Multi-agent and Semantic Web Systems: Querying

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Contents

This lecture will discuss two kinds of querying:

- querying with XML
- querying with SPARQL

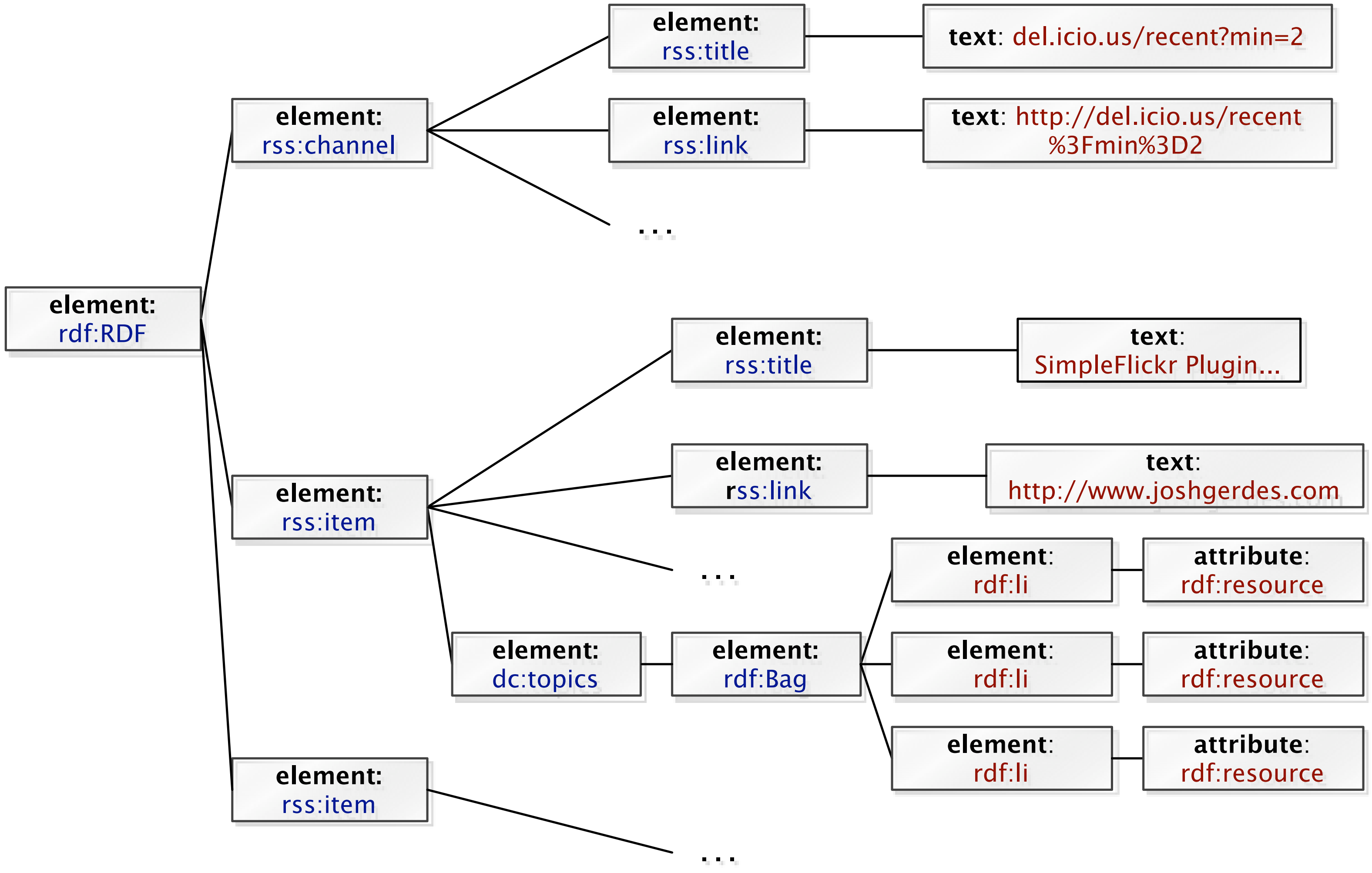
Storing RDF

- flat file — easy, but doesn't scale
- triplestore — database that is customized for storing triples
  - large triplestores measured in terms of billions
  - see http://en.wikipedia.org/wiki/Triplestore for list of current technologies
  - We have a local data repository http://data.inf.ed.ac.uk uses that 4store (http://www.4store.org/)

