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ICWE 2012 Tutorial

An Introduction to SPARQL and Queries over Linked Data

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Chapter 2: SPARQL

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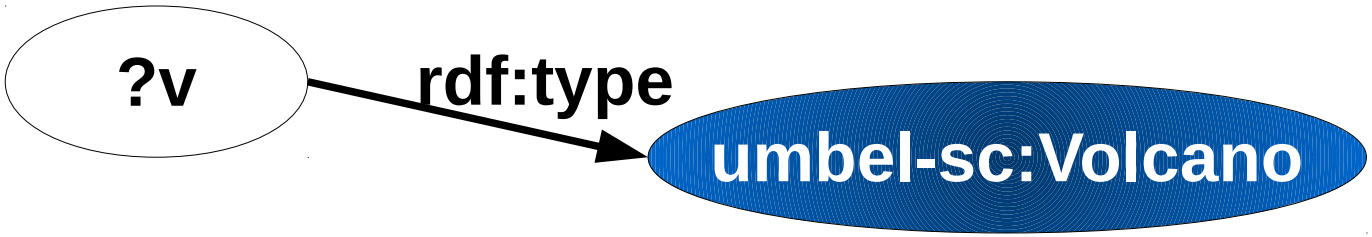
SPARQL in General

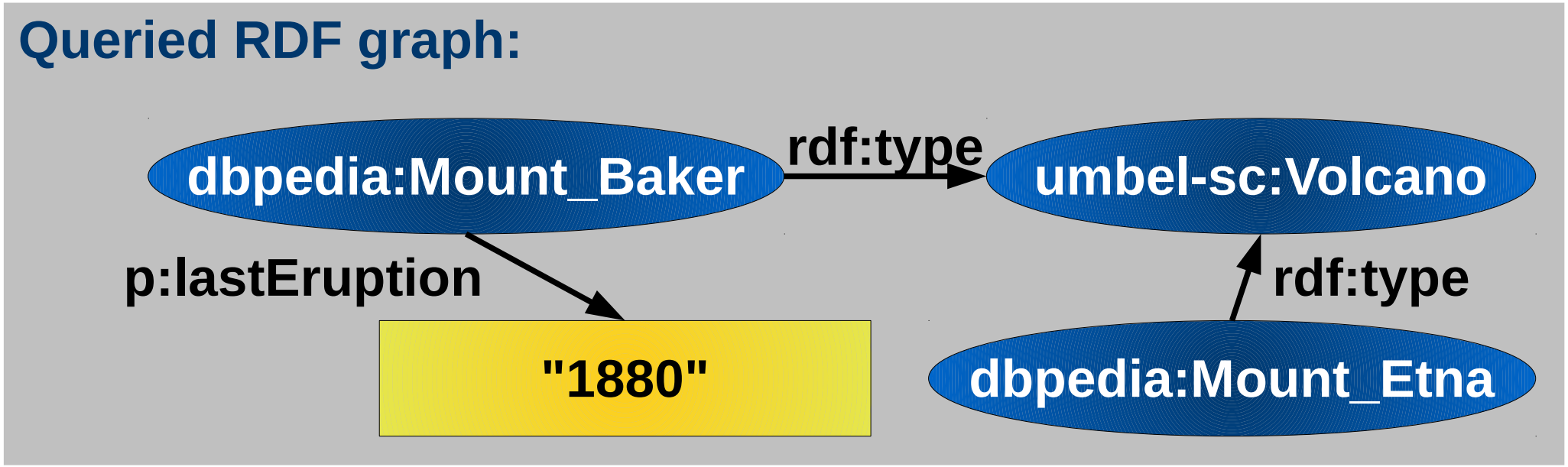
- **A family of W3C recommendations**
- **SPARQL Query**
  - Declarative query language for RDF data
  - Our focus today
- **SPARQL Update**
  - Declarative update language for RDF data
- **SPARQL Protocol**
  - Communication between SPARQL processing services (a.k.a. SPARQL endpoints) and clients
- **SPARQL Query Results XML Format**
  - XML format for serializing query results

