documentation, Tools, Developers). The main content includes a yellow-highlighted section titled "Linked Data in HTML" explaining that RDFa is an extension to HTML5 for markup. Below that is a section titled "Linked Data" with a paragraph about data silos and a link to "Learn more about Linked Data". The "Immediate Benefits" section lists advantages like enhanced search engine results and social media integration.

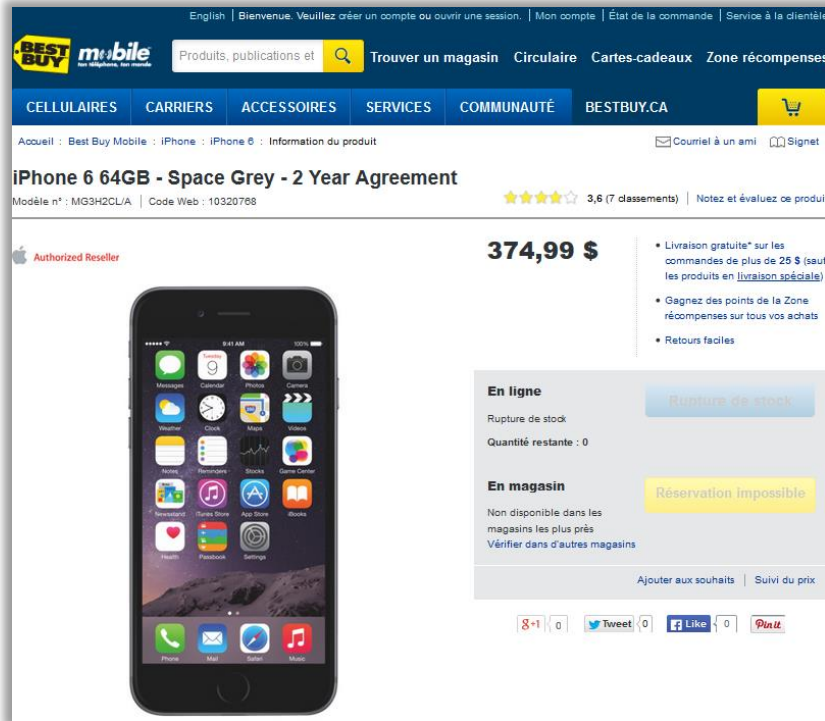


```
@prefix rdfa: <http://www.w3.org/ns/rdfa#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

<https://rdfa.info/play/>
  rdfa:usesVocabulary foaf: .
<https://rdfa.info/play/#manu>
  rdf:type foaf:Person;
  foaf:name "Manu Sporny";
  foaf:knows <https://rdfa.info/play/#alex>;
  foaf:knows <https://rdfa.info/play/#brian> .
<https://rdfa.info/play/#alex>
  rdf:type foaf:Person;
  foaf:name "Alex Milowski" .
<https://rdfa.info/play/#brian>
  rdf:type foaf:Person;
  foaf:name "Brian Sletten" .
```



RDF Serialization - RDFa



RDFa used par :

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

...



RDF Serialization - RDFa

- https://w3techs.com/technologies/overview/structured_data/all

W³Techs

Web Technology Surveys

W3Techs - World Wide Web Technology Surveys

W3Techs provides information about the usage of various types of technologies on the web.

Our vision

Provide the most reliable and most extensive source of information on web technology usage.

Technologies > Structured Data

Usage of structured data formats for websites

This diagram shows the percentages of websites using various structured data formats. See [technologies overview](#) for explanations on the methodologies used in the surveys. Our reports are updated daily.

How to read the diagram:
45.5% of the websites use none of the structured data formats that we monitor.
RDFa is used by 47.7% of all the websites.

None	45.5%
RDFa	47.7%
Meta-tag-based formats	29.0%
JSON-LD	26.5%
Microdata	15.1%
Microformats	0.1%

W3Techs.com, 2 October 2019

Percentages of websites using various structured data formats
Note: a website may use more than one structured data format

Is there a technology missing?

Registered users can [make a proposal](#) to add a technology.

Do you want to stay informed about this survey?

Use our monthly technology survey [RSS](#) [RSS Feed](#).

Registered users can also [subscribe](#) to a monthly technology survey email.

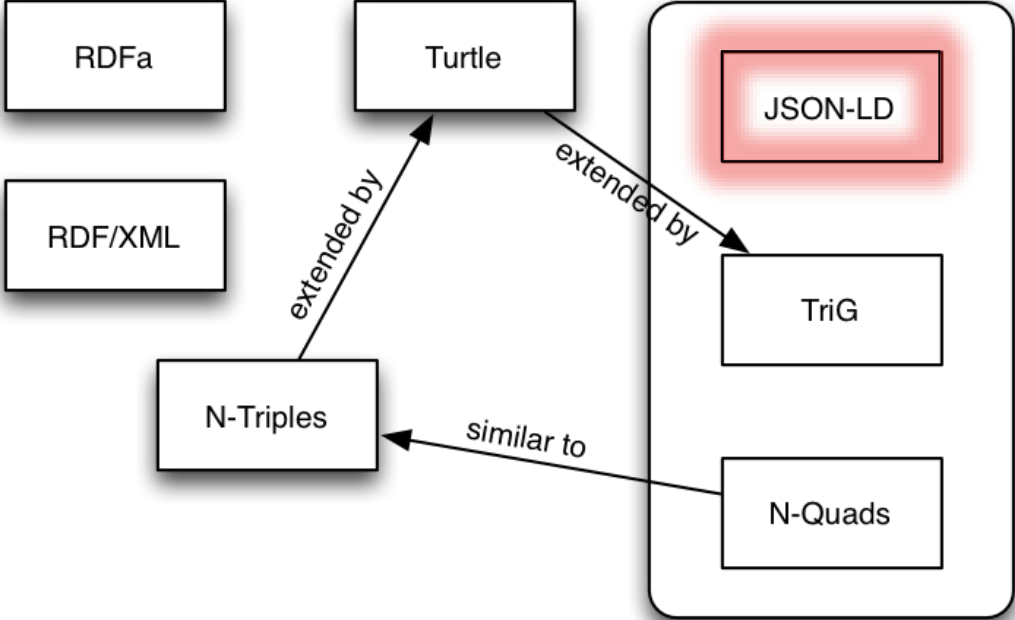
RDF Serialization - JSON-LD

media (MIME) type: application/json+ld

RDF 1.0



RDF 1.1



RDF Serialization - JSON-LD

- **JSON-LD** (JavaScript Object Notation for Linked Data): method of encoding Linked Data using JSON
 - primarily intended to be a way to use Linked Data in Web-based programming environments, to build interoperable Web services, and to store Linked Data in JSON-based storage engines
 - syntax designed to easily integrate into deployed systems that already use JSON, and provides a smooth upgrade path from JSON to JSON-LD (i.e allows existing JSON to be interpreted as Linked Data with minimal changes).

<https://www.w3.org/TR/json-ld/>

W3C Recommendation

W3C

JSON-LD 1.0

A JSON-based Serialization for Linked Data

W3C Recommendation 16 January 2014

This version:
<http://www.w3.org/TR/2014/REC-json-ld-20140116/>

Latest published version:

<https://w3c.github.io/json-ld-syntax/>

W3C Editor's Draft

JSON-LD 1.1

A JSON-based Serialization for Linked Data

W3C Editor's Draft 01 October 2018

This version:
<https://w3c.github.io/json-ld-syntax/>

Latest published version:
<https://www.w3.org/TR/json-ld11/>

Latest editor's draft:
<https://w3c.github.io/json-ld-syntax/>

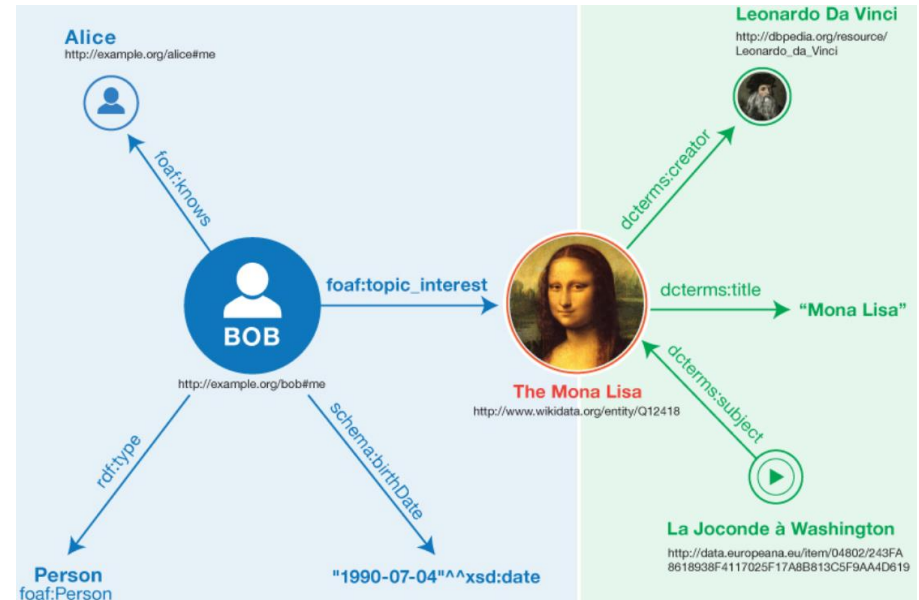
Editor:
Gregg Kellogg (Spec-Ops) (v1.0 and v1.1)

Former editors:
Manu Sporny (Digital Bazaar) (v1.0)
Markus Lischke (Graz University of Technology) (v1.0)

RDF Serialization - JSON-LD

- JSON (JavaScript Object Notation)
 - lightweight, language-independent data interchange format.
 - easy to parse and easy to generate

```
{  
  "type": "Person",  
  "name": "Bob",  
  "birthdate": "1990-07-04",  
  "knows": "http://example.org/alice#me",  
  "topic_interest": {  
    "title": "Mona Lisa",  
    "subject_of": "http://data.europeana.eu/item/04802/243FA8618938F4117025F17A8B813C5F9AA4D619",  
    "creator": "http://dbpedia.org/resource/Leonardo_da_Vinci"  
  }  
}
```



JSON-LD key idea : transform such a JSON document to RDF with minimal changes

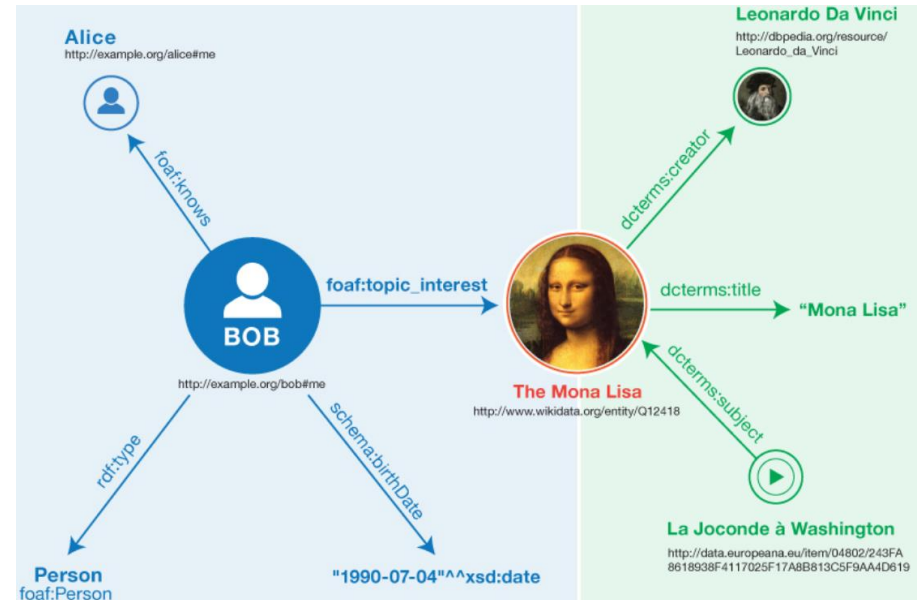
- ➔ universal identifiers for JSON objects,
- ➔ a mechanism in which a JSON document can refer to an object described in another JSON document elsewhere on the Web,
- ➔ datatype and language handling.

