AMPER Course

Introduction to SPARQL

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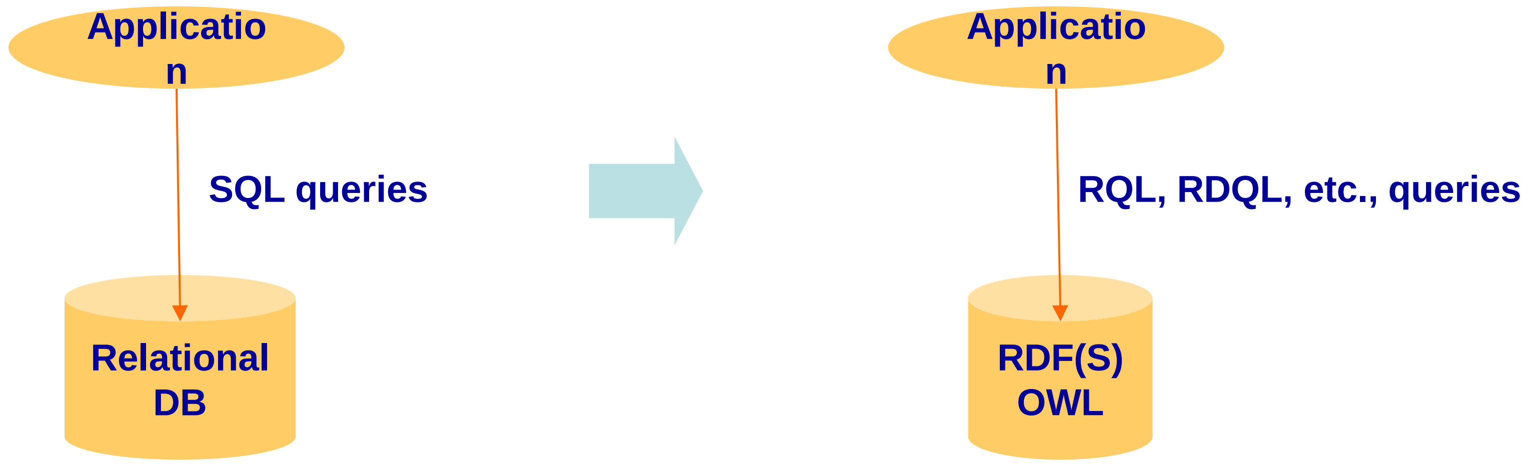
RDF(S) query languages

- Languages developed to allow accessing datasets expressed in RDF(S) (and in some cases OWL)



- Supported by the most important language APIs
  - Jena (HP labs)
  - Sesame (Aduna)
  - Boca (IBM)
  - ...
- There are some differences wrt languages like SQL, such as
  - Combination of different sources
  - Trust management
  - Open World Assumption

Query types

- Selection and extraction
  - "Select all the essays, together with their authors and their authors' names".
  - "Select everything that is related to the book 'Bellum Civille'"
- Reduction: we specify what it should not be returned
  - "Select everything except for the ontological information and the book translators"
- Restructuring: the original structure is changed in the final result
  - "Invert the relationship 'author' by 'is author of'"
- Aggregation
  - "Return all the essays together with the mean number of authors per essay"
- Combination and inferences
  - "Combine the information of a book called 'La guerra civil' and whose author is Julius Caesar with the book whose identifier is 'Bellum Civille'"
  - "Select all the essays, together with its authors and author names", *including also the instances of the subclasses of Essay*.
  - "Obtain the relationship 'coauthor' among persons who have written the same book".

