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

4 – INTERROGER LES DONNÉES AVEC SPARQL

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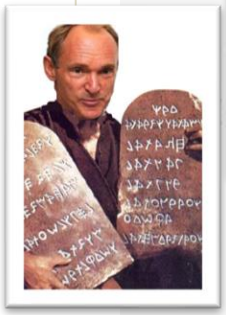
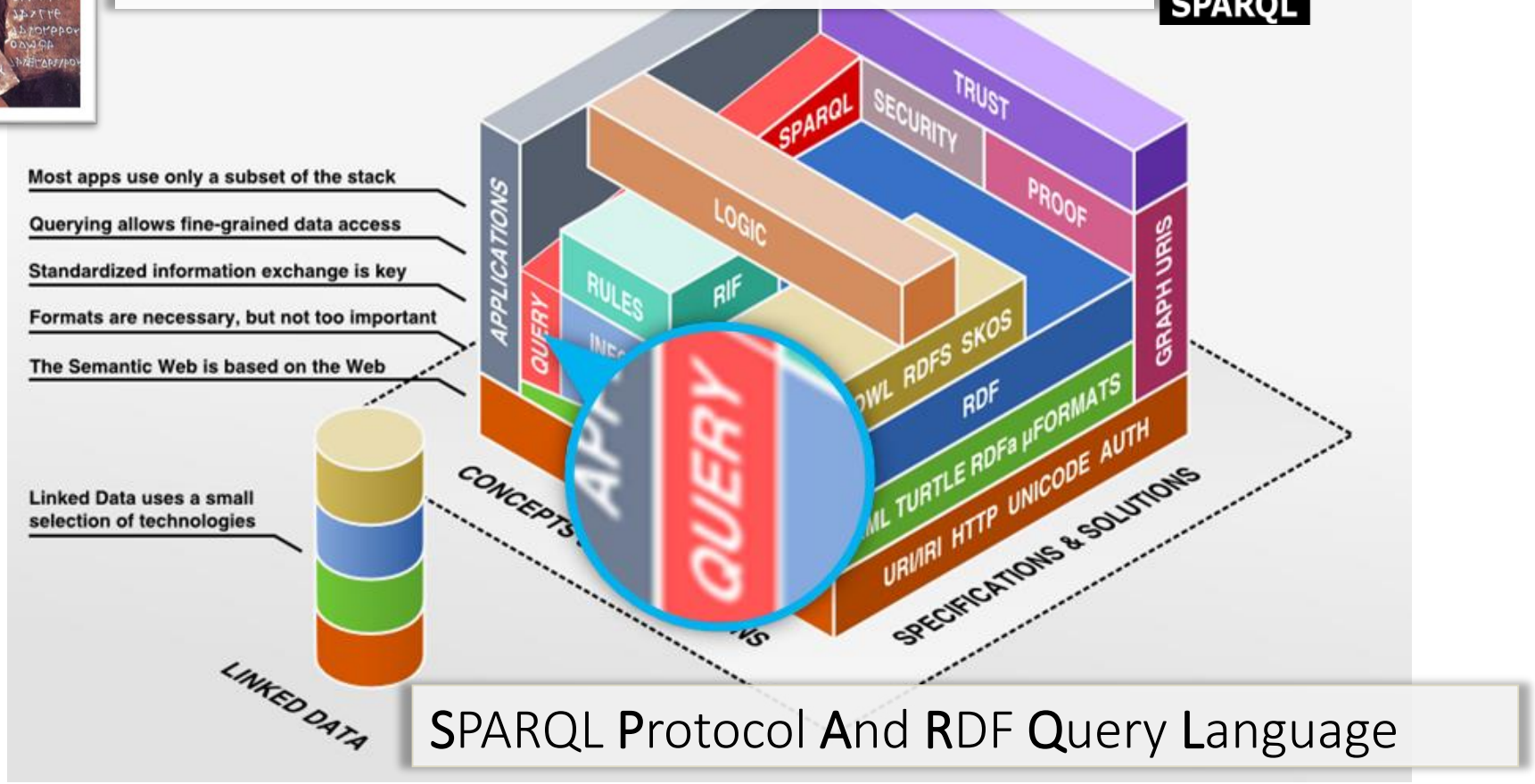
Querying Linked Data with SPARQL



Linked Data: 3rd Principle

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



SPARQL Protocol And RDF Query Language

SPARQL : introduction

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

SPARQL Protocol And RDF Query Language
overview

Client

a protocol to send SPARQL Request over HTTP
(SPARQL protocol for RDF Specification)

SPARQL Protocol Layer

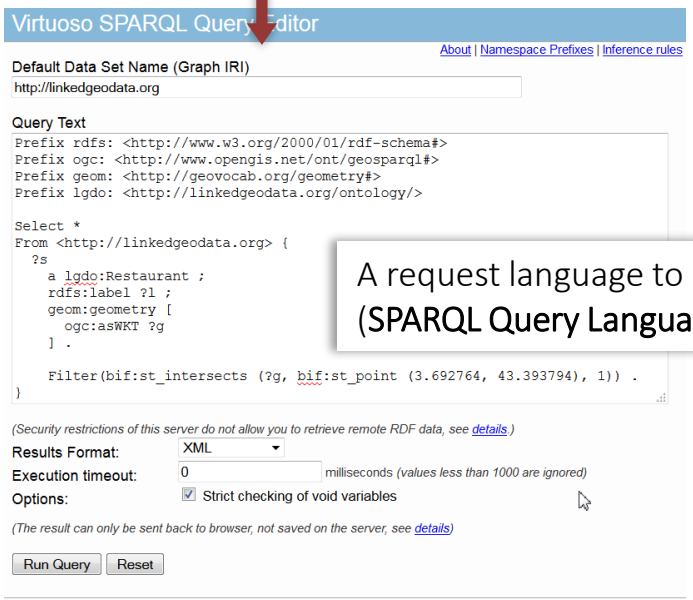
HTTP

Server

An XML output format (and now also JSON, …) for SPARQL queries results (SPARQL Query XML Results Format)