Querying RDF Data

- Querying is crucial to being able to use RDF data.
- Allows data across different data repositories to be combined.
- Allows selected data to be re-used and re-presented.
- Compare XML and SPARQL.

Node Tree for a del.icio.us RSS Feed



Pick a path through XML tree

A path expression:
`/rdf:RDF/rss:item/dc:topics/rdf:Bag/rdf:li`

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Reading from right to left:

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Reading from right to left:

- Select every node with tag `rdf:li`

Pick a path through XML tree

A path expression:
`/rdf:RDF/rss:item/dc:topics/rdf:Bag/rdf:li`

Reading from right to left:

- Select every node with tag `rdf:li`
- that's the direct child of an `rdf:Bag` element

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A path expression:
`/rdf:RDF/rss:item/dc:topics/rdf:Bag/rdf:li`

Reading from right to left:

- Select every node with tag `rdf:li`
- that's the direct child of an `rdf:Bag` element
- that's the direct child of a `dc:topics` element

Pick a path through XML tree

A path expression:
`/rdf:RDF/rss:item/dc:topics/rdf:Bag/rdf:li`

Reading from right to left:

- Select every node with tag `rdf:li`
- that's the direct child of an `rdf:Bag` element
- that's the direct child of a `dc:topics` element
- that's the direct child of an `rss:item` element

Pick a path through XML tree

A path expression:
`/rdf:RDF/rss:item/dc:topics/rdf:Bag/rdf:li`

Reading from right to left:

- Select every node with tag `rdf:li`
- that's the direct child of an `rdf:Bag` element
- that's the direct child of a `dc:topics` element
- that's the direct child of an `rss:item` element
- that's the direct child of the `rdf:RDF` element

