SPARQL - Querying the Web of Data

Seminar WS 2008/2009

An Introduction to SPARQL

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SPARQL in General

- SPARQL Protocol and RDF Query Language
- SPARQL Query Language for RDF
  - Declarative
  - Based on the RDF data model (triples/graph)
  - Our focus
- SPARQL Query Results XML Format
  - Representation of the results of SPARQL queries
- SPARQL Protocol for RDF
  - Transmission of SPARQL queries and the results
  - SPARQL endpoint: Web service that implements the protocol
Main Idea of SPARQL Queries

- Main idea: pattern matching
  - Describe subgraphs of the queried RDF graph
  - Subgraphs that match your description yield a result
  - Mean: graph patterns (i.e. RDF graphs with variables)

```sparql
?v rdf:type umbel-sc:Volcano
```
Main Idea of SPARQL Queries

Queried graph:

- **dbpedia:Mount_Baker**
  - `rdf:type` **umbel-sc:Volcano**
  - `p:lastEruption` "1880"

- **dbpedia:Mount_Etna**
  - `rdf:type` **umbel-sc:Volcano**

Results:

- `?v` `rdf:type` **umbel-sc:Volcano**
- `?v` `rdf:type` **dbpedia:Mount_Baker**
- `?v` `rdf:type` **dbpedia:Mount_Etna**
Components of SPARQL Queries

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

SELECT ?v
FROM <http://example.org/myGeoData>
WHERE {
  ?v rdf:type umbel-sc:Volcano .
}
ORDER BY ?name
Components of SPARQL Queries

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

SELECT ?v
FROM <http://example.org/myGeoData>
WHERE {
  ?v rdf:type umbel-sc:Volcano .
}
ORDER BY ?name

- **Prologue:**
  - **Prefix definitions** enable CURIEs in the query
  - **Attention:** No period (".") character to separate (as in N3)
Components of SPARQL Queries

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX umbel-sc: <http://umbel.org/umbel/sc/>
SELECT ?v
FROM <http://example.org/myGeoData>
WHERE {
  ?v rdf:type umbel-sc:Volcano .
}
ORDER BY ?name
```

- Result form specification:
  - SELECT, DESCRIBE, CONSTRUCT, or ASK
  - SELECT: - Variable list or asterisk ("*") character for all
    - DISTINCT for disjoint results

An Introduction to SPARQL
Components of SPARQL Queries

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX umbel-sc: <http://umbel.org/umbel/sc/>
SELECT ?v
FROM <http://example.org/myGeoData>
WHERE {
  ?v rdf:type umbel-sc:Volcano .
}
ORDER BY ?name

• Dataset specification:
  • Specify the dataset to be queried
  • Use FROM and FROM NAMED clauses (each with a URI)
Components of SPARQL Queries

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX umbel-sc: <http://umbel.org/umbel/sc/>
SELECT ?v
FROM <http://example.org/myGeoData>
WHERE {
  ?v rdf:type umbel-sc:Volcano .
}
ORDER BY ?name

• Query Pattern:
  • WHERE clause specifies the graph pattern to be matched
Components of SPARQL Queries

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

SELECT ?v
FROM <http://example.org/myGeoData>
WHERE {
    ?v rdf:type umbel-sc:Volcano .
}
ORDER BY ?name

- Solution modifiers:
  - Modify the result set, but not the single results
  - ORDER BY, LIMIT, or OFFSET
Graph Patterns

• Different **types of graph patterns** for the query pattern (WHERE clause):
  • Basic graph pattern (BGP)
  • Group graph pattern
  • Optional graph pattern
  • Union graph pattern
  • Graph graph pattern
  • (Constraints)
Basic Graph Patterns

- Set of triple patterns (i.e. RDF triples with variables)
- Variable names prefixed with “?” or “$” (e.g. ?v, $v)

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX umbel-sc: <http://umbel.org/umbel/sc/>

SELECT ?name
WHERE {
  ?v rdf:type umbel-sc:Volcano .
}
```
Basic Graph Patterns

- Set of triple patterns (i.e. RDF triples with variables)
- Variable names prefixed with “?” or “$” (e.g. ?v, $v)
- Turtle syntax (similar to N3)
- Syntactical sugar as in N3 (e.g. property and object lists)

```sparql
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX umbel-sc: <http://umbel.org/umbel/sc/>

SELECT ?name
WHERE {
  ?v rdf:type umbel-sc:Volcano ;
  rdfs:label ?name .
}
```
Basic Graph Patterns

