SPARQL Protocol and RDF Query Language (SPARQL)
Semantic Web (CSC751)

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1. Announcements

2. In retrospect

3. Query types

4. Basics
Reading

- 7.1.1-7.1.8 [HKR09]

Acknowledgement

- Most of the examples in this lecture slides are borrowed from SPARQL Query Language for RDF
Orphan ⊑ Human \( \sqcap \forall \text{hasParent.} \neg \text{Alive} \)
Query types

1. Retrieve instances.

```
SELECT ?x WHERE {
  ?x rdf:type family:Person .
}
```

2. Retrieve subclasses.

```
SELECT ?x WHERE {
  ?x rdfs:subClassOf family:Person .
}
```

3. Retrieve subclasses, and their instances.

```
SELECT ?x ?y WHERE {
  ?y rdfs:subClassOf family:Person .
}
```
We have written a simple framework to query the knowledge base using Jena and Pellet API. It is available in the class web site.

```java
public interface OwlHelper {
    InfModel loadInfModel(File kb);
    InfModel loadInfModel(File tBox, File aBox);
    void startReasoner(InfModel model);
    void execQuery(String query, Model model, ResultSetCallback callback);
}

public interface ResultSetCallback {
    void run(ResultSet resultSet, Query query);
}
```

You can use this framework in your code as follows:

```java
OwlHelper helper = OwlHelperFactory.createDefaultOwlHelper();
InfModel model = helper.loadInfModel(kbFile);
helper.startReasoner(model);
...
String query = ...;
helper.execQuery(query, model, new ResultSetFormatterCallback());
```
SPARQL

- W3C recommendation for querying RDF and RDFS.
- We can use SPARQL to a certain extent to query OWL 2 DL knowledge bases. But the preferred way is *conjunctive queries*.

Graph patterns

- SPARQL is based on matching *graph patterns* w.r.t. RDF, RDFS (supported features), or OWL (supported features) graphs.
- A *graph pattern* is similar to *triple pattern*, but with the option of *variables* in subject, predicate or object. e.g.,

```
<http://family.org/family.owl#daughter>
<http://family.org/family.owl#hasParent> ?parent .
```

- ?parent is a *variable*. This variable could also be written as $parent.
Basic graph patterns

- A **basic graph pattern** (BGP) is a set of **triple patterns** written as a sequence of triple patterns separated by a period if necessary.
- Therefore, BGP is a **conjunction of triple patterns**. e.g.,

```sql
?x <http://family.org/family.owl#hasParent> ?parent .
?x <http://family.org/family.owl#hasUncle> ?uncle
```

- There is no keyword for conjunction in SPARQL.
Group graph patterns

- A group graph pattern is a set of graph patterns delimited with braces. e.g.,

```{  
  { ?x <http://family.org/family.owl#hasParent> ?y . }  
  { ?x <http://family.org/family.owl#hasUncle> ?z . }  
  { }  
}
```

- `{ }` is the empty group graph pattern.
- Group graph patterns are used with other constructors, which we will see in few slides.
Major query parts

- **PREFIX**: declares the namespace prefix,
- **SELECT**: determines the general result format, and
- **WHERE**: actual query is initiated with group graph patterns.

The result of a query is a set of *bindings* for the variables appearing in the **SELECT** clause. These binding are shown in tabular format.

**SELECT** and **WHERE** clauses are like in SQL. But keep in mind that SPARQL and SQL are very different languages.
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX family: <http://family.org/family.owl#>
SELECT ?x
WHERE
{
  family:daughter family:hasParent ?x .
}
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX family: <http://family.org/family.owl#>

SELECT ?x ?y ?z
{
  ?x family:hasParent ?y .
  ?x family:hasUncle ?z
}

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>family:daughter</td>
<td>family:mother</td>
<td>family:uncle</td>
</tr>
<tr>
<td>family:daughter</td>
<td>family:father</td>
<td>family:uncle</td>
</tr>
<tr>
<td>family:son</td>
<td>family:mother</td>
<td>family:uncle</td>
</tr>
<tr>
<td>family:son</td>
<td>family:father</td>
<td>family:uncle</td>
</tr>
</tbody>
</table>
Queries with literals

- We have careful when matching literals. e.g.,

```
SELECT ?x WHERE { ?x ?p "Ubbo" .}
```

and

```
SELECT ?x WHERE { ?x ?p "Ubbo"@en .}
```

have different results.

