Axel Polleres (Siemens AG) &
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Querying and Exchanging XML and RDF on the Web

WWW'2012 Tutorial

http://polleres.net/WWW2012Tutorial/

This tutorial presents partially joint work with: Nuno Lopes (DERI), Stefan Bischof (Siemens AG)…
… and of course the whole W3C SPARQL WG

XML & RDF: one Web – two formats

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XSLT/XQuery

RSS

This Tutorial

SPARQL

<XML/>

SOAP/WSDL

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A Sample Scenario…

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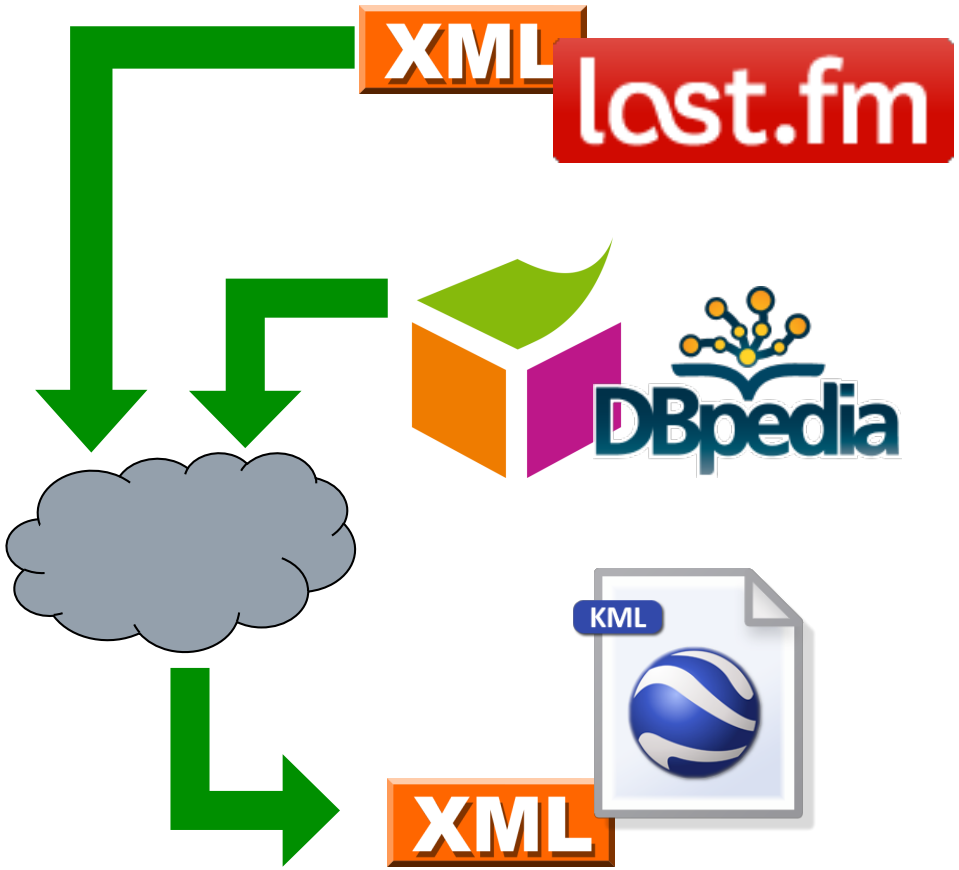
Example: Favourite artists location

Display information about your favourite artists on a map



Last.fm knows what music you listen to, your most played artists, etc.

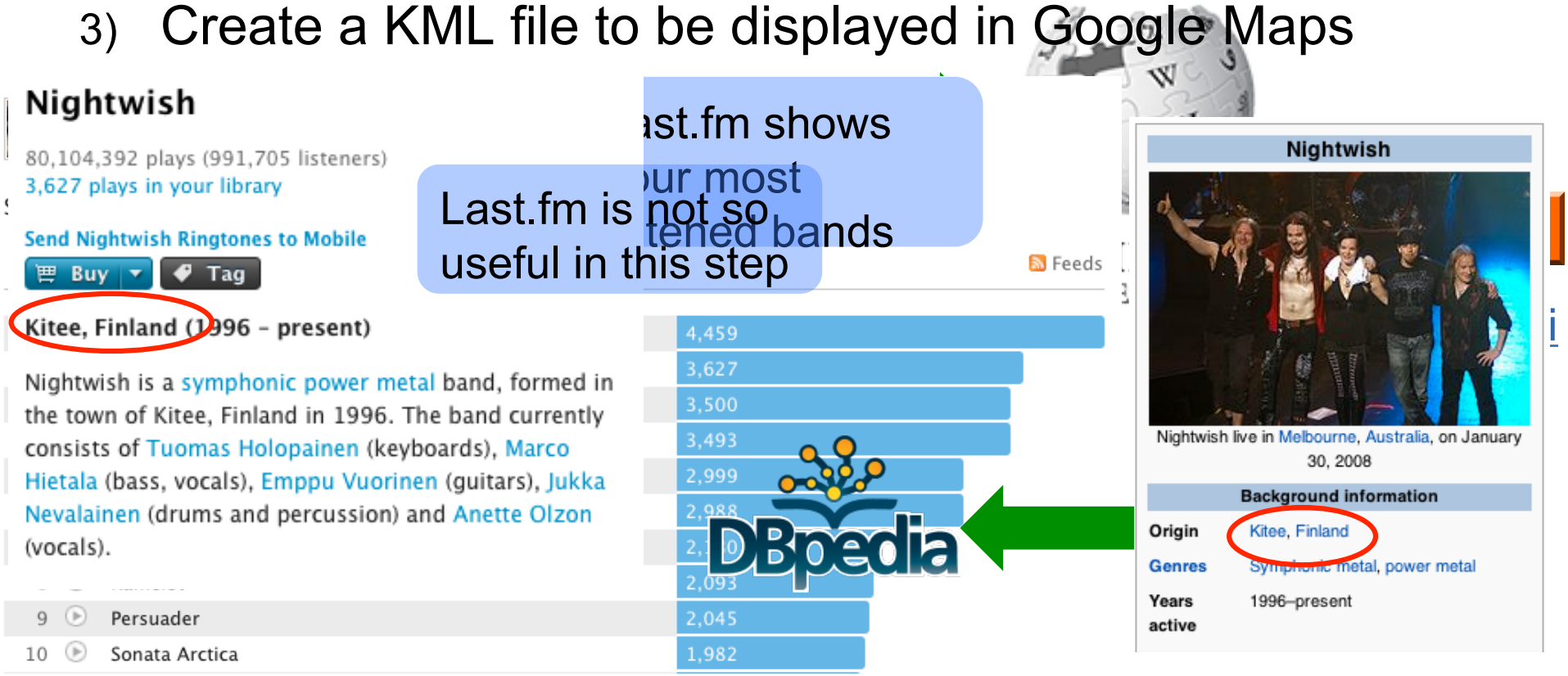
Using RDF allows to combine Last.fm info with other information on the web, e.g. location.