RDF Serialization - JSON-LD

@context : points to a JSON document describing how the document can be mapped to an RDF graph

```
{
  "@context": "example-context.json",
  "@id": "http://example.org/bob#me",
  "@type": "Person",
  "name": "Bob",
  "birthdate": "1990-07-04",
  "knows": "knows": "http://example.org/alice#me",
  "topic_interest": {
    "@id": "http://www.wikidata.org/entity/Q12418",
    "title": "Mona Lisa",
    "subject_of": "http://data.europeana.eu/item/04802/243FA8618938F4117025F17A8B813C5F9AA4D619",
    "creator": "http://dbpedia.org/resource/Leonardo_da_Vinci"
  }
}
```

@id when used as a key in a JSON-LD document, points to an IRI identifying the resource corresponding to the current JSON object.

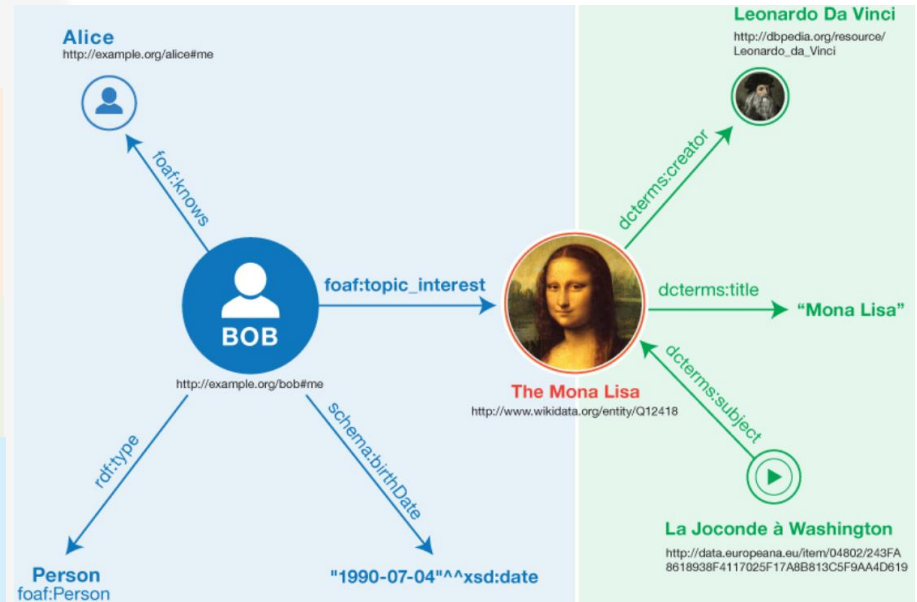


RDF Serialization - JSON-LD

definition of FOAF namespace

specify how to map Person, interest and knows to types and properties in the FOAF namespace

```
{
  "@context": {
    "foaf": "http://xmlns.com/foaf/0.1/",
    "Person": "foaf:Person",
    "interest": "foaf:topic_interest",
    "knows": {
      "@id": "foaf:knows",
      "@type": "@id"
    },
    "birthdate": {
      "@id": "http://schema.org/birthDate",
      "@type": "http://www.w3.org/2001/XMLSchema#date"
    },
    "dcterms": "http://purl.org/dc/terms/",
    "title": "dcterms:title",
    "creator": {
      "@id": "dcterms:creator",
      "@type": "@id"
    },
    "subject_of": {
      "@reverse": "dcterms:subject",
      "@type": "@id"
    }
  }
}
```



This context describes how the JSON-LD document can be mapped to an RDF graph

```
{
  "@context": "example-context.json",
  "@id": "http://example.org/bob#me",
  "@type": "Person",
  "name": "Bob",
  "birthdate": "1990-07-04",
  "knows": "http://example.org/alice#me",
  "topic_interest": {
    "@id": "http://www.wikidata.org/entity/Q12418",
    "title": "Mona Lisa",
    "subject_of": "http://data.europeana.eu/item/04802/243FA8618938F4117025F17A8B813C5F9AA4D619",
    "creator": "http://dbpedia.org/resource/Leonardo_da_Vinci"
  }
}
```

@reverse : used to specify that, whenever we encounter "subject_of": "x" in a JSON-LD document using this context, we should map it to the RDF triple < x IRI, dcterms:subject, the resource corresponding to the parent JSON object >.

JSON-LD and Google search

<https://developers.google.com/search/docs/guides/intro-structured-data>

The screenshot shows the Google Search documentation page for 'Introduction to Structured Data'. The page title is 'Introduction to Structured Data'. A search bar at the top right contains the word 'joconde'. The main content area includes a section titled 'Introduction to Structured Data' with a sub-section 'Google uses structured data that it finds on the web'. Below this, there is a code block for JSON-LD:

```
<script type="application/ld+  
{  
  "@context": "http://schema.  
  "@type": "Organization",  
  "url": "http://www.example.  
  "name": "Unlimited Ball Bea  
  "contactPoint": {
```

Google uses structured data that it finds on the web :

- to understand the content of the page,
- to gather information about the web and the world in general. (→ Google Knowledge Graph)
- to enable special search result features and enhancements



Google recommends using JSON-LD for structured data whenever possible.

The screenshot shows the Google Knowledge Graph for 'La Joconde'. It features a search bar with 'La Joconde' and a search button. Below the search bar, there is a card for 'La Joconde' with a thumbnail image of the Mona Lisa. The card includes the following information:

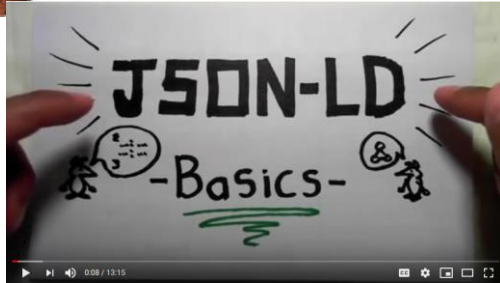
- La Joconde** - Tableau de Léonard de Vinci
- La Joconde, ou Portrait de Mona Lisa voire simplement Mona Lisa, est un tableau de l'artiste Léonard de Vinci, réalisé entre 1503 et 1506 ou entre 1513 et 1516, et peut-être jusqu'à 1519, qui représente un portrait mi-corps, probablement celui de la Florentine Lisa Gherardini, épouse de Francesco del Giocondo. [Wikipédia](#)
- Artiste** : Léonard de Vinci
- Dimensions** : 77 cm x 53 cm
- Numéro d'inventaire** : INV. 779
- Dimensions (H x L)** : 77 x 53 cm
- Lieu de création** : Florence
- Mouvement** : Haute Renaissance

Below the card, there is a section for 'Recherches associées' with a link to 'Voir d'autres éléments (plus de 15)'. This section displays a grid of related images and titles:

- La Cène - Léonard de Vinci
- Salvator Mundi - Léonard de Vinci
- David - Michel-Ange
- La Dame à l'hermine - Léonard de Vinci
- Homme de Vitruve - Léonard de Vinci

RDF Serialization - JSON-LD

Manu Sporny



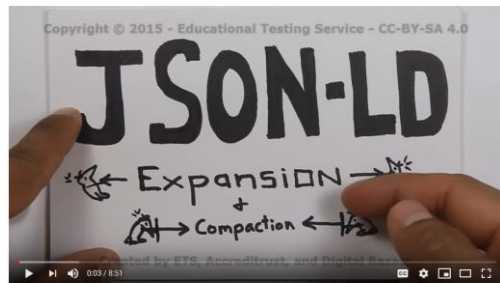
What is JSON-LD?

<https://www.youtube.com/watch?v=vioCbTo3C-4>



JSON-LD: Core Markup

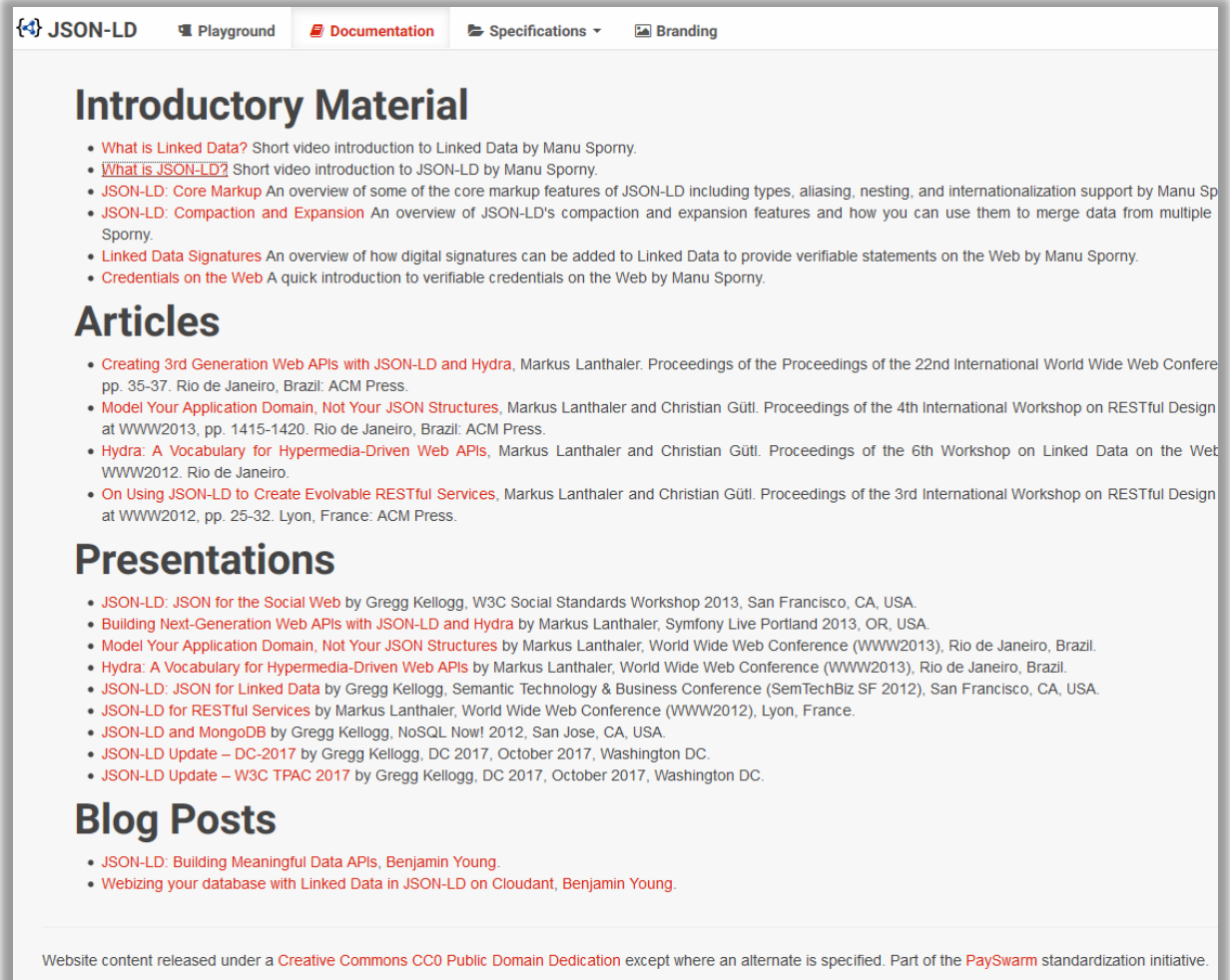
https://www.youtube.com/watch?v=UmvWk_TQ30A



JSON-LD: Compaction and Expansion

<https://www.youtube.com/watch?v=Tm3fD89dqRE>

to learn more about JSON-LD
<https://json-ld.org/learn.html>



JSON-LD Playground Documentation Specifications Branding

Introductory Material

- [What is Linked Data?](#) Short video introduction to Linked Data by Manu Sporny.
- [What is JSON-LD?](#) Short video introduction to JSON-LD by Manu Sporny.
- [JSON-LD: Core Markup](#) An overview of some of the core markup features of JSON-LD including types, aliasing, nesting, and internationalization support by Manu Sporny.
- [JSON-LD: Compaction and Expansion](#) An overview of JSON-LD's compaction and expansion features and how you can use them to merge data from multiple Sporny.
- [Linked Data Signatures](#) An overview of how digital signatures can be added to Linked Data to provide verifiable statements on the Web by Manu Sporny.
- [Credentials on the Web](#) A quick introduction to verifiable credentials on the Web by Manu Sporny.