User Interface

SPARQL Endpoint

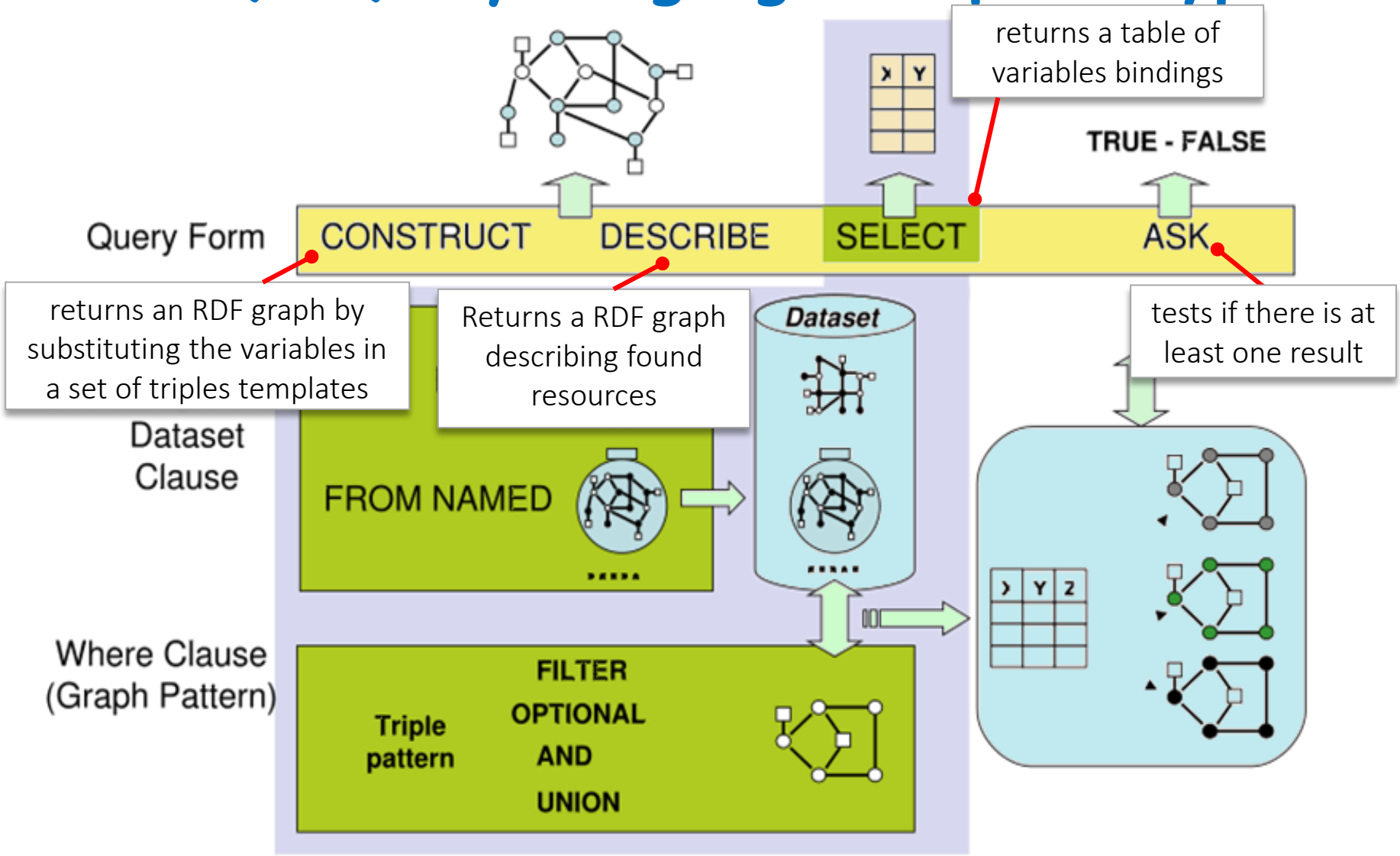


A request language to query RDF graphs
(SPARQL Query Language)

SPARQL endpoint

- Pour poser des requêtes: le langageSPARQL accessible par des points d'accès via un service web
  - INSEE http://rdf.insee.fr/sparql
  - Dbpedia http://fr.dbpedia.org/sparql
  - SPARQLer http://sparql.org/sparql.html General-purpose query endpoint for Web-accessible data
  - bio2rdf http://bio2rdf.org/sparql Bioinformatics data from around 40 public database

SPARQL Query Language: request types



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

Forme la plus courante d'une requête SPARQL (SELECT) :

SELECT ?v1 ?v2 … ?vn

FROM <description.rdf>

WHERE {

(sujet1 | vi) (predicat1 | vj) (objet1 | vk) .

…

(sujetx | va) (predicaty | vb) (objetz | vc) .

}

Il existe également d'autres éléments dans le langage SPARQL qui permettent de spécifier des préfixes (**PREFIX**), des conditions (**FILTER**), des disjonctions (**UNION**), des filtres sur la production des résultats (**LIMIT** et **OFFSET**).

Types de requêtage dans SPARQL

4 Types de requêtage mais uniquement du **requêtage** à la différence de SQL

(LDD + LMD) :

SELECT : **rechercher** de ressources du modèle, résultats restitués sous un format tabulaire

ASK : **indiquer** si la requête retourne un **résultat non vide** (test de vacuité)

DESCRIBE : **obtenir des informations** à propos de ressources présentes dans le modèle (le moins exploité des quatre)

CONSTRUCT : **construire de nouveaux graphes RDF** à partir des résultats de la requête servant de ”template”

Forme générale d'une requête SPARQL

ici requête SELECT :

Prologue

BASE prefix :<namespace-uri >

PREFIX prefix :<namespace-uri >

Head

SELECT [DISTINCT] variable-list

Body

FROM source-list

WHERE pattern

ORDER BY expression

LIMIT integer > 0

OFFSET integer > 0

Prologue d'une requête SPARQL

BASE suivi d'un raccourci pour une URI de base auxquelles les URIs seront concaténées.

Une seule base par requête.

Exemple : BASE <http ://www.lis.univ-amu/data/>

PREFIX suivi d'une déclaration d'un raccourci pour des espaces de nom.

Il est courant d'avoir plusieurs préfixes.

Exemple : PREFIX fb :<http ://rdf.freebase.com/ns/>

Head d'une requête SPARQL

SELECT suivi d'une liste de variables dont on souhaite connaître les valeurs répondant à la requête.

Note : la requête peut utiliser d'autres variables.

CONSTRUCT suivi d'un template de triplets pour construire un entrepôt des triplets répondant à la requête.

ASK pour tester s'il existe des solutions vérifiant les conditions de la requête.