Show your top bands hometown in Google Maps.

Example: Favourite artists location

How to implement the visualisation?

1) Get your favourite bands
2) Get the hometown of the bands
3) Create a KML file to be displayed in Google Maps



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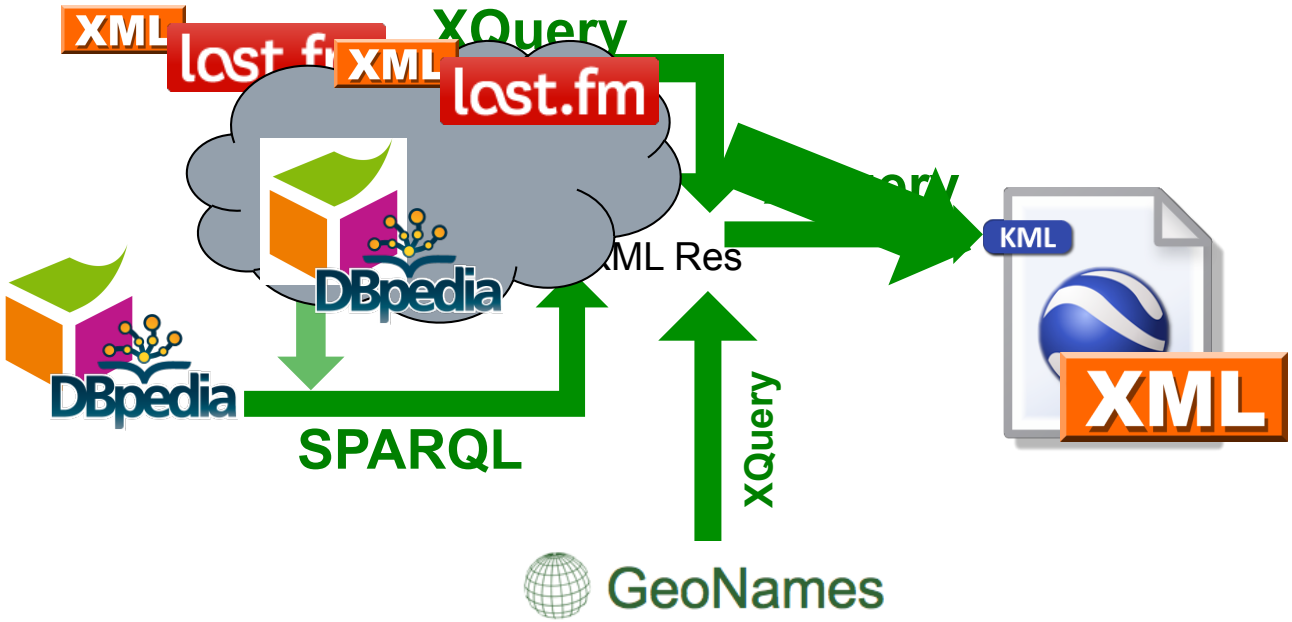
Example: Favourite artists location

How to implement the visualisation?

1) Get your favourite bands
2) Get the hometown of the bands
3) Create a KML file to be displayed in Google Maps



Transformation and Query Languages

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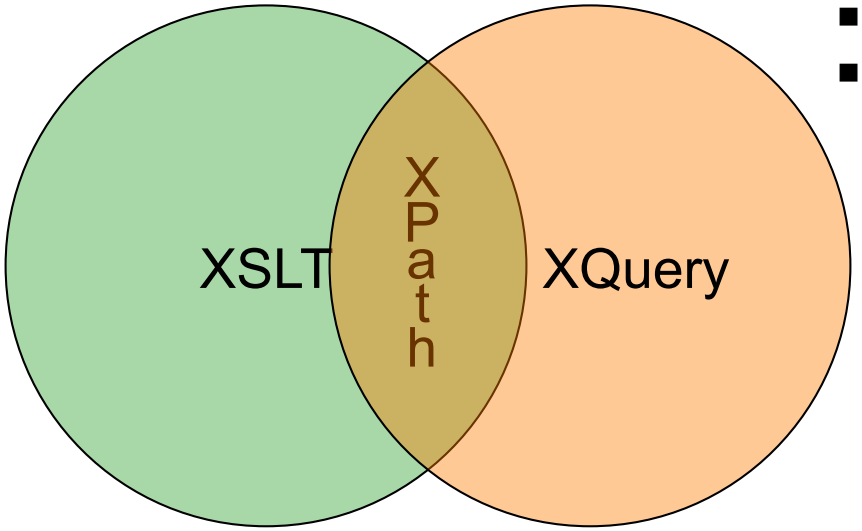
XML Transformation Language
Syntax: XML



- XPath is the common core
- Mostly used to select nodes from an XML doc

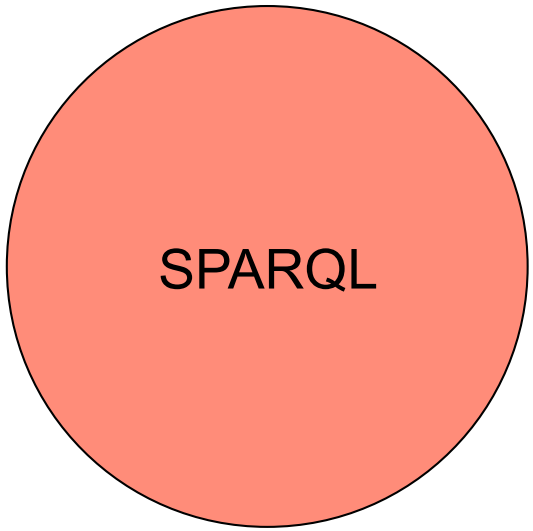
XML world / RDF world

- XML Query Language
- non-XML syntax

RDF/XML… ambiguous

- Query Language for RDF
- Pattern based
- declarative

SPARQL XML Result format



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Tutorial Overview

Session 1

XQuery Overview – Sherif
SPARQL Overview – Axel
XSPARQL: a combined language – Axel