- xsd data types:

```
SELECT ?x WHERE { ?x ?hasAge "38"^^xsd:nonNegativeInteger .}
```

```
| x
|----------------------
| family:father |
```

or

```
SELECT ?x WHERE { ?x ?hasAge 38.}
```
"chat"
'chat'@fr with language tag "fr"
"xyz"^^<http://example.org/ns/userDatatype>
"abc"^^appNS:appData_type
"'The librarian said, "Perhaps you would enjoy 'War and Peace'."'"
1, which is the same as "1"^^xsd:integer
1.3, which is the same as "1.3"^^xsd:decimal
1.300, which is the same as "1.300"^^xsd:decimal
1.0e6, which is the same as "1.0e6"^^xsd:double
true, which is the same as "true"^^xsd:boolean
false, which is the same as "false"^^xsd:boolean
Blank nodes 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 . }

<table>
<thead>
<tr>
<th>x</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>_:c</td>
<td>&quot;Alice&quot;</td>
</tr>
<tr>
<td>_:d</td>
<td>&quot;Bob&quot;</td>
</tr>
</tbody>
</table>
Blank nodes in graph patterns

- Blank nodes assert the existence of a corresponding element in the input graph, but they do not provide any information about the identity of this element.
- Blank nodes cannot appear in a `SELECT` clause.
- The scope of blank node is the BGP in which it appears. A blank node which appears more than once in the same BGP stands for the same term.
Constraints on variables

- **FILTER** restricts variable bindings to those for which the filter expression evaluates to `true`.

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

```

```sparql
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) 
} 
=> "The Semantic Web"  23
```
Constraints on variables

- Regular expression filter:

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

**SPARQL Tutorial**

- Group graph patterns are used to restrict the scope of the `FILTER`.
- `FILTER` is a restriction on solutions over the whole group in which it appears.
- One can have multiple `FILTER` conditions in a group graph pattern. The result is equivalent to a single filter with conjuncted filter conditions.
- `FILTER` can have very complex boolean conditions.
These graph patterns have same set of solutions

```
{
  ?x foaf:name ?name .
  FILTER regex(?name, "Smith")
}

{
  FILTER regex(?name, "Smith")
  ?x foaf:name ?name .
}

{
  ?x foaf:name ?name .
  FILTER regex(?name, "Smith")
}
```
OPTIONAL graph patterns

- With OWA, the complete structures cannot be assumed in all RDF graphs (this is of the ABox).
- Therefore, we need a way to extract the available information, even though some part of the query pattern does not match.
- **OPTIONAL** provides this facility. If the graph pattern does not match, it does not create bindings, but does not eliminate the solution as well.

KB

```turtle
@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" .
```
OPTIONAL example

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

<table>
<thead>
<tr>
<th>name</th>
<th>mbox</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Alice&quot;</td>
<td><a href="mailto:alice@example.com">mailto:alice@example.com</a></td>
</tr>
<tr>
<td>&quot;Alice&quot;</td>
<td><a href="mailto:alice@work.example">mailto:alice@work.example</a></td>
</tr>
<tr>
<td>&quot;Bob&quot;</td>
<td></td>
</tr>
</tbody>
</table>
**OPTIONAL properties**

- Normally, we start with a graph pattern $P_1$ and then apply **OPTIONAL** to another graph pattern $P_2$ that follows it.
  
  ```
  P1 OPTIONAL { P2 }
  ```

- **OPTIONAL** is a binary operator.

- **OPTIONAL** is left-associative.
  
  ```
  P1 OPTIONAL { P2 } OPTIONAL { P3 }
  <=>
  { P1 OPTIONAL { P2 } } OPTIONAL { P3 }
  ```

- **OPTIONAL** has higher precedence than conjunction.
  
  ```
  { OPTIONAL { P } }
  <=>
  { { } OPTIONAL { P } }
  ```
The group graph pattern following the OPTIONAL can be as complex as possible.

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

:book2 ns:price 42 .
```
**FILTER in OPTIONAL example**