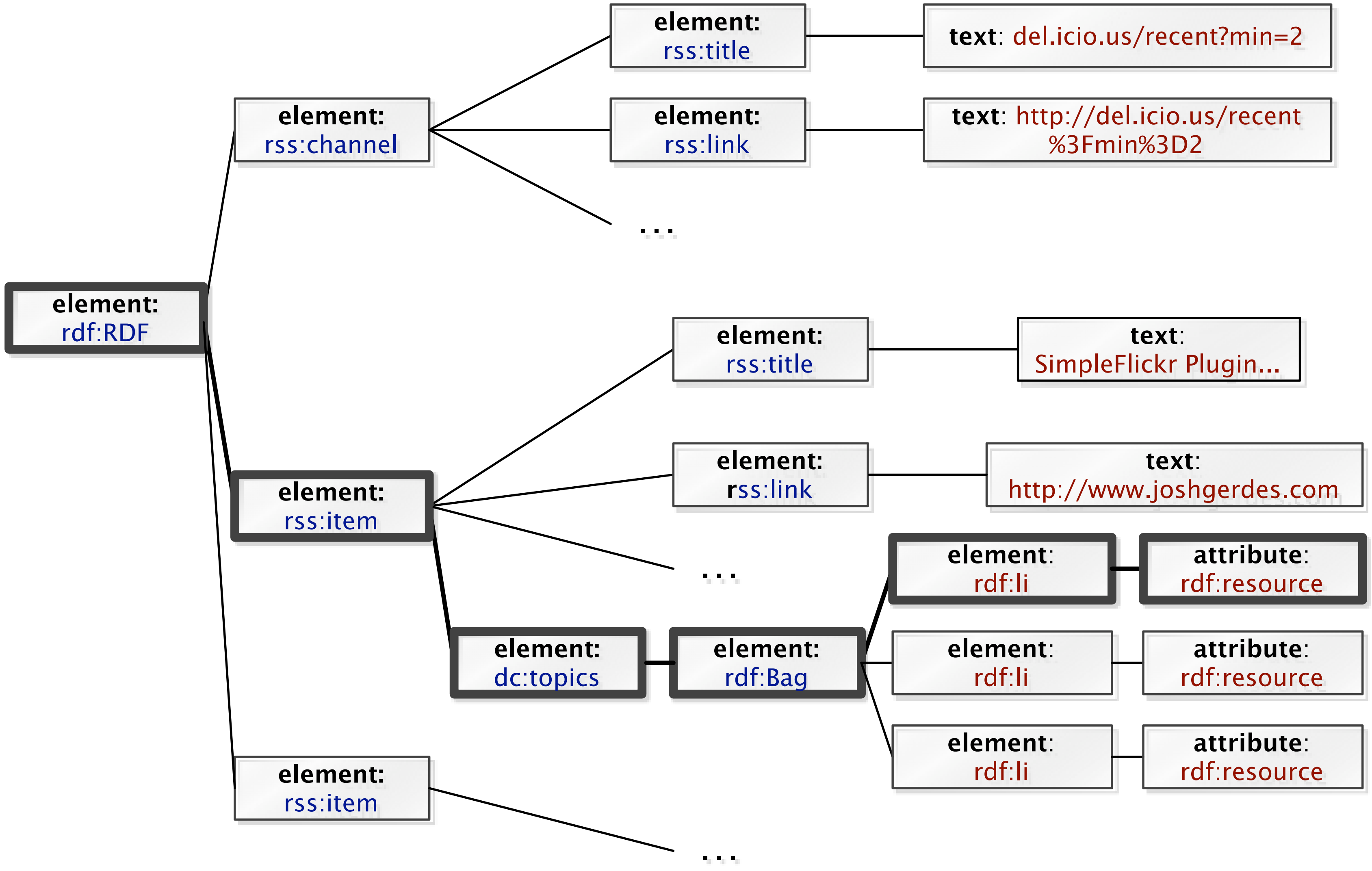
Pick a path through XML tree

A path expression:
`/rdf:RDF/rss:item/dc:topics/rdf:Bag/rdf:li`

Reading from right to left:

- Select every node with tag `rdf:li`
- that's the direct child of an `rdf:Bag` element
- that's the direct child of a `dc:topics` element
- that's the direct child of an `rss:item` element
- that's the direct child of the `rdf:RDF` element
- at the root of the document ('/').

The path through the node tree



Remarks on XML query

- Basic idea: search along paths in an XML tree.

- `XPath` provides an exact syntax for this.