Session 2

XQuery implementations – Sherif
SPARQL implementations – Sherif
XSPARQL implementations – Axel
(optional) Compression formats for XML+RDF: EXI+HDT – Sherif

Q/A - Discussion

Switch to other slideset for details on XQuery

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XQuery: Back to our Sample Scenario…

Querying XML Data from Last.fm 1/2

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```
<lfm status="ok">
  <topartists type="overall">
    <artist rank="1">
      <name>Therion</name>
      <playcount>4459</playcount>
      <url>http://www.last.fm/music/Therion</url>
    </artist>
    <artist rank="2">
      <name>Nightwish</name>
      <playcount>3627</playcount>
      <url>http://www.last.fm/music/Nightwish</url>
    </artist>
  </topartists>
</lfm>
```

Last.fm API format:

- root element: “lfm”, then “topartists”
- sequence of “artist”

Querying this document with XPath:

XPath steps: `/lfm` Selects the “lfm” root element

`//artist` Selects all the “artist” elements

XPath Predicates `//artist[@rank = 1]` Selects the “artist” with rank 1

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Querying XML Data from Last.fm 2/2

- iterate over sequences
- assign values to variables
- filter expressions
- create XML elements

Prolog:	P	`declare namespace` *prefix="namespace-URI"*
Body:	F	`for` *var* `in` *XPath-expression*
	L	`let` *var* `:=` *XPath-expression*
	W	`where` *XPath-expression*
	O	`order by` *XPath-expression*
Head:	R	`return` *XML + nested XQuery*

Query:

Retrieve information regarding a users' 2nd top artists from the

Last.fm API

```
let $doc := "http://ws.audioscrobbler.com/2.0/user.gettopartist"
for $artist in doc($doc)//artist
where $artist[@rank = 2]
return <artistData>{$artist}</artistData>
```

Result for user “jacktrades”

```
<artistData>
   <artist rank="2">
      <name>Nightwish</name>
            <playcount>3850</playcount>
            <mbid>00a9f935-ba93-4fc8-a33a-993abe9c936b</mbid>
                  <url>http://www.last.fm/music/Nightwish</url>
      <streamable>1</streamable>
            <image size="small">http://userserve-ak.last.fm/serve/34/149929.jpg</image>
        <image size="medium">http://userserve-ak.last.fm/serve/64/149929.jpg</image>
        <image size="large">http://userserve-ak.last.fm/serve/126/149929.jpg</image>
        <image size="extralarge">http://userserve-ak.last.fm/serve/252/149929.jpg</image>
        <image size="mega">http://userserve-ak.last.fm/serve/500/149929/Nightwish.jpg</image>
    </artist>
</artistData>
```

Query:

Retrieve information regarding a users' 2nd top artists from the

Last.fm API

```
let $doc := "http://ws.audioscrobbler.com/2.0/user.gettopartist"
for $artist in doc($doc)//artist
where $artist[@rank = 2]
return <artistData>{$artist}</artistData>
```

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Q/A - Discussion

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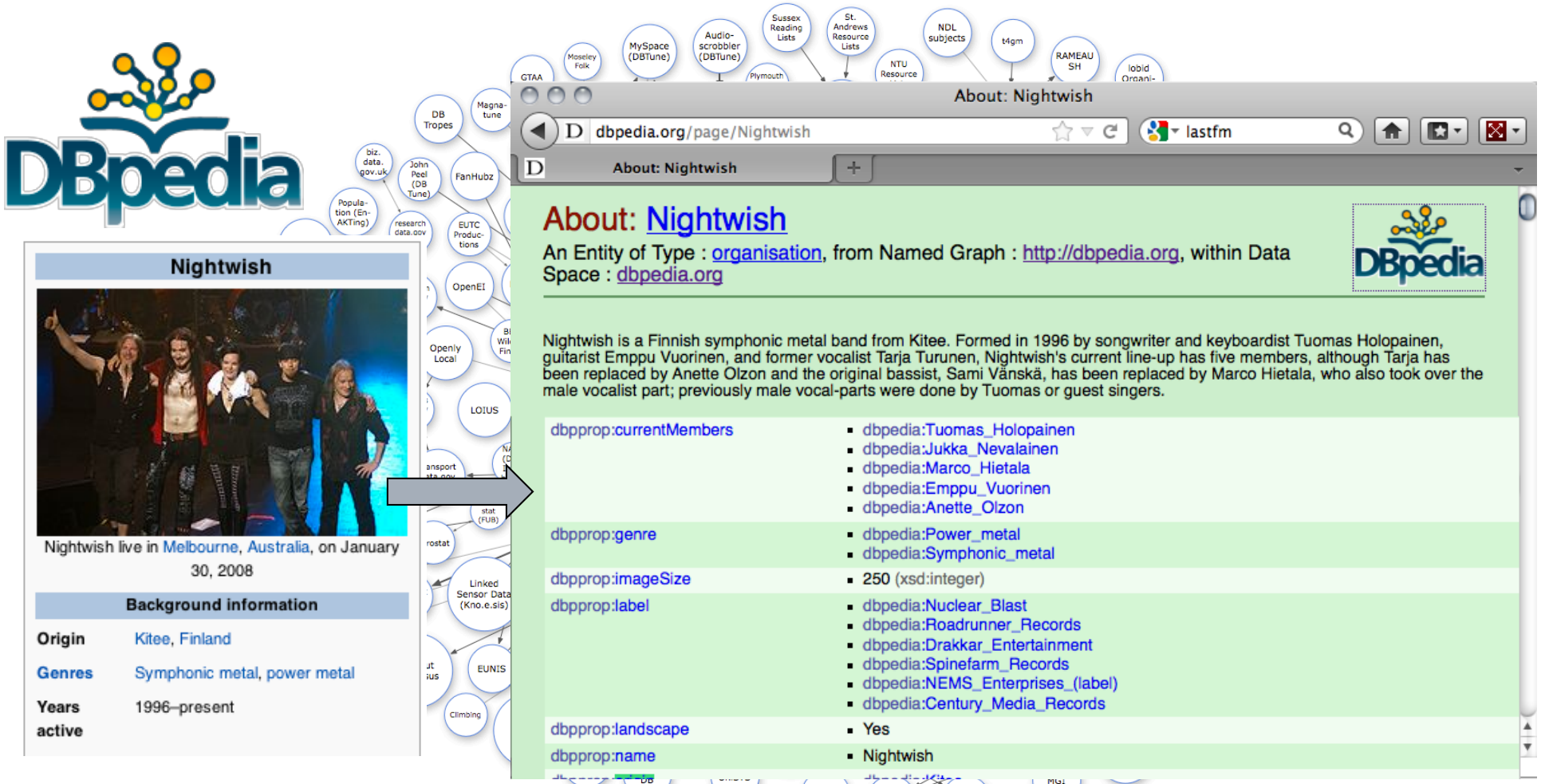
Now what about RDF Data?

Lots of RDF Data out there, ready to “query the Web”



Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. http://lod-cloud.net/ as of September 2010

XML vs. RDF

XML: *"treelike" semi-structured Data (mostly schema-less, but "implicit" schema by tree structure… not easy to combine, e.g. how to combine lastfm data with wikipedia data?*

