INFOH509 XML & WEB TECHNOLOGIES

LECTURE 9: SPARQL

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WHAT HAVE WE GAINED?

Current – no structure

In modern molecular biology, the **genome** is the entirety of an organism's hereditary information. It is encoded either in DNA or, for many types of virus, in RNA.

The genome includes both the genes and the non-coding sequences of the DNA.[1] The term was adapted in 1920 by Hans Winkler, Professor of Botany at the University of Hamburg, Germany. The Oxford English Dictionary suggests the name to be a portmanteau of the words ***gen***e and *chromos**ome***. A few related *-ome* words already existed, such as *biome* and *rhizome*, forming a vocabulary into which *genome* fits systematically.[2]

Future – structured by RDF (subject, predicate, object)

```
b:genome    b:field      b:molecular-bio .
b:DNA       b:encode     b:genes         .
b:DNA       b:encode     b:non-coding-seq .
b:genome    b:include    b:non-coding-seq .
b:genome    b:include    b:gene          .
b:genome    b:related-to b:rhizome       .
```

- RDF is meant to assert knowledge (statements) about entities (resources)
- By convention is clear what the subject, predicate, and object are
- With extra knowledge more inferences can be made
  (e.g.: John Doe is a person)

WHAT HAVE WE GAINED?

Current – no structure

```
<lecturer name="John Doe">
  <teaches>XML Technologies</teaches>
</lecturer>
```

Future – structured by RDF (subject, predicate, object)

uni:john-doe	a	terms:lecturer .
uni:john-doe	terms:teaches	crs:xml .
crs:xml	a	terms:course .