Articles

- [Creating 3rd Generation Web APIs with JSON-LD and Hydra](#), Markus Lanthaler. Proceedings of the Proceedings of the 22nd International World Wide Web Conference, pp. 35-37. Rio de Janeiro, Brazil: ACM Press.
- [Model Your Application Domain, Not Your JSON Structures](#), Markus Lanthaler and Christian Gütl. Proceedings of the 4th International Workshop on RESTful Design at WWW2013, pp. 1415-1420. Rio de Janeiro, Brazil: ACM Press.
- [Hydra: A Vocabulary for Hypermedia-Driven Web APIs](#), Markus Lanthaler and Christian Gütl. Proceedings of the 6th Workshop on Linked Data on the Web WWW2012. Rio de Janeiro.
- [On Using JSON-LD to Create Evolvable RESTful Services](#), Markus Lanthaler and Christian Gütl. Proceedings of the 3rd International Workshop on RESTful Design at WWW2012, pp. 25-32. Lyon, France: ACM Press.

Presentations

- [JSON-LD: JSON for the Social Web](#) by Gregg Kellogg, W3C Social Standards Workshop 2013, San Francisco, CA, USA.
- [Building Next-Generation Web APIs with JSON-LD and Hydra](#) by Markus Lanthaler, Symphony Live Portland 2013, OR, USA.
- [Model Your Application Domain, Not Your JSON Structures](#) by Markus Lanthaler, World Wide Web Conference (WWW2013), Rio de Janeiro, Brazil.
- [Hydra: A Vocabulary for Hypermedia-Driven Web APIs](#) by Markus Lanthaler, World Wide Web Conference (WWW2013), Rio de Janeiro, Brazil.
- [JSON-LD: JSON for Linked Data](#) by Gregg Kellogg, Semantic Technology & Business Conference (SemTechBiz SF 2012), San Francisco, CA, USA.
- [JSON-LD for RESTful Services](#) by Markus Lanthaler, World Wide Web Conference (WWW2012), Lyon, France.
- [JSON-LD and MongoDB](#) by Gregg Kellogg, NoSQL Now! 2012, San Jose, CA, USA.
- [JSON-LD Update – DC-2017](#) by Gregg Kellogg, DC 2017, October 2017, Washington DC.
- [JSON-LD Update – W3C TPAC 2017](#) by Gregg Kellogg, DC 2017, October 2017, Washington DC.

Blog Posts

- [JSON-LD: Building Meaningful Data APIs](#), Benjamin Young.
- [Webizing your database with Linked Data in JSON-LD on Cloudbant](#), Benjamin Young.

Website content released under a [Creative Commons CC0 Public Domain Dedication](#) except where an alternate is specified. Part of the [PaySwarm](#) standardization initiative.

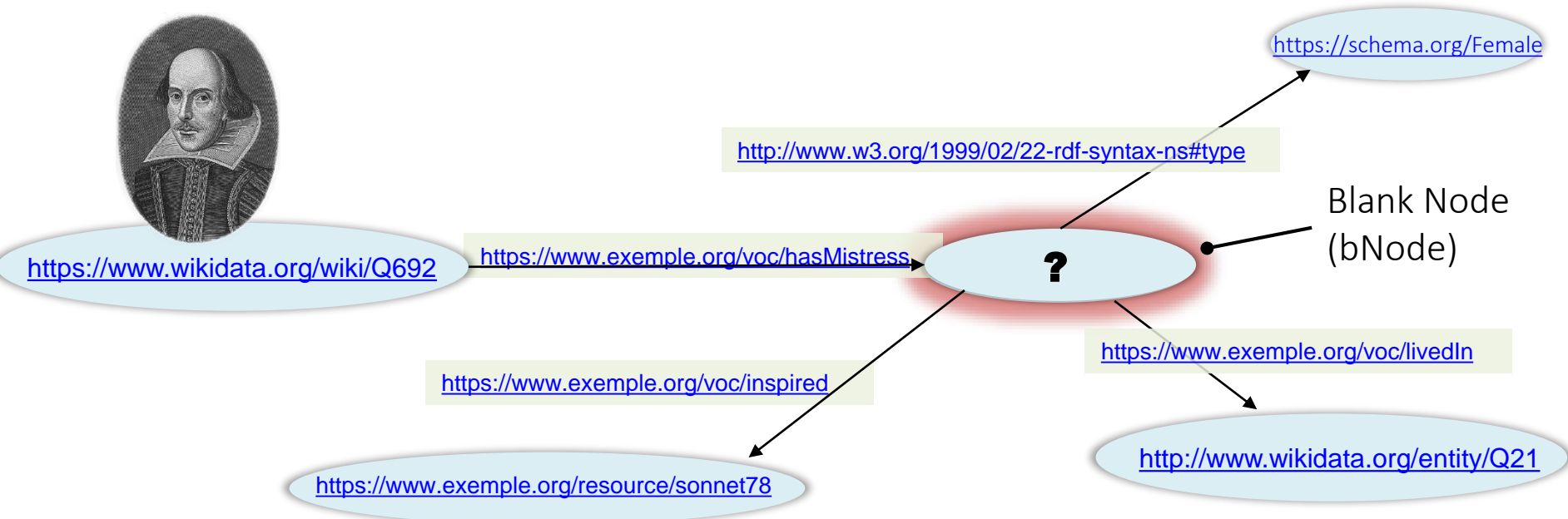
RDF outline

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

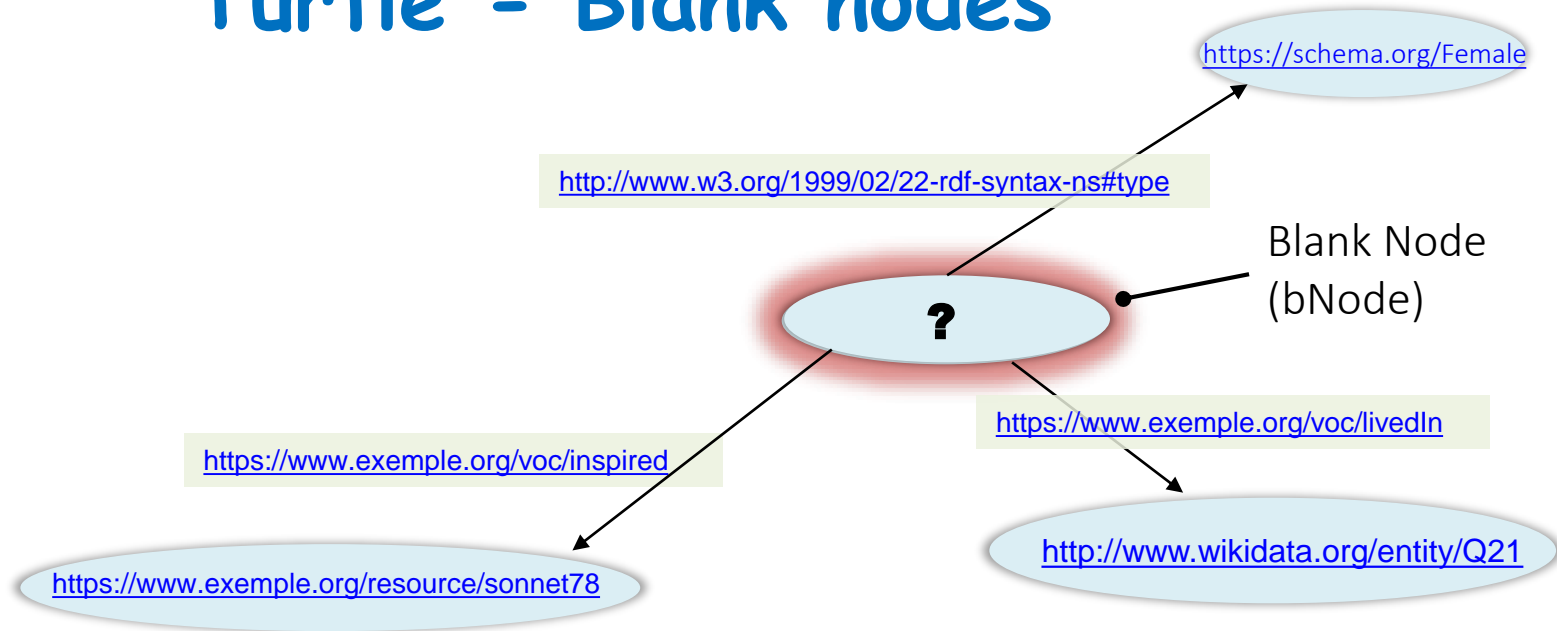
RDF Blank nodes

- RDF provides the possibility to define resources nodes without providing an explicit identification (URI). → **blank** (anonymous) **nodes**

Consider the following statements: *"William Shakespeare had a mistress whose remains identity is unknown, but we know she was a woman living in England and was inspiration of sonnet 8"*



Turtle - Blank nodes

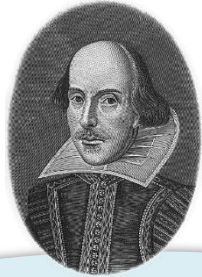


```
@prefix voc: <https://www.exemple.org/voc/> .  
@prefix wd: <http://www.wikidata.org/entity/> .  
@prefix schema: <http://www.wikidata.org/entity/> .
```

anonymous
blank node
as subject

```
[ ] rdf:type schema:Female;  
    voc:livedIn wd:Q21;  
    voc:inspired <sonnet78>.
```

Turtle - Blank nodes



<https://www.wikidata.org/wiki/Q692>

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

<https://schema.org/Female>

<https://www.exemple.org/voc/hasMistress>

?

Blank Node
(bNode)

<https://www.exemple.org/voc/livedIn>

<https://www.exemple.org/voc/livedIn>

<https://www.exemple.org/resource/sonnet78>

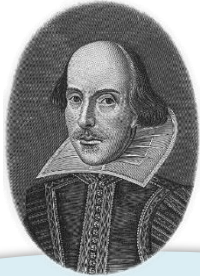
<http://www.wikidata.org/entity/Q21>

```
@prefix voc: <https://www.exemple.org/voc/> .  
@prefix wd: <http://www.wikidata.org/entity/> .  
@prefix schema: <http://www.wikidata.org/entity/> .
```

nested
anonymous
blank node
as object

```
wd:Q692 voc:hasMistress [ rdf:type schema:Female;  
  voc:livedInd wd:Q21;  
  voc:inspired <sonnet78>  
] .
```


Turtle - Blank nodes



<https://www.wikidata.org/wiki/Q692>

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

<https://schema.org/Female>

Blank Node
(bNode)

<https://www.exemple.org/voc/hasMistress>

?

<https://www.exemple.org/voc/livedIn>

<https://www.exemple.org/voc/livedIn>

<https://www.exemple.org/resource/sonnet78>

<https://www.exemple.org/voc/Y>

<http://www.wikidata.org/entity/Q21>

<https://www.exemple.org/resource/X>

```
@prefix voc: <https://www.exemple.org/voc/> .
@prefix wd: <http://www.wikidata.org/entity/> .
@prefix schema: <http://www.wikidata.org/entity/> .
```

déreferenceable
blank node. Can be
only be referenced from
inside document/graph

```
_:ID284 rdf:type schema:Female;
      voc:livedInd wd:Q21;
      voc:inspired <sonnet78> .
```

```
wd:Q692 voc:hasMistress _:ID284 .
<X> voc:Y _:ID284 .
```