```
<table>
   <tr>
      <th colspan="2">Background information</th>
   </tr>
   <tr>
      <th>Origin</th>
      <td>
         <a title="Kitee" href="/wiki/Kitee">Kitee</a>, <a title="Finland" href="/wiki/Finland">Finland</a>
      </td>
   </tr>
   <tr>
      <th>
         <a title="Music genre" href="/wiki/Music_genre">Genres</a>
      </th>
      <td>
         <a title="Symphonic metal" href="/wiki/Symphonic_metal">Symphonic metal</a>, <a title="Gothic metal" href="/wiki
/Gothic_metal">gothic metal</a>
      </td>
   </tr>
   <tr>
      <th>Years active</th>
      <td>1996-present</td>
   </tr>
</table>
```

```
<artistData>
   <artist rank="2">
      <name>Nightwish</name>
            <playcount>3850</playcount>
            <mbid>00a9f935-ba93-4fc8-a33a-993abe9c936b</mbid>
                  <url>http://www.last.fm/music/Nightwish</url>
      <streamable>1</streamable>
            <image size="small">http://userserve-ak.last.fm/serve/34/149929.jpg</image>
        <image size="medium">http://userserve-ak.last.fm/serve/64/149929.jpg</image>
        <image size="large">http://userserve-ak.last.fm/serve/126/149929.jpg</image>
        <image size="extralarge">http://userserve-ak.last.fm/serve/252/149929.jpg</image>
        <image size="mega">http://userserve-ak.last.fm/serve/500/149929/Nightwish.jpg</image>
    </artist>
</artistData>
```

RDF Simple, declarative, graph-style format based on dereferenceable URIs (= Linked Data)

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Subject Predicate Object

Subject U x B

Predicate U

Object U x B x L

URIs, e.g.
`http://www.w3.org/2000/01/rdf-schema#label`
`http://dbpedia.org/ontology/origin`
`http://dbpedia.org/resource/Nightwish`
`http://dbpedia.org/resource/Kitee`

Blanknodes:
"existential variables in the data" to express incomplete information, written as _:x or []

Literals, e.g.
`"Jacktrades"`
`"Kitee"@en`
`"Китеэ"@ru`

RDF Simple, declarative, graph-style format based on dereferenceable URIs (= Linked Data)

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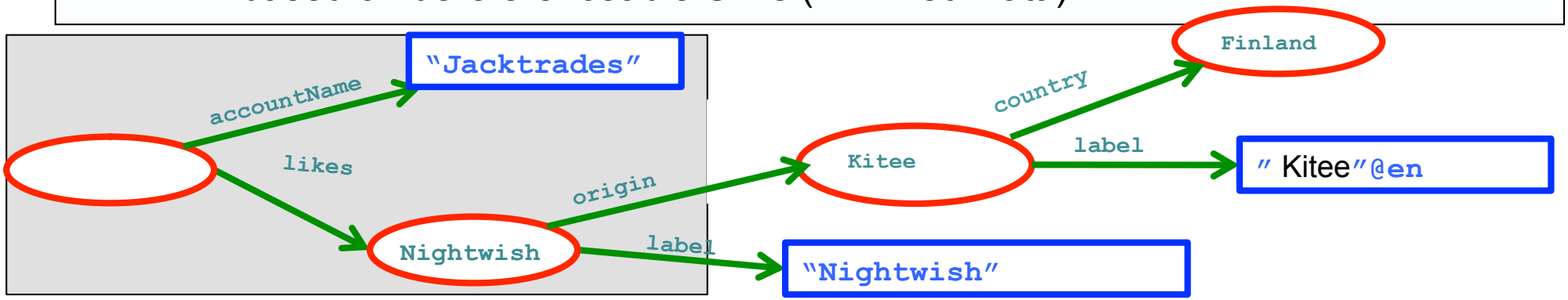

Various syntaxes, RDF/XML, Turtle, N3, RDFa,...