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX ns: <http://example.org/ns#>
SELECT ?title ?price
WHERE {
  OPTIONAL {
    ?x ns:price ?price .
    FILTER (?price < 30)
  }
}
```

```
<table>
<thead>
<tr>
<th>title</th>
<th>price</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Sparql Tutorial&quot;</td>
<td></td>
</tr>
<tr>
<td>&quot;A New Sparql Tutorial&quot;</td>
<td></td>
</tr>
<tr>
<td>&quot;The Semantic Web&quot;</td>
<td>23</td>
</tr>
</tbody>
</table>
```
Multiple OPTIONAL

@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 . }
}

<table>
<thead>
<tr>
<th>name</th>
<th>mbox</th>
<th>hpage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Alice&quot;</td>
<td></td>
<td><a href="http://work.example.org/alice/">http://work.example.org/alice/</a></td>
</tr>
<tr>
<td>&quot;Bob&quot;</td>
<td><a href="mailto:bob@work.example">mailto:bob@work.example</a></td>
<td></td>
</tr>
</tbody>
</table>
Example

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


ex:book3 ns:price 34 .

**Queries**

```
PREFIX ex: <http://example.org/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX ns: <http://example.org/ns#>

********************
SELECT ?book ?title
  { ?book ns:price ?price .}
}

********************
SELECT ?book ?title
  OPTIONAL { ?book dc:title ?title .} }
  { ?book ns:price ?price .}
}

********************
SELECT ?book ?title
  OPTIONAL { { ?book dc:title ?title .}
  { ?book ns:price ?price .} }
}

********************
```
UNION

- **UNION** provides the facility to form *disjunction of graph patterns*, such that one of several graph patterns may match. All the alternative matching patterns are returned.

---

**KB**

```sparql
@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:creator "Bob" .

_:c dc10:title "SPARQL" .
_:c dc11:title "SPARQL (updated)" .
```
**UNION example**

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

<table>
<thead>
<tr>
<th>title</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;SPARQL Protocol Tutorial&quot;</td>
</tr>
<tr>
<td>&quot;SPARQL&quot;</td>
</tr>
<tr>
<td>&quot;SPARQL (updated)&quot;</td>
</tr>
<tr>
<td>&quot;SPARQL Query Language Tutorial&quot;</td>
</tr>
</tbody>
</table>
UNION example

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

---

<table>
<thead>
<tr>
<th>author</th>
<th>title</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Alice&quot;</td>
<td>&quot;SPARQL Query Language Tutorial&quot;</td>
</tr>
<tr>
<td>&quot;Bob&quot;</td>
<td>&quot;SPARQL Protocol Tutorial&quot;</td>
</tr>
</tbody>
</table>
Semantic of UNION

- UNION is a binary operator.
- Group graph patterns are evaluated independently and combine the results using set theoretic union.
- We have to decide whether to use same variable in each alternative, as this decision provides different results.

UNION example

```sql
SELECT ?x ?y
```

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;SPARQL (Updated)&quot;</td>
<td></td>
</tr>
<tr>
<td>&quot;SPARQL Protocol ...&quot;</td>
<td></td>
</tr>
<tr>
<td>&quot;SPARQL&quot;</td>
<td></td>
</tr>
<tr>
<td>&quot;SPARQL Query ...&quot;</td>
<td></td>
</tr>
</tbody>
</table>
Properties of **UNION**

- **UNION** is left-associative.
- **UNION** and **OPTIONAL** have same precedence.
- **UNION** has higher precedence than conjunction.
- **Commutative**

\[
P \text{ UNION } Q \iff Q \text{ UNION } P
\]

- **Associative**

\[
\{P \text{ UNION } Q\} \text{ UNION } R \iff P \text{ UNION } \{Q \text{ UNION } R\}
\]
**OPTIONAL, UNION examples**

```
{ {s1 p1 o1} UNION {s2 p2 o2}
  OPTIONAL {s3 p3 o3} }
<=>
{ { {s1 p1 o1} UNION {s2 p2 o2} }
  OPTIONAL {s3 p3 o3} }
```