RDF/XML - Blank Nodes

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

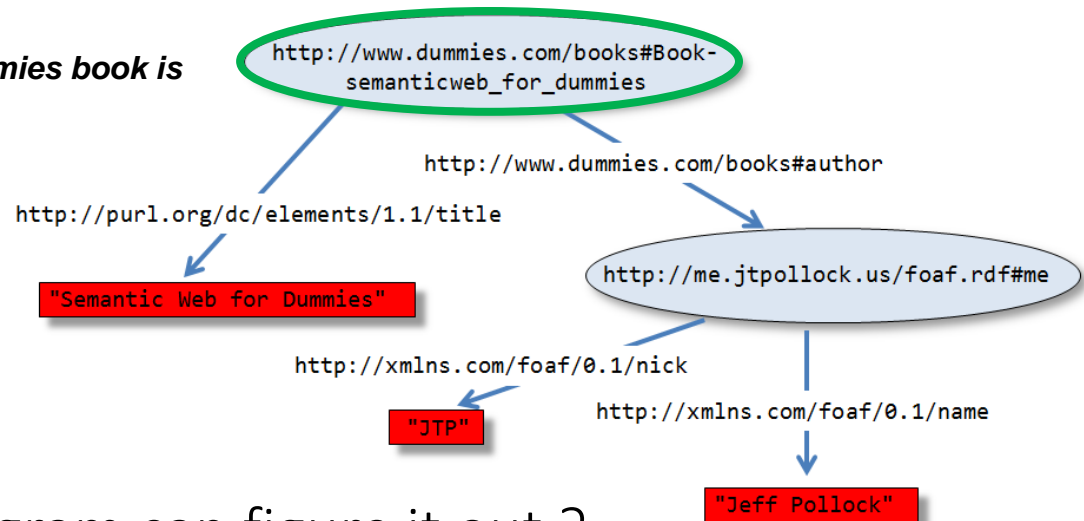
RDF outline

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

Identifying the type of a resource

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

The Semantic Web For Dummies book is authored by Jeff Pollock



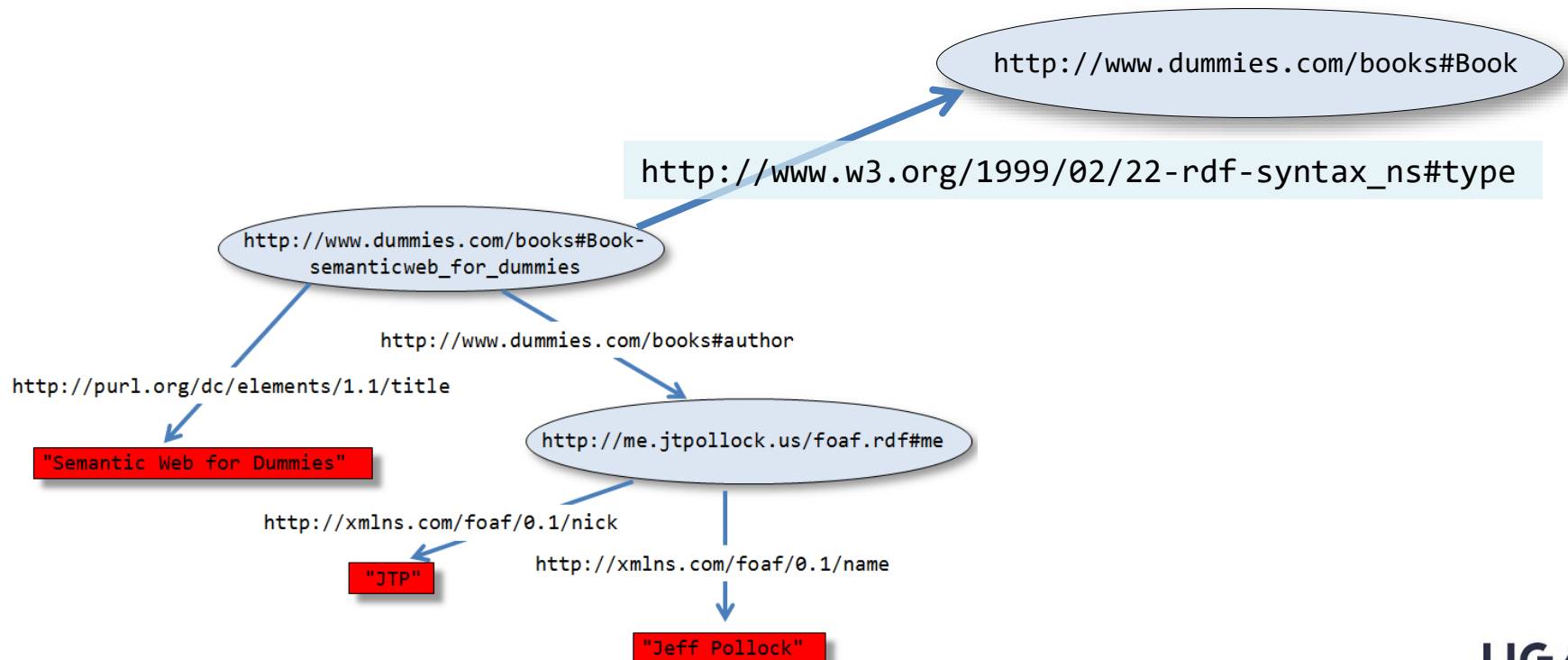
We know it's a book...

but how a computer program can figure it out ?

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

Identifying the type of a resource

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



Identifying the type of a resource

- N3 - Turtle

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

```
swbook:Book-semanticweb_for_dummies
```

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

shortcut for
rdf:type

↗ a **swbook:Book**.

- XML/RDF

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

```
<rdf:RDF
```

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

```
  xmlns:books="http://www.dummies.com/books#">
```

```
  <rdf:Description
```

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

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

```
    <books:author
```

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

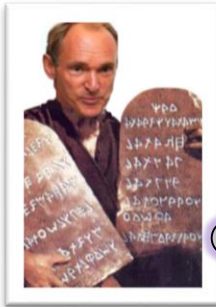
```
  </rdf:Description>
```

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

RDF outline

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

RDF and Data Integration



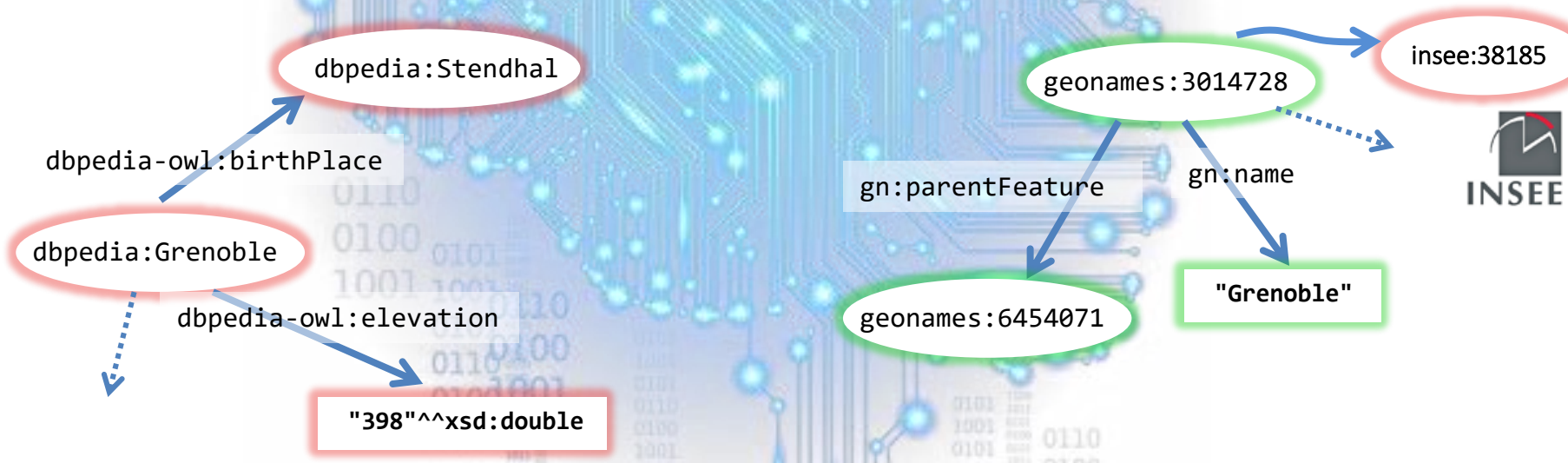
Linked Data : 4th Principle
Include links to other URIs, so that they can discover more things.