RDF(S) query language families

- **SquishQL Family**
  - SquishQL
  - rdfDB Query Language
  - RDQL
  - BRQL
  - TriQL
- **XPath, XSLT, Xquery**
  - XQuery for RDF
  - XsRQL
  - TreeHugger and RDFTwig
  - RDFT, Nexus Query Language
  - RDFPath, Rpath and RXPath
  - Versa

Triple database Query structure

XML repository Query syntax

- **RQL Family**
  - RQL
  - SeRQL
  - eRQL
- **Controlled natural language**
  - Metalog
- **Other**
  - Algae
  - iTQL
  - N3QL
  - PerlRDF Query Language
  - RDEVICE Deductive Language
  - RDFQBE
  - RDFQL
  - TRIPLE
  - WQL

Description graphs Query semantics

SPARQL

W3C Recommendation

15 January 2008

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SPARQL

- **SPARQL P**rotocol **a**nd **R**DF **Q**uery **L**anguage
- **Supported by:** Jena, Sesame, IBM Boca, etc.
- **Features**
  - It supports most of the aforementioned queries
  - It supports datatype reasoning (datatypes can be requested instead of actual values)
  - The domain vocabulary and the knowledge representation vocabulary are treated differently by the query interpreters.
  - It allows making queries over properties with multiple values, over multiple properties of a resource and over reifications
  - Queries can contain optional statements
  - Some implementations support aggregation queries
- **Limitations**
  - Neither set operations nor existential or universal quantifiers can be included in the queries
  - It does not support recursive queries

SPARQL is also a protocol

- SPARQL is a Query Language ...:
  Find names and websites of contributors to PlanetRDF:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name ?website
FROM <http://planetrdf.com/bloggers.rdf>
WHERE {
     ?person foaf:weblog ?website .
     ?person foaf:name ?name .
     ?website a foaf:Document }
```

- ... and a Protocol.
  `http://.../qps`**`?query-lang=`**`http://www.w3.org/TR/rdf-sparql-query/`**`&graph-id=`**`http://planetrdf.com/bloggers.rdf`**`&query=`**`PREFIXfoaf: <http://xmlns.com/foaf/0.1/...`

- Services running SPARQL queries over a set of graphs
- A transport protocol for invoking the service
- Based on ideas from earlier protocol work such as Joseki
- Describing the service with Web Service technologies

A simple SPARQL query

Data:

```
@prefix dc: <http://purl.org/dc/elements/1.1/> .
@prefix : <http://example.org/book/> .
:book1 dc:title "SPARQL Tutorial" .
```

Query:

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

Query result:

title
"SPARQL Tutorial"

- A pattern is *matched* against the RDF data
- Each way a pattern can be matched yields a solution
- The sequence of solutions is filtered by: Project, distinct, order, limit/offset
- One of the result forms is applied: SELECT, CONSTRUCT, DESCRIBE, ASK

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Turtle: URIs, blank nodes, literals

- URIs

  Enclosed in <>

  ```
  <URI>
  ```

  or

  ```
  @prefix prefix <http://....>
  prefix:name
  ```

- Blank Nodes

  ```
  :name
  ```

  or

  `[]` for a Blank Node used once

- Literals

  ```
  "Literal"
  "Literal"@language
  """Long literal with
  newlines"""
  ```

- Datatyped Literals

  "lexical form"^^datatype URI

  ```
  "10"^^xsd:integer
  "2006-09-04"^^xsd:date
  ```

Turtle: Triples and abbreviations

- Triples separated by .

  `:a :b :c . :d :e :f .`
- Common triple predicate and subject:

  `:a :b :c, :d .`

  which is the same as `:a :b :c . :a :b :d .`
- Common triple subject:

  `:a :b :c; :d :e .`

  which is the same as: `:a :b :c . :a :d :e .`
- Blank node as a subject

  `:a :b [ :c :d ]`

  which is the same as: `:a :b _:x . _:x :c :d .`

  for blank node `_:x`
- RDF Collections
  - `:a :b ( :c :d :e :f )`

    which is short for many triples

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Graph patterns

- Basic Graph Patterns, where a set of triple patterns must match
- Group Graph Pattern, where a set of graph patterns must all match
- Optional Graph patterns, where additional patterns may extend the solution
- Alternative Graph Pattern, where two or more possible patterns are tried
- Patterns on Named Graphs, where patterns are matched against named graphs

Basic graph patterns: Multiple matches

```
@prefix foaf:  <http://xmlns.com/foaf/0.1/> .