**Data**

```
dbpedia:Mount_Etna  rdf:type  umbel-sc:Volcano ;
     rdfs:label  "Etna" .
dbpedia:Mount_Baker rdf:type  umbel-sc:Volcano .
dbpedia:Beerenberg rdf:type  umbel-sc:Volcano ,
     umbel-sc:NaturalElevation ;
     rdfs:label  "Beerenberg"@en ;
     rdfs:label  "Бееренберг"@ru .
```

**Question:** What are the names of all (known) volcanos?

**Query**

```
SELECT  ?name WHERE {
  ?v  rdf:type  umbel-sc:Volcano ;
  rdfs:label  ?name . }
```

*Prefix definitions omitted

**Result:**

<table>
<thead>
<tr>
<th>?name</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Etna&quot;</td>
</tr>
<tr>
<td>&quot;Бееренберг&quot;@ru</td>
</tr>
<tr>
<td>&quot;Beerenberg&quot;@en</td>
</tr>
</tbody>
</table>
Basic Graph Patterns

SELECT ?type WHERE {
    ?v rdf:type ?type ;
    rdfs:label "Beerenberg" .
}

Question: List all types of the volcano called “Beerenberg”
An Introduction to SPARQL

Basic Graph Patterns

SELECT ?type WHERE {
    ?v rdf:type ?type ;
    rdfs:label "Beerenberg" @en .
}

• Question: List all types of the volcano called “Beerenberg”

Data

dbpedia:Mount_Etna rdf:type umbel-sc:Volcano ;
    rdfs:label "Etna" .

dbpedia:Mount_Baker rdf:type umbel-sc:Volcano .

dbpedia:Beerenberg rdf:type umbel-sc:Volcano,
    umbel-sc:NaturalElevation ;
    rdfs:label "Beerenberg"@en ;
    rdfs:label "Бееренберг"@ru .

Query

umbel-sc:Volcano
umbel-sc:NaturalElevation
Basic Graph Patterns

- Question: Where are all (known) volcanos located? List the names.

- **Blank nodes** in SPARQL queries
  - Permitted as subject and object of a triple pattern
  - Like non-selectable variables

```
Data

dbpedia:Mount_Baker rdf:type umbel-sc:Volcano ;
    p:location dbpedia:United_States .
dbpedia:United_States rdfs:label "United States" .
```

```
Query

SELECT ?name WHERE {
    _:x rdf:type umbel-sc:Volcano ;
```

```
?name
"United States"
```
Basic Graph Patterns

• Blank nodes in the queried graph
• Blank node identifiers may occur in the results

SELECT ?l ?name WHERE {
  ?v rdf:type umbel-sc:Volcano ;
  p:location [ rdfs:label "United States"@en ,
               "États-Unis"@fr ] .
}

Data

```
dbpedia:Mount_Baker rdf:type umbel-sc:Volcano ;
  p:location [ rdfs:label "United States"@en ,
               "États-Unis"@fr ] .
```

```
dbpedia:Mount_Etna rdf:type umbel-sc:Volcano ;
  p:location [ rdfs:label "Italy" ] .
```

Query

```
?name
"United States"@en
"États-Unis"@fr
"Italy"
```
Optional Graph Patterns

SELECT ?v ?name WHERE {
  ?v rdf:type umbel-sc:Volcano ;
  rdfs:label ?name .
}

• Question: What are all (known) volcanos and their names?

• Problem: Mount Baker missing (it has no name)

<table>
<thead>
<tr>
<th>?v</th>
<th>?name</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbpedia:Mount_Etna</td>
<td>&quot;Etna&quot;</td>
</tr>
<tr>
<td>dbpedia:Beerenberg</td>
<td>&quot;Beerenberg&quot;@en</td>
</tr>
</tbody>
</table>
Optional Graph Patterns

- Keyword OPTIONAL allows for optional patterns

```sparql
SELECT ?v ?name WHERE {
    ?v rdf:type umbel-sc:Volcano .
    OPTIONAL { ?v rdfs:label ?name }
}
```

<table>
<thead>
<tr>
<th>?v</th>
<th>?name</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbpedia:Mount_Etna</td>
<td>&quot;Etna&quot;</td>
</tr>
<tr>
<td>dbpedia:Mount_Baker</td>
<td>&quot;Beerenberg&quot;@en</td>
</tr>
<tr>
<td>dbpedia:Beerenberg</td>
<td>&quot;Beerenberg&quot;@en</td>
</tr>
</tbody>
</table>