Body d'une requête SPARQL

Peut contenir les clauses :

FROM (optionnel) permet de spécifier différents graphes de triplets dans lesquels il faut chercher. Si pas mentionné, on suppose qu'un graphe a été spécifié au processeur SPARQL

WHERE suivi d'une déclaration de pattern (motif) pouvant contenir : plusieurs patterns, plusieurs patterns de base, des filtres, des unions, des présences optionnelles

ORDER BY trier par …

LIMIT pour donner un nombre maximal de réponses

OFFSET pour commencer à partir d'un numéro de réponse

Les contraintes OPTIONAL et FILTER

Remarques :

pattern = ensemble de triplets contenant des noms de variables

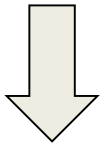
les triplets sont séparés par le symbole « . »

un tuple de variables satisfait le pattern si tous les triplets sont satisfaits par le tuple : on parle de requête conjonctive

SPARQL Query Language
ASK query

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

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



the boolean result

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

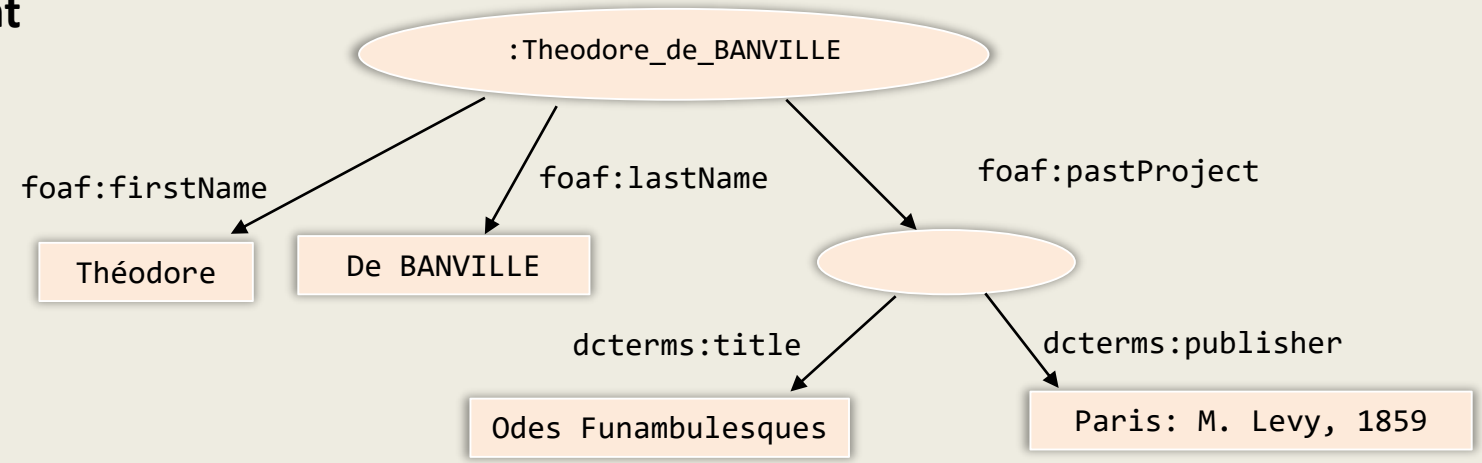
SPARQL Query Language
CONSTRUCT query

- SELECT returns a flat list of variables bindings
  - the application program is in charge of processing these bindings (sometimes by converting solution tuples into triples and adding them to a RDF graph)

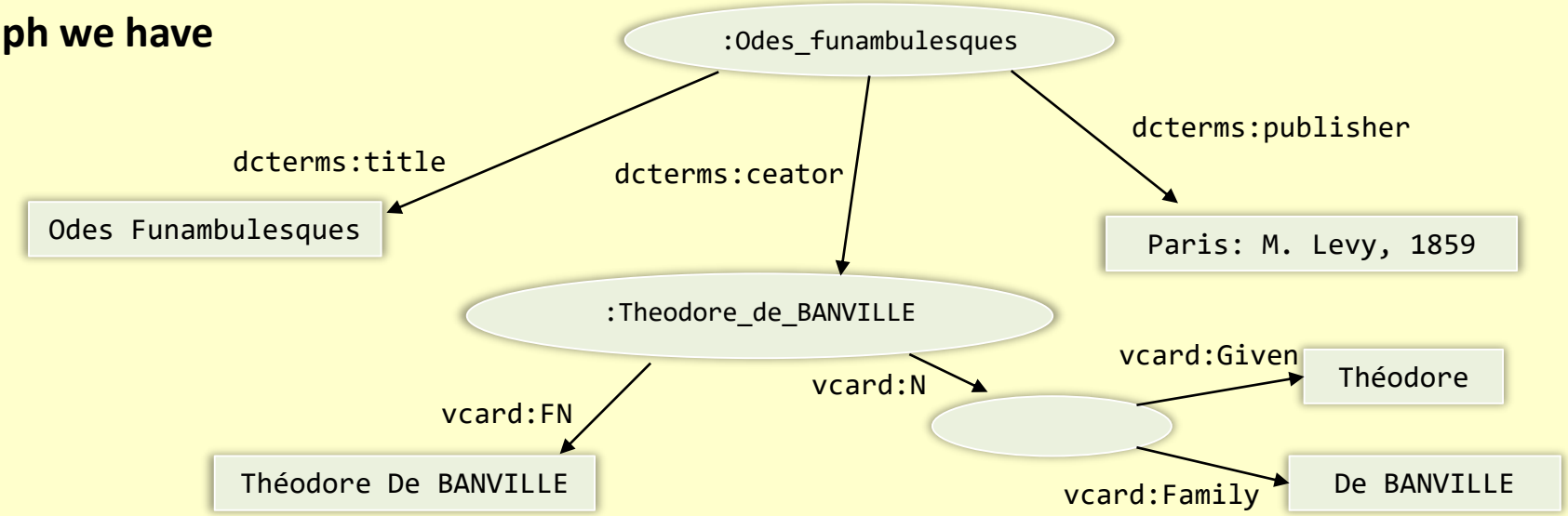
- CONSTRUCT allows you to directly product a RDF graph containing the variables values
  - the WHERE and FILTER clause works the same way as the SELECT form
  - bindings of the variables are inserted into a new graph constructed from template triples specified in the CONSTRUCT clause (which replace the SELECT clause).