- RDF is meant to assert knowledge (statements) about entities (resources)
- By convention is clear what the subject, predicate, and object are
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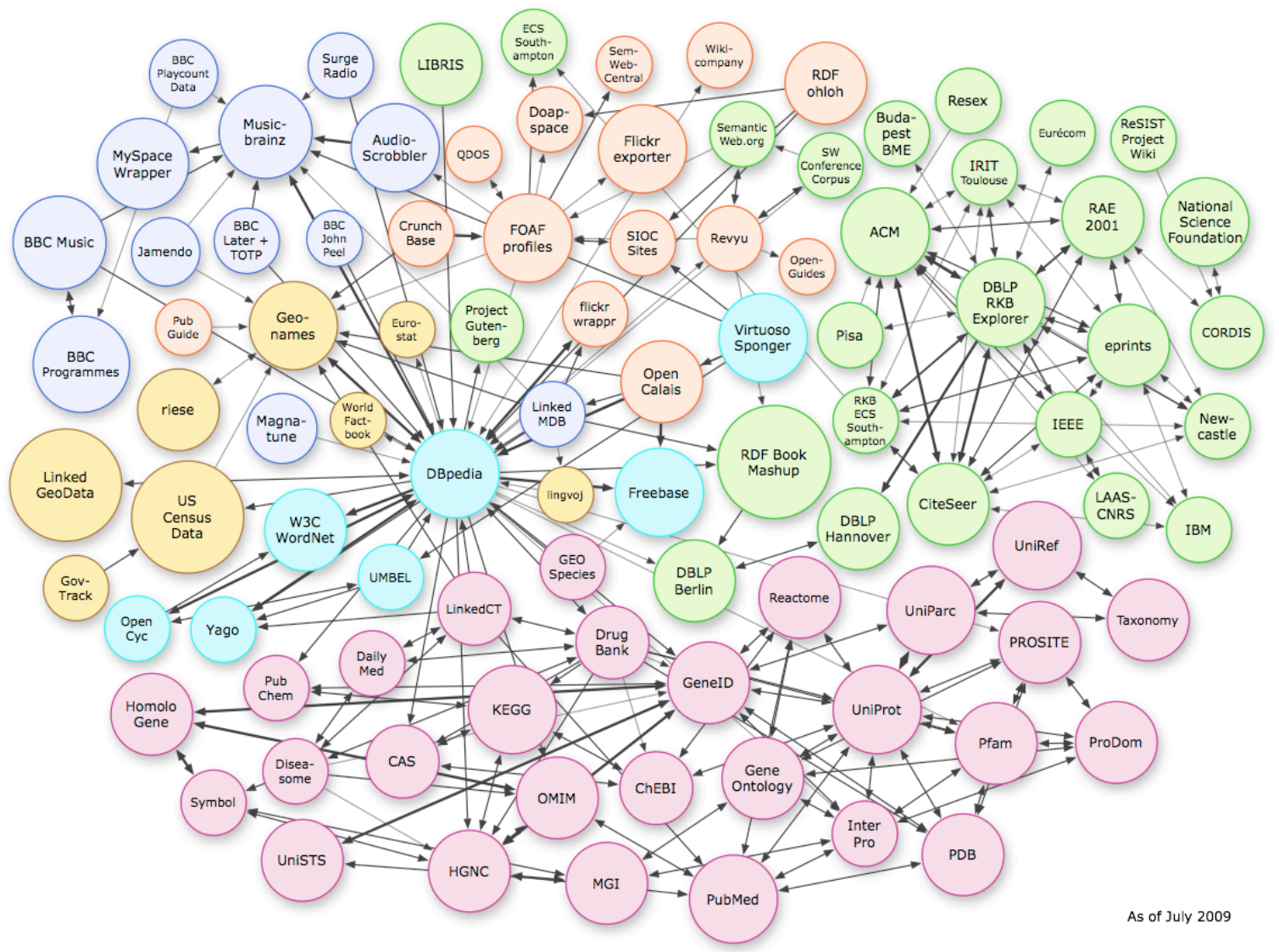
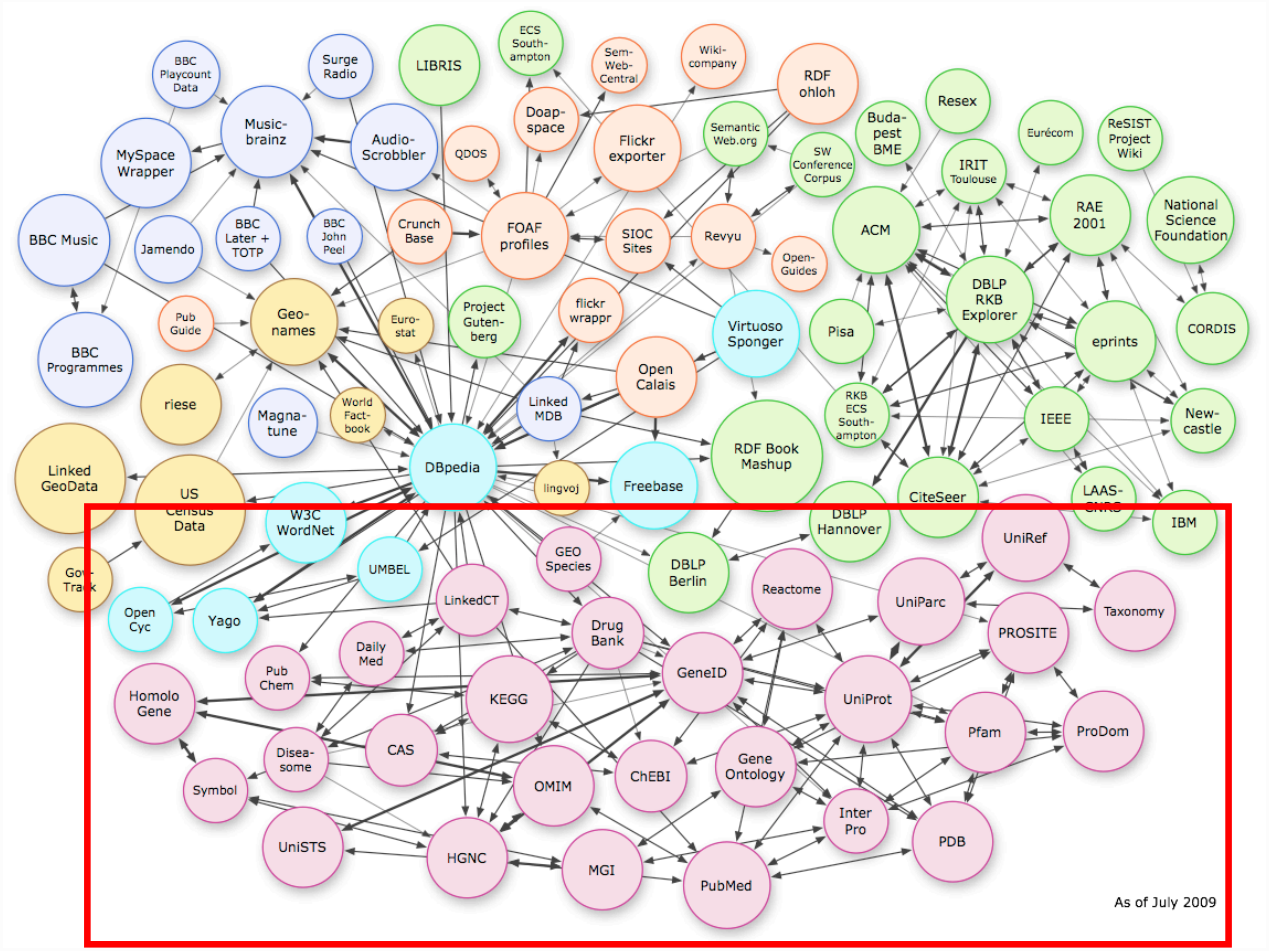
THE WEB OF LINKED DATA