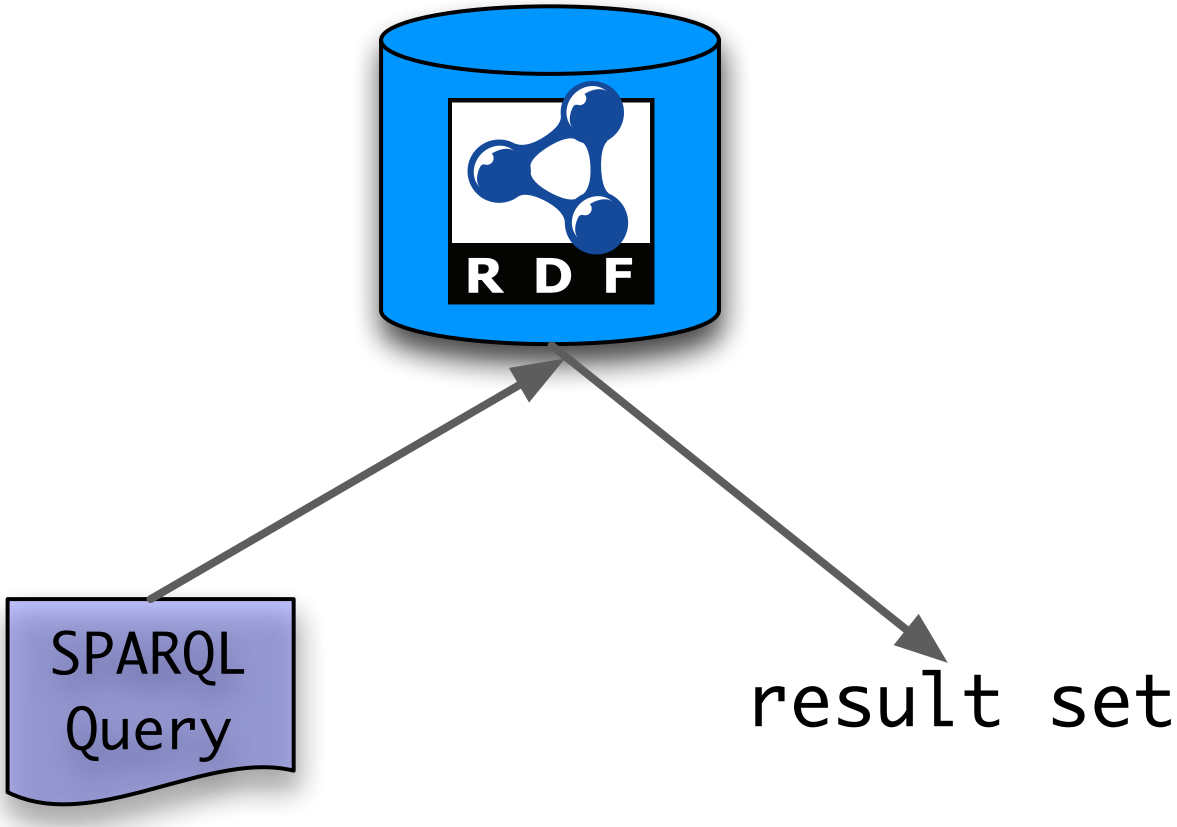
- Most modern programming languages provide rich support for XML parsing and querying.

- Requires you know how data is encoded in the XML document.

