


RDF and RDF Schema

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Main References

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Capítulo 4: Ontology languages

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Lassila O, Swick R (1999) *Resource Description Framework (RDF) Model and Syntax Specification*. W3C Recommendation.
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Prud'hommeaux E, Seaborne A (2008) *SPARQL Query Language for RDF*. W3C Recommendation.
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Jena web site: *http://jena.sourceforge.net/*
Jena API: *http://jena.sourceforge.net/tutorial/RDF_API/*
Jena tutorials: *http://www.ibm.com/developerworks/xml/library/j-jena/index.html*
http://www.xml.com/pub/a/2001/05/23/jena.html

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/

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Sample RDF APIs

RDF libraries for different languages:

- Java, Python, C, C++, C#, .Net, Javascript, Tcl/Tk, PHP, Lisp, Obj-C, Prolog, Perl, Ruby, Haskell
- List in http://esw.w3.org/topic/SemanticWebTools

Usually related to a RDF repository

- **Multilanguage:**
  - Redland RDF Application Framework (C, Perl, PHP, Python and Ruby): http://www.redland.opensource.ac.uk/
- **Java:**
  - Jena: http://jena.sourceforge.net/
  - Sesame: http://www.openrdf.org/
- **PHP:**
  - RAP - RDF API for PHP: http://www4.wiwiss.fu-berlin.de/bizer/rdfapi/
- **Python:**
  - RDFLib: http://rdflib.net/
  - Pyrple: http://infomesh.net/pyrple/

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Jena

- **Java framework for building Semantic Web applications**
- **Open source software from HP Labs**
- **The Jena framework includes:**
  - A RDF API
  - An OWL API
  - Reading and writing RDF in RDF/XML, N3 and N-Triples
  - In-memory and persistent storage
  - A rule based inference engine
  - SPARQL query engine

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Sesame

- **A framework for *storage*, *querying* and *inferencing* of RDF and RDF Schema**
- **A Java Library for handling RDF**
- **A Database Server for (remote) access to *repositories* of RDF data**
- **Highly expressive query and transformation languages**
  - SeRQL, SPARQL
- **Various backends**
  - Native Store
  - RDBMS (MySQL, Oracle 10, DB2, PostgreSQL)
  - main memory
- **Reasoning support**
  - RDF Schema reasoner
  - OWL DLP (OWLIM)
  - domain reasoning (custom rule engine)

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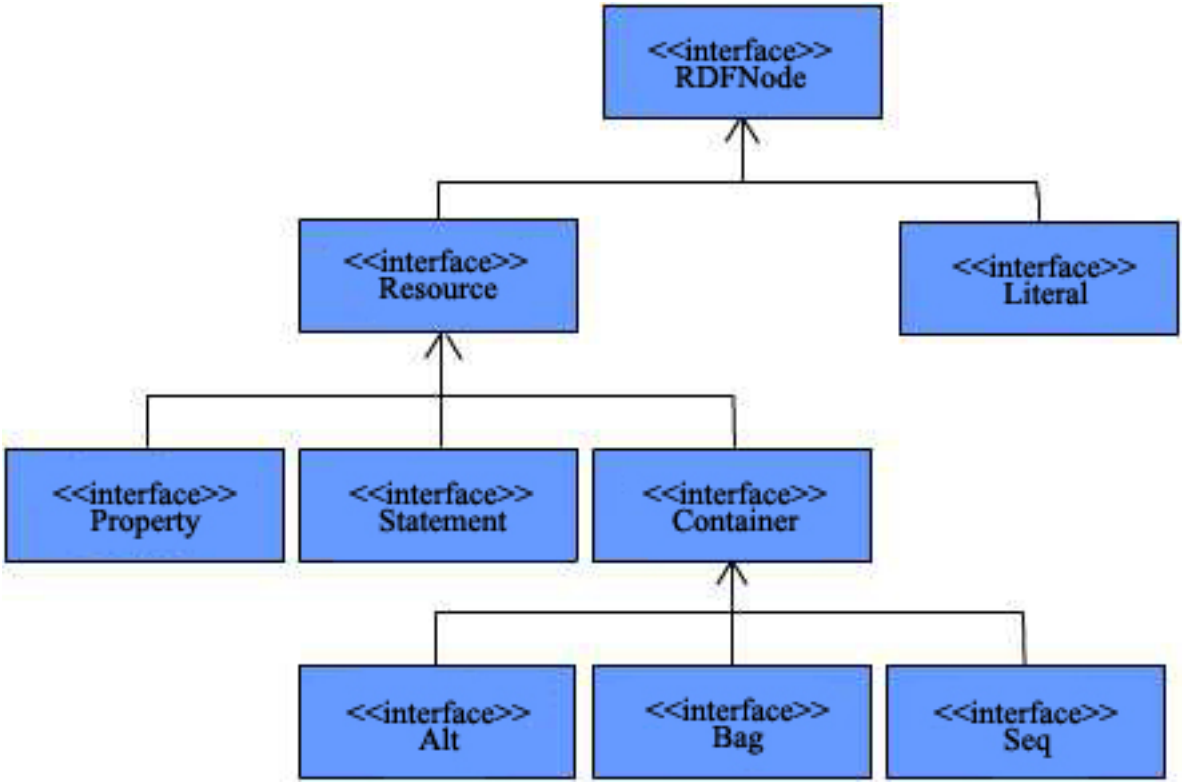
Jena API Structure