- Optional patterns may yield unbound variables
**Union Graph Patterns**

**Data**

```
{ 
  dbpedia:Mount_Etna  rdf:type  umbel-sc:Volcano ;
  rdfs:label  "Etna" ;
  p:location dbpedia:Italy .

  dbpedia:Mount_Baker  rdf:type  umbel-sc:Volcano ;
    p:location dbpedia:United_States .

  dbpedia:Beerenberg  rdf:type  umbel-sc:Volcano ;
    rdfs:label  "Beerenberg"@en ;
    p:location dbpedia:Norway .
}
```

**Query**

```
SELECT ?v WHERE {
  ?v  rdf:type  umbel-sc:Volcano ;
  p:location  ? .
}
```

**Question:** What volcanos are located in the Italy or in Norway?
Union Graph Patterns

- Union graph patterns allow for alternatives

SELECT ?v WHERE {
    { ?v rdf:type umbel-sc:Volcano ;
      p:location dbpedia:Italy } UNION
    { ?v rdf:type umbel-sc:Volcano ;
      p:location dbpedia:Norway } }

SELECT ?v WHERE {
    ?v rdf:type umbel-sc:Volcano .
    { ?v p:location dbpedia:Italy } UNION
    { ?v p:location dbpedia:Norway } }
Group Graph Patterns

```
SELECT ?v WHERE {
  ?v rdf:type umbel-sc:Volcano .

  { ?v p:location dbpedia:Italy } union

  { ?v p:location dbpedia:Norway }
}
```

Semantically equivalent

```
SELECT ?v WHERE {
  { ?v rdf:type umbel-sc:Volcano }

  { { ?v p:location dbpedia:Italy } union
    { ?v p:location dbpedia:Norway } }
}
```
Constraints

- Constraints filter solutions
- Keyword FILTER followed by expression
- Filter expressions contain operators and functions

```sparql
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX umbel-sc: <http://umbel.org/umbel/sc/>
PREFIX p: <http://dbpedia.org/property/>

SELECT ?v
WHERE {
  ?v rdf:type umbel-sc:Volcano ;
    p:lastEruption ?le .
  FILTER ( ?le > 1900 )
}
```
Constraints

- Operators and functions operate on RDF terms
- Filter expressions evaluate to true, false, or error
- Truth table:

| A | B | A || B | A && B |
|---|---|------|-------|
| T | T | T    | T     |
| T | F | T    | F     |
| F | T | T    | F     |
| F | F | F    | F     |
| T | E | T    | E     |
| E | T | T    | E     |
| F | E | E    | F     |
| E | F | E    | F     |
| E | E | E    | E     |
### Constraints

- **Unary operators:**

<table>
<thead>
<tr>
<th>Operator</th>
<th>Type(A)</th>
<th>Result type</th>
</tr>
</thead>
<tbody>
<tr>
<td>! A</td>
<td>xsd:boolean</td>
<td>xsd:boolean</td>
</tr>
<tr>
<td>+ A</td>
<td>numeric</td>
<td>numeric</td>
</tr>
<tr>
<td>- A</td>
<td>numeric</td>
<td>numeric</td>
</tr>
<tr>
<td>BOUND(A)</td>
<td>variable</td>
<td>xsd:boolean</td>
</tr>
<tr>
<td>isURI(A)</td>
<td>RDF term</td>
<td>xsd:boolean</td>
</tr>
<tr>
<td>isBLANK(A)</td>
<td>RDF term</td>
<td>xsd:boolean</td>
</tr>
<tr>
<td>isLITERAL(A)</td>
<td>RDF term</td>
<td>xsd:boolean</td>
</tr>
<tr>
<td>STR(A)</td>
<td>literal / URI</td>
<td>simple literal</td>
</tr>
<tr>
<td>LANG(A)</td>
<td>literal</td>
<td>simple literal</td>
</tr>
<tr>
<td>DATATYPE(A)</td>
<td>literal</td>
<td>simple literal</td>
</tr>
</tbody>
</table>
Constraints

- Question: List all types of the volcano called “Beerenberg”

```
SELECT ?type WHERE {
    ?v rdf:type ?type ;
    rdfs:label ?name .
    FILTER ( STR(?name) = "Beerenberg" )
}
```