GeoNames

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

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



RDF and Data Integration

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

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



- Dataset "A": a simplified bookstore data base

BOOKS

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

FK

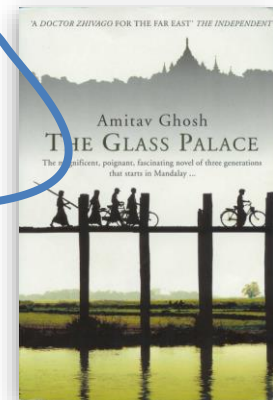
AUTHORS

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

FK

PUBLISHERS

ID	Publisher's name	City
id_qpr	Harper Collins	London



RDF and Data Integration

BOOKS

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

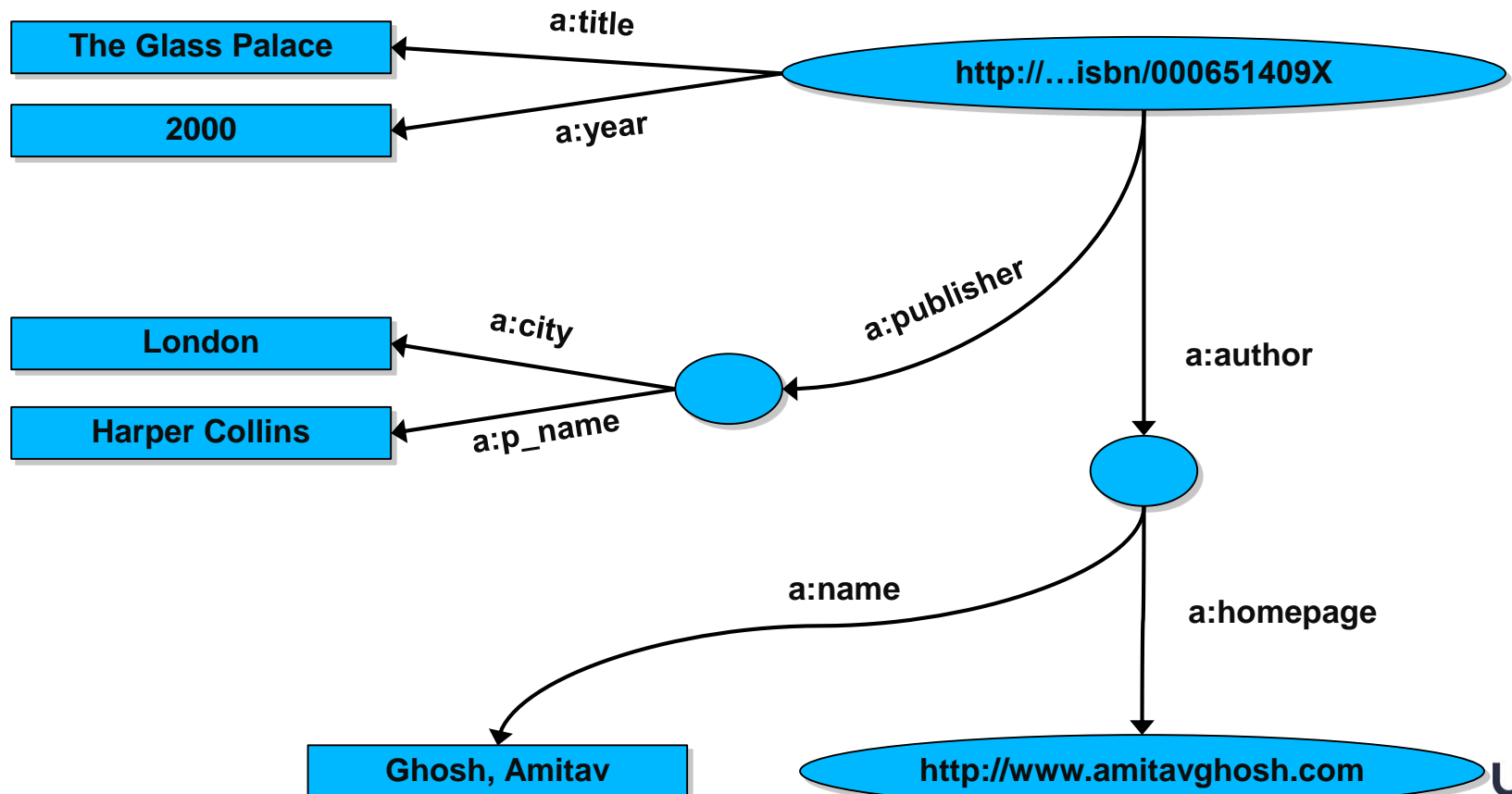
AUTHORS

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

PUBLISHERS

ID	Publisher's name	City
id_qpr	Harper Collins	London

- 1st: export your data as a RDF graph



RDF and Data Integration

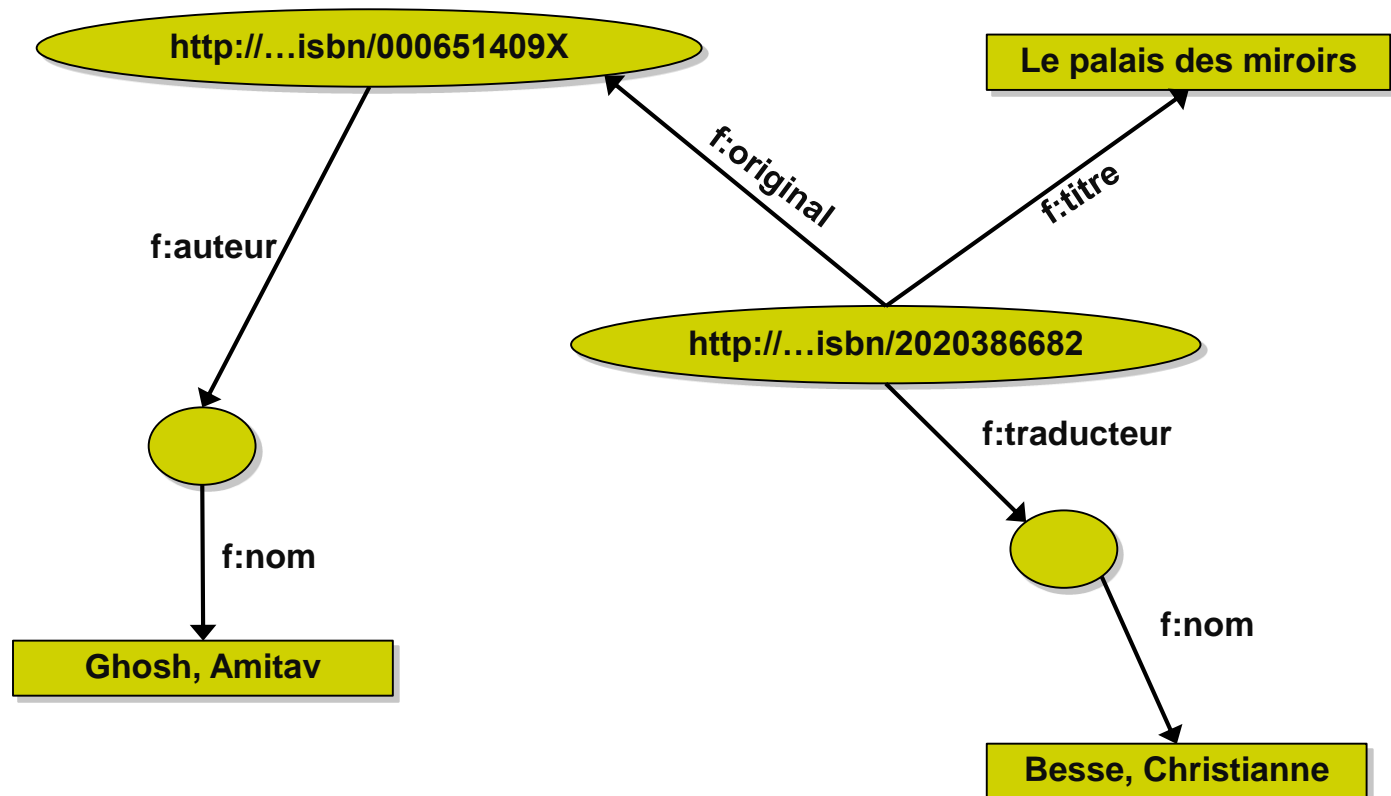
- Another dataset "F" : a google docs spreadsheet bookstore data

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

RDF and Data Integration

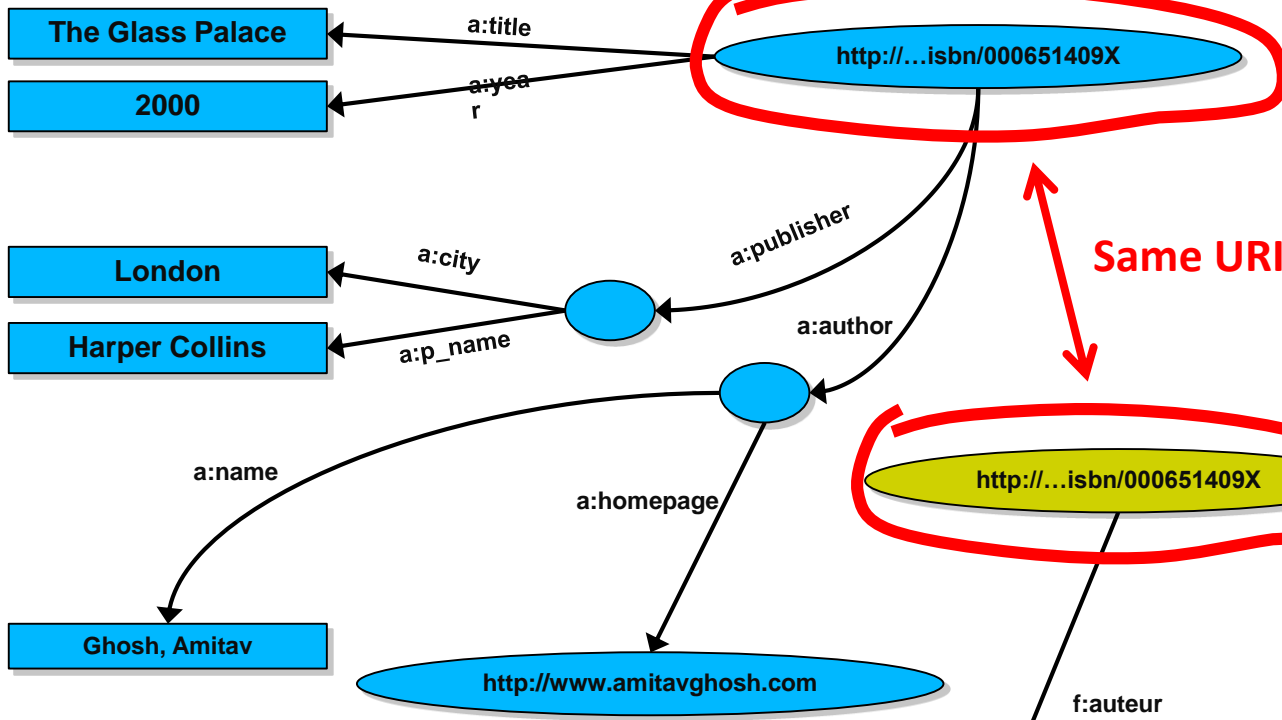
A	B	C	D	
1	ID	Titre	Traducteur	Original
2	ISBN 2020286682	Le Palais des Miroirs	\$A12\$	ISBN 0-00-6511409-X
3				
4				
5				
6	ID	Auteur		
7	ISBN 0-00-6511409-X	\$A11\$		
8				
9				
10	Nom			
11	Ghosh, Amitav			
12	Besse, Christianne			

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



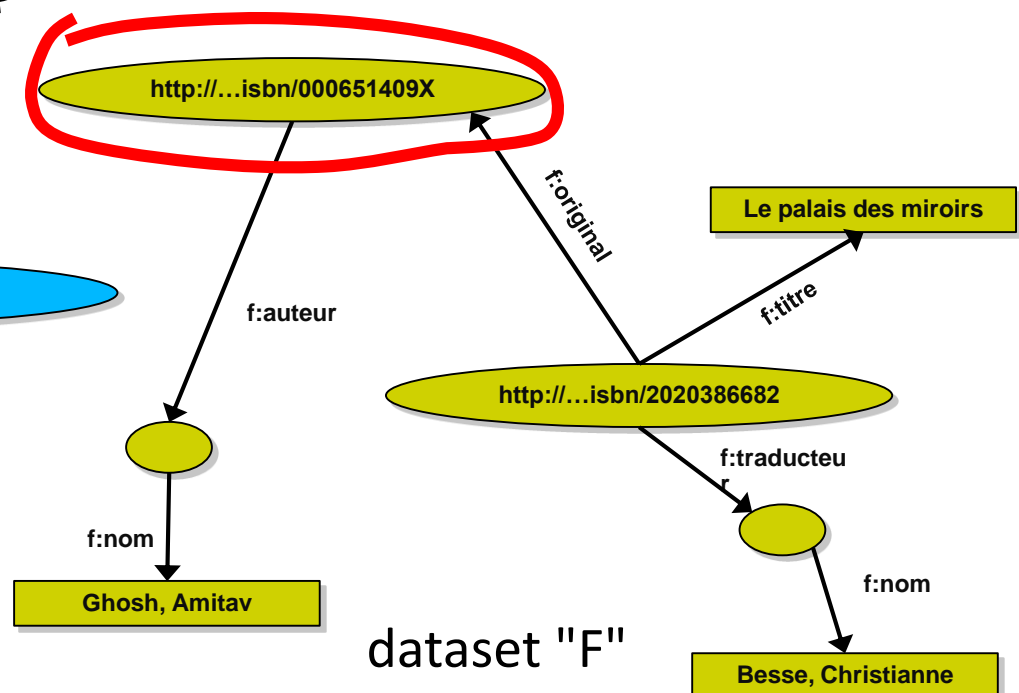
RDF and Data Integration

dataset "A"



- 3rd: start merging your data

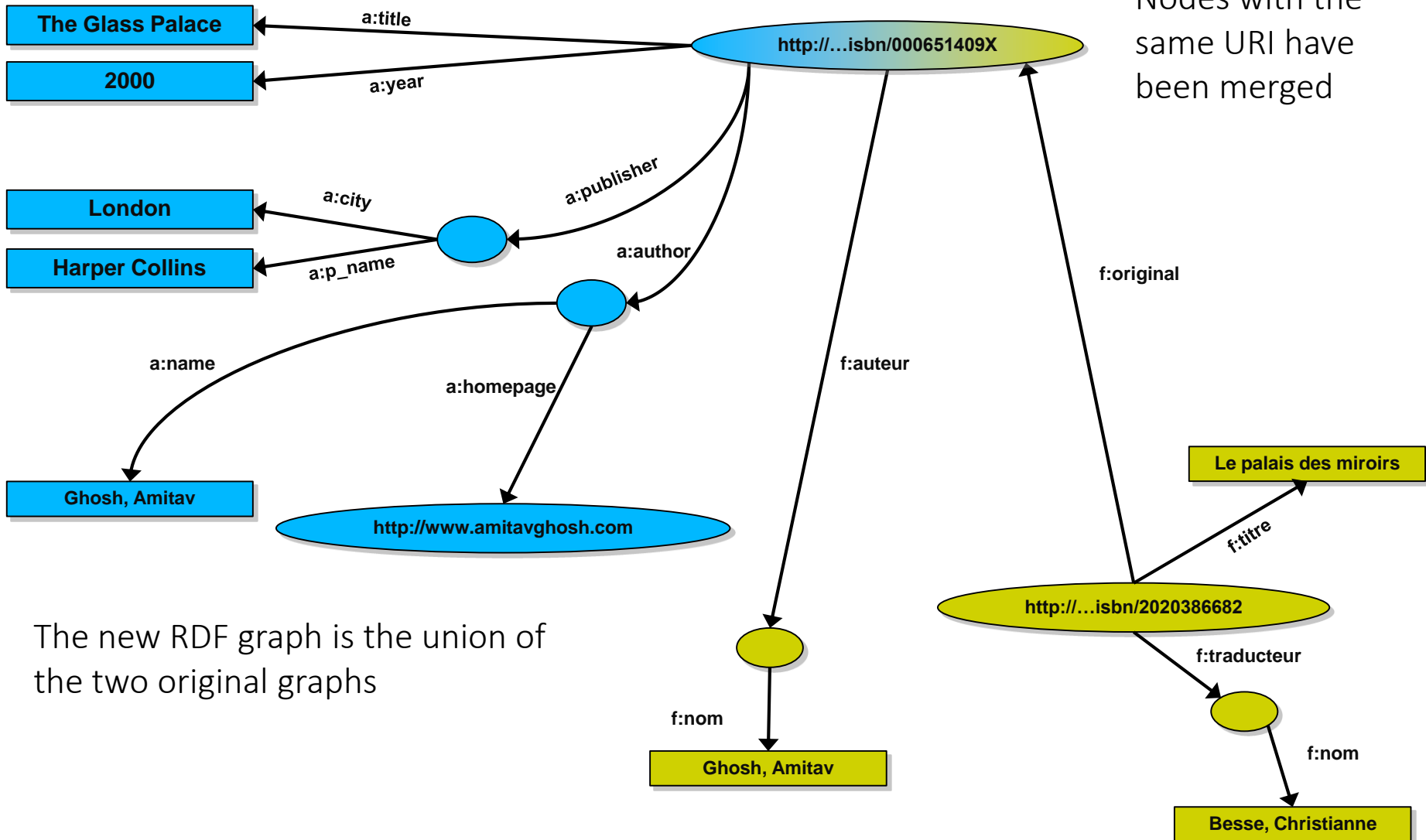
Same URI!