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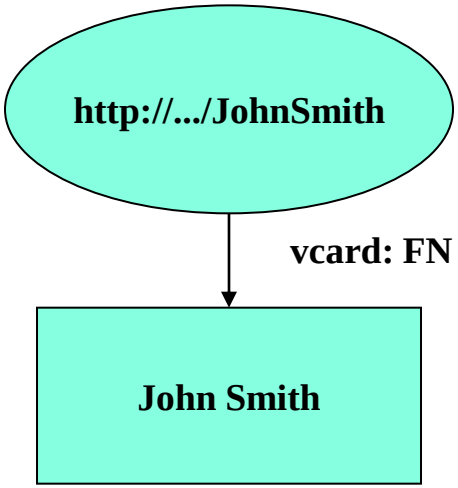
Data Model




```
// some definitions
static String personURI = "http://somewhere/JohnSmith";
static String fullName = "John Smith";
// create an empty Model
Model model = ModelFactory.createDefaultModel();
// create the resource
Resource johnSmith = model.createResource(personURI);
// add the property
johnSmith.addProperty(VCARD.FN, fullName);
```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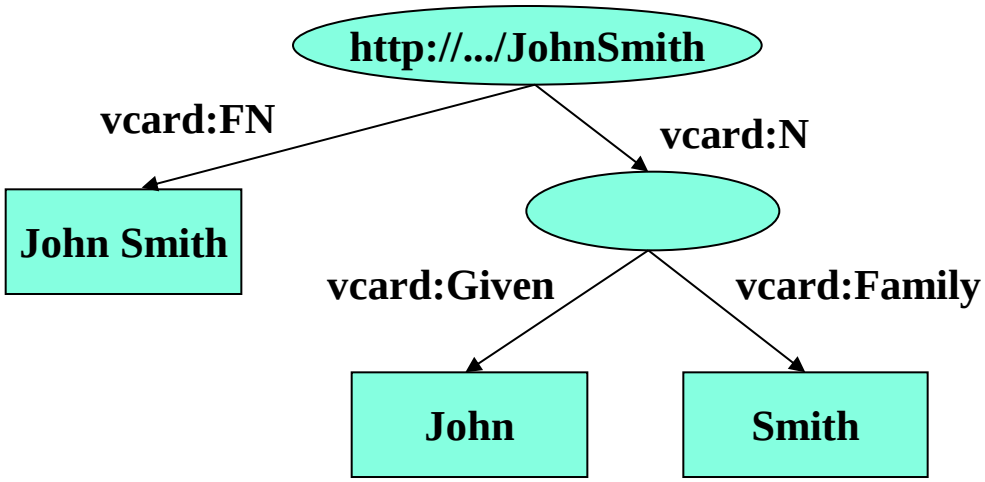
Another data model




```
// some definitions
String personURI = "http://somewhere/JohnSmith";
String givenName = "John";
String familyName = "Smith";
String fullName = givenName + " " + familyName;
// create an empty
Model Model model = ModelFactory.createDefaultModel();
// create the resource
// and add the properties cascading style
Resource johnSmith = model.createResource(personURI)
     .addProperty(VCARD.FN, fullName)
     .addProperty(VCARD.N, model.createResource()
     .addProperty(VCARD.Given, givenName)
     .addProperty(VCARD.Family, familyName));
```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Statements

```
// list the statements in the Model
StmtIterator iter = model.listStatements();
// print out the predicate, subject and object of each statement
while (iter.hasNext())
{
    Statement stmt = iter.nextStatement(); // get next statement
    Resource subject = stmt.getSubject(); // get the subject
    Property predicate = stmt.getPredicate(); // get the predicate
    RDFNode object = stmt.getObject(); // get the object
    System.out.print(subject.toString());
    System.out.print(" " + predicate.toString() + " ");
    if (object instanceof Resource) {
        System.out.print(object.toString());
     }
     else { // object is a literal
        System.out.print(" \"" + object.toString() + "\"");
     }
     System.out.println(" .");
} // end of while
```

```
http://somewhere/JohnSmith http://www.w3.org/2001/vcard-rdf/3.0#N anon:14df86:ecc3dee17b:-7fff

anon:14df86:ecc3dee17b:-7fff http://www.w3.org/2001/vcard-rdf/3.0#Family "Smith"

anon:14df86:ecc3dee17b:-7fff http://www.w3.org/2001/vcard-rdf/3.0#Given "John"

http://somewhere/JohnSmith http://www.w3.org/2001/vcard-rdf/3.0#FN
    "John Smith" .
```