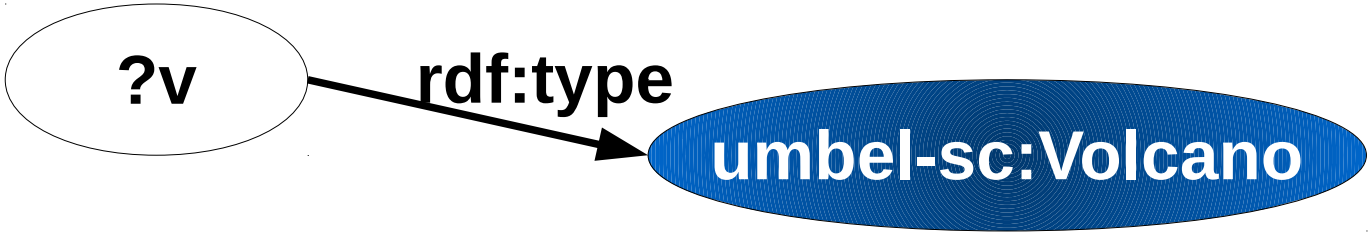
Main Idea of SPARQL Queries

- **Pattern matching:**
  - Describe subgraphs of the queried RDF graph
  - Subgraphs that match your description contribute an answer
  - Mean: graph patterns (i.e. RDF graphs with variables)