dataset "F"

RDF and Data Integration

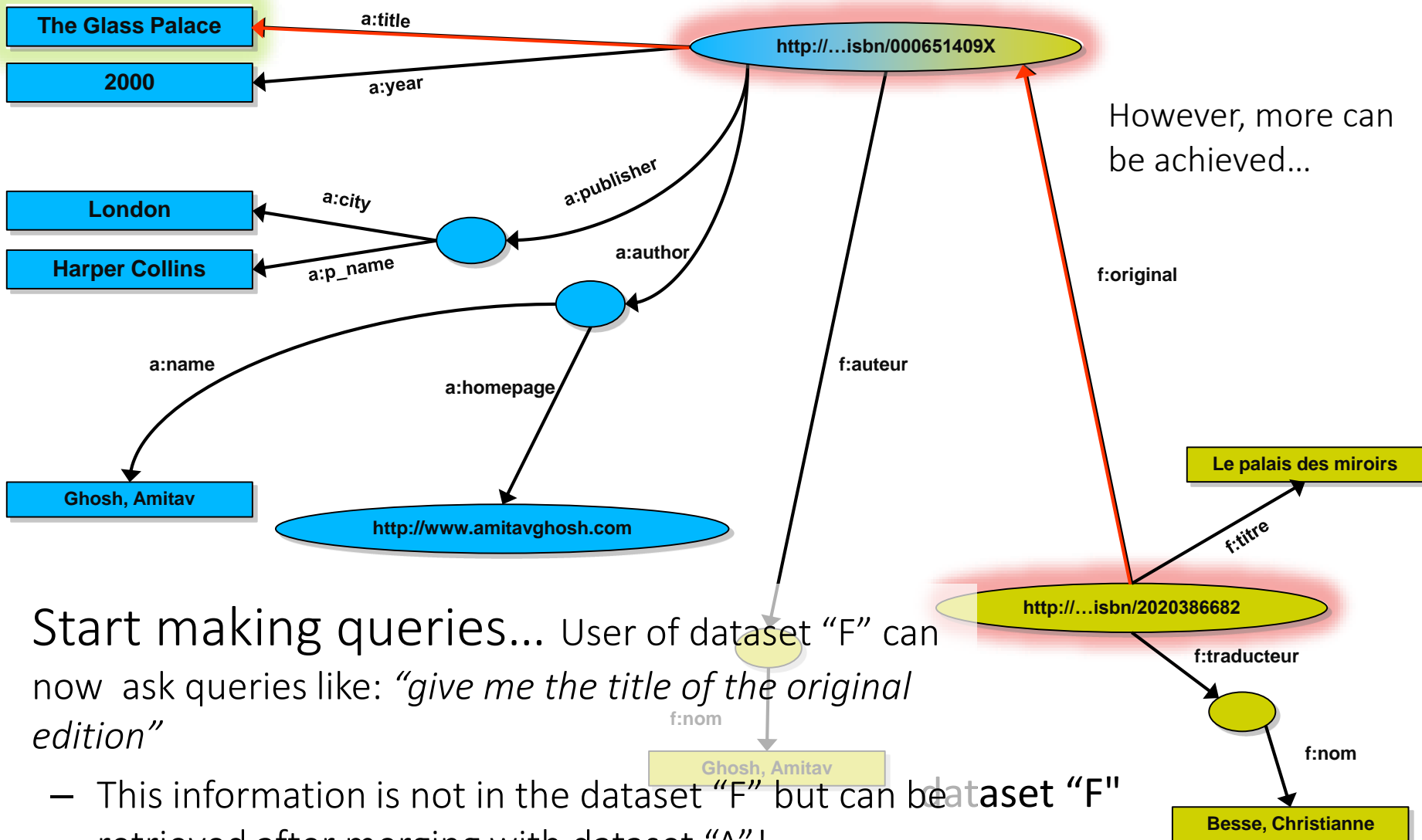
Nodes with the same URI have been merged



The new RDF graph is the union of the two original graphs

RDF and Data Integration

dataset "A"

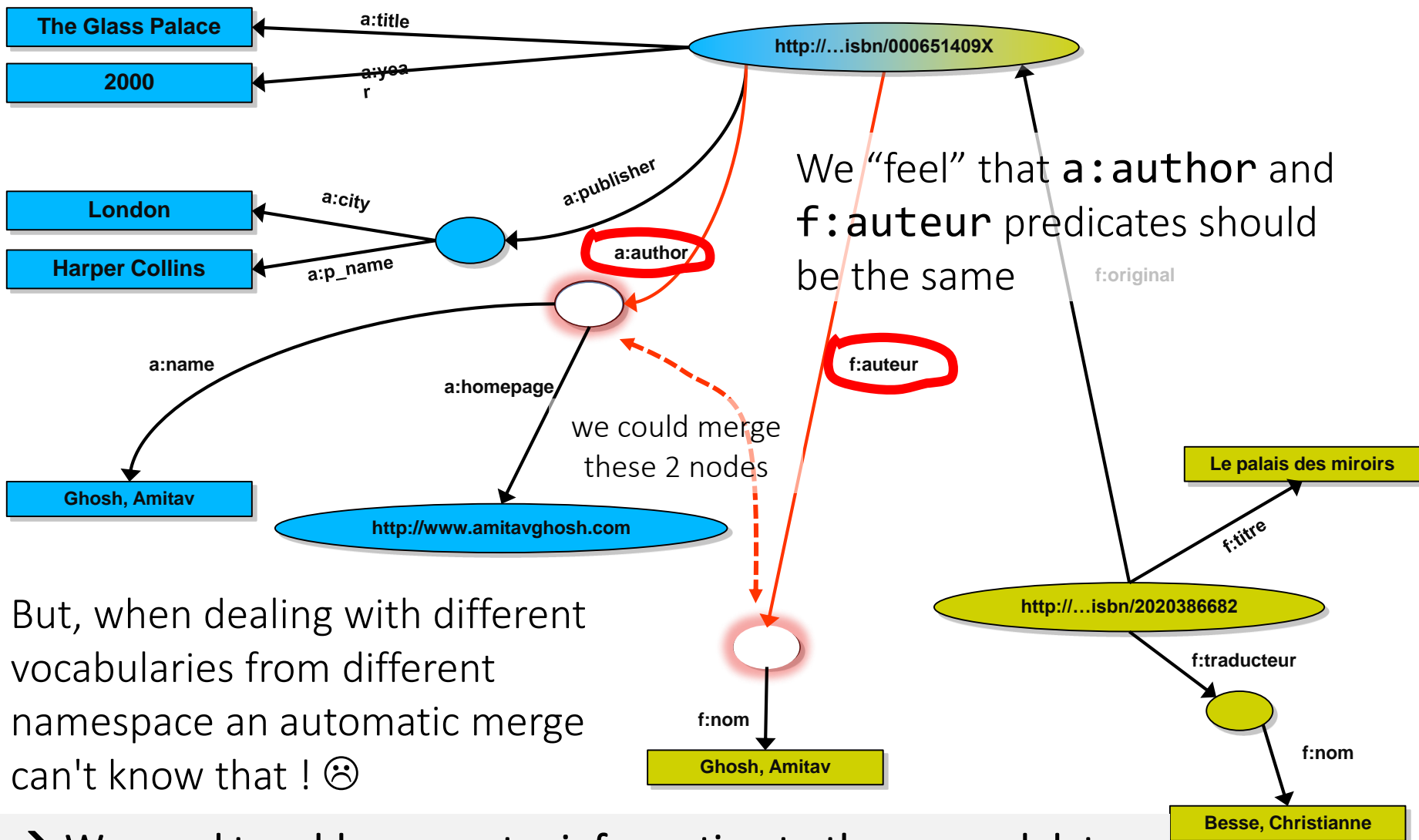


However, more can be achieved...

f:original

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

RDF and Data Integration



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

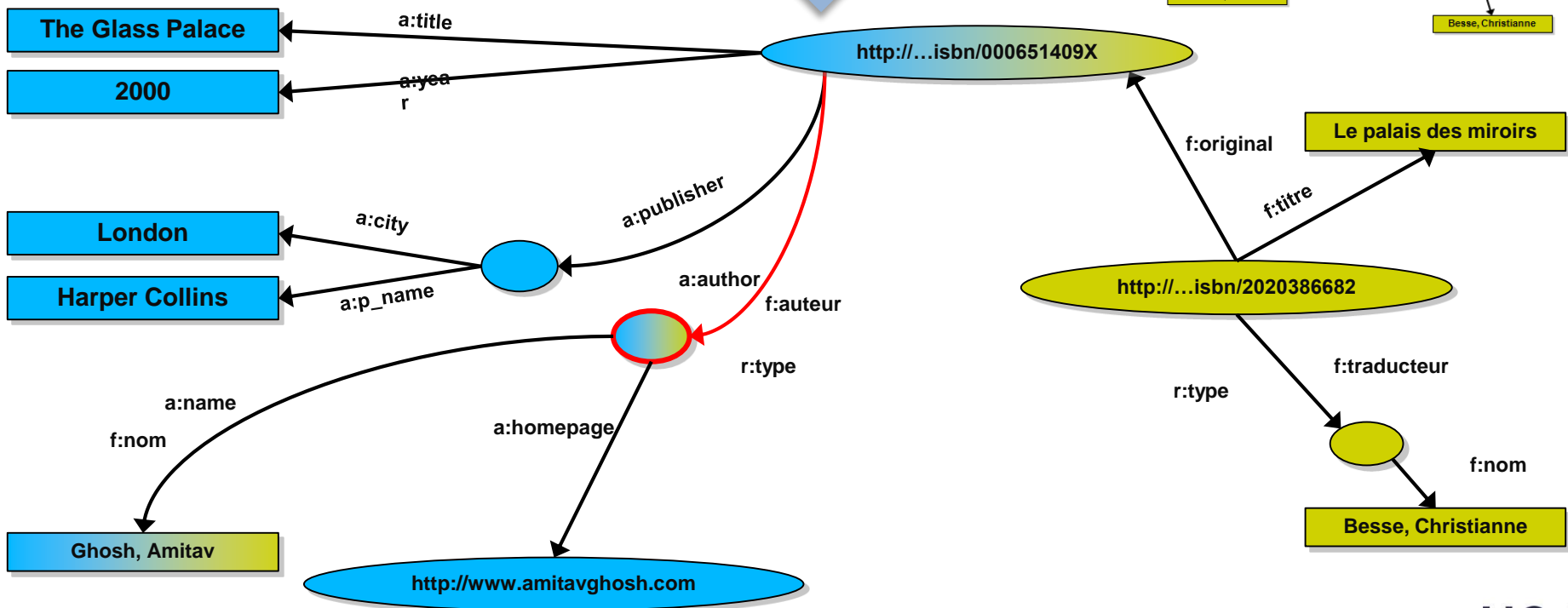
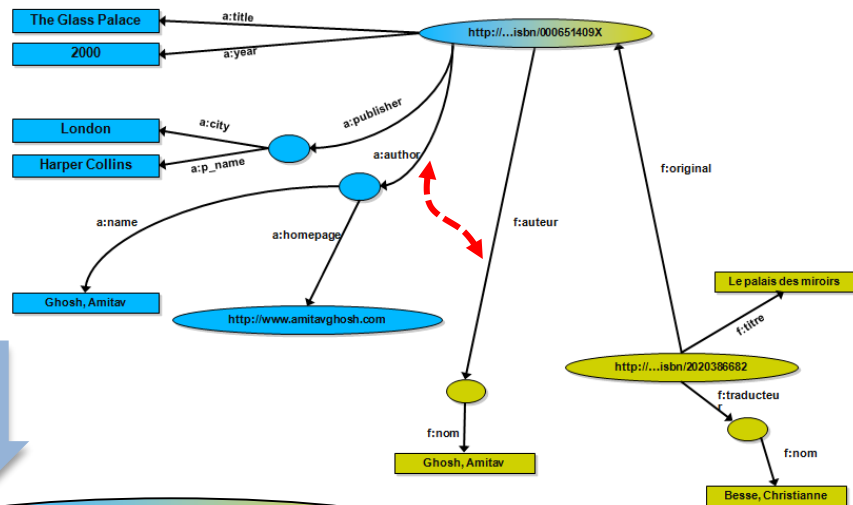
→ We need to add some extra information to the merged data