Writing RDF

```
Model model = ModelFactory.createDefaultModel();
Resource jsmith =
model.createResource("http://somewhere/johnsmith")
     .addProperty(VCARD.FN, "John Smith")
     .addProperty(VCARD.N, model.createResource()
     .addProperty(VCARD.Given,"John")
     .addProperty(VCARD.Family, "Smith"));
model.write(new PrintWriter(System.out));
```

```
model.write(System.out, "RDF/XML-ABBREV");

model.write(System.out, "N-TRIPLE");
```

```
<rdf:RDF
  xmlns:rdf='http://www.w3.org/1999/02/22-rdf-syntax-ns#'
  xmlns:vcard='http://www.w3.org/2001/vcard-rdf/3.0#'
 >
  <rdf:Description rdf:nodeID='A0'>
    <vcard:Given>John</vcard:Given>
    <vcard:Family>Smith</vcard:Family>
  </rdf:Description>
  <rdf:Description rdf:about='http://somewhere/johnsmith'>
    <vcard:FN>John Smith</vcard:FN>
    <vcard:N rdf:nodeID='A0'/>
  </rdf:Description>
</rdf:RDF>
```

Reading RDF

```
// create an empty model
Model model = ModelFactory.createDefaultModel();

// use the FileManager to find the input file
InputStream in = FileManager.get().open( inputFileName );
if (in == null) {
    throw new IllegalArgumentException("File not found");
}

// read the RDF/XML file
model.read(in, "");

// write it to standard out
model.write(System.out);
```

```
<rdf:RDF
  xmlns:rdf='http://www.w3.org/1999/02/22-rdf-syntax-ns#'
  xmlns:vcard='http://www.w3.org/2001/vcard-rdf/3.0#'
 >
  <rdf:Description rdf:nodeID="A0">
    <vcard:Family>Smith</vcard:Family>
    <vcard:Given>John</vcard:Given>
  </rdf:Description>
  <rdf:Description rdf:about='http://somewhere/JohnSmith/'>
    <vcard:FN>John Smith</vcard:FN>
    <vcard:N rdf:nodeID="A0"/>
  </rdf:Description>
...
</rdf:RDF>
```


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Navigating a model

```
// retrieve the John Smith vcard resource from the model
Resource vcard = model.getResource(johnSmithURI);
```

Three ways of retrieving property values:

```
// retrieve the value of the N property
Resource name = (Resource) vcard.getProperty(VCARD.N).getObject();

// retrieve the value of the N property
Resource name = vcard.getProperty(VCARD.N).getResource();

// retrieve the given name property
String fullName = vcard.getProperty(VCARD.N).getString();
```


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Multiple values in properties

```
// add two nickname properties to vcard
vcard.addProperty(VCARD.NICKNAME, "Smithy")
     .addProperty(VCARD.NICKNAME, "Adman");

// set up the output
System.out.println("The nicknames of \"" + fullName + "\" are:");

// list the nicknames
StmtIterator iter = vcard.listProperties(VCARD.NICKNAME);
while (iter.hasNext()) {
  System.out.println(" " + iter.nextStatement() .getObject() .toString());
}
```


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Querying a model

```
// select all the resources with a VCARD.FN property
ResIterator iter = model.listSubjectsWithProperty(VCARD.FN);
if (iter.hasNext()) {
  System.out.println("The database contains vcards for:");
  while (iter.hasNext()) {
    System.out.println(" " + iter.nextStatement()
                                 .getProperty(VCARD.FN) .getString());
  }
} else {
  System.out.println("No vcards were found in the database");
}
```

```
The database contains vcards for:
 Sarah Jones
 John Smith
 Matt Jones
 Becky Smith
```