SPARQL Query Language
CONSTRUCT query

The graph we want



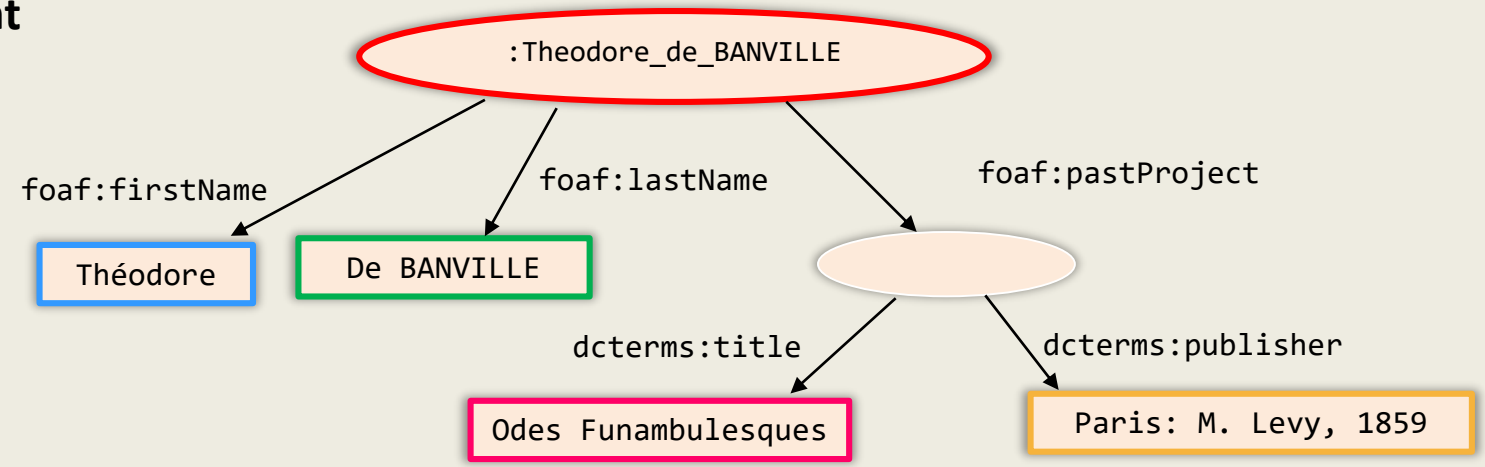
The graph we have



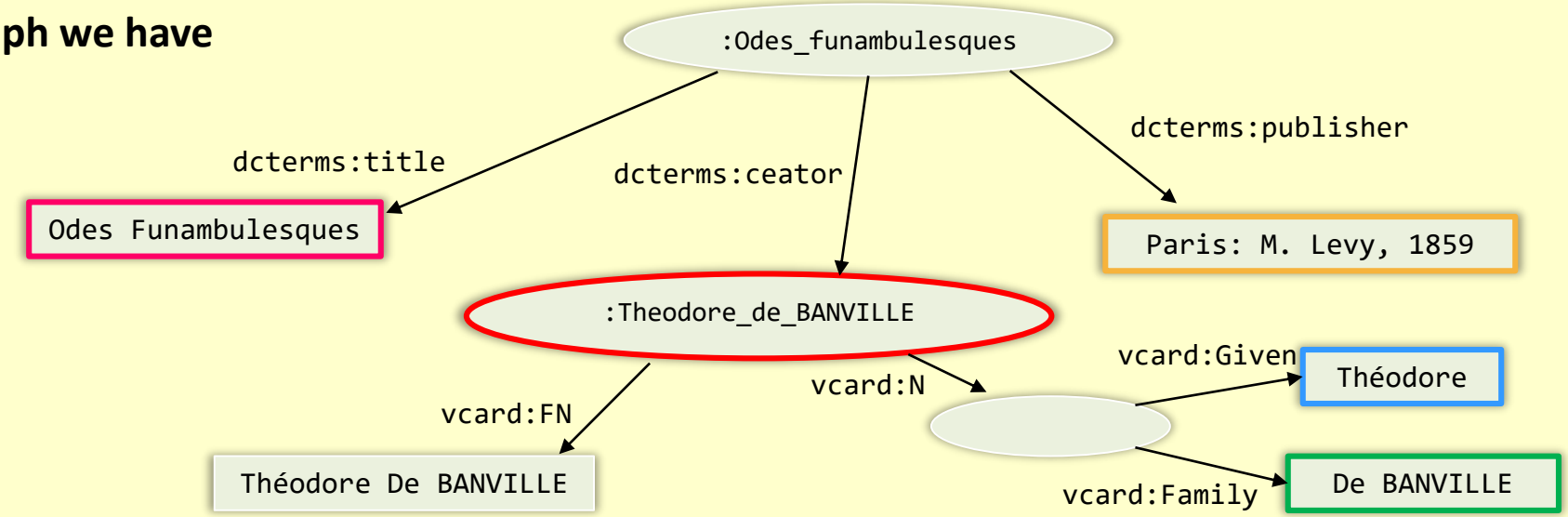
D'après : http://pagesperso-systeme.lip6.fr/Jean-Francois.Perrot/inalco/XML/RDF/SPARQL/IntroSPARQL.html