```
<http://dbpedia.org/resource/Nightwish> <http://dbpedia.org/property/origin>
                                <http://dbpedia.org/resource/Kitee> .
<http://dbpedia.org/resource/Nightwish> <http://www.w3.org/2000/01/rdf-schema#label>
                               "Kitee"@es .
```

```
_:x <http://xmlns.com/foaf/0.1/accountName> "Jacktrades" .
_:x <http://graph.facebook.com/likes> <http://dbpedia.org/resource/Nightwish> .
```

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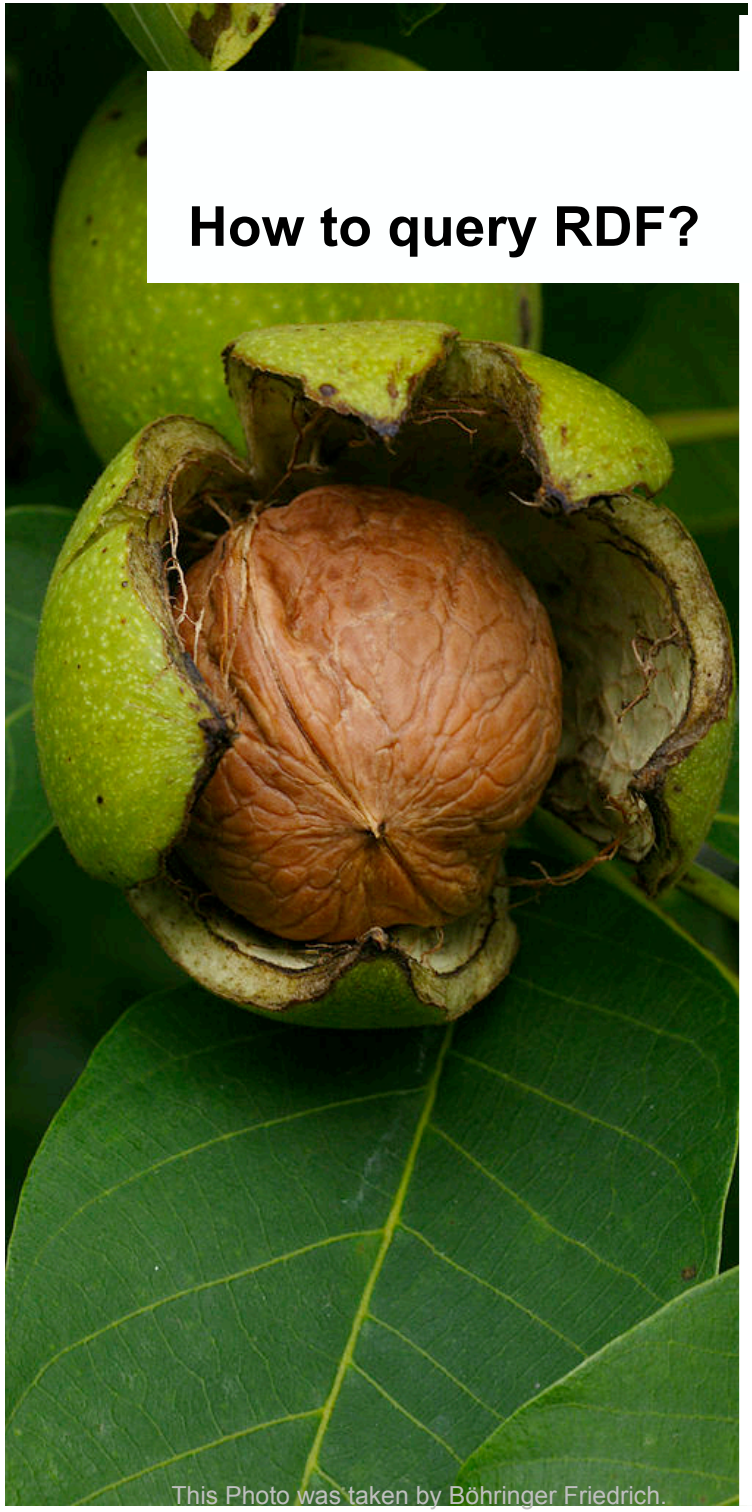

This Photo was taken by Böhringer Friedrich.

SPARQL in a Nutshell...

SPARQL + Linked Data give you Semantic search almost “for free”

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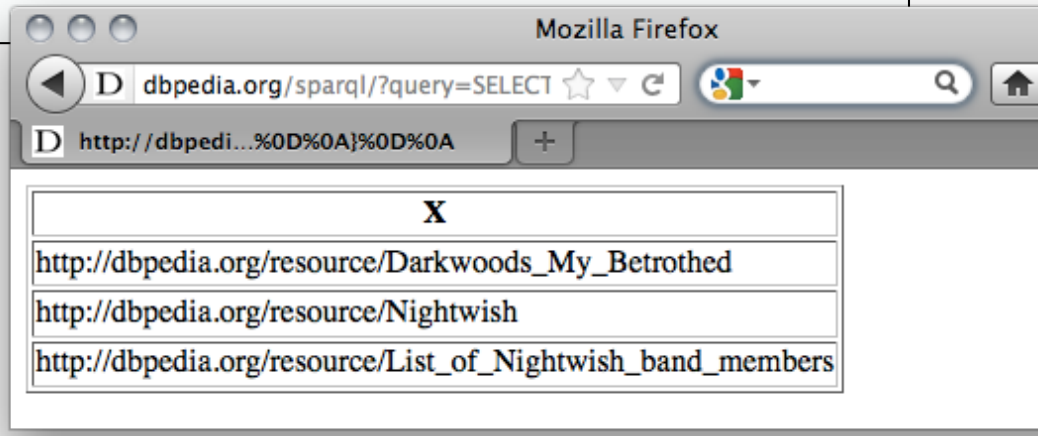
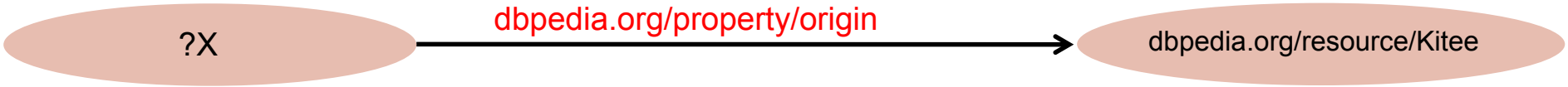
Which bands origin from Kitee?