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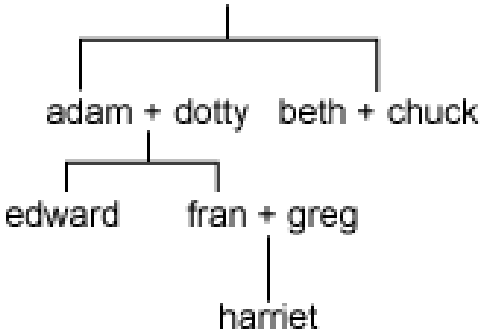
Create resources

```
// URI declarations
String familyUri = "http://family/";
String relationshipUri = "http://purl.org/vocab/relationship/";

// Create an empty Model
Model model = ModelFactory.createDefaultModel();

// Create a Resource for each family member, identified by their URI
Resource adam = model.createResource(familyUri+"adam");
Resource beth = model.createResource(familyUri+"beth");
Resource dotty = model.createResource(familyUri+"dotty");
// and so on for other family members

// Create properties for the different types of relationship to represent
Property childOf = model.createProperty(relationshipUri,"childOf");
Property parentOf = model.createProperty(relationshipUri,"parentOf");
Property siblingOf = model.createProperty(relationshipUri,"siblingOf");
Property spouseOf = model.createProperty(relationshipUri,"spouseOf");

// Add properties to adam describing relationships to other family members
adam.addProperty(siblingOf,beth);
adam.addProperty(spouseOf,dotty);
adam.addProperty(parentOf,edward);

// Can also create statements directly . . .
Statement statement = model.createStatement(adam,parentOf,fran);

// but remember to add the created statement to the model
model.add(statement);
```



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Querying a model

```
// List everyone in the model who has a child:
ResIterator parents = model.listSubjectsWithProperty(parentOf);

// Because subjects of statements are Resources, the method returned a ResIterator
while (parents.hasNext()) {

  // ResIterator has a typed nextResource() method
  Resource person = parents.nextResource();

  // Print the URI of the resource
  System.out.println(person.getURI());
}

// Can also find all the parents by getting the objects of all "childOf" statements
// Objects of statements could be Resources or literals, so the Iterator returned
// contains RDFNodes
NodeIterator moreParents = model.listObjectsOfProperty(childOf);

// To find all the siblings of a specific person, the model itself can be queried
NodeIterator siblings = model.listObjectsOfProperty(edward, siblingOf);

// But it's more elegant to ask the Resource directly
// This method yields an iterator over Statements
StmtIterator moreSiblings = edward.listProperties(siblingOf);
```


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Using selectors to query a model

```
// Find the exact statement "adam is a spouse of dotty"
model.listStatements(adam,spouseOf,dotty);

// Find all statements with adam as the subject and dotty as the object
model.listStatements(adam,null,dotty);

// Find any statements made about adam
model.listStatements(adam,null,null);

// Find any statement with the siblingOf property
model.listStatements(null,siblingOf,null);
```


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Exercise

- **Objective**
  - Understand how to use an RDF(S) management API
- **Tasks**
  - Read an ontology in RDF(S) from two files:
    - GP_Santiago.rdfs (conceptualization)
    - GP_Santiago.rdf (instances)
  - Write the class hierarchy of the ontology, including the instances of each class:

```
Class Practica2:MedioTransporte
  Class Practica2:Tren
  Class Practica2:Bicicleta
    Instance Practica2:GP_Santiago_Instance_70
  Class Practica2:Automovil
  Class Practica2:AutoBus
  Class Practica2:APie
Class Practica2:InfraEstructuraTransporte
  Class Practica2:ViaFerrea
  Class Practica2:Sendero
  Class Practica2:Carretera
    Instance Practica2:A6
...
```


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Set up

- **Requirements:**
  - Java JDK 5
  - Eclipse (optional)
  - Ant (optional)
  - Material at: http://delicias.dia.fi.upm.es/wiki/index.php/Master09-10

- **Create a directory for your project**
- **Copy Jena libraries:**
  - Unzip *Jena-2.6.2.zip/**lib*** in the project directory
- **Copy the ontologies:**
  - Copy *ontologies/**rdf*** in the project directory