```
{ {s1 p1 o1} OPTIONAL {s2 p2 o1}
  UNION {s3 p3 o3} OPTIONAL
  {s4 p4 o4} OPTIONAL {s5 p5 o5} }
<=>
{ { { {s1 p1 o1} OPTIONAL {s2 p2 o1}
    UNION {s3 p3 o3}
    } UNION {s4 p4 o4}
    } OPTIONAL {s5 p5 o5} }
```
UNION and conjunction

```
{ {s1 p1 o1} UNION {s2 p2 o1}
  {s3 p3 o3}
}
<=>
{ {s1 p1 o1} UNION {s2 p2 o1}
  {s3 p3 o3}
}
```
@prefix ex: <http://example.org/>.
@prefix dc: <http://purl.org/dc/elements/1.1/>.
@prefix ns: <http://example.org/ns#>.

ex:book1 dc:title "Semantic Web".

ex:book2 dc:title "SPARQL".

ex:book3 dc:title "RDF".
Example

PREFIX ex: <http://example.org/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX ns: <http://example.org/ns#>
WHERE
{ 
  UNION 
  { ?book dc:creator ex:jones .} 
  { ?book ns:price ?price . } 
}

<table>
<thead>
<tr>
<th>book</th>
<th>title</th>
<th>price</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://example.org/book3">http://example.org/book3</a></td>
<td>35</td>
<td></td>
</tr>
<tr>
<td><a href="http://example.org/book2">http://example.org/book2</a></td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>
Example

```sql
PREFIX ex: <http://example.org/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX ns: <http://example.org/ns#>

WHERE
{
  UNION
}
```

<table>
<thead>
<tr>
<th>book</th>
<th>title</th>
<th>price</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://example.org/book1">http://example.org/book1</a></td>
<td>&quot;Semantic Web&quot;</td>
<td></td>
</tr>
<tr>
<td><a href="http://example.org/book3">http://example.org/book3</a></td>
<td></td>
<td>35</td>
</tr>
<tr>
<td><a href="http://example.org/book2">http://example.org/book2</a></td>
<td></td>
<td>30</td>
</tr>
</tbody>
</table>
More about **FILTER** and special operators

- **FILTER** supports $=, >, <, \geq, \leq$, and $\neq$ operators.
- Each operator is defined for all datatype that SPARQL supports. e.g., `xsd:dateTime`
- All literals that have different datatypes are not compatible with prior operators, but $=$ and $\neq$.
- But, they produce an error if unknown datatypes are given.
- Multiple filter conditions are combined with `&&` (logical *and*), `||` (logical *or*) and `!` (logical *not*).
- Conjunction: can be expressed with multiple **FILTER** within one graph pattern.
- Disjunction: a graph pattern could be split into multiple alternative patterns that use equal conditions with one of filter part.
- Supports numerical operators, $+, -, \times, \div$, only if the variable are bounded in a meaningful way.
### Unary operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>BOUND(A)</code></td>
<td>true if A is a bounded variable</td>
</tr>
<tr>
<td><code>isURI(A)</code></td>
<td>true if A is a URI</td>
</tr>
<tr>
<td><code>isBLANK(A)</code></td>
<td>true if A is a blank node</td>
</tr>
<tr>
<td><code>isLITERAL(A)</code></td>
<td>true if A is a RDF literal</td>
</tr>
<tr>
<td><code>STR(A)</code></td>
<td>maps RDF literals or URIs to the corresponding lexical representation of type <code>xsd:string</code></td>
</tr>
<tr>
<td><code>LANG(A)</code></td>
<td>returns language code of an RDF literal as <code>xsd:string</code>, or an empty string if no such setting is specified</td>
</tr>
<tr>
<td><code>DATATYPE(A)</code></td>
<td>returns the URI of an RDF literal datatype of the value “<code>xsd:string</code>” for untyped literals without language setting; not applicable to literals with language setting</td>
</tr>
<tr>
<td><code>sameTERM(A,B)</code></td>
<td>true if A and B are the same RDF terms (direct term comparison)</td>
</tr>
<tr>
<td><code>langMATCHES(A,B)</code></td>
<td>true if the literal A is a language tag that matches the pattern B</td>
</tr>
<tr>
<td><code>REGEX(A,B)</code></td>
<td>true if the regular expression B can be matched to the string A</td>
</tr>
</tbody>
</table>
Example

PREFIX ex: <http://example.org/>
SELECT ?book
WHERE
{
  { ?book ex:isPublishedBy <http://crc-press.com/uri> . }
  OPTIONAL { ?book ex:author ?author . }
  FILTER( DATATYPE(?author) = <http://www.w3.org/2001/XMLSchema#string>)
}

PREFIX ex: <http://example.org/>
SELECT ?book
WHERE
{
  FILTER( REGEX(?title, "^Foundations of") )
}
Query forms

- Tabular representation is useful for processing results sequentially.
- If the structure and mutual relations of objects in the results set are more important, RDF representation of the results is more appropriate.
- **CONSTRUCT** returns RDF graph specified by a graph template.
- **ASK** tests whether or not a graph pattern has a solution. This returns whether or not a solution exists.
Example **CONSTRUCT**