SPARQL Query Language
CONSTRUCT query

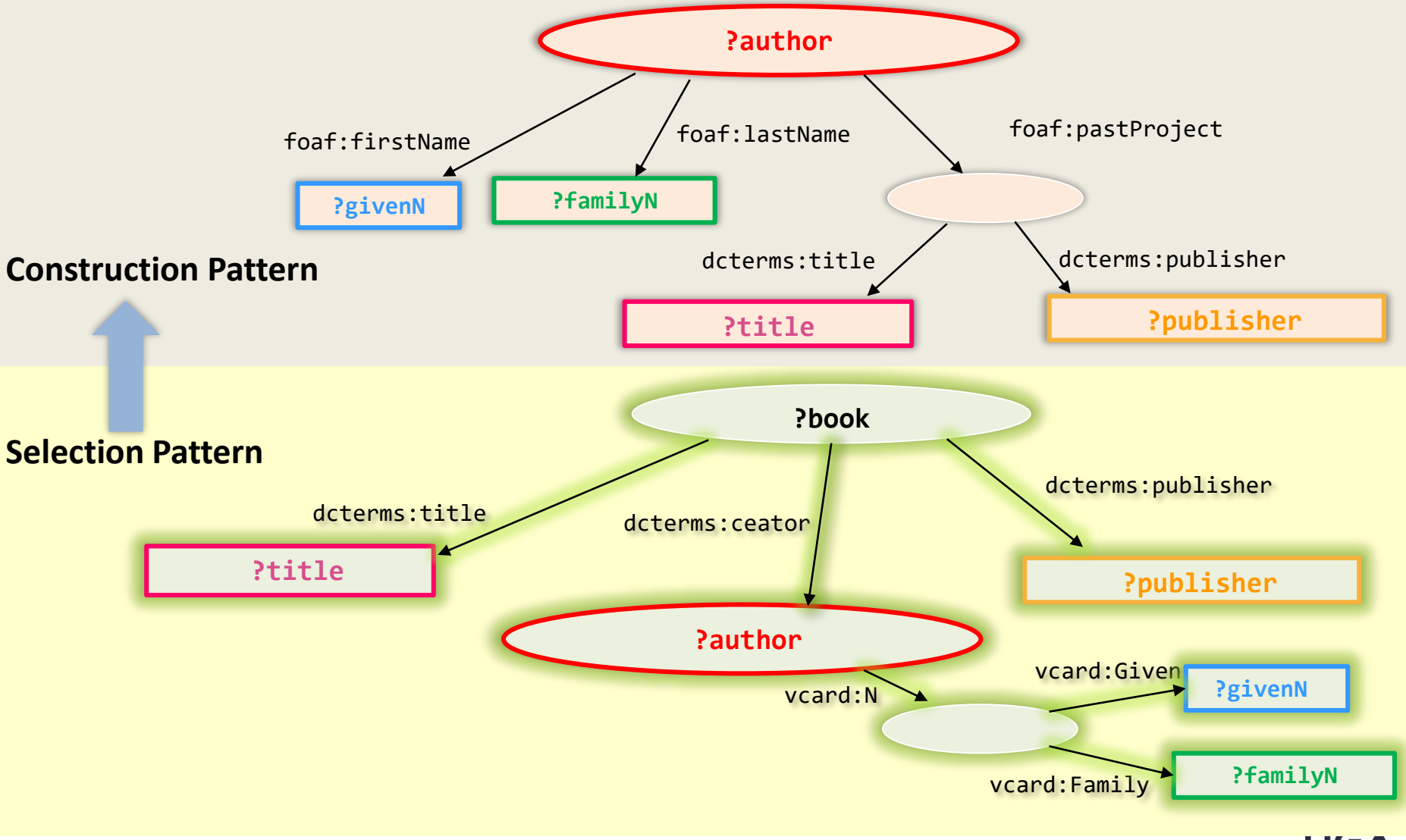
The graph we want



The graph we have



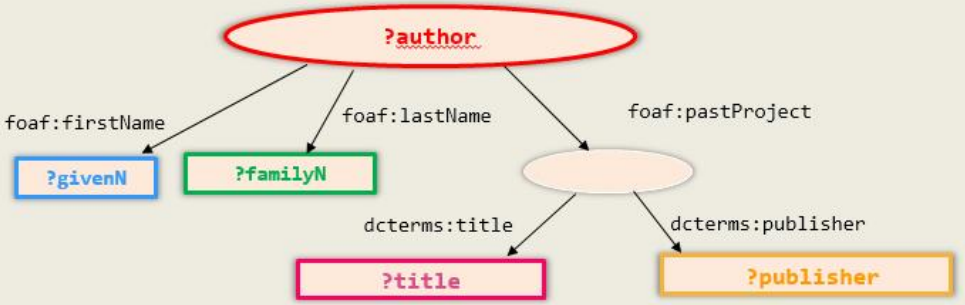
SPARQL Query Language
CONSTRUCT query



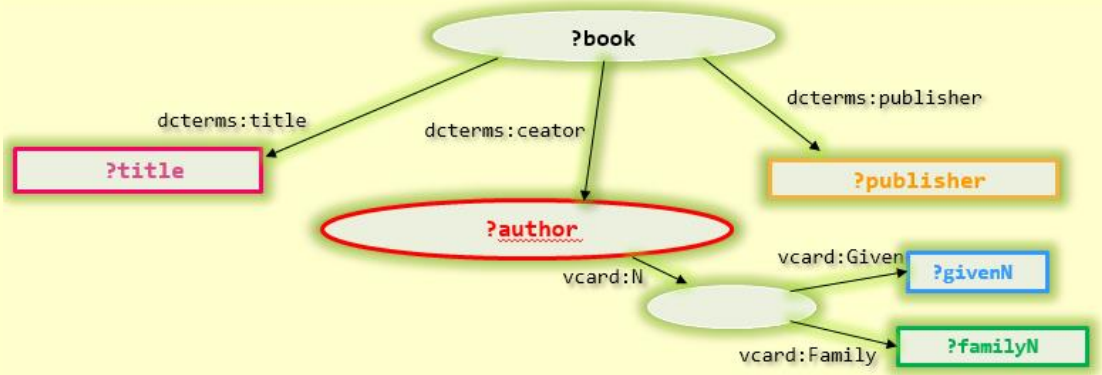
SPARQL Query Language
CONSTRUCT query

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

CONSTRUCT {
  ?author foaf:firstName ?givenN;
          foaf:lastName  ?familyN;
          foaf:pastProject [
              dc:title ?title;
              dc:publisher ?publisher
          ]
}
```



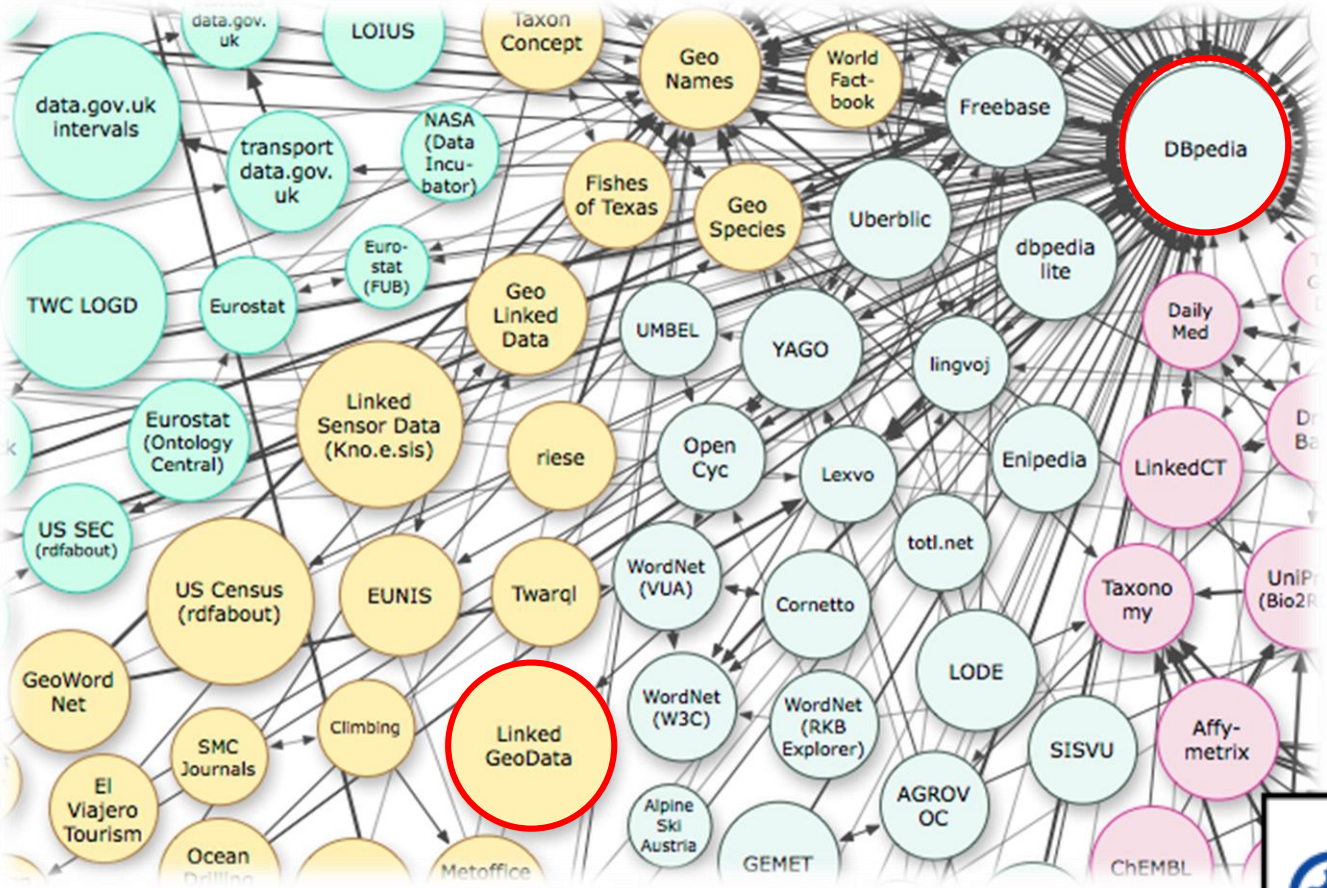