Or copy the JenaProjectTemplate directory in your computer

- **With Eclipse:**
  - Create a new Java project (from existing source)
  - Append the Jena libraries to your classpath if needed (check JDK libs)
  - Write Java code using the Jena API
    http://jena.sourceforge.net/javadoc/index.html
  - Compile
  - Run

- **With Ant:**
  - Write Java code using the Jena API
    http://jena.sourceforge.net/javadoc/index.html
  - Run “ant”

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Hints

- **Create ontology model:**
- `public static OntModel createOntologyModel(OntModelSpec spec)`
- **Read the ontology in the file**
- `Model read(java.lang.String url)`
- **Add all the statements in another model to this model**
- `Model add(Model m)`

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More hints

- **List root classes**
- `ExtendedIterator listHierarchyRootClasses()`
- **List subclasses of a class**
- `ExtendedIterator listSubClasses(boolean direct)`
- **List instances of a class**
- `ExtendedIterator listInstances(boolean direct)`

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   - 5.4 Restricting values and solutions
   - 5.5 SPARQL query forms
   - 5.6 Hands-on activity

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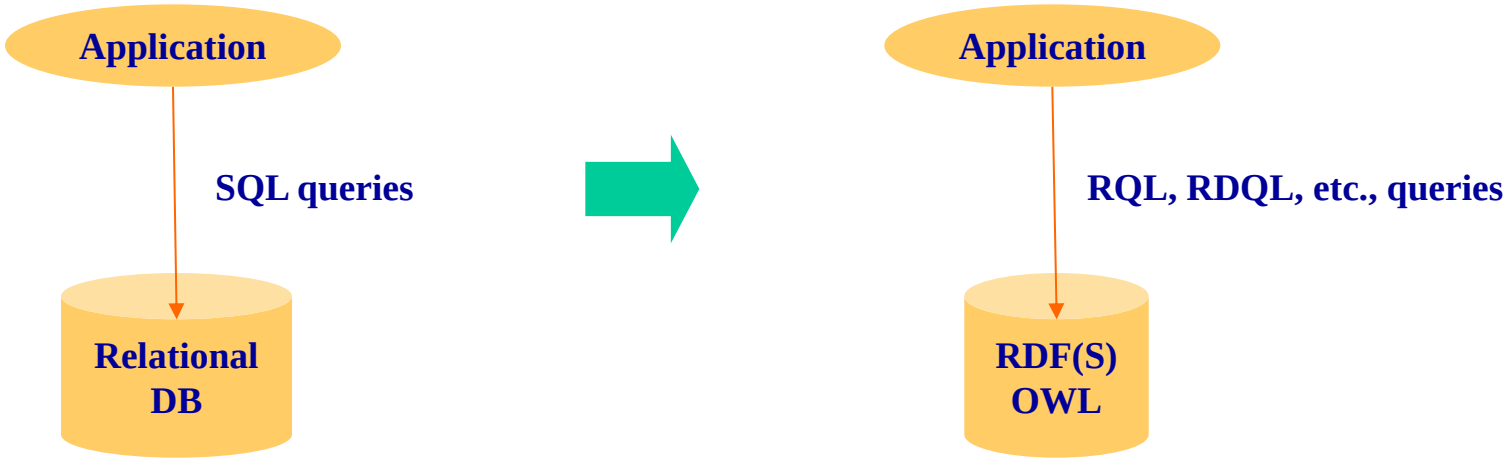
RDF(S) query languages

- **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

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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"
- **Aggregation**
  - "Return all the essays together with the mean number of authors per essay"
- **Restructuring**: the original structure is changed in the final result
  - "Invert the relationship 'has author' by 'is author of'"
- **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".

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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

- **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

XML repository Query syntax

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

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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

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SPARQL Endpoints

- **SPARQL protocol services**
  - Enables users (human or other) to query a knowledge base using SPARQL
  - Results are typically returned in one or more machine-processable formats.
- **List of SPARQL Endpoints**
  - http://esw.w3.org/topic/SparqlEndpoints
- **Programmatic access using libraries:**
  - ARC, RAP, Jena, Sesame, Javascript SPARQL, PySPARQL, etc.
- **Examples:**

Project	Endpoint
BBC Programmes and Music	http://bbc.openlinksw.com/sparql/
DBLP Bibliography Database	http://www4.wiwiss.fu-berlin.de/dblp/sparql
DBpedia	http://dbpedia.org/sparql
Musicbrainz	http://dbtune.org/musicbrainz/sparql
U.S. Census	http://www.rdfabout.com/sparql

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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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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

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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>

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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>

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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"

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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")}
       }
```


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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"	

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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>	

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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"

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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 .
```


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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

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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

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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 }
```

- **Limit modifier:** restrict the number of solutions

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

- **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
```


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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.