```
SELECT ?X
WHERE
{
 ?X  <http://dbpedia.org/property/origin> <http://dbpedia.org/resource/Kitee>
}
```



Try it out at http://dbpedia.org/snorql/

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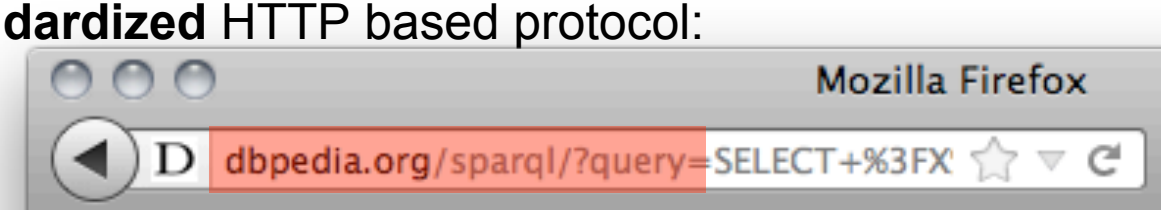
SPARQL – Standard RDF Query Language and Protocol

SPARQL (2008):

```
SELECT ?X
WHERE
{
 ?X  <http://dbpedia.org/property/origin> <http://dbpedia.org/resource/Kitee>
}
```

- SQL “Look-and-feel” for the Web
- Essentially “graph matching” by *triple patterns*
- Allows conjunction (.) , disjunction (UNION), optional (OPTIONAL) patterns and filters (FILTER)
- Construct new RDF from existing RDF
- Solution modifiers (DISTINCT, ORDER BY, LIMIT, …)
- A **standardized** HTTP based protocol:



Conjunction (.) , disjunction (UNION), optional (OPTIONAL) patterns and filters (FILTER)

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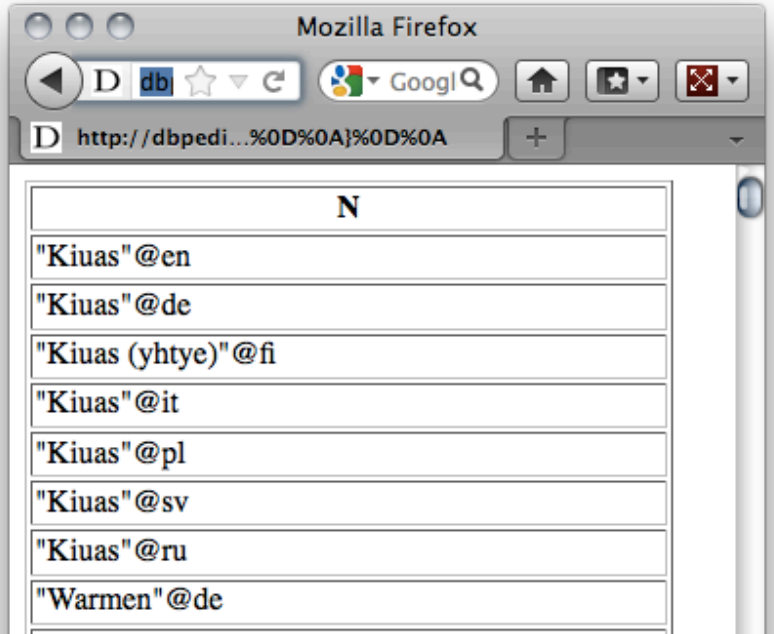
***Names** of **bands** from **cities in Finland**?*

```
PREFIX : <http://dbpedia.org/resource/>
PREFIX dbprop: <http://dbpedia.org/property/>
PREFIX dbont: <http://dbpedia.org/ontology/>
PREFIX category: <http://dbpedia.org/resource/Category:>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?N
WHERE
{
 ?X a dbont:Band ; rdfs:label ?N ;
    dbprop:origin [ dcterms:subject category:Cities_and_towns_in_Finland] .
}
```

- *Shortcuts for namespace prefixes and to group triple patterns*

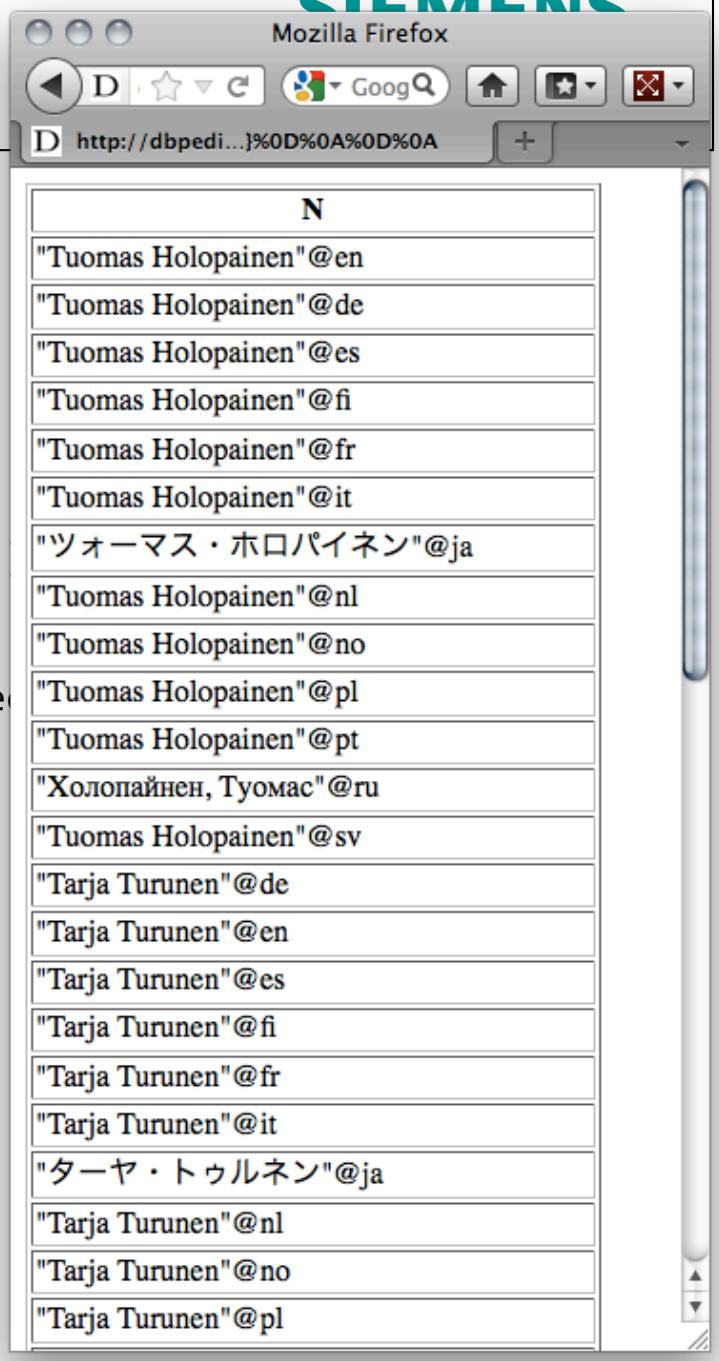


Conjunction (.) , **disjunction (UNION)**, optional (OPTIONAL) patterns and filters (FILTER)

*Names of things **that origin or were born in** Kitee?*