```
WHERE {
  ?book dc:title ?title;
        dc:creator ?author;
        dc:publisher ?publisher .
  ?author vcard:N  [
        vcard:Given ?givenN;
        vcard:Family ?familyN
      ] .
 }
```



SPARQL Query Language
DESCRIBE query

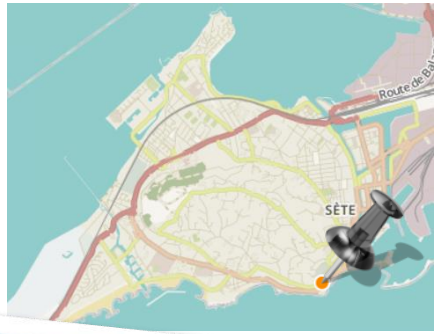
- `DESCRIBE` – Returns an RDF graph, based on what the query processor is configured to return.
  - SPARQL specification says : "the useful information the service has about a resource"
  - in theory this should help you understand the context of the resources returned… but there is no warranty.

SPARQL in action with LinkedGeoData



SPARQL Query Language: SELECT

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



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

Select ?s, ?l From <http://linkedgeodata.org>
Where
{
     ?s    a lgdo:Restaurant ;
           rdfs:label ?l ;
           geom:geometry [
              ogc:asWKT ?g
           ] .

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

SPARQL Query Language: SELECT

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

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

Select ?s, ?l From <http://linkedgeodata.org>
Where
{
      ?s    a lgdo:Restaurant ;
            rdfs:label ?l ;
            geom:geometry [
               ogc:asWKT ?g
            ] .

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

variable

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

SPARQL Query Language
Select

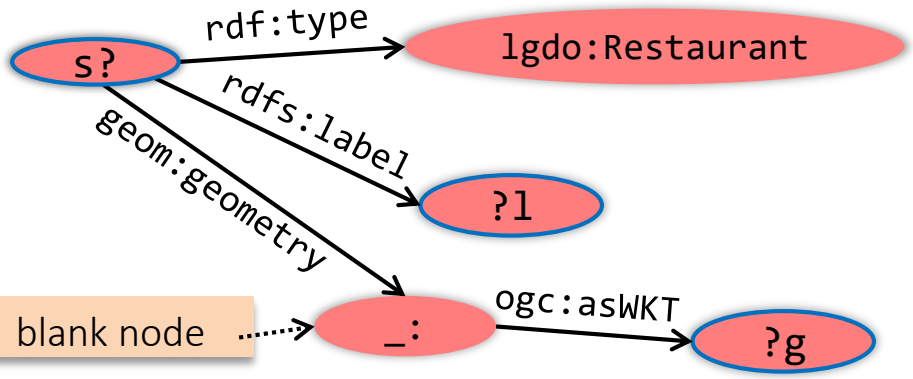
- Graph patterns can be combined to construct complex (conjunctive) requests.

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

Select ?s, ?l From <http://linkedgeodata.org>
Where
{
      ?s    a lgdo:Restaurant ;
            rdfs:label ?l ;
            geom:geometry [
                ogc:asWKT ?g
            ] .

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

variable



SPARQL Query Language
Select - Filters

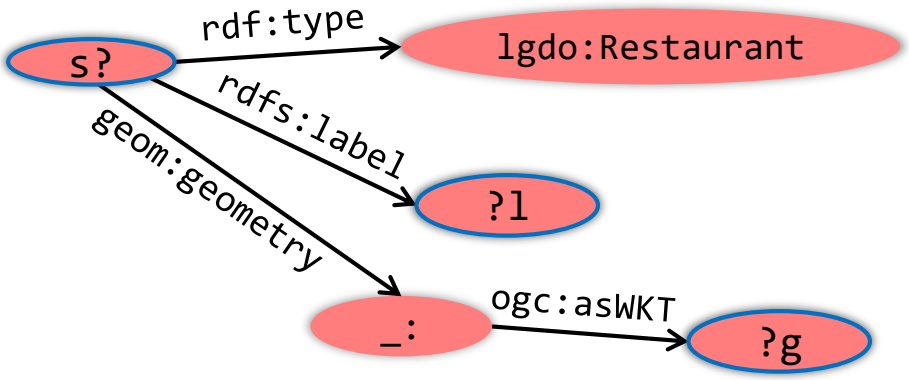
- Possibility to filter results
  - A filter allows to constrain solution values

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

Select ?s, ?l From <http://linkedgeodata.org>
Where
{
     ?s    a lgdo:Restaurant ;
           rdfs:label ?l ;
           geom:geometry [
              ogc:asWKT ?g
           ] .

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

Graph Pattern



Filter on ?g variable

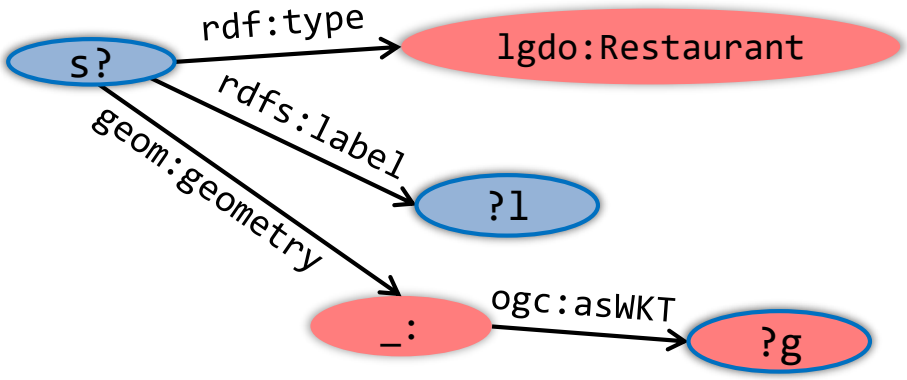
SPARQL Query Language
Select

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

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

Select ?s, ?l From <http://linkedgeodata.org>
Where
{
     ?s    a lgdo:Restaurant ;
           rdfs:label ?l ;
           geom:geometry [
              ogc:asWKT ?g