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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"

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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" .
```


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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
```


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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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Exercise

- **Objective**
  - **Understand how to perform SPARQL queries**
- **Tasks**
  - **Perform a set of SPARQL queries over the sample ontology.**
    - **Browse to:**
      - **http://my.computer.ip:8080/openrdf-workbench**
    - **Select repository GP_InMemoryRDFS**
    - **Select the Query option from the left menu**

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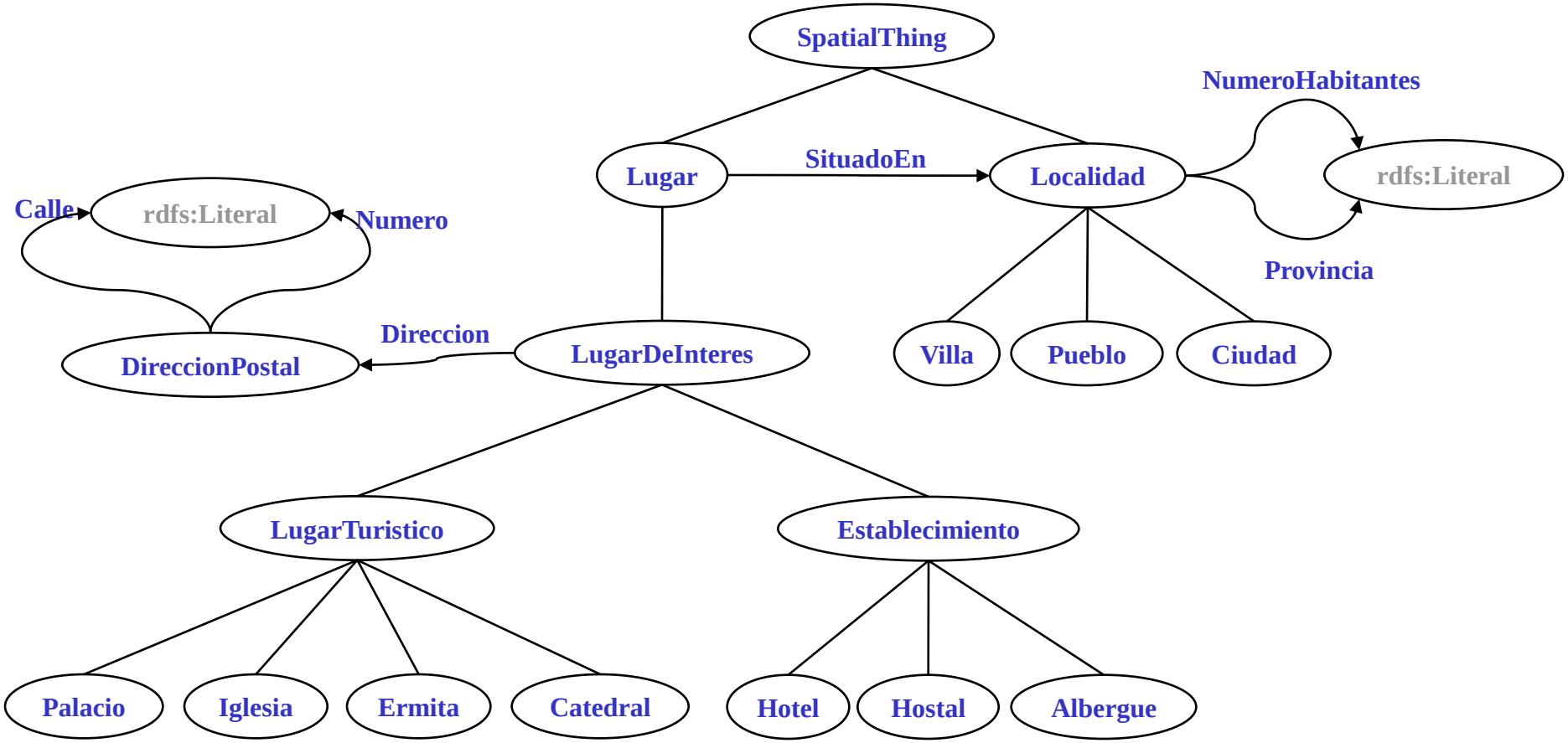
Sample ontology



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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. }
```


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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)
```


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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.}
```


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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. }
```


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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}
```


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