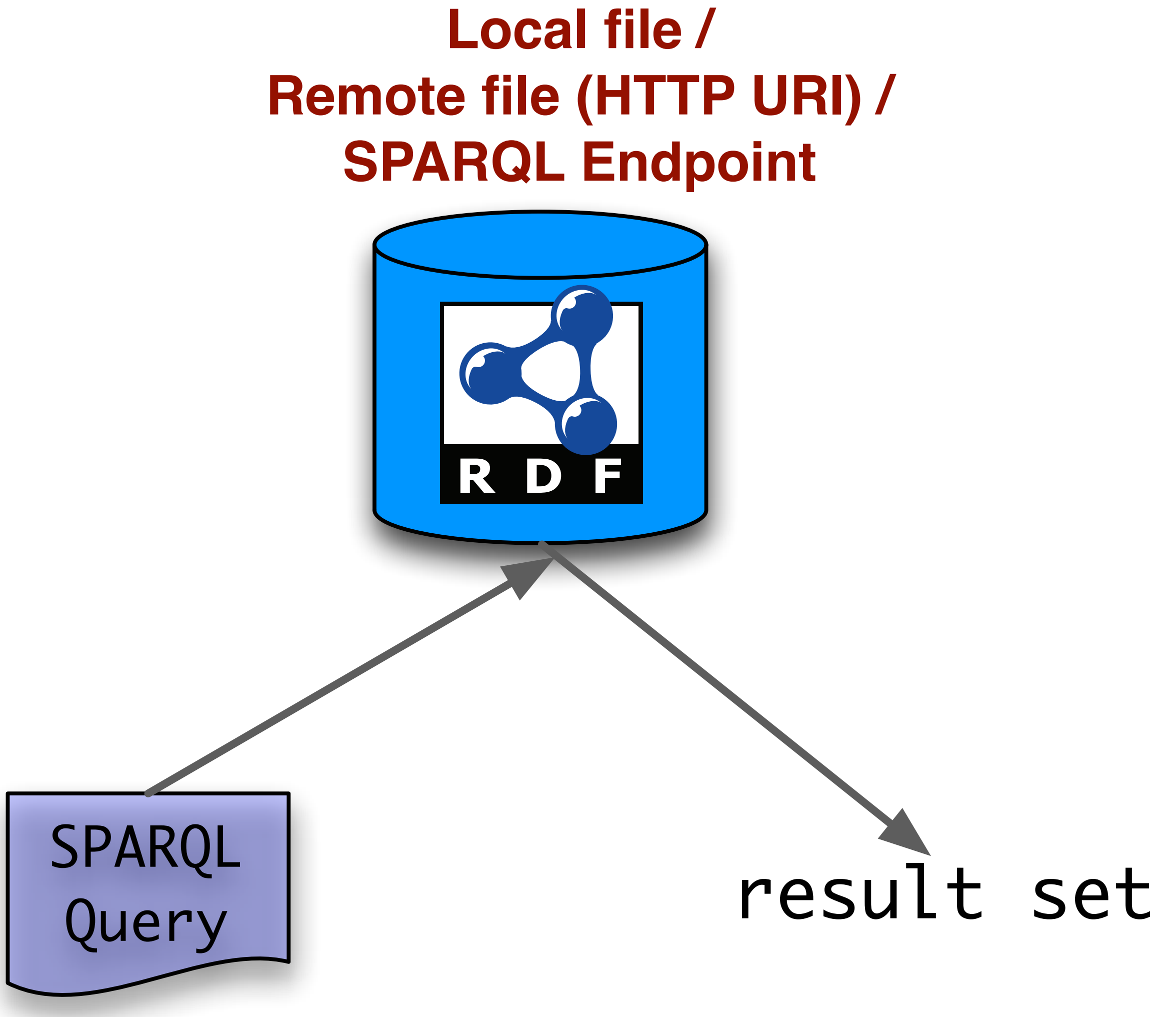
RDF Query

- Make use of the graph model, not the (XML) serialisation.
- At least half a dozen competing proposals during approx 10 year period:
  - Path-based query
  - SQL-like pattern matching
- SPARQL is now the standard approach, and is 2nd type of language.