           ] .

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



SPARQL Query Language
Select clause - DataSets

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

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

Select ?s, ?l From <http://linkedgeodata.org>
Where
{
     ?s    a lgdo:Restaurant ;
           rdfs:label ?l ;
           geom:geometry [
              ogc:asWKT ?g
           ] .

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

graph on which the query is executed

SPARQL Query Language
Select -Filters

- Filters : allow to restrict the values in a solution
  - Boolean expression the request solutions must satisfy.
  - rich expression language based on Xpath, XQuery and special operators defined by SPARQL.

    see section 17 of SPARQL 1.1 Query Language specification document
    https://www.w3.org/TR/2013/REC-sparql11-query-20130321/#expressions
  - Relational operators: **<, >, =, <=, >=, !=**
    - Boolean operators: **&&, ||, !**
    - Arithmetic operator: **+ * - /**
    - Variable binding tests: **isURI(?x), isBlank(?x), isLiteral(?x), bound(?x**)
    - Regular expressions: **regex(?x, "A.*")**
    - Access to attributes/values **lang(), datatype(), str()**
    - Casting ((re-)typing functions) **xsd:integer(?x)**
    - External functions / extensions

SPARQL Query Language
Solution Modifiers

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

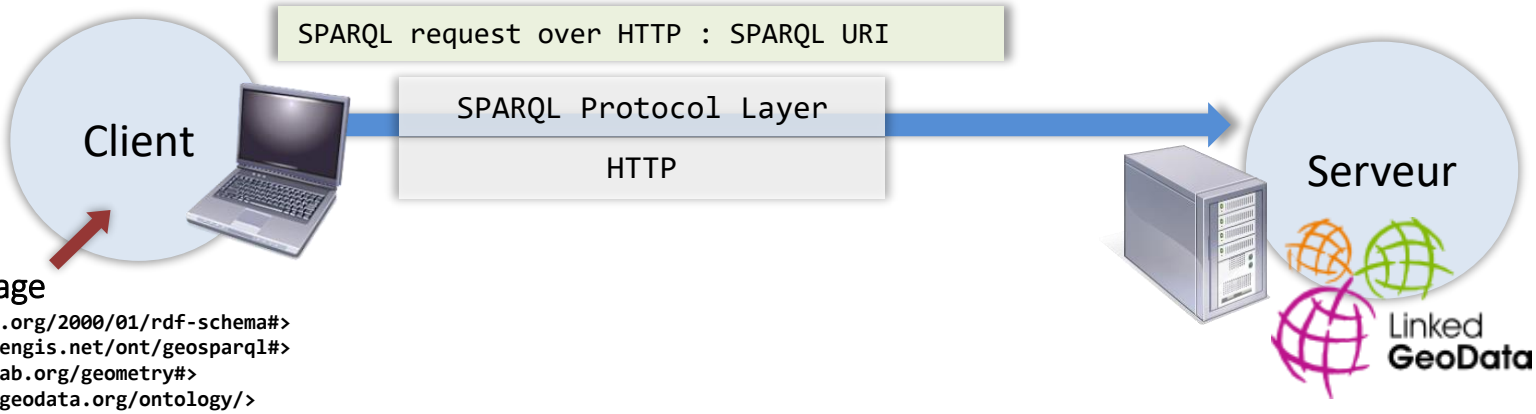
- The solution modifiers OFFSET/LIMIT and ORDER BY always apply to all result forms

example

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

SPARQL Protocol

http://linkedgeodata.org/sparql?default-graph-uri=http%3A%2F%2Flinkedgeodata.org&query=Prefix+rdfs%3A+%3Chttp%3A%2F%2Fwww.w3.org%2F2000%2F01%2Frdf-schema%23%3E%0D%0APrefix+ogc%3A+%3Chttp%3A%2F%2Fwww.opengis.net%2Font%2Fgeosparql%23%3E%0D%0APrefix+geom%3A+%3Chttp%3A%2F%2Fgeovocab.org%2Fgeometry%23%3E%0D%0APrefix+lgdo%3A+%3Chttp%3A%2F%2Flinkedgeodata.org%2Fontology%2F%3E%0D%0A%0D%0ASelect+*%0D%0AFrom+%3Chttp%3A%2F%2Flinkedgeodata.org%3E+%7B%0D%0A++%3Fs%0D%0A++++a+lgdo%3ARestaurant+%3B%0D%0A++++rdfs%3Alabel+%3Fl+%3B++++%0D%0A++++geom%3Ageometry+%5B%0D%0A++++++ogc%3AasWKT+%3Fg%0D%0A++++%5D+.%0D%0A%0D%0A++++Filter%28bif%3Ast_intersects+%28%3Fg%2C+bif%3Ast_point+%283.692764%2C+43.393794%29%2C+1%29%29+.%0D%0A%7D&format=application%2Fsparql-results%2Bxml



SPARQL Query Language

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

Select ?s, ?l From <http://linkedgeodata.org>
Where {
     ?s    a lgdo:Restaurant ;
           rdfs:label ?l ;
           geom:geometry [
              ogc:asWKT ?g
           ] .
     Filter(bif:st_intersects (?g, bif:st_point (3.692764, 43.393794), 1)) .
}
```