RDF and Data Integration

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

```
a:author owl:equivalentProperty f:auteur
```

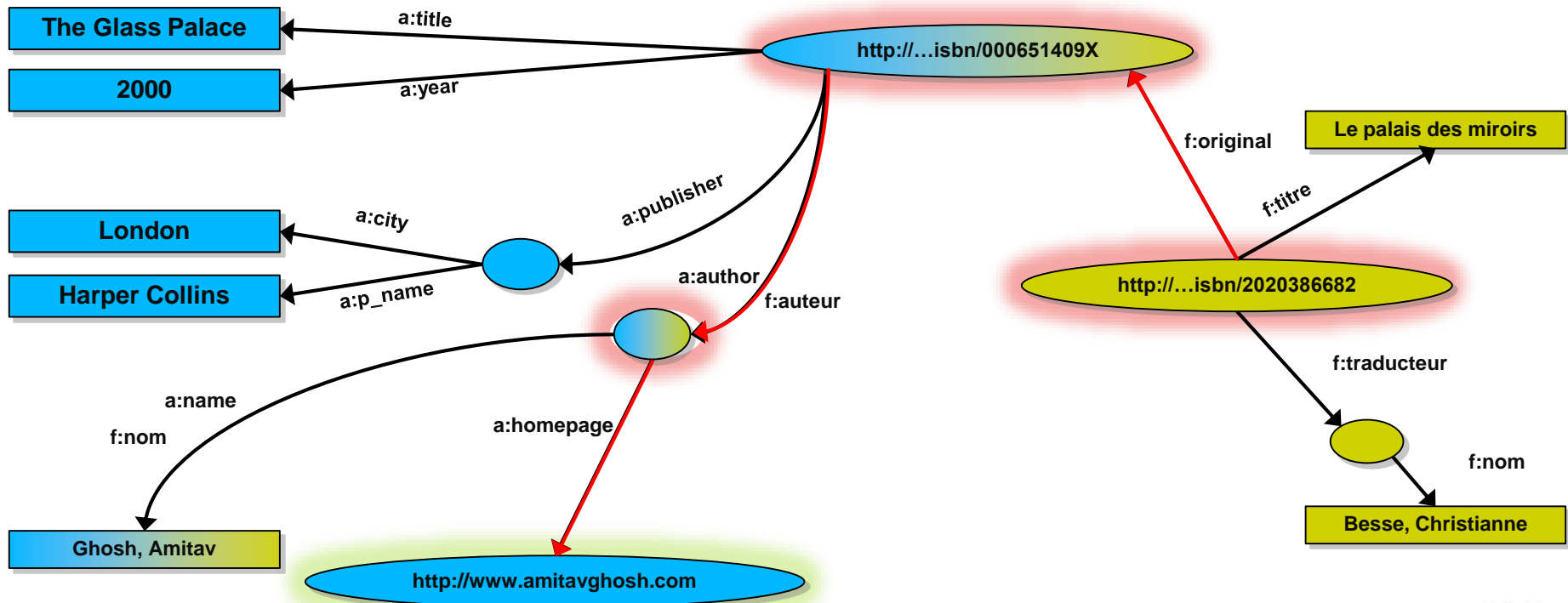
The well defined meaning (semantic) of this property allows to performs the merging



RDF and Data Integration

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

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



Examples of Links between datasets

Prefixes

dbpedia: "http://dbpedia.org/resource/"
 dbo: "http://dbpedia.org/ontology/"
 geonames: "http://sws.geonames.org/"
 gn: "http://www.geonames.org/ontology#"

insee: "http://id.insee.fr/geo/commune/"
 inseePop: http://id.insee.fr/demo/populationLegale/commune/
 inseeDef: http://rdf.insee.fr/def/demo#populationTotale

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



GeoNames



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

<http://sws.geonames.org/2972315/>

"449328"^^xsd:integer

inseeDef:populationTotal

dbpedia:David_Skrela

geonames:2972315

inseePop:31555/2010

dbpedia-owl:birthPlace

gn:parentFeature

gn:name

inseeDef:population

dbpedia:Toulouse

owl:sameAs

dbo:populationTotal

geonames:6453974

"Toulouse"

insee:31555

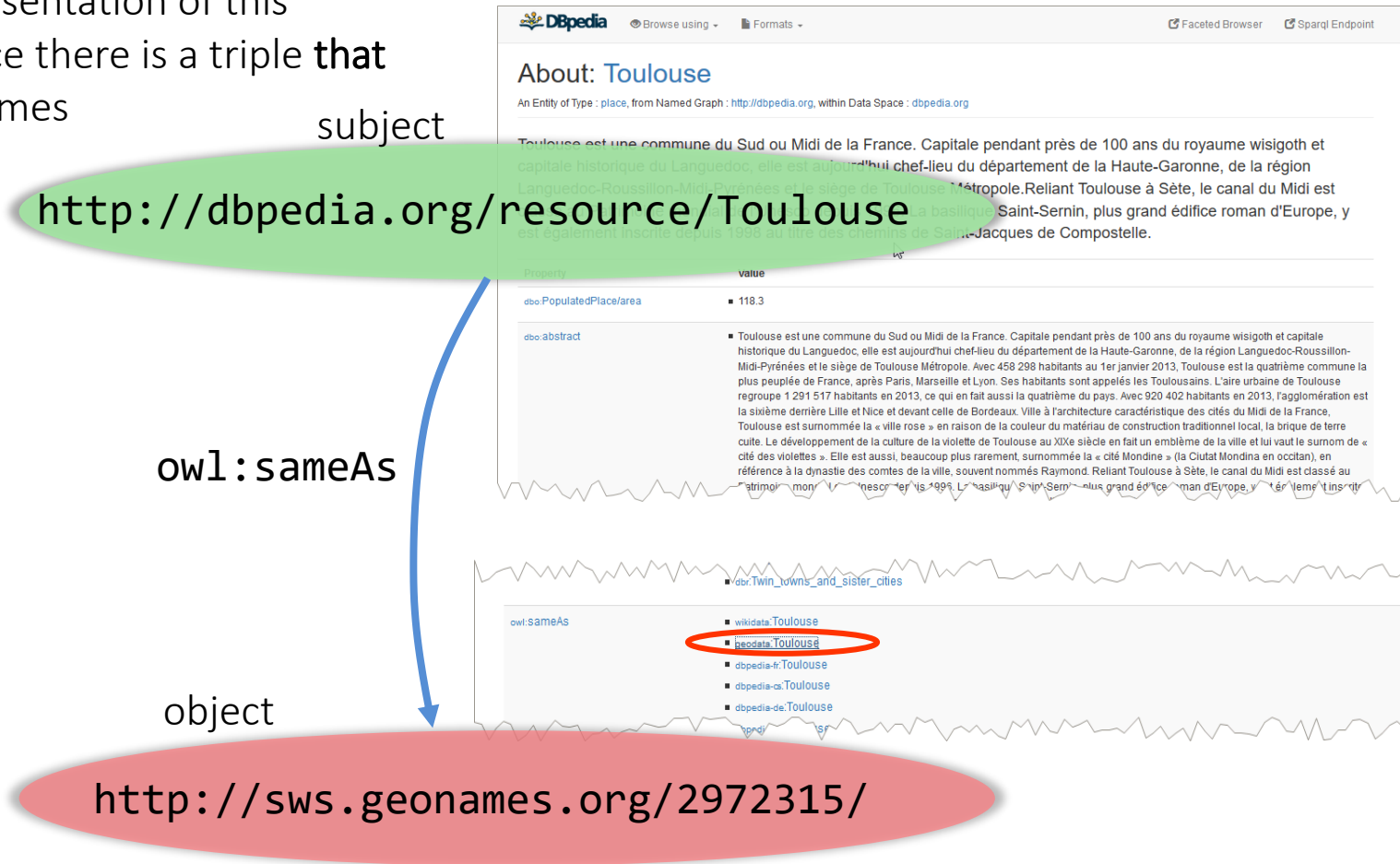
"461190"^^xsd:integer

owl:sameAs



Examples of Links between datasets

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



DBpedia

Browse using - Formats -

Faceted Browser Sparql Endpoint

About: Toulouse

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

Toulouse est une commune du Sud ou Midi de la France. Capitale pendant près de 100 ans du royaume wisigoth et capitale historique du Languedoc, elle est aujourd'hui chef-lieu du département de la Haute-Garonne, de la région Languedoc-Roussillon-Midi-Pyrénées et le siège de Toulouse Métropole. Reliant Toulouse à Sète, le canal du Midi est la basilique Saint-Sernin, plus grand édifice roman d'Europe, y est également inscrite depuis 1998 au titre des chemins de Saint-Jacques de Compostelle.

Property	value
<code>dbo:PopulatedPlace/area</code>	118.3
<code>dbo:abstract</code>	Toulouse est une commune du Sud ou Midi de la France. Capitale pendant près de 100 ans du royaume wisigoth et capitale historique du Languedoc, elle est aujourd'hui chef-lieu du département de la Haute-Garonne, de la région Languedoc-Roussillon-Midi-Pyrénées et le siège de Toulouse Métropole. Avec 458 298 habitants au 1er janvier 2013, Toulouse est la quatrième commune la plus peuplée de France, après Paris, Marseille et Lyon. Ses habitants sont appelés les Toulousains. L'aire urbaine de Toulouse regroupe 1 291 517 habitants en 2013, ce qui en fait aussi la quatrième du pays. Avec 920 402 habitants en 2013, l'agglomération est la sixième derrière Lille et Nice et devant celle de Bordeaux. Ville à l'architecture caractéristique des cités du Midi de la France, Toulouse est surnommée la « ville rose » en raison de la couleur du matériau de construction traditionnel local, la brique de terre cuite. Le développement de la culture de la violette de Toulouse au XXe siècle en fait un emblème de la ville et lui vaut le surnom de « cité des violettes ». Elle est aussi, beaucoup plus rarement, surnommée la « cité Mondine » (la <i>Ciutat Mondina</i> en occitan), en référence à la dynastie des comtes de la ville, souvent nommés Raymond. Reliant Toulouse à Sète, le canal du Midi est classé au patrimoine mondial de l'UNESCO depuis 1998. La basilique Saint-Sernin, plus grand édifice roman d'Europe, y est également inscrite.