Envisions the Web as a single HUGE database consisting of RDF data



APPLICATION: E-SCIENCE



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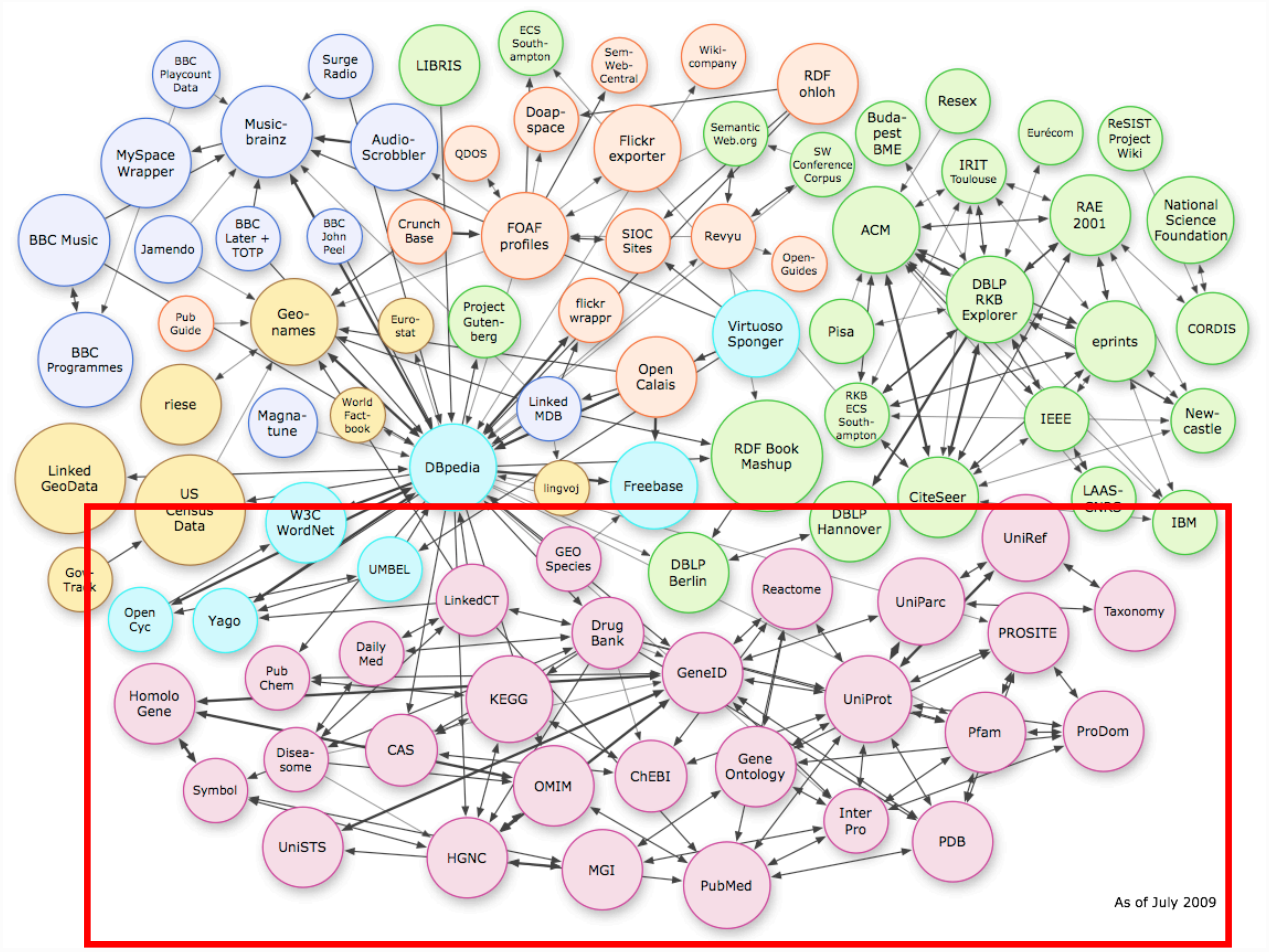
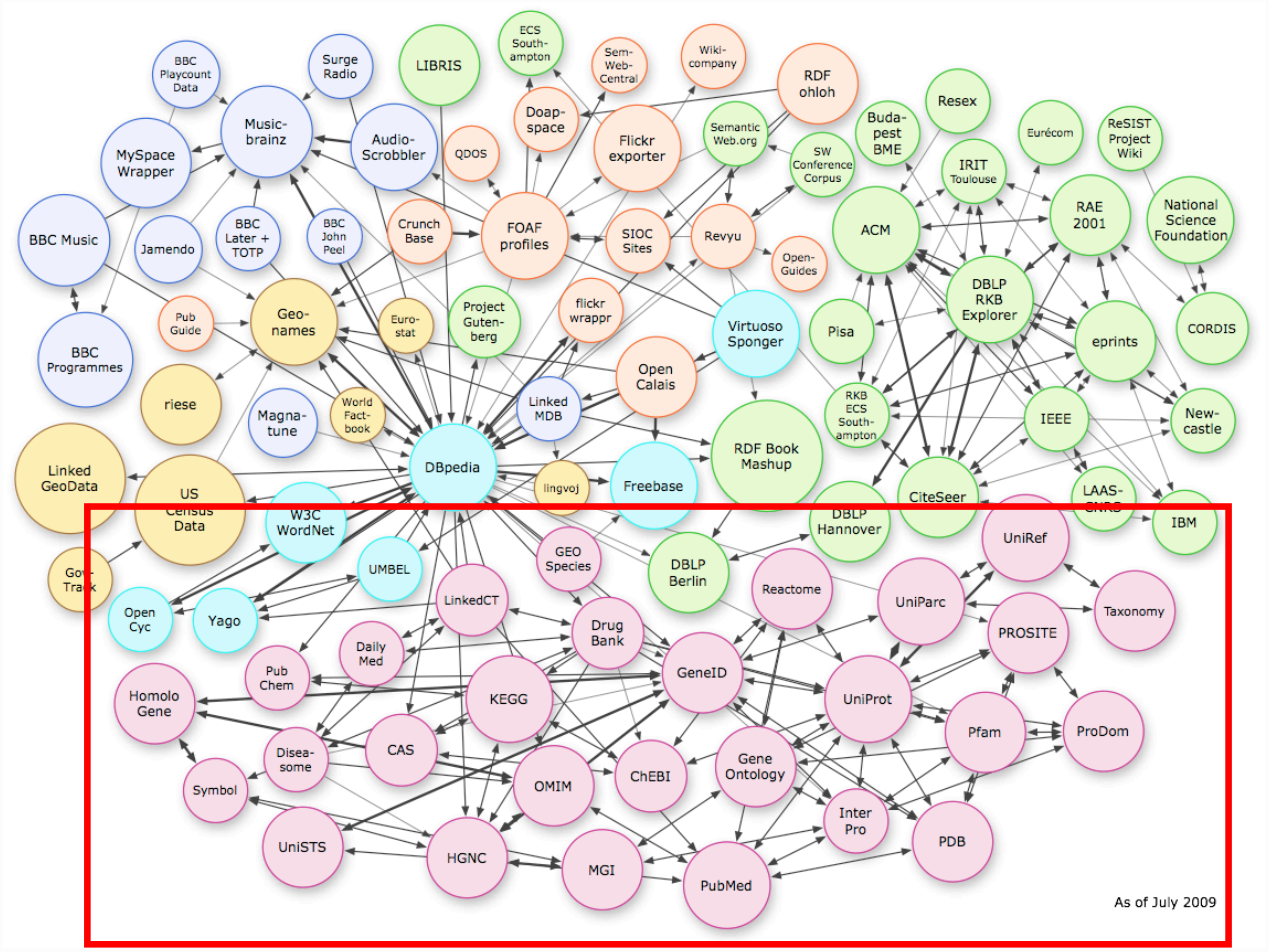