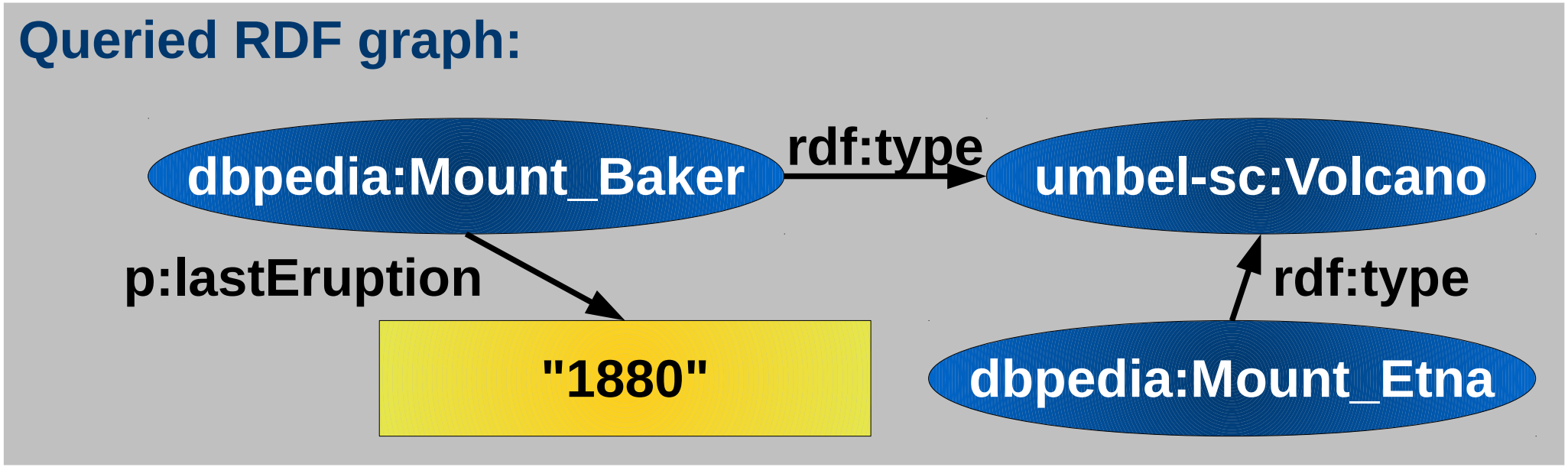


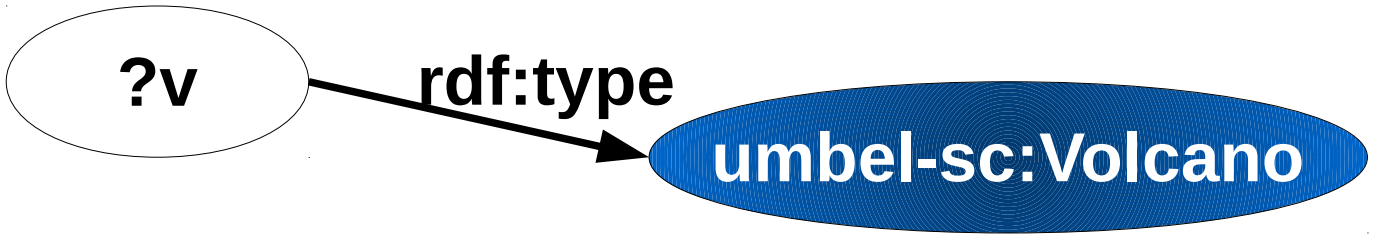
Main Idea of SPARQL Queries





Main Idea of SPARQL Queries





Result:

?v
dbpedia:Mount_Baker 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 for using compact URIs (CURIEs)
  - Attention (difference to Turtle): No period (“.”) character as separator

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

    (more about that later)

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 RDF dataset to be queried (more about that later)

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

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)**
- **Turtle syntax**
  - Including syntactical sugar (e.g. property and object lists)

```
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 .
  ?v rdfs:label ?name .
}
```

Basic Graph Patterns

- **Set of triple patterns (i.e. RDF triples with variables)**
- **Variable names prefixed with “?” or “$” (e.g. ?v, $v)**
- **Turtle syntax**
  - Including syntactical sugar (e.g. property and object lists)

```
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 (Example)

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  .
```

*Prefix definitions omitted

Basic Graph Patterns (Example)

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

Basic Graph Patterns (Example)

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:

?name
"Etna"
"Бееренберг"@ru
"Beerenberg"@en

Basic Graph Patterns (Example)

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: List all types of the volcano called “Beerenberg”**

Query

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

?type

Empty!

Basic Graph Patterns (Example)

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: List all types of the volcano called “Beerenberg”**

Query

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

?type
umbel-sc:Volcano
umbel-sc:NaturalElevation

Basic Graph Patterns (Example)

Data

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

- **Question: Where are all (known) volcanos located?**
  (List the names of these locations)

Basic Graph Patterns (Example)

Data

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

- **Question: Where are all (known) volcanos located? (List the names of these locations)**
- **Blank nodes in SPARQL queries**
  - As subject or object of a triple pattern
  - “Non-selectable” variables

Query

```
SELECT ?name WHERE {
 _:x rdf:type umbel-sc:Volcano ;
     p:location [ rdfs:label ?name ] . }
```

?name
"United States"

Basic Graph Patterns (Example)

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" ] .
```

- **Blank nodes in the queried data**

Basic Graph Patterns (Example)

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" ] .
```

- **Blank nodes in the queried data**
  - Blank node identifiers may occur in the results

Query

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

?l	?name
_:x	"United States"@en
_:x	"États-Unis"@fr
_:y	"Italy"

Optional 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 ;
                   rdfs:label "Beerenberg"@en .
```

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

Query

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

?v	?name
dbpedia:Mount_Etna	"Etna"
dbpedia:Beerenberg	"Beerenberg"@en

- **Problem: Mount Baker missing (it has no name)**

Optional Graph Patterns

- **Keyword OPTIONAL allows for optional patterns**

Query

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

?v	?name
dbpedia:Mount_Etna	"Etna"
dbpedia:Mount_Baker	
dbpedia:Beerenberg	"Beerenberg"@en

- **Optional patterns may result in 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 .
```

