



AGH

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SPARQL

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SPARQL

- Introduction
- Graph Patterns
- Query Execution and Ordering
- Query Forms
- Testing Values
- SPARQL Support



Introduction

- RDF – flexible and extensible way to represent information about WWW resources
- SPARQL - query language for getting information from RDF graphs. It provides facilities to:
 - extract information in the form of URIs, blank nodes, plain and typed literals.
 - extract RDF subgraphs.
 - construct new RDF graphs based on information in the queried graphs
- matching graph patterns
- variables – global scope; indicated by '?' or '\$'
- query terms – based on Turtle syntax
- terms delimited by "<>" are *relative URI references*
- data description format - Turtle



Graph Patterns

Basic Graph Pattern – set of *Triple Patterns*

Group Pattern - a set of graph patterns must all match

Value Constraints - restrict RDF terms in a solution

Optional Graph Patterns .- additional patterns may extend the solution

Alternative Graph Pattern – two or more possible patterns are tried

Patterns on Named Graphs - patterns are matched against named graphs



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Basic Graph Pattern

- Set of Triple Patterns
 - **Triple Pattern** – similar to an RDF Triple (subject, predicate, object), but any component can be a query variable; literal subjects are allowed
 - `?book dc:title ?title`
 - Matching a triple pattern to a graph: bindings between variables and RDF Terms
- Matching of Basic Graph Patterns
 - A **Pattern Solution** of Graph Pattern GP on graph G is any substitution S such that S(GP) is a subgraph of G.

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

x	v	rdf:type	rdf:type	rdf:Property
rdf:type	rdf:Property			

Basic Graph Pattern - Multiple Matches

```
Data @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> .
```

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

Query



Group Graph Pattern
(set of graph
patterns) also!

Query Result

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



Basic Graph Pattern - Blank Nodes

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .  
Data  _:a foaf:name "Alice" .  
      _:b foaf:name "Bob" .
```

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

Query

Query Result

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



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Group Pattern

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

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



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Value Constraints

Data

```

@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/>
PREFIX ns: <http://example.org/ns#>
SELECT ?title ?price
WHERE { ?x ns:price ?price .
        FILTER ?price < 30 .
        ?x dc:title ?title . }

```

Query

	title	price
Query Result	"The Semantic Web"	23



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Optional graph patterns

Data

```

@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/>
```

```
PREFIX ns: <http://example.org/ns#>
```

```
SELECT ?title ?price
```

```
WHERE { ?x dc:title ?title .
```

```
    OPTIONAL { ?x ns:price ?price .
```

```
        FILTER ?price < 30 } }
```

Query

Query Result

title	price
"SPARQL Tutorial"	
"The Semantic Web"	23



Multiple Optional Blocks

Data

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
_: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 } }
```

Query

Query Result

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



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Alternative Graph Patterns

Data

```
@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" .
_:b dc11:title "SPARQL Protocol Tutorial" .
_: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 ?x ?y
WHERE { { ?book dc10:title ?x } UNION { ?book dc11:title ?
y } }
```

Query

Query Result

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



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RDF Dataset

- RDF data stores may hold multiple RDF graphs:
 - record information about each graph
 - queries that involve information from more than one graph
 - *RDF Dataset* in SPARQL terminology
 - the background graph, which does not have a name, and zero or more named graphs, identified by URI reference
- the relationship between named and background graphs:
 - (i) to have information in the background graph that includes provenance information about the named graphs (the application is not directly trusting the information in the named graphs)
 - (ii) to include the information in the named graphs in the background graph as well.



RDF Dataset- The Relationship between Named and Background Graphs (I)

Background graph

```
@prefix dc: <http://purl.org/dc/elements/1.1/> .  
<http://example.org/bob> dc:publisher "Bob" .  
<http://example.org/alice> dc:publisher "Alice" .
```

Graph: <http://example.org/bob>

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .  
_:a foaf:name "Bob" .  
_:a foaf:mbox  
<mailto:bob@oldcorp.example.org> .
```

Graph: <http://example.org/alice>

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .  
_:a foaf:name "Alice" .  
_:a foaf:mbox <mailto:alice@work.example.org> .
```

RDF Dataset- The Relationship between Named and Background Graphs (II)

Background graph

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .  
_:x foaf:name "Bob" .  
_:x foaf:mbox <mailto:bob@oldcorp.example.org> .  
_:y foaf:name "Alice" .  
_:y foaf:mbox <mailto:alice@work.example.org> .
```

Graph: <http://example.org/bob>

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .  
_:a foaf:name "Bob" .  
_:a foaf:mbox  
<mailto:bob@oldcorp.example.org> .
```

Graph: <http://example.org/alice>

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .  
_:a foaf:name "Alice" .  
_:a foaf:mbox <mailto:alice@work.example.org> .
```



Querying the Dataset

Graph: <http://example.org/foaf/aliceFoaf>

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
_:a foaf:name "Alice" .
_:a foaf:mbox <mailto:alice@work.example> .
_:a foaf:knows _:b .
_:b rdfs:seeAlso <http://example.org/foaf/bobFoaf> .
<http://example.org/foaf/bobFoaf> rdf:type foaf:PersonalProfileDocument .
_:b foaf:name "Bob" .
_:b foaf:mbox <mailto:bob@work.example> .
_:b foaf:age 32 .
```