`owl:sameAs`

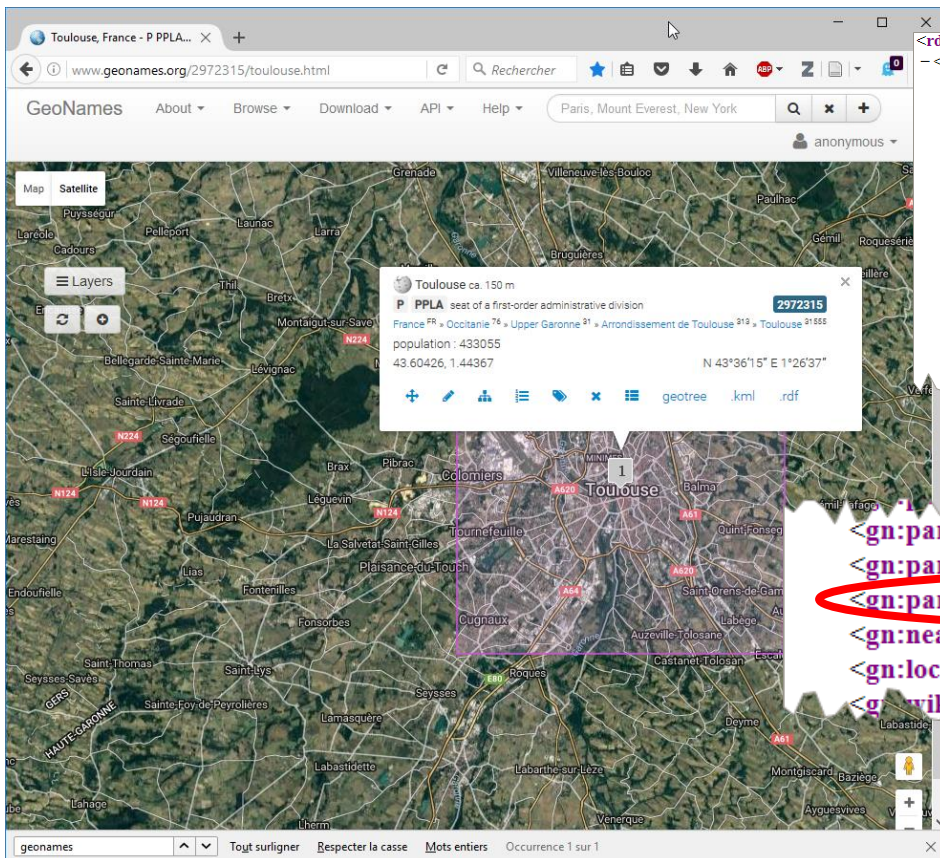
- `wikidata:Toulouse`
- `geonames:Toulouse`
- `dbpedia-fr:Toulouse`
- `dbpedia-ca:Toulouse`
- `dbpedia-de:Toulouse`

URN <http://sws.geonames.org/2972315/> One resource

URL Multiple representations

URL <http://www.geonames.org/2972315/toulouse.html>

URL <http://sws.geonames.org/2972315/about.rdf>



```
<rdf:RDF>
- <gn:Feature rdf:about="http://sws.geonames.org/2972315/">
  <rdfs:isDefinedBy rdf:resource="http://sws.geonames.org/2972315/about.rdf"/>
  <gn:name>Toulouse</gn:name>
  <gn:alternateName xml:lang="am">ቡህተ</gn:alternateName>
  <gn:alternateName xml:lang="ko">툴루즈</gn:alternateName>
  <gn:alternateName xml:lang="th">ตุลูลุ</gn:alternateName>
  <gn:alternateName xml:lang="ja">トゥールーズ</gn:alternateName>
  <gn:alternateName xml:lang="ms">Lapangan Terbang Blagnac</gn:alternateName>
  <gn:alternateName xml:lang="an">Tolosa</gn:alternateName>
  <gn:alternateName xml:lang="br">Tolosa</gn:alternateName>
  <gn:alternateName xml:lang="co">Tolosa</gn:alternateName>
  <gn:alternateName xml:lang="es">Tolosa</gn:alternateName>
  <gn:alternateName xml:lang="frp">Tolosa</gn:alternateName>
  <gn:alternateName xml:lang="gl">Tolosa</gn:alternateName>
  <gn:alternateName xml:lang="it">Tolosa</gn:alternateName>
```

```
<gn:parentADM2 rdf:resource="http://sws.geonames.org/3169150/">
<gn:parentADM3 rdf:resource="http://sws.geonames.org/3169150/">
<gn:parentADM4 rdf:resource="http://sws.geonames.org/6453974/">
<gn:nearbyFeatures rdf:resource="http://sws.geonames.org/2972315/nearby.rdf"/>
<gn:locationMap rdf:resource="http://www.geonames.org/2972315/toulouse.html"/>
<gn:wikipediaTitle rdf:resource="http://fr.wikipedia.org/wiki/Toulouse"/>
```

Examples of Links between datasets

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

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

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

Examples of Links between datasets

Geonames resource Toulouse (ADM 4)

```

<gn:parentADM4 rdf:resource="http://sws.geonames.org/6453974/" />
<gn:parentADM3 rdf:resource="http://sws.geonames.org/2972314/" />
<gn:childrenFeatures rdf:resource="http://sws.geonames.org/6453974/contains.rdf" />
<gn:locationMap rdf:resource="http://www.geonames.org/6453974/toulouse.html" />
<owl:sameAs rdf:resource="http://id.insee.fr/geo/commune/31555" />
</gn:Feature>
- <foaf:Document rdf:about="http://www.insee.fr/fr/infocentre/infocentre" />
  <foaf:primaryTopic rdf:resource="http://www.insee.fr/fr/infocentre/infocentre" />
  <foaf:license rdf:resource="http://creativecommons.org/licenses/by/3.0/" />
  
```

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

<http://sws.geonames.org/6453974/>

owl:sameAs

<http://id.insee.fr/geo/commune/31555>

INSEE resource for Toulouse



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

Description of node <<http://id.insee.fr/geo/commune/31555>>

Subject	Predicate	Object
http://id.insee.fr/geo/commune/31555	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://rdf.insee.fr/def/geo#Commune
http://id.insee.fr/geo/commune/31555	http://www.w3.org/2002/07/owl#sameAs	http://data.ign.fr/id/geo/commune/31555
http://id.insee.fr/geo/commune/31555	http://rdf.insee.fr/def/demo#population	http://id.insee.fr/demo/populationLegale/commune/31555/2010
http://id.insee.fr/geo/commune/31555	http://rdf.insee.fr/def/demo#population	http://data.ign.fr/id/geo/commune/31555/2011
http://id.insee.fr/geo/commune/31555	http://rdf.insee.fr/def/demo#population	http://id.insee.fr/demo/populationLegale/commune/31555/2011
http://id.insee.fr/geo/commune/31555	http://rdf.insee.fr/def/demo#population	http://id.insee.fr/demo/populationLegale/commune/31555/2012
http://id.insee.fr/geo/commune/31555	http://rdf.insee.fr/def/demo#population	http://id.insee.fr/demo/populationLegale/commune/31555/2013
http://id.insee.fr/geo/commune/31555	http://rdf.insee.fr/def/demo#population	http://id.insee.fr/demo/populationLegale/commune/31555/2014
http://id.insee.fr/geo/commune/31555	http://rdf.insee.fr/def/demo#population	http://id.insee.fr/demo/populationLegale/commune/31555/2015
http://id.insee.fr/geo/commune/31555	http://rdf.insee.fr/def/geo#nom	"Toulouse"



It could become even more powerful

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

RDF outline

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

Persisting RDF Data

- Small datasets (few triples)
 - RDF files stored locally or published on the web
 - Use any serialization format : **.nt**, **.rdf**, **.ttl**, etc ...
- Large datasets (thousands to millions of triples)
 - Database solutions better
 - Usually in form of RDF storage (triplestore) or Graph database
- Legacy data
 - Keep in original form but expose as RDF to the outer world
 - Provide a mapping to RDF.

Persisting RDF Data

- **Native RDF stores** (Triple stores)
 - implement their own database engine without reusing the storage and retrieval functionalities of other database management systems.
- **AllegroGraph** (commercial) RDF graph database and application framework developed by Franz Inc.
 - <https://allegrograph.com/allegrograph/> , <http://franz.com/agraph/allegrograph/>
 - the free RDFStore server edition (< 50 million triples)
 - developer edition (< 600 million triples)
 - enterprise edition storage capacity only limited by the underlying server infrastructure (1+Trillion).
 - Clients connectors are available for Java, Python, Lisp, Clojure, Ruby, Perl, C#, and Scala.

Persisting RDF Data

- Native RDF stores (continued...)
- **GraphDB™** (commercial formerly OWLIM) - An Enterprise Triplestore with Meaning (GNU LGPL license and commercial) provided by Ontotext
 - <http://ontotext.com/products/graphdb/>
 - GraphDB™ Lite, (Free)
 - GraphDB™ Standard Edition
 - GraphDB™ Enterprise.
- **Stardog** (commercial) an enterprise data unification platform built on smart graph technology: query, search, inference, and data virtualization.
 - <http://stardog.com/>
- **Apache Jena TDB** (open-source) - a component of the Jena Semantic Web framework (open-source java software – Apache foundation).
 - <http://jena.apache.org/>
- ...

Persisting RDF Data

- DBMS-backed stores
 - RDF Stores that use the storage and retrieval functionality provided by another database management system.
 - Save triples into Relational Database
 - Various strategies: 1 giant table for alls triplet → hexastore (create indexes for all possible combinations: spo, pos, osp, sop, pso, ops)
 - Building an Efficient RDF Store Over a Relational Database (Mihaela A. Bornea et al., [SIGMOD '13](https://cs.uwaterloo.ca/~gweddell/cs848/papers/Bornea.pdf) Proceedings of the 2013 ACM SIGMOD International Conference on Management of Data)
<https://cs.uwaterloo.ca/~gweddell/cs848/papers/Bornea.pdf>

Persisting RDF Data

- DBMS-backed stores (continued...)
- **Apache Jena SDB** (open-source) another component of the Jena Semantic Web framework
 - <http://jena.apache.org/>
 - Provides storage and query for RDF datasets using conventional relational databases: Microsoft SQL Server, Oracle 10g, IBM DB2, PostgreSQL, MySQL, HSQLDB, H2, and Apache Derby.
- **Oracle Spatial and Graph** (commercial, formerly Oracle Semantic Technologies) a W3C standards-based, full-featured graph store in Oracle Database for Linked Data and Social Networks applications.
 - <http://www.oracle.com/technetwork/database/options/spatialandgraph/overview/rdfsemantic-graph-1902016.html>
- **Semantics Platform** (commercial) - a family of products for building medium and large scale semantics-based applications using the Microsoft .NET framework.
 - <http://www.intellidimension.com/products/semantics-platform/>
- ...

Persisting RDF Data

- **Hybrid Stores**

- RDF Stores that supports both architectural styles (native and DBMS-backed).

- **OpenLink Virtuoso Universal Server**

- <http://virtuoso.openlinksw.com/>
- hybrid storage solution for a range of data models, including relational data, RDF and XML, and free text documents.
- Through its unified storage it can be also seen as a mapping solution between RDF and other data formats, therefore it can serve as an integration point for data from different, heterogeneous sources.
- used to host many important Linked Data sets (e.g., DBpedia),
- open-source version – commercial

- **Blazegraph** (former Bigdata)(open-source and commercial license) is ultra-scalable, high-performance graph database with support for the Blueprints and RDF/SPARQL APIs. <https://www.blazegraph.com/product/>

- ...

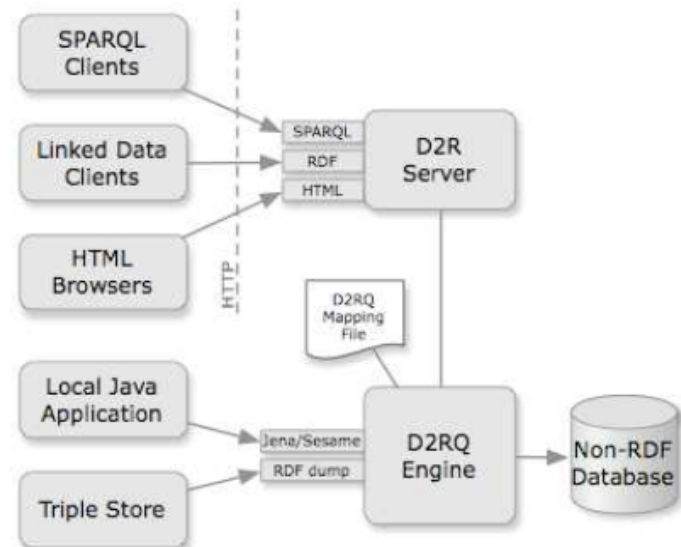
Persisting RDF Data

- Legacy systems Mapping RDF-relational databases
 - W3C RDB2RDF Working Group published two recommendations (september 2012)
 - R2RML: RDB to RDF Mapping Language, <http://www.w3.org/TR/r2rml/>
 - A Direct Mapping of Relational Data to RDF, <http://www.w3.org/TR/rdb-direct-mapping/>
 - DR2Q Accessing Relational Databases as Virtual RDF Graphs <http://d2rq.org/>

The D2RQ Platform consists of:

- ❑ **D2RQ Mapping Language**, a declarative mapping language for describing the relation between an ontology and an relational data model.
- ❑ **D2RQ Engine**, a plug-in for the Jena Semantic Web toolkit, which uses the mappings to rewrite Jena API calls to SQL queries against the database and passes query results up to the higher layers of the frameworks.
- ❑ **D2R Server**, an HTTP server that provides a Linked Data view, a HTML view for debugging and a SPARQL Protocol endpoint over the database.

Supported databases: Oracle, MySQL, PostgreSQL, SQL Server, HSQLDB, Interbase/Firebird



Persisting RDF Data

RDF Triple Stores

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

RDF outline

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

References

- RDF is part of W3C Semantic Web W3C activity

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

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

RDF Working Group

Recommandations

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

Notes

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

RDFa Working Group

Recommandations

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

Notes

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

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