SPARQL Protocol

- SPARQL request over HTTP (SPARQL URI) has 4 components:

the SPARQL endpoint URL
http://linkedgeodata.org/sparql

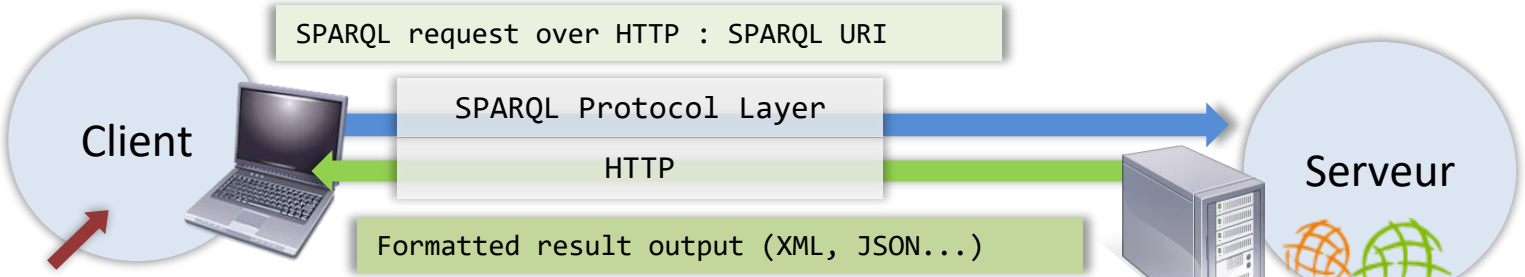
The RDF graphs to request (optional)
default-graph-uri=http://linkedgeodata.org
named-graph-uri=...

http://linkedgeodata.org/sparql?default-graph-uri=http%3A%2F%2Flinkedgeodata.org
&query=Prefix+rdfs%3A+%3Chttp%3A%2F%2Fwww.w3.org%2F2000%2F01%2Frdf-schema%23%3E%0D%0APrefix+ogc%3A+%3Chttp%3A%2F%2Fwww.opengis.net%2Font%2Fgeosparql%23%3E%0D%0APrefix+geom%3A+%3Chttp%3A%2F%2Fgeovocab.org%2Fgeometry%23%3E%0D%0APrefix+lgdo%3A+%3Chttp%3A%2F%2Flinkedgeodata.org%2Fontology%2F%3E%0D%0A%0D%0ASelect+*%0D%0AFrom+%3Chttp%3A%2F%2Flinkedgeodata.org%3E+%7B%0D%0A++%3Fs%0D%0A++++a+lgdo%3ARestaurant+%3B%0D%0A++++rdfs%3Alabel+%3Fl+%3B++++%0D%0A++++geom%3Ageometry+%5B%0D%0A++++++ogc%3AasWKT+%3Fg%0D%0A++++%5D+.%0D%0A%0D%0A+++++Filter%28bif%3Ast_intersects+%28%3Fg%2C+bif%3Ast_point+%283.692764%2C+43.393794%29%2C+1%29%29+.%0D%0A%7D**&format**=application%2Fsparql-results%2Bxml

The query string
(URL encoded)

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

SPARQL output format



SPARQL Query Language

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

Select ?s, ?l From <http://linkedgeodata.org>
Where {
     ?s     a lgdo:Restaurant ;
            rdfs:label ?l ;
            geom:geometry [
               ogc:asWKT ?g
            ] .
     Filter(bif:st_intersects (?g, bif:st_point (3.692764, 43.393794), 1))
}
```

```
<sparql xmlns="http://www.w3.org/2005/sparql-results#"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:schemaLocation="http://www.w3.org/2001/sw/DataAccess/rf1/result2.xsd">
 <head>
    <variable name="s"/>
    <variable name="l"/>
 </head>
 <results distinct="false" ordered="true">
    <result>
        <binding name="s">
            <uri>http://linkedgeodata.org/triplify/node1304006380</uri>
        </binding>
        <binding name="l">
            <literal>L&#39;Hostal</literal>
        </binding>
    </result>
    <result>
        <binding name="s">
            <uri>http://linkedgeodata.org/triplify/node1952213273</uri>
        </binding>
        <binding name="l">
            <literal>L&#39;Ultima</literal>
        </binding>
    </result>
 </results>
</sparql>
```

Variables from the SELECT clause

one ***result*** element for each row in the result set

binding of one the variables of this result

SPARQL 1.1: functionalities 2013

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

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

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

Persons who don't have a name

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

    - `MINUS` removing solutions related to another pattern.

SPARQL 1.1: functionalities 2013

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

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

The data

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

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

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

y
:bob
:carol

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

1: inner query evaluation

2: outer query evaluation

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

SPARQL 1.1: functionalities 2013

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

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

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

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

find out the name of http://dbpedia.org/resource/Snoopy

evaluation of this pattern is delegated to the respective remote SPARQL service **`http://dbpedia.org/sparql`**

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

SPARQL 1.1: functionalities 2013

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

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