```
SELECT ?N
WHERE
{
 { ?X  dbprop:origin <http://dbpedia.org/resource/Kitee>
 UNION
 { ?X  dbont:birthPlace <http://dbpedia.org/resource/Kite

?X rdfs:label ?N
}
```



N
"Tuomas Holopainen"@en
"Tuomas Holopainen"@de
"Tuomas Holopainen"@es
"Tuomas Holopainen"@fi
"Tuomas Holopainen"@fr
"Tuomas Holopainen"@it
"ツォーマス・ホロパイネン"@ja
"Tuomas Holopainen"@nl
"Tuomas Holopainen"@no
"Tuomas Holopainen"@pl
"Tuomas Holopainen"@pt
"Холопайнен, Туомас"@ru
"Tuomas Holopainen"@sv
"Tarja Turunen"@de
"Tarja Turunen"@en
"Tarja Turunen"@es
"Tarja Turunen"@fi
"Tarja Turunen"@fr
"Tarja Turunen"@it
"ターヤ・トゥルネン"@ja
"Tarja Turunen"@nl
"Tarja Turunen"@no
"Tarja Turunen"@pl

Conjunction (.) , disjunction (UNION), optional (OPTIONAL) patterns and **filters (FILTER)**

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Cites Finland with a

```
SELECT ?C ?N
WHERE
{
 ?C  dcterms:subject category:Cities_and_towns_in_Finland ;
     rdfs:label ?N .
 FILTER( LANG(?N) = "de" )

}
```

SPARQL has lots of FILTER functions to filter text with regular expressions (REGEX), filter numerics (<,>,=,+,-…), dates, etc.)

Conjunction (.) , disjunction (UNION), **optional (OPTIONAL)** patterns and filters (FILTER)

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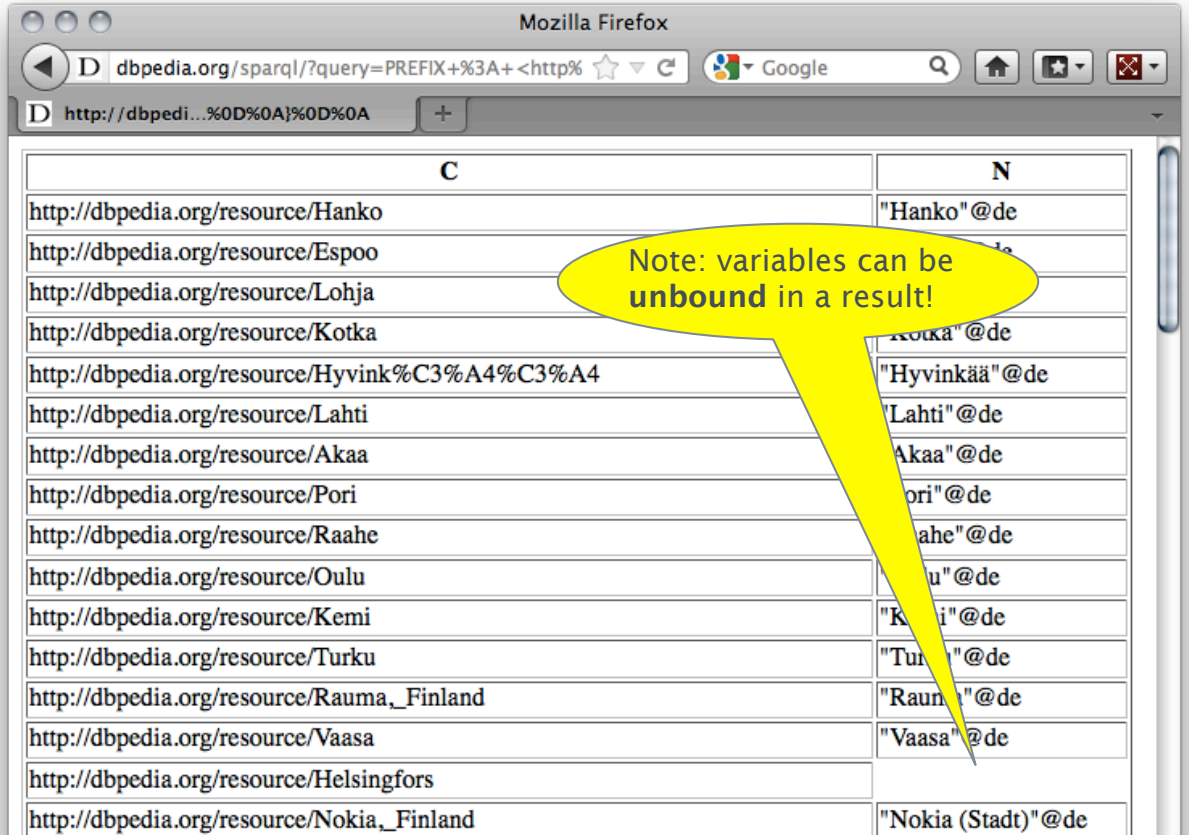
Cites Finland with optionally their German (@de) name

```
SELECT ?C ?N
WHERE
{
 ?C  dcterms:subject category:Cities_and_towns_in_Finland .
 OPTIONAL { ?C rdfs:label ?N . FILTER( LANG(?N) = "de" ) }
}
```



C	N
http://dbpedia.org/resource/Hanko	"Hanko"@de
http://dbpedia.org/resource/Espoo	
http://dbpedia.org/resource/Lohja	
http://dbpedia.org/resource/Kotka	"@de
http://dbpedia.org/resource/Hyvink%C3%A4%C3%A4	"Hyvinkää"@de
http://dbpedia.org/resource/Lahti	"Lahti"@de
http://dbpedia.org/resource/Akaa	"@de
http://dbpedia.org/resource/Pori	"@de
http://dbpedia.org/resource/Raahe	"@de
http://dbpedia.org/resource/Oulu	"@de
http://dbpedia.org/resource/Kemi	"@de
http://dbpedia.org/resource/Turku	"@de
http://dbpedia.org/resource/Rauma,_Finland	"@de
http://dbpedia.org/resource/Vaasa	"@de
http://dbpedia.org/resource/Helsingfors	
http://dbpedia.org/resource/Nokia,_Finland	"Nokia (Stadt)"@de

BTW, why does “Helsingfors” not have a German label?

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Helsingfors is the Swedisch name of of Helsinki, and only exists in dbpedia as a redirect to Helsinki:

property	hasValue	isValueOf
owl:sameAs	-	<http://www4.wiwiss.fu-berlin.de/flickrwrappr/photos/Helsingfors>
dbpedia:ontology/deathPlace	-	:Ossian_Schauman
dbpedia:ontology/birthPlace	-	:Lydia_Chukovskaya
dbpedia:ontology/birthPlace	-	:Olav_Ri%C3%A9go
foaf:primaryTopic	-	<http://en.wikipedia.org/wiki/Helsingfors>
rdfs:label	"Helsingfors"@en	-
dbpedia:ontology/wikiPageRedirects	:Helsinki	-
<http://purl.org/dc/terms/subject>	:Category:Cities_and_towns_in_Finland	-
foaf:page	<http://en.wikipedia.org/wiki/Helsingfors>	-

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OPTIONAL can be “stacked” to model preferences:

Cites Finland with optionally (if they have one) their German (@de) name … and otherwise try to find whether there is a redirect to a resource with a German name

```
SELECT ?C ?N
WHERE
{
 ?C  dcterms:subject category:Cities_and_towns_in_Finland .
 OPTIONAL { ?C rdfs:label ?N . FILTER( LANG(?N) = "de" ) }
 OPTIONAL { ?C dbont:wikiPageRedirects  [rdfs:label ?N] . FILTER( LANG(?N) = ”de" ) }
}
```

Unfortunately doesn’t work as intended on DBpedia SPARQL endpoint, cf.

https://twitter.com/#!/AxelPolleres/status/189257251154960384

Missing features in SPARQL1.0 (and why SPARQL1.1 was needed)

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Based on implementation experience, in 2009 new W3C SPARQL WG founded to address common feature requirements requested urgently by the community: ***http://www.w3.org/2009/sparql/wiki/Main_Page***

1. **Negation**
2. **Assignment/Project Expressions**
3. **Aggregate functions (SUM, AVG, MIN, MAX, COUNT, …)**
4. **Subqueries**
5. **Property paths**

6. **Updates**
7. **Entailment Regimes**

- Other issues for wider usability:
  - Result formats (JSON, CSV, TSV),
  - Graph Store Protocol (REST operations on graph stores)

  - ***Goal: SPARQL 1.1 W3C Recommendation this summer***

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1. Negation: MINUS and NOT EXISTS

Select Persons without a homepage:

```
SELECT ?X
WHERE{ ?X rdf:type foaf:Person
       OPTIONAL { ?X foaf:homepage ?H }
       FILTER( !bound( ?H ) ) }
```

***Negation as failure** in SPARQL1.0 is "ugly":*
***SPARQL1.1** has two alternatives to do the same*

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1. Negation: MINUS and NOT EXISTS

Select Persons without a homepage:

```
SELECT ?X
WHERE{ ?X rdf:type foaf:Person
         FILTER ( NOT EXISTS { ?X foaf:homepage ?H } ) }
```

***Negation as failure** in SPARQL1.0 is "ugly":*
***SPARQL1.1** has two alternatives to do the same*

- *NOT EXISTS in FILTERs*
  - *detect non-existence*

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1. Negation: MINUS and NOT EXISTS

Select Persons without a homepage:

```
SELECT ?X
WHERE{ ?X rdf:type foaf:Person
       MINUS { ?X foaf:homepage ?H } ) }
```

***Negation as failure** in SPARQL1.0 is "ugly":*
***SPARQL1.1** has two alternatives to do the same*

- *NOT EXISTS in FILTERs*
  - *detect non-existence*
- *(P1 MINUS P2) as a new binary operator*
  - *"Remove rows with matching bindings"*
  - *only effective when P1 and P2 share variables*

2. Assignment/Project Expressions

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Assignments, Creating new values… not possible in SPARQL1.0:

```
PREFIX ex: <http://example.org/>
SELECT ?Item ?NewP
WHERE { ?Item ex:price ?Pr FILTER (?NewP = ?Pr * 1.1) }
```

Data:

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

ex:lemonade1      ex:price 3 .
ex:beer1          ex:price 3 .
ex:wine1          ex:price 3.50 .
```

Results:

?Item	?NewP

2. Assignment/Project Expressions

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Assignments, Creating new values… now available in SPARQL1.1

```
PREFIX ex: <http://example.org/>
SELECT ?Item (?Pr * 1.1 AS ?NewP )
WHERE { ?Item ex:price ?Pr }
```

Data:

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

ex:lemonade1      ex:price 3 .
ex:beer1          ex:price 3 .
ex:wine1          ex:price 3.50 .
```

Results:

?Item	?NewP
lemonade1	3.3
beer1	3.3
wine1	3.85

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3. Aggregates

"Count items per categories"

```
PREFIX ex: <http://example.org/>
SELECT ?T (Count(?Item) AS ?C)
WHERE { ?Item rdf:type ?T }
GROUP BY ?T
```

Data:

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

ex:lemonade1    ex:price 3 ;
                rdf:type ex:Softdrink.
ex:beer1        ex:price 3;
                rdf:type ex:Beer.
ex:wine1        ex:price 3.50 ;
                rdf:type ex:Wine.
ex:wine