Data

```
@prefix dbpedia: <http://dbpedia.org/resource/>
@prefix umbel-sc: <http://dbpedia.org/umbel-sc/>

dbpedia:Mount_Etna rdf:type umbel-sc:Volcano ;
    rdfs:label "Etna" .

dbpedia:Beerenberg rdf:type umbel-sc:Volcano ,
    umbel-sc:NaturalElevation ;
    rdfs:label "Beerenberg"@en ;
    rdfs:label "Бееренберг"@ru .
```
Constraints

• Binary operators:
  • Logical connectives && and || for xsd:boolean
  • Comparison operators =, !=, <, >, <=, and >= for numeric datatypes, xsd:dateTime, xsd:string, and xsd:boolean
  • Comparison operators = and != for other datatypes
  • Arithmetic operators +, -, *, and / for numeric datatypes

• Furthermore:
  • REGEX(String,Pattern) or REGEX(String,Pattern,Flags)
  • sameTERM(A,B)
  • langMATCHES(A,B)
Constraints

SELECT ?v WHERE {
  ?v rdf:type umbel-sc:Volcano ;
  rdfs:label "Etna" .
}

SELECT ?v WHERE {
  ?v rdf:type umbel-sc:Volcano ;
  rdfs:label "Beerenberg"@en ;
  rdfs:label "Бееренберг"@ru .
}

• Question: What volcanos have an “e” in their name?

Data

An Introduction to SPARQL
Constraints

SELECT ?v WHERE {
    ?v rdf:type umbel-sc:Volcano ;
    rdfs:label ?name .
    FILTER( REGEX(STR(?name),"e","i") )
}

• Question: What volcanos have an “e” in their name?
Negation

SELECT ?v WHERE {
  ?v rdf:type umbel-sc:Volcano .
  OPTIONAL { ?v rdfs:label ?name } 
  FILTER( ! BOUND(?name) )
}

Question: What volcanos do not have a name in our data?

Data

dbpedia:Mount_Etna rdf:type umbel-sc:Volcano ;
               rdfs:label "Etna" .

dbpedia:Mount_Baker rdf:type umbel-sc:Volcano .

dbpedia:Beerenberg rdf:type umbel-sc:Volcano ;
               rdfs:label "Beerenberg"@en ;
               rdfs:label "Бееренберг"@ru .
**Negation**

**Data**

- `dbpedia:Mount_Etna` rdf:type `umbel-sc:Volcano` .
  - rdfs:label "Etna" .
- `dbpedia:Beerenberg` rdf:type `umbel-sc:Volcano` .
  - rdfs:label "Beerenberg"@en ;
  - rdfs:label "Бееренберг"@ru .

**Question:** What volcanos are **not** called “Beerenberg”?  

```sparql
SELECT ?v WHERE {
  ?v rdf:type umbel-sc:Volcano .
  FILTER (STR(?name) != "Beerenberg")
}
```

**An Introduction to SPARQL**
Negation

- Question: What volcanos are not called “Beerenberg”?

```
SELECT ?v WHERE {
  ?v rdf:type umbel-sc:Volcano .
    FILTER (STR(?name) = "Beerenberg") }
  FILTER ( ! BOUND(?name) )
}
```

### Data

- `dbpedia:Mount_Etna` rdf:type umbel-sc:Volcano ;
  rdfs:label "Etna" .
- `dbpedia:Beerenberg` rdf:type umbel-sc:Volcano ;
  rdfs:label "Beerenberg"@en ;
  rdfs:label "Бееренберг"@ru .
Graph Graph Patterns

- SPARQL queries are executed against an RDF dataset
- An **RDF dataset** comprises:
  - One **default graph** and
  - Zero or more **named graphs** (identified by an URI)
- Keyword **GRAPH** makes one of the named graphs the **active graph** used for pattern matching
Graph Graph Patterns

dbpedia:Mount_Etna rdfs:seeAlso <http://example.org/d1>.
dbpedia:Mount_Baker rdfs:seeAlso <http://example.org/d2>.

dbpedia:Mount_Etna http://example.org/d1
  rdf:type umbel-sc:Volcano ;
  rdfs:label "Etna" .

dbpedia:Mount_Baker http://example.org/d2
  rdf:type umbel-sc:Volcano .

dbpedia:Beerenberg http://example.org/d3
  rdf:type umbel-sc:Volcano ;
  rdfs:label "Beerenberg"@en .