- **Question: What volcanos are located in Italy or in Norway?**

Query

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

Union Graph Patterns

- **Union graph patterns allow for alternatives**

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

Query

Union Graph Patterns

- **Union graph patterns allow for alternatives**

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

Query

Semantically equivalent

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

Query

Group Graph Patterns

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

Query

Semantically equivalent

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

Query

Constraints on Solutions

- **Syntax: Keyword FILTER followed by filter expression**

```
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 )
}
```

- **Filter expressions contain operators and functions**
- **Operators and functions operate on RDF terms**

Constraints (Truth Table)

- **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

Unary Operators in Constraints

Operator	Type(A)	Result type
! A	xsd:boolean	xsd:boolean
+ A	numeric	numeric
- A	numeric	numeric
BOUND(A)	variable	xsd:boolean
isURI(A)	RDF term	xsd:boolean
isBLANK(A)	RDF term	xsd:boolean
isLITERAL(A)	RDF term	xsd:boolean
STR(A)	literal / URI	simple literal
LANG(A)	literal	simple literal
DATATYPE(A)	literal	simple literal

Constraints (Example)

Data

```
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  .
```

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

Query

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

Constraints (Example)

Data

```
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 "Беренберг"@ru  .
```

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

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

Query

?type
umbel-sc:Volcano
umbel-sc:NaturalElevation

Constraints (Further Operators)

- **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 (Example)

Data

```
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 "Беренберг"@ru  .
```

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

Query

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

?v
dbpedia:Beerenberg
dbpedia:Beerenberg

Constraints (Example)

Data

```
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  .
```

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

Query

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

?v
dbpedia:Mount_Etna
dbpedia:Beerenberg
dbpedia:Beerenberg

Graph Graph Patterns

- **SPARQL queries are executed over an RDF dataset:**
  - One default graph and
  - Zero or more named graphs (identified by an URI)

Graph Graph Patterns

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

Default Graph

```
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

- **SPARQL queries are executed over an RDF dataset:**
  - One default graph and
  - Zero or more named graphs (identified by an 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
```

- **Dataset specification:**
  - Specify the RDF dataset to be queried (more about that later)

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 RDF dataset to be queried

    ~~(more about that later)~~ here ...
- **Specification using FROM and FROM NAMED**

Graph Graph Patterns

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

Default Graph

```
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

Graph Graph Patterns

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

Default Graph

```
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

- **Evaluation of patterns w.r.t. active graph**
- **GRAPH clause for making a named graph the active graph**

Graph Graph Patterns

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

Default Graph

http://example.org/d1

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

http://example.org/d2

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

http://example.org/d3

```
el-sc:Volcano ;
Beerenberg"@en .
```

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

?v
dbpedia:Mount_Etna

Graph Graph Patterns

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

Default Graph

http://example.org/d1

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

http://example.org/d2

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

ample.org/d3

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

?v
dbpedia:Mount_Etna
dbpedia:Mount_Baker
dbpedia:Beerenberg

Graph Graph Patterns

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

Default Graph

```
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

ample.org/d3

```
SELECT ?v ?g WHERE {
  GRAPH ?g {
    ?v rdf:typ
  }
}
```

?v	?g
dbpedia:Mount_Etna	<http://example.org/d1>
dbpedia:Mount_Baker	<http://example.org/d2>
dbpedia:Beerenberg	<http://example.org/d3>

Graph Graph Patterns

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

Default Graph

http://example.org/d1

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

http://example.org/d2

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

ample.org/d3

```
no ;
den .
```

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

?v
dbpedia:Mount_Etna
dbpedia:Mount_Baker

Negation

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 "Беренберг"@ru .
```

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

Negation

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 "Беренберг"@ru .
```

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

Query

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

?v
dbpedia:Mount_Baker

Negation as Failure

Negation

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 "Беренберг"@ru .
```

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

Negation

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 "Беренберг"@ru .
```

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

Query

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

Negation

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 "Беренберг"@ru .
```