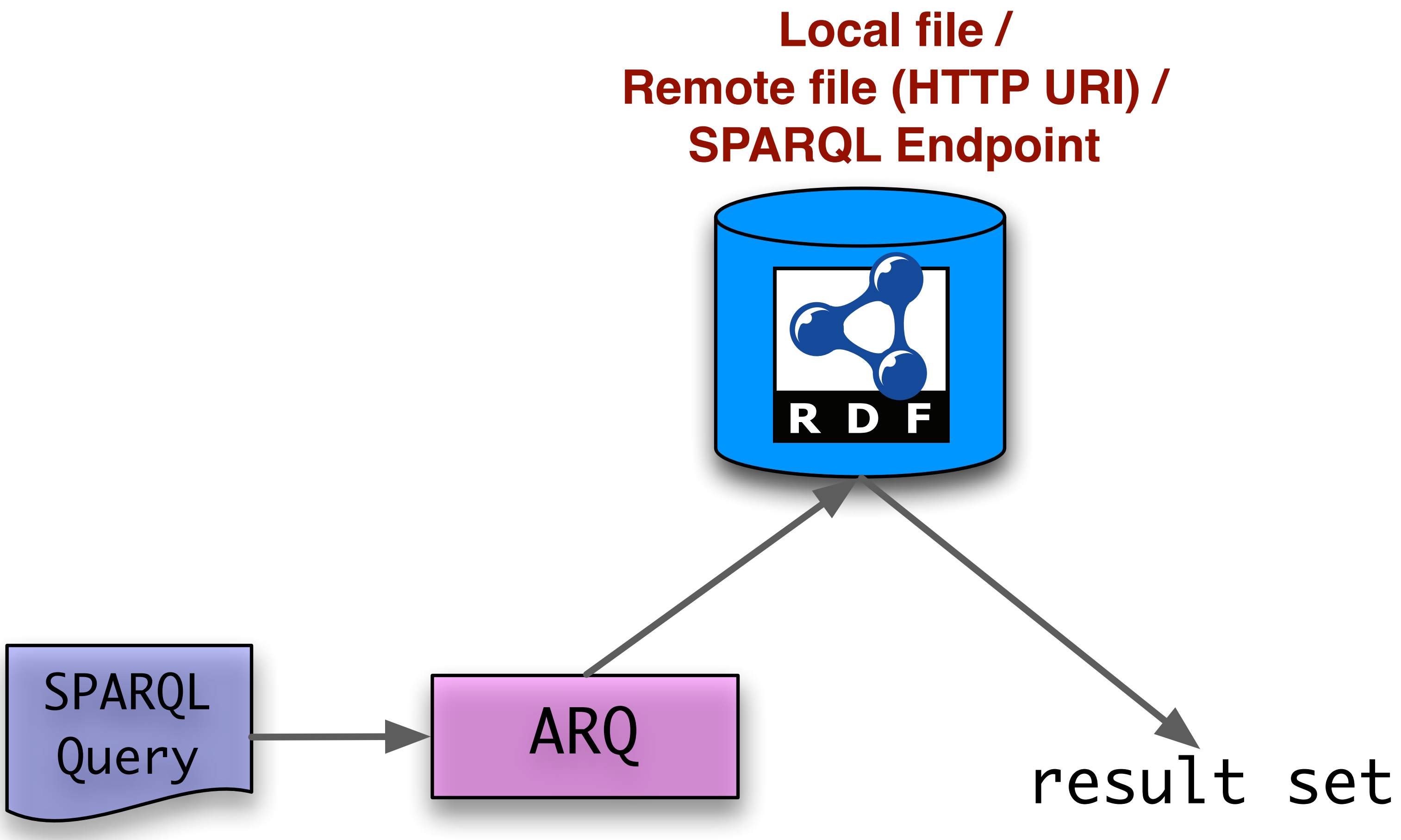
SPARQL overview



SPARQL overview



SPARQL overview



SPARQL query example

Query

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

SPARQL components

1. Basic graph pattern matching
2. Graph expressions
3. Solution modifiers

Basic graph patterns (BGPs)

- Basic graph patterns are a block of adjacent triple patterns that match, or don't match, all together.

- Every named variable must receive some value for the pattern to have been matched.

- Filters add restrictions on the values variables can take.

Graph expressions

- Graph expressions:
  - `OPTIONAL`, `UNION`, `GRAPH`, groups (things between {})
- Combine BGPs in various ways to give more complicated patterns.
- Graph expressions are recursive so you can have patterns within patterns.
- A SPARQL query has one graph expression in the `WHERE` clause.

Solution modifiers

- Solution modifiers:
  - `DISTINCT, ORDER BY, LIMIT/OFFSET`
- Apply to output of matching the query graph pattern;
- process it in various ways to yield the result set.

Patterns

- Based on triples.
- Combination of URIs/QNames, literals and variables.
- Variable names:
  - `?var, $var`
  - cannot start with an integer, or contain ‘:’, ‘-’ or ‘.’.

Small FOAF file

FOAF

```
@prefix : <#> .
@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#>.

:ehk a foaf:Person;
     foaf:mbox_sha1sum ”e9403...”;
     foaf:name ”Ewan Klein”;

     foaf:knows [ a foaf:Person;
           rdfs:seeAlso <http://www.ibiblio.org/hhalpin/foaf.rdf>;
             foaf:mbox_sha1sum ”c5e75...”;
             foaf:name ”Harry Halpin”];
```

SELECT example

Query: example-00.rq

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

Running the Query

```
arq --query=example-00.rq \
    --data=http://homepages.inf.ed.ac.uk/ewan/foaf.n3
```

- Run query against the RDF data to be found at URI.
- URI has to be addressable via HTTP when the query is executed.