An Introduction to SPARQL
Graph Patterns

SELECT ?ν WHERE {
    GRAPH <http://example.org/d1> {
        ?ν rdf:type umbel-sc:Volcano .
    }
}

dbpedia:Mount_Etna rdfs:seeAlso <http://example.org/d1>.
dbpedia:Mount_Baker rdfs:seeAlso <http://example.org/d2>.
dbpedia:Beerenberg rdfs:seeAlso <http://example.org/d3>.

dbpedia:Mount_Etna rdf:type umbel-sc:Volcano ;
    rdfs:label "Etna" .

dbpedia:Mount_Baker rdf:type umbel-sc:Volcano .

http://example.org/d1

http://example.org/d2

http://example.org/d3

dbpedia:Mount_Etna

dbpedia:Mount_Baker

http://example.org/d3

dbpedia:Beerenberg"@en .

http://example.org/d1
Graph Graph Patterns

```
dbpedia:Mount_Etna rdfs:seeAlso <http://example.org/d1>.
dbpedia:Mount_Baker rdfs:seeAlso <http://example.org/d2>.
dbpedia:Mount_Etna rdf:type umbel-sc:Volcano ;
rdfs:label "Etna" .
http://example.org/d1
dbpedia:Mount_Baker rdf:type umbel-sc:Volcano .
http://example.org/d2
dbpedia:Beerenberg rdf:type umbel-sc:Volcano ;
rdfs:label "Beerenberg"@en .
http://example.org/d3

SELECT ?v WHERE {
  GRAPH ?g {
    ?v rdf:type umbel-sc:Volcano .
  }
}
```

An Introduction to SPARQL
Graph Graph Patterns

```
SELECT ?v ?g WHERE {
  GRAPH ?g {
    ?v rdf:type umbel-sc:Volcano ;
    rdfs:label "Etna" .
  }
  dbpedia:Mount_Etna rdfs:seeAlso <http://example.org/d1> .
  dbpedia:Mount_Baker rdfs:seeAlso <http://example.org/d2> .
  dbpedia:Beerenberg rdf:type umbel-sc:Volcano ;
  rdfs:label "Beerenberg"@en .
}
```

Graph Graph Patterns

```sparql
SELECT ?v WHERE {
  _:x rdfs:seeAlso ?g
  GRAPH ?g {
    ?v rdf:type umbel-sc:Volcano .
  }
}
```

- `dbpedia:Mount_Etna rdfs:seeAlso <http://example.org/d1>.`
- `dbpedia:Mount_Baker rdfs:seeAlso <http://example.org/d2>.`

```sparql
dbpedia:Mount_Etna http://example.org/d1
  rdf:type umbel-sc:Volcano ;
  rdfs:label "Etna" .

dbpedia:Mount_Baker http://example.org/d2
  rdf:type umbel-sc:Volcano .
```

```
SELECT ?v WHERE {
  _:x rdfs:seeAlso ?g
  GRAPH ?g {
    ?v rdf:type umbel-sc:Volcano .
  }
}
```

```
http://example.org/d3
```

```
SELECT ?v WHERE {
  _:x rdfs:seeAlso ?g
  GRAPH ?g {
    ?v rdf:type umbel-sc:Volcano .
  }
}
```

```
dbpedia:Mount_Etna
dbpedia:Mount_Baker
```
Graph Graph Patterns

- Question: Which named graphs contain the name of a volcano that is not referenced in the default graph?
Graph Graph Patterns

An Introduction to SPARQL
Different **types of graph patterns** for the query pattern (WHERE clause):

- Basic graph pattern (BGP)
- Group graph pattern
- Optional graph pattern – keyword OPTIONAL
- Union graph pattern – keyword UNION
- Graph graph pattern – keyword GRAPH
- Constraints – keyword FILTER
Result Forms

- **SELECT**
  - Sequence of results (i.e. sets of variable bindings)
  - Selected variables separated by space (not by comma!)
  - Asterisk (“*”) character selects all variables in the pattern

- **ASK**
  - Check if there is at least one result
  - Example: Do we have volcanos that do not have a name?

```
ASK WHERE {
?v rdf:type umbel-sc:Volcano .
OPTIONAL { ?v rdfs:label ?name }
FILTER( ! BOUND(?name) )
}
```
Result Forms

- **DESCRIBE**
  - Returns an RDF graph with data about resources
  - Nondeterministic (i.e. query processor determines the actual structure of the returned RDF graph)
  - Name the resource:

  ```sparql
describe <http://dbpedia.org/resource/Beerenberg>
```