- Query: What proteins are absent in diabetes patients?

APPLICATION: E-SCIENCE



- Query: What proteins are absent in diabetes patients?
- Required: A means to query RDF

SPARQL

- To support structured queries like “What proteins are absent in diabetes patients?”, the W3C has proposed SPARQL: Simple Protocol and RDF Query Language
- SPARQL is essentially the SQL for RDF

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Example

```
PREFIX bio: <http://science.org/biology/terms>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?prot_name
WHERE {



}
```

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     ?disease      bio:scientific_name    ”diabetes mellitus”.



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}
     ————————
       subject
```

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}
     ________      ________________________
       subject              predicate
```

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}
```

subject predicate object

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SELECT ?prot_name
WHERE {
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     ?disease      bio:symptom_lack_of    ?protein .


}
```

subject | predicate | object

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     ?disease      bio:symptom_lack_of    ?protein .
     ?protein      rdf:type               bio:protein .

}
```

subject | predicate | object

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     ?protein      rdf:type               bio:protein .
     ?protein      bio:name               ?prot_name .
}
```

subject | predicate | object

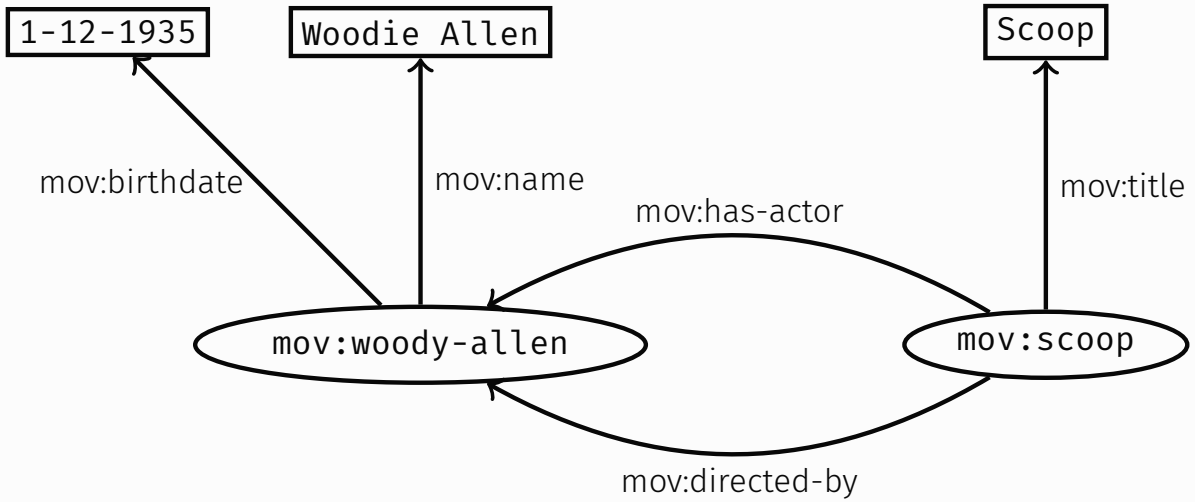
SPARQL

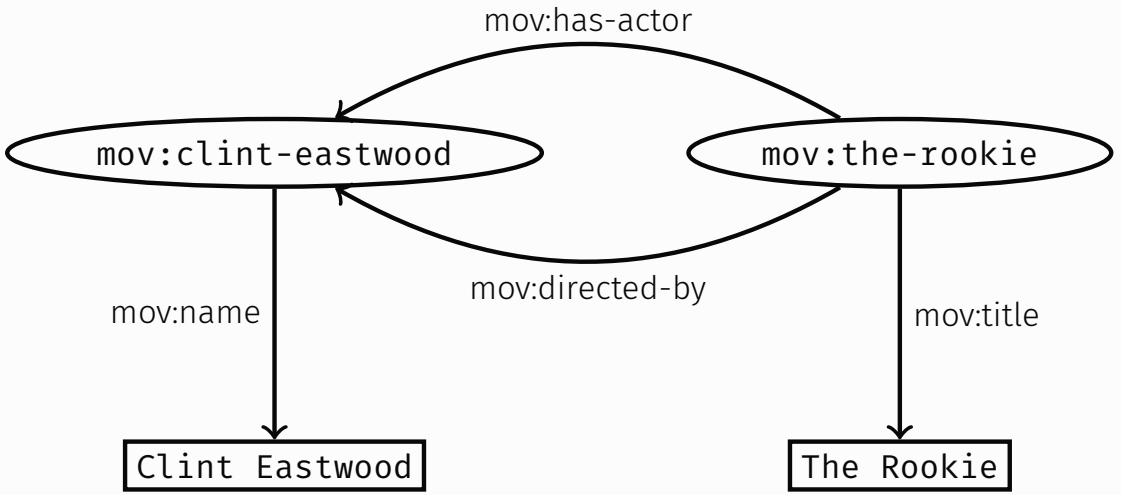
- `PREFIX` directives can be used to abbreviate URIs
- The basic syntax is a `SELECT` - `WHERE` clause
- A `FROM` clause is optional
- The where clause consists of graph patterns: RDF triples with variables
- Variables are denoted by `?var` with `var` a variable name

Example: directors who have acted in their own movies

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?director ?movie
WHERE {
     ?movie         mov:directed-by     ?director .
     ?movie         mov:has-actor       ?director .
}
```

Example Input:





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}
```

?director	?movie
mov:woody-allen	mov:scoop
mov:clint-eastwood	mov:the-rookie

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Example: directors who have acted in their own movies