```sparql
@prefix ex: <http://example.org/> .

ex:alice ex:email "alice@example.org" .
ex:alice ex:email "a.miller@example.org" .
ex:alice ex:phone "123456789" .
ex:alice ex:phone "987654321" .

PREFIX ex: <http://example.org/>
CONSTRUCT {  
  _id1 ex:email ?email .  
  _id1 ex:phone ?phone .  
  _id1 ex:person ?person .}
WHERE  
{  
}

_y ex:email "alice@example.org";
...```
Example ASK

PREFIX ex: <http://example.org/>

ASK
{
}

=> TRUE
Modifiers

- To narrow down the result set.
- Modifiers controls the details regarding the form and size of result lists.
- Most constructs affects only results obtained with SELECT.

<table>
<thead>
<tr>
<th>Modifier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORDER BY</td>
<td>sort in ascending order based on the meaningful bounded variable.</td>
</tr>
<tr>
<td>DESC</td>
<td>sort by descending order</td>
</tr>
<tr>
<td>ASC</td>
<td>sort by ascending order</td>
</tr>
<tr>
<td>LIMIT</td>
<td>maximum results</td>
</tr>
<tr>
<td>OFFSET</td>
<td>starting position for piecewise retrieval of results</td>
</tr>
<tr>
<td>DISTINCT</td>
<td>remove repetitions from result set</td>
</tr>
</tbody>
</table>
Order of application

- All the parameters are allowed to be combined. Therefore, SPARQL defines the following processing steps:
  - Sort results based on ORDER BY.
  - Remove non selected variables from the result set (*projection*).
  - Remove duplicate results.
  - Remove the number of initial results as specified by OFFSET.
  - Remove all results after the number specified by LIMIT.

- **LARQ**: combination of ARQ and Lucene. This is a specific example.
Examples

PREFIX ex: <http://example.org/>
SELECT ?book ?price
WHERE
{
}
ORDER BY ?price
*******************************************************************************
SELECT ?book ?price
WHERE
{
}
ORDER BY ASC(?price)
*******************************************************************************
SELECT *
WHERE
{
}
ORDER BY ?s LIMIT 5 OFFSET 25
The Manchester OWL

DL Query

- Searching in a classified ontology using Manchester OWL syntax.
- It is based on OWL abstract syntax and DL style syntax.
- Supports some, only, value, min, exactly, max, and, or, and not.
- Supports data values and datatypes with XSD facets.
- Lets see an example based on photography ontology (OWL 2).
Example\(^1\)

- **Which equipment can reduce blur?**
  Equipment and reduces some Blur

- **What types of lens is a 35-120mm?**
  Lens and (hasMinEffectiveFocalLength value 35) and (hasMaxEffectiveFocalLength value 120)

- **Which adjustments can I use to increase the exposure without affecting the depth of field?**
  Adjustment and increases some ExposureLevel and not(affects some DepthOfField)

\(^1\text{http://protegewiki.stanford.edu/wiki/DLQueryTab}\)
Example

- Person and hasAge some nonNegativeInteger
- Person and hasAge some int[>40]
- Person and hasAge some int[>10,<40]
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