- Specify the resource with a query pattern:

  ```sparql
describe ?v where {
    FILTER ( STR(?name) = "Beerenberg" )
  }
```

- Multiple variables possible or asterisk ("*") for all
Result Forms

- **CONSTRUCT**
  - Returns an RDF graph created from a template
  - Template: graph pattern with variables from the query pattern

```sparql
CONSTRUCT { ?v rdfs:label ?name ;
            rdf:type myTypes:VolcanosOutsideTheUS }
WHERE {
  ?v rdf:type umbel-sc:Volcano ;
  rdfs:label ?name .
  OPTIONAL { ?v p:location ?l
            FILTER ( ?l = dbpedia:United_States ) }
  FILTER ( ! BOUND(?l) )
}
```
Result Forms

Data

dbpedia:Mount_Etna  rdf:type  umbel-sc:Volcano ;
   rdfs:label  "Etna" ;
   p:location  dbpedia:Italy .

dbpedia:Mount_Baker  rdf:type  umbel-sc:Volcano ;
   rdfs:label  "Mount Baker" ;
   p:location  dbpedia:United_States .

dbpedia:Beerenberg  rdf:type  umbel-sc:Volcano ;
   rdfs:label  "Beerenberg"@en ;
   p:location  dbpedia:Norway .

Result

dbpedia:Mount_Etna  rdfs:label  "Etna" ;
   rdf:type  myTypes:VolcanosOutsideTheUS .

dbpedia:Beerenberg  rdf:type  myTypes:VolcanosOutsideTheUS ;
   rdfs:label  "Beerenberg"@en .
Solution Modifiers

- Modify the result set, but not the single results
- Permitted for SELECT queries only
  - DISTINCT
  - ORDER BY
  - LIMIT
  - OFFSET
Solution Modifiers

- **DISTINCT** – removes duplicates from the result set

```
SELECT ?type
WHERE { _:x rdf:type umbel-sc:Volcano ;
         rdfs:label "Etna" .

dbpedia:Mount_Etna rdf:type umbel-sc:Volcano .

dbpedia:Mount_Baker rdf:type umbel-sc:Volcano .

dbpedia:Beerenberg rdf:type umbel-sc:Volcano, umbel-sc:NaturalElevation ;
         rdfs:label "Beerenberg"@en ;
         rdfs:label "Бееренберг"@ru .
```

**Data**
Solution Modifiers

- **DISTINCT** – removes duplicates from the result set

```
SELECT DISTINCT ?type
WHERE { _:x rdf:type ?type }
```

Data

```
dbpedia:Mount_Etna rdf:type umbel-sc:Volcano ;
    rdfs:label "Etna" .
dbpedia:Mount_Baker rdf:type umbel-sc:Volcano .
dbpedia:Beerenberg rdf:type umbel-sc:Volcano ,
    umbel-sc:NaturalElevation ;
    rdfs:label "Beerenberg"@en ;
    rdfs:label "Бееренберг"@ru .
```

Query

```
umbel-sc:Volcano
umbel-sc:NaturalElevation
```
Solution Modifiers

- **ORDER BY** – orders the results

**Query**

```
SELECT ?v WHERE { ?v rdf:type umbel-sc:Volcano ;
                 rdfs:label ?name }
ORDER BY ?name
```

- Order for different kinds of elements:
  - unbound variable < blank node < URI < literal
- **ASC** for ascending (default) and **DESC** for descending
- Hierarchical order criteria:

**Query**

```
SELECT ?name WHERE { ?v rdf:type umbel-sc:Volcano ;
                     p:lastEruption ?le ;
                     rdfs:label ?name }
ORDER BY DESC(?le), ?name
```
Solution Modifiers

- **LIMIT** – limits the number of results

```sparql
SELECT ?name WHERE { ?v rdf:type umbel-sc:Volcano ;
rames:label ?name } ORDER BY ?name LIMIT 5
```

- **OFFSET** – position/index of the first returned results

```sparql
SELECT ?name WHERE { ?v rdf:type umbel-sc:Volcano ;
rames:label ?name } ORDER BY ?name LIMIT 5 OFFSET 10
```

- Only useful if the order is predictable (i.e. ordered results)
Further Reading

- W3C RDF Data Access Working Group
- SPARQL Query Language for RDF
- SPARQL Protocol for RDF
- SPARQL Query Results XML Format
- SPARQL interface for dbpedia:
  [http://dbpedia.org/snorql/](http://dbpedia.org/snorql/)