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

Query

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

?v
dbpedia:Mount_Etna
dbpedia:Mount_Baker
dbpedia:Beerenberg

Negation

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 .
```

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

Query

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

!=

?v
dbpedia:Mount_Etna
dbpedia:Mount_Baker
dbpedia:Beerenberg

Negation

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 .
```

- **Question: What volcanos are not called "Beerenberg"?**

Query

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

!=

?v
dbpedia:Mount_Etna
dbpedia:Mount_Baker
dbpedia:Beerenberg

Negation

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 "Беренберг"@ru .
```

- **Question: What volcanos are not called "Beerenberg"?**

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

?v
dbpedia:Mount_Etna
dbpedia:Mount_Baker

Negation as Failure

Graph Graph Patterns

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

Default Graph

```
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

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

Graph Graph Patterns

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

Default

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

http://example.org/d1

```
SELECT ?g WHERE {
  GRAPH ?g {
    ?v rdf:type umbel-sc:Volcano ;
       rdfs:label ?name .
  }
  OPTIONAL { ?v rdfs:seeAlso ?r }
  FILTER ( ! BOUND(?r) )
}
```

http://example.org/d2

```
sc:Volcano .
```

http://example.org/d3

```
-sc:Volcano ;
erenberg"@en .
```

ain the name of a
e default graph?

Summary – Graph Patterns

- **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

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

    (more about that later)

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

~~(more about that later)~~ here ...

Result Forms

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

Result Forms

- **SELECT**
  - Result: sequence of solutions (i.e. sets of variable bindings)
  - Selected variables separated by space (not by comma!)
  - Asterisk character (“*”) selects all variables in the pattern
- **ASK**
  - Check whether there is at least one result
  - Result: true or false
  - Example: Do we have data about volcanos?

Query

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

Result Forms

- **DESCRIBE**
  - Result: an RDF graph with data about resources
  - Non-deterministic (i.e. query processor defines the actual structure of the resulting RDF graph)
  - Example: just name the resource

```
DESCRIBE <http://dbpedia.org/resource/Beerenberg>
```

Query

Result Forms

- **DESCRIBE**
  - Result: an RDF graph with data about resources
  - Non-deterministic (i.e. query processor defines the actual structure of the resulting RDF graph)
  - Example: just name the resource

```
DESCRIBE <http://dbpedia.org/resource/Beerenberg>
```

Query

  - Example: Specify the resource(s) with a query pattern

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

Query

  - Multiple variables possible or asterisk (“*”) for all

Result Forms

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

Result Forms

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

Query

```
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 .
```

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:**
  - Only for SELECT queries
  - Modify the result set as a whole (not single solutions)
  - Keywords: DISTINCT, ORDER BY, LIMIT, and OFFSET

Solution Modifiers

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

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 "Беренберг"@ru  .
```

Query

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

?type
umbel-sc:Volcano
umbel-sc:Volcano
umbel-sc:NaturalElevation
umbel-sc:Volcano

Solution Modifiers

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

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

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

?type
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
```

Solution Modifiers

- **ORDER BY orders the results**

Query

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

- How do we order 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**

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

Query

Solution Modifiers

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

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

Query

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

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

Query

- **Order of result should be predictable (i.e. combine with ORDER BY)**

SPARQL 1.1

- **New features of SPARQL 1.1 Query:**
  - Aggregate functions (e.g. COUNT, SUM, AVG)
  - Subqueries
  - Negation (EXISTS, NOT EXISTS, MINUS)
  - Assignments (e.g. BIND, SELECT expressions)
  - Property paths
  - Basic query federation (SERVICE, BINDINGS)
- **SPARQL 1.1 Update:**
  - Graph update (INSERT DATA, DELETE DATA, INSERT, DELETE, DELETE WHERE, LOAD, CLEAR)
  - Graph management (CREATE, DROP, COPY, MOVE, ADD)

Outline

Chapter 1:
Linked Data and

Chapter 2:
The SPARQL Query Lang

Now: Hands-on

Chapter 3:
Querying Linked Data on the Web

http://olafhartig.de/icwe.html

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