Result Set

```
 -------------------
|  name             |
=====================

| ”Ewan Klein”      |

| ”Harry Halpin”    |

--------------------
```

Matching

Query matches the graph:

- find a set of *variable* ↦ *value* bindings, such that
- result of replacing variables by values is a triple in the graph.

Solution1:

variable `?x` has value blank node `_:a` and variable `?name` has value `"Ewan"`

Triple (`_:a foaf:name "Ewan"`) is in the graph.

Solution 2:

variable `?x` has value blank node `_:b` and variable `?name` has value `"Harry"`

Triple (`_:b foaf:name "Harry"`) is in the graph.

Multiple patterns

Query example-01.rq

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name1 ?name2
FROM <http://homepages.inf.ed.ac.uk/ewan/foaf.n3>
WHERE {
      ?person1 foaf:knows ?person2 .
      ?person1 foaf:name  ?name1 .
      ?person2 foaf:name  ?name2 .
      }
```

‘get name1 and name2 where person1 knows person2, and person1 has name1 and person2 had name2’

Running the Query

```
arq --query=example-01.rq
```

Result set

```
-------------------------------------
|  name1           |  name2          |
=====================================

| ”Ewan Klein”    |  ”Harry Halpin”  |

-------------------------------------
```

More on patterns

- Dots ‘.’ separate patterns in the query.
- Can use N3 abbreviatory syntax in Basic Graph Patterns

Abbreviated Version of example-01.rq

```
...
WHERE {
      [ foaf:knows [ foaf:name  ?name2] ;
        foaf:name  ?name1 ] .
      }
```

Multiple data sources

Query

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name1  ?name2
FROM <http://homepages.inf.ed.ac.uk/ewan/foaf.n3>
FROM <http://www.ibiblio.org/hhalpin/foaf.rdf>
WHERE {
      ?person1 foaf:name ?name1 ;
               foaf:knows [ foaf:name ?name2 ];
      }
```

NB: Multiples FROM clauses allowed in a query.

Multiple data sources

Results

```
--------------------------------------
| name1          | name2             |
======================================
| ”Harry Halpin” | ”Daniel Weitzner” |
| ”Harry Halpin” | ”Tim Berners-Lee” |
| ”Harry Halpin” | ”Dan Connolly”    |
| ”Harry Halpin” | ”Ian Davis”       |
| ”Harry Halpin” | ”Paolo Bouquet”   |
| ”Ewan Klein”   | ”Harry Halpin”    |
--------------------------------------
```

Multiple data sources

Query

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name1  ?name2
WHERE {
      ?person1 foaf:name ?name1 ;
               foaf:knows [ foaf:name ?name2 ];
      }
```

Running the Query

```
arq --query=example-00.rq \
    --data=http://homepages.inf.ed.ac.uk/ewan/foaf.n3 \
    --data=http://www.ibiblio.org/hhalpin/foaf.rdf
```

- Create models from the data sets;
- merge the models;
- run query against model.

SPARQL query forms

SELECT: Like SQL; returns a tuple of values.

CONSTRUCT: Builds a new graph by inserting values into a triple pattern.

ASK: Asks whether a query has a solution in a graph.

Conclusions

- XML-based query depends on paths through the node tree.

- SPARQL matches triple patterns in the RDF graph.

- XML-based query depends on knowing the syntactic structure of the serialisation.
  - There are different but equivalent serialisations of RDF in XML;
  - these would require different XML queries.

- SPARQL query depends on knowing the graph structure of the RDF store.
  - There are different but equivalent serialisations of RDF (in XML, N3, ...);
  - these can all be matched using the same SPARQL query.

Task

- Using your rdf dataset, think up some SPAQRL queries which could be run on it. What would the outcome be?