_:a  foaf:name   "Johnny Lee Outlaw" .
_:a  foaf:mbox   <mailto:jlow@example.com> .
_:b  foaf:name   "Peter Goodguy" .
_:b  foaf:mbox   <mailto:peter@example.org> .
_:c  foaf:mbox   <mailto:carol@example.org> .
```

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

name	mbox
"Johnny Lee Outlaw"	<mailto:jlow@example.com>
"Peter Goodguy"	<mailto:peter@example.org>

Basic graph patterns: Matching RDF literals

```
@prefix dt:   <http://example.org/datatype#> .
@prefix ns:   <http://example.org/ns#> .
@prefix :     <http://example.org/ns#> .
@prefix xsd:  <http://www.w3.org/2001/XMLSchema#> .

:x   ns:p     "cat"@en .
:y   ns:p     "42"^^xsd:integer .
:z   ns:p     "abc"^^dt:specialDatatype .
```

```
SELECT ?v WHERE { ?v ?p "cat" }
```

v

```
SELECT ?v WHERE { ?v ?p "cat"@en }
```

v
<http://example.org/ns#x>

```
SELECT ?v WHERE { ?v ?p 42 }
```

v
<http://example.org/ns#y>

```
SELECT ?v WHERE { ?v ?p "abc"^^<http://example.org/datatype#specialDatatype> }
```

v
<http://example.org/ns#z>

Basic graph patterns: Blank node labels in query results

```
@prefix foaf:  <http://xmlns.com/foaf/0.1/> .

_:a  foaf:name   "Alice" .
_:b  foaf:name   "Bob" .
```

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

x	name
_:c	"Alice"
_:d	"Bob"

=

x	name
_:r	"Alice"
_:s	"Bob"

Group graph pattern

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

```
SELECT ?x
WHERE {}
```

```
PREFIX foaf:    <http://xmlns.com/foaf/0.1/>
SELECT ?name ?mbox
WHERE  { { ?x foaf:name ?name . }
         { ?x foaf:mbox ?mbox . FILTER regex(?name, "Smith")}
       }
```

Optional graph patterns

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

_:a  rdf:type        foaf:Person .
_:a  foaf:name       "Alice" .
_:a  foaf:mbox       <mailto:alice@example.com> .
_:a  foaf:mbox       <mailto:alice@work.example> .

_:b  rdf:type        foaf:Person .
_:b  foaf:name       "Bob" .
```

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

name	mbox
"Alice"	<mailto:alice@example.com>
"Alice"	<mailto:alice@work.example>
“Bob"	

Multiple optional graph patterns

```
@prefix foaf:       <http://xmlns.com/foaf/0.1/> .

_:a  foaf:name       "Alice" .
_:a  foaf:homepage   <http://work.example.org/alice/> .

_:b  foaf:name       "Bob" .
_:b  foaf:mbox       <mailto:bob@work.example> .
```

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name ?mbox ?hpage
WHERE  { ?x foaf:name  ?name .
         OPTIONAL { ?x foaf:mbox ?mbox } .
         OPTIONAL { ?x foaf:homepage ?hpage }
       }
```

name	mbox	hpage
"Alice"		<http://work.example.org/alice/>
“Bob"	<mailto:bob@work.example>	

Alternative graph patterns

```
@prefix dc10:  <http://purl.org/dc/elements/1.0/> .
@prefix dc11:  <http://purl.org/dc/elements/1.1/> .

_:a  dc10:title     "SPARQL Query Language Tutorial" .
_:a  dc10:creator   "Alice" .
_:b  dc11:title     "SPARQL Protocol Tutorial" .
_:b  dc11:creator   "Bob" .
_:c  dc10:title     "SPARQL" .
_:c  dc11:title     "SPARQL (updated)" .
```

```
PREFIX dc10:  <http://purl.org/dc/elements/1.0/>
PREFIX dc11:  <http://purl.org/dc/elements/1.1/>
SELECT ?title
WHERE  { { ?book dc10:title  ?title } UNION
         { ?book dc11:title  ?title } }
```

title
"SPARQL Protocol Tutorial"
"SPARQL"
"SPARQL (updated)"
"SPARQL Query Language Tutorial"