Graph: <http://example.org/foaf/bobFoaf>

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
_:1 foaf:mbox <mailto:bob@work.example> .
_:1 rdfs:seeAlso <http://example.org/foaf/bobFoaf> .
_:1 foaf:age 35 .
<http://example.org/foaf/bobFoaf> rdf:type foaf:PersonalProfileDocument .
```

Querying the Dataset - Accessing Graph Labels

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?src ?bobAge
WHERE { GRAPH ?src
        { ?x foaf:mbox
          <mailto:bob@work.example> .
          ?x foaf:age ?bobAge }
        }
}
```

src	bobAge
<http://example.org/foaf/aliceFoaf>	32
<http://example.org/foaf/bobFoaf>	35

Querying the Dataset - Restricting by Graph Label

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

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

```
SELECT ?age
```

```
WHERE
```

```
{
```

```
  GRAPH data:bobFoaf {
```

```
    ?x foaf:mbox <mailto:bob@work.example> .
```

```
    ?x foaf:age ?age }
```

```
}
```

age
35



Querying the Dataset - Restricting via Query Pattern

```
PREFIX data: <http://example.org/foaf/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?mbox ?age ?ppd
WHERE
  { GRAPH data:aliceFoaf
    { ?alice foaf:mbox <mailto:alice@work.example> ;
      foaf:knows ?whom .
      ?whom foaf:mbox ?mbox ;
      rdfs:seeAlso ?ppd .
      ?ppd a foaf:PersonalProfileDocument . } .
  GRAPH ?ppd { ?w foaf:mbox ?mbox ;
    foaf:age ?age } }
```

mbox	age	ppd
<mailto:bob@work.example>	35	<http://example.org/foaf/bobFoaf>

- **Optional-1:** an optional pattern that has a common variable with a(more) basic graph pattern(s) must be executed after the basic graph pattern(s)
- **Optional-2:** there can't be two optionals with a common variable, if that variable does not occur in a basic graph pattern as well
- **Constraint:** constraints are evaluated after variables are assigned values



Query forms:

- **SELECT**
 - returns all, or a subset of the variables bound in a query pattern match
 - formats : XML or RDF/XML
- **CONSTRUCT**
 - returns an RDF graph constructed by substituting variables in a set of triple templates
- **DESCRIBE**
 - returns an RDF graph that describes the resources found.
- **ASK**
 - returns whether a query pattern matches or not.



CONSTRUCT Examples(I)

```
@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 }
```

```
@prefix vcard: <http://www.w3.org/2001/vcard-rdf/3.0#> .  
<http://example.org/person#Alice> vcard:FN "Alice" .
```

#extracting a whole graph from the target RDF dataset

```
CONSTRUCT { ?s ?p ?o }  
WHERE { GRAPH <http://example.org/myGraph> { ?s ?p ?o } . }
```



CONSTRUCT Examples(II)

accessing a graph conditional on other information contained in the metadata about named graphs in the dataset

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX app: <http://example.org/ns#>
CONSTRUCT { ?s ?p ?o }
WHERE { GRAPH ?g { ?s ?p ?o } .
        { ?g dc:publisher <http://www.w3.org/> } .
        { ?g dc:date ?date } .
        FILTER app:myDate(?date) > "2005-02-
8T00:00:00Z"^^xsd:dateTime.
}
```



DESCRIBE

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

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .  
@prefix vcard: <http://www.w3.org/2001/vcard-rdf/3.0> .  
@prefix myOrg: <http://myorg.example/employees#> .  
_:a myOrg:employeeId "1234" ;  
    foaf:mbox_sha1sum "ABCD1234" ;  
    vcard:N [ vcard:Family "Smith" ;  
             vcard:Given "John" ] .  
foaf:mbox_sha1sum rdf:type owl:InverseFunctionalProperty .
```



ASK

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

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> . @prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .

_: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" } .



Testing Values

- Named functions and syntactically constructed operations:
 - operands: subset of XML Schema DataTypes {xsd:string, xsd:decimal, xsd:double, xsd:dateTime} and types derived from xsd:decimal.
- Subset of XPath functions and operators
 - Operands: xs:string, xs:double, xs:float, xs:decimal, xs:integer, xs:dateTime
 - additional operators: sop:RDFterm-equal, sop:bound , sop:isURI, sop:isBlank, sop:isLiteral, sop:str , sop:lang, sop:datatype, sop:logical-or, sop:logical-and
- Type Promotion : xs:double, xs:float, xs:decimal
 - each of the numeric types is promoted to any type higher in the above list when used as an argument to function expecting that higher type.



Support for SPARQL

- SPARQL and Jena
 - module called ARQ that implements SPARQL; also parses queries expressed in RDQL or its own internal language.
 - not yet part of the standard Jena distribution; available from either Jena's CVS repository or as a self-contained download
- Twinkle
 - simple Java interface that wraps the ARQ SPARQL Processor library (the add-on to Jena).
- Redland
 - set of free software packages that provide support for RDF, including querying with RDQL and SPARQL using the Rasqal RDF Query Library. .