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?director ?movie
FROM <http://example.org/mdb.ttl>
WHERE {
     ?movie        mov:directed-by     ?director .
     ?movie        mov:has-actor       ?director .
}
```

?director	?movie
mov:woody-allen	mov:scoop
mov:clint-eastwood	mov:the-rookie

SPARQL: OPTIONAL

- `OPTIONAL` clauses allow you to use information in the RDF graph if it is present, but does not eliminate solutions if it is missing

Example: director must have a birthdate

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?director ?movie ?bd
WHERE {
     ?movie          mov:directed-by     ?director .
     ?movie          mov:has-actor       ?director .
     ?director       mov:birthdate       ?bd .
}
```

?director	?movie	?bd
mov:woody-allen	mov:scoop	”1-12-1935”

SPARQL: OPTIONAL

- `OPTIONAL` clauses allow you to use information in the RDF graph if it is present, but does not eliminate solutions if it is missing

Example: return birthdate if available

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?director ?movie ?bd
WHERE {
     ?movie         mov:directed-by     ?director .
     ?movie         mov:has-actor       ?director .
     OPTIONAL {?director  mov:birthdate   ?bd . }
}
```

?director	?movie	?bd
mov:woody-allen	mov:scoop	”1-12-1935”
mov:clint-eastwood	mov:the-rookie	

SPARQL: FILTER

- `FILTER` clauses allow you to specify additional constraints on candidate solutions
- These constraints can use a small set of operators from XPath 2.0
- the operator `bound` can be used to test if a variable is bound or not
- the operator `regex` can be used to test if a variable matches a regular expression
- the operators `<`, `>`, `<=`, `>=`, `=`, `!=` can be used to compare

Example: directors that do not have a birthdate

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?director
WHERE {
       ?movie         mov:directed-by     ?director .
       OPTIONAL {?director  mov:birthdate   ?bd . }
       FILTER (!bound(?bd))
}
```

?director
mov:clint-eastwood

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- the operators `<`, `>`, `<=`, `>=`, `=`, `!=` can be used to compare

Example: directors who's name contains "allen" as a substring

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?director
WHERE {
       ?movie        mov:directed-by     ?director .
       ?director     mov:name            ?name .
       FILTER regex(?name, "allen", "i")
}
```

?director
mov:woody-allen

SPARQL: FILTER

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- the operator `regex` can be used to test if a variable matches a regular expression
- the operators `<`, `>`, `<=`, `>=`, `=`, `!=` can be used to compare

Example: movies that have rating at least 3

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?movie
WHERE {
       ?movie          mov:rating          ?x .
       FILTER (?x >= 3)
}
```

SPARQL: FILTER NOT EXISTS

- As of SPARQL 1.1 there is an easier way to find data that does not meet certain data using `FILTER NOT EXISTS`.
- `FILTER NOT EXISTS` takes as argument another graph pattern that should not be found in the data.

Example: directors that do not have a birthdate

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?director
WHERE {
       ?movie         mov:directed-by     ?director .
       FILTER NOT EXISTS { ?director  mov:birthdate   ?bd . }
}
```

?director
mov:clint-eastwood

SPARQL: UNION

- Using the **UNION** keyword, we can let patterns be evaluated independently

Example: Directors who's name contains "allen" as a substring or do not have a birthdate

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?director
WHERE {
    {
       ?movie        mov:directed-by     ?director .
       ?director     mov:name            ?name .
       FILTER regex(?name, "allen", "i")
    }
UNION
    {
       ?movie        mov:directed-by     ?director .
       OPTIONAL {?director  mov:birthdate   ?bd . }
       FILTER (!bound(?bd))
    }
}
```

SPARQL: CONSTRUCT

- SELECT queries returns tables listing variable bindings
- CONSTRUCT queries construct a new RDF graph