```
SELECT ?x ?y
WHERE  { { ?book dc10:title ?x } UNION
         { ?book dc11:title  ?y } }
```

x	y
	"SPARQL (updated)"
	"SPARQL Protocol Tutorial"
"SPARQL"	
"SPARQL Query Language Tutorial"	

```
SELECT ?title ?author
WHERE
  { { ?book dc10:title ?title . ?book dc10:creator ?author }
    UNION
    { ?book dc11:title ?title . ?book dc11:creator ?author }}
```

author	title
"Alice"	"SPARQL Protocol Tutorial"
“Bob”	"SPARQL Query Language Tutorial"

Patterns on named graphs

```
# Named graph: http://example.org/foaf/aliceFoaf
@prefix foaf:<http://.../foaf/0.1/> .
@prefix rdf:<http://.../1999/02/22-rdf-syntax-ns#> .
@prefix rdfs:<http://.../2000/01/rdf-schema#> .

_:a  foaf:name      "Alice" .
_:a  foaf:mbox      <mailto:alice@work.example> .
_:a  foaf:knows     _:b .

_:b  foaf:name      "Bob" .
_:b  foaf:mbox      <mailto:bob@work.example> .
_:b  foaf:nick      "Bobby" .
_:b  rdfs:seeAlso   <http://example.org/foaf/bobFoaf> .

<http://example.org/foaf/bobFoaf>
     rdf:type       foaf:PersonalProfileDocument .
```

```
# Named graph: http://example.org/foaf/bobFoaf
@prefix foaf:<http://.../foaf/0.1/> .
@prefix rdf:<http://.../1999/02/22-rdf-syntax-ns#> .
@prefix rdfs:<http://.../2000/01/rdf-schema#> .

_:z  foaf:mbox      <mailto:bob@work.example> .
_:z  rdfs:seeAlso   <http://example.org/foaf/bobFoaf> .
_:z  foaf:nick      "Robert" .

<http://example.org/foaf/bobFoaf>
     rdf:type       foaf:PersonalProfileDocument .
```

Patterns on named graphs II

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

SELECT ?src ?bobNick
FROM NAMED <http://example.org/foaf/aliceFoaf>
FROM NAMED <http://example.org/foaf/bobFoaf>
WHERE
  {
    GRAPH ?src
    { ?x foaf:mbox <mailto:bob@work.example> .
      ?x foaf:nick ?bobNick
    }
  }
```

src	bobNick
<http://example.org/foaf/aliceFoaf>	"Bobby"
<http://example.org/foaf/bobFoaf>	"Robert"

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

SELECT ?nick
FROM NAMED <http://example.org/foaf/aliceFoaf>
FROM NAMED <http://example.org/foaf/bobFoaf>
WHERE
  {
     GRAPH data:bobFoaf {
         ?x foaf:mbox <mailto:bob@work.example> .
         ?x foaf:nick ?nick }
  }
```

nick
"Robert"

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Restricting values

```
@prefix dc:   <http://purl.org/dc/elements/1.1/> .
@prefix :     <http://example.org/book/> .
@prefix ns:   <http://example.org/ns#> .

:book1  dc:title  "SPARQL Tutorial" .
:book1  ns:price  42 .
:book2  dc:title  "The Semantic Web" .
:book2  ns:price  23 .
```

```
PREFIX  dc:  <http://purl.org/dc/elements/1.1/>
SELECT  ?title
WHERE   { ?x dc:title ?title
          FILTER regex(?title, "^SPARQL")
        }
```

title
"SPARQL Tutorial"

```
PREFIX  dc:  <http://purl.org/dc/elements/1.1/>
SELECT  ?title
WHERE   { ?x dc:title ?title
          FILTER regex(?title, "web", "i" )
        }
```

title
"The Semantic Web"

```
PREFIX  dc:  <http://purl.org/dc/elements/1.1/>
PREFIX  ns:  <http://example.org/ns#>
SELECT  ?title ?price
WHERE   { ?x ns:price ?price .
          FILTER (?price < 30.5)
          ?x dc:title ?title . }
```

title	price
"The Semantic Web"	23

Value tests

- Based on XQuery 1.0 and XPath 2.0 Function and Operators
- XSD boolean, string, integer, decimal, float, double, dateTime
- Notation <, >, =, <=, >= and != for value comparison Apply to any type
- BOUND, isURI, isBLANK, isLITERAL
- REGEX, LANG, DATATYPE, STR (lexical form)
- Function call for casting and extensions functions

Solution sequences and modifiers

- Order modifier: put the solutions in order

```
SELECT ?name
WHERE { ?x foaf:name ?name ; :empId ?emp }
ORDER BY ?name DESC(?emp)
```

- Projection modifier: choose certain variables

```
SELECT ?name
WHERE
 { ?x foaf:name ?name }
```

- Distinct modifier: ensure solutions in the sequence are unique

```
SELECT DISTINCT ?name
WHERE { ?x foaf:name ?name }
```

- Reduced modifier: permit elimination of some non-unique solutions

```
SELECT REDUCED ?name
WHERE { ?x foaf:name ?name }
```

- Offset modifier: control where the solutions start from in the overall sequence of solutions

```
SELECT  ?name WHERE { ?x foaf:name ?name }
ORDER BY ?name
LIMIT   5
OFFSET  10
```

- Limit modifier: restrict the number of solutions

```
SELECT ?name
WHERE { ?x foaf:name ?name }
LIMIT 20
```

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SPARQL query forms

- SELECT
  - Returns all, or a subset of, the variables bound in a query pattern match.
- CONSTRUCT
  - Returns an RDF graph constructed by substituting variables in a set of triple templates.
- ASK
  - Returns a boolean indicating whether a query pattern matches or not.
- DESCRIBE
  - Returns an RDF graph that describes the resources found.

SPARQL query forms: SELECT

```
@prefix  foaf:  <http://xmlns.com/foaf/0.1/> .

_:a    foaf:name   "Alice" .
_:a    foaf:knows  _:b .
_:a    foaf:knows  _:c .

_:b    foaf:name   "Bob" .

_:c    foaf:name   "Clare" .
_:c    foaf:nick   "CT" .
```

```
PREFIX foaf:    <http://xmlns.com/foaf/0.1/>
SELECT ?nameX ?nameY ?nickY
WHERE
  { ?x foaf:knows ?y ;
       foaf:name ?nameX .
    ?y foaf:name ?nameY .
    OPTIONAL { ?y foaf:nick ?nickY }
  }
```

nameX	nameY	nickY
"Alice"	"Bob"	
"Alice"	"Clare"	"CT"

SPARQL query forms: CONSTRUCT

```
@prefix  foaf:  <http://xmlns.com/foaf/0.1/> .

_:a     foaf:name    "Alice" .
_:a     foaf:mbox    <mailto:alice@example.org> .
```

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

CONSTRUCT   { <http://example.org/person#Alice> vcard:FN ?name }

WHERE       { ?x foaf:name ?name }
```

Query result:

```
@prefix vcard: <http://www.w3.org/2001/vcard-rdf/3.0#> .

<http://example.org/person#Alice> vcard:FN "Alice" .
```

SPARQL query forms: ASK

```
@prefix foaf:        <http://xmlns.com/foaf/0.1/> .

_:a  foaf:name        "Alice" .
_:a  foaf:homepage    <http://work.example.org/alice/> .

_:b  foaf:name        "Bob" .
_:b  foaf:mbox        <mailto:bob@work.example> .
```

```
PREFIX foaf:    <http://xmlns.com/foaf/0.1/>
ASK  { ?x foaf:name  "Alice" }
```

Query result:

```
yes
```

SPARQL query forms: DESCRIBE

```
PREFIX ent:  <http://org.example.com/employees#>
DESCRIBE ?x WHERE { ?x ent:employeeId "1234" }
```

Query result:

```
@prefix foaf:   <http://xmlns.com/foaf/0.1/> .
@prefix vcard:  <http://www.w3.org/2001/vcard-rdf/3.0> .
@prefix exOrg:  <http://org.example.com/employees#> .
@prefix rdf:    <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix owl:    <http://www.w3.org/2002/07/owl#>

_:a     exOrg:employeeId    "1234" ;

        foaf:mbox_sha1sum   "ABCD1234" ;
        vcard:N
         [ vcard:Family       "Smith" ;
           vcard:Given        "John"   ] .

foaf:mbox_sha1sum  rdf:type  owl:InverseFunctionalProperty .
```

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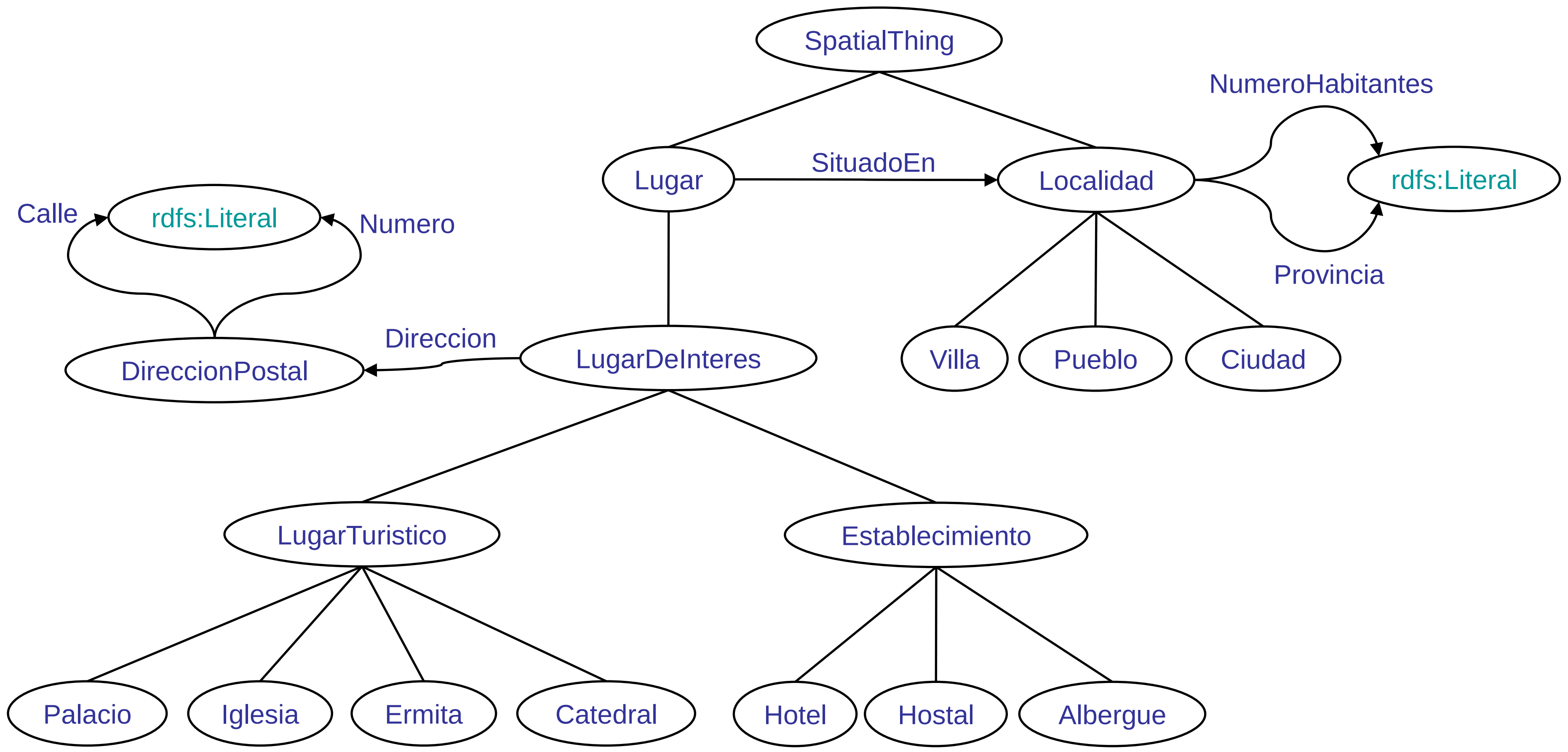
Hands-on

- Perform a set of queries over the sample ontology

- Browse to:
  - http://my.computer.ip:8080/openrdf-workbench
- Select repository *GP-native-rdfs*
- Select the *Query* option from the left menu

Sample ontology



Queries on the model

1) Get all the classes

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?x WHERE { ?x a rdfs:Class. }
```

2) Get the subclasses of the class *Establecimiento*

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
SELECT ?x WHERE { ?x rdfs:subClassOf pr:Establecimiento. }
```

3) Get the instances of the class *Ciudad*

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
SELECT ?x WHERE { ?x a pr:Ciudad. }
```

Queries on the instances

4) Get the number of inhabitants of *Santiago de Compostela*

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
SELECT ?x WHERE { pr:Santiago_de_Compostela pr:NumeroHabitantes ?x. }
```

5) Get the number of inhabitants of *Santiago de Compostela* and of *Arzua*

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
SELECT ?x WHERE {
                  {pr:Santiago_de_Compostela pr:NumeroHabitantes ?x.}
                  UNION
                  {pr:Arzua pr:NumeroHabitantes ?x.}
                }
```

6) Get different places with the inhabitants number, ordering the results by the name of the place (ascending)

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?x ?y  WHERE { $sitio pr:NumeroHabitantes ?y;
                             rdfs:label ?x.}
ORDER BY ASC(?x)
```

Queries on the instances II

7) Get all the instances of *Localidad* with their inhabitant number (if it exists)

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?x ?y  WHERE { $sitio a pr:Localidad;
                             rdfs:label ?x.
                      OPTIONAL {$sitio pr:NumeroHabitantes ?y.} }
```

8) Get all the places with more than 200.000 inhabitants

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?x ?y  WHERE { $sitio pr:NumeroHabitantes ?y;
                             rdfs:label ?x.
                      FILTER(?y > 200000) }
```

9) Get postal data of *Pazo de Breogan (calle, número, localidad, provincia)*

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?calle ?numero ?poblacion ?provincia
WHERE { pr:Pazo_Breogan pr:SituadoEn $pob;
                        pr:Direccion $dir.
        $pob rdfs:label ?poblacion;
             pr:Provincia ?provincia.
        $dir pr:Calle ?calle;
             pr:Numero ?numero.}
```

Queries with inference

10) Get the subclasses of class *Lugar*

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
SELECT ?x WHERE { ?x rdfs:subClassOf pr:Lugar. }
```

11) Get the instances of class *Localidad*

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
SELECT ?x WHERE { ?x a pr:Localidad. }
```

Special query (SELECT *)

12) Get the values of all the variables in the query

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
SELECT * WHERE { ?x pr:NumeroHabitantes ?y. }
```

Different query forms

13) Describe the resource with *rdfs:label* "*Madrid*"

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
DESCRIBE ?x WHERE { ?x rdfs:label "Madrid". }
```

14) Construct the RDF(S) graph that directly relates all the touristic places with their respective provinces, using a new property called "*estaEn*".

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
CONSTRUCT {?x pr:estaEn ?y}
WHERE {
        ?x a pr:LugarTuristico;
             pr:SituadoEn $pob.
        $pob pr:Provincia ?y. }
```

15) Ask if there is some instance of *Pueblo*

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
ASK WHERE {?a a pr:Pueblo}
```

16) Ask if there is some instance of *Ermita*

```
PREFIX pr: <http://GP-onto.fi.upm.es/Practica2#>
ASK WHERE {?a a pr:Ermita}
```

References

- SPARQL specification
  - http://www.w3.org/TR/rdf-sparql-query/
- SPARQL validator
  - http://www.sparql.org/validator.html
- SPARQL implementations
  - http://esw.w3.org/topic/SparqlImplementations
- SPARQL tutorials
  - http://jena.sourceforge.net/ARQ/Tutorial/
  - http://www.w3.org/2004/Talks/17Dec-sparql/intro/all.html
  - http://www.cs.man.ac.uk/~bparsia/2006/row-tutorial/

AMPER Course

Introduction to SPARQL

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