Example: assign all courses to John Doe

```
PREFIX terms: <http://ulb.be/terms>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
CONSTRUCT
{
    <http://ulb.ac.be/staff/jdoe> terms:teaches ?x
}
WHERE { ?x rdf:type terms:course }
```

SPARQL: CONSTRUCT

- SELECT queries returns tables listing variable bindings
- CONSTRUCT queries construct a new RDF graph

Example: assign all courses to John Doe and give them 5 credits

```
PREFIX terms: <http://ulb.be/terms>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
CONSTRUCT
{
    <http://ulb.ac.be/staff/jdoe> terms:teaches ?x .
    ?x terms:credits "5"
}
WHERE { ?x rdf:type terms:course }
```

SPARQL: ASK

- SELECT queries returns tables listing variable bindings
- CONSTRUCT queries construct a new RDF graph
- ASK queries check whether the graph pattern occurs in the RDF graph (returns a boolean)

Example: is there some resource with both a birthdate and a name?

```
PREFIX mov: <http://movies-in-rdf.org>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
ASK
{
    ?x mov:name ?n .
    ?x mov:birthdate ?d
}
```

SPARQL: REMOTE DATA SOURCES

- The **FROM** clause states that the query should be answered on a particular dataset (argument to the FROM clause)
- The dataset is downloaded (if necessary) and then the query answer is computed.

Example: query Tim-Berners-Lee's FOAF file?

```
PREFIX dc: <http://purl.org/dc/elements/1.1>
SELECT ?title
FROM <http://dig.csail.mit.edu/2008/webdav/timbl/foaf.rdf>
WHERE {
    ?s dc:title ?title .
}
```

SPARQL: QUERYING REMOTE SPARQL SERVICES

- The `SERVICE` keyword ships (a part of) a query to a remote SPARQL endpoint, and retrieves the results.
- (New in SPARQL 1.1.)

Example: Ship a subquery to DBpedia?

```
SELECT ?p ?o
WHERE {
    SERVICE <http://dbpedia.org/sparql>
    { SELECT ?p ?o
       WHERE { <http://dbpedia.org/resource/Brussels> ?p ?o. }
    }
}
```

SPARQL: SORTING, AGGREGATING, LIMITING

- The `ORDER BY` modifier allows to sort the results (by default ascendingly, but one can specify descending also).
- The `LIMIT` *N* modifies retrieves only the first *N* results.

Example: sort results by price (ascending) and, for items with the same price, by name (descending)

```
PREFIX terms: <http://ulb.be/terms>
SELECT ?name ?price
WHERE {
    ?prod rdf:type terms:product .
    ?prod terms:name ?name .
    ?prod terms:price ?price .
}
ORDER BY ?price DESC(?name)
```

SPARQL: SORTING, AGGREGATING, LIMITING

- The `ORDER BY` modifier allows to sort the results (by default ascendingly, but one can specify descending also).
- The `LIMIT` *N* modifies retrieves only the first *N* results.

Example: retrieve the product with the highest price

```
PREFIX terms: <http://ulb.be/terms>
SELECT ?name ?price
WHERE {
    ?prod rdf:type terms:product .
    ?prod terms:name ?name .
    ?prod terms:price ?price .
}
ORDER BY ?price
LIMIT 1
```

SPARQL: SORTING, AGGREGATING, LIMITING

- SPARQL 1.1. allows aggregate operators (`MAX, MIN, AVG, ...`) in the SELECT clause to compute aggregate values.

Example: compute the average price

```
PREFIX terms: <http://ulb.be/terms>
SELECT AVG(?price) as ?avgPrice
WHERE {
    ?prod rdf:type terms:product .
    ?prod terms:name ?name .
    ?prod terms:price ?price .
}
```

REFERENCES

- P. Hitzler, M. Krötzsch, S. Rudolph. *Foundations of Semantic Web technologies*. Chapter 7 (7.1.1 – 7.1.8).
- B. Ducharme. *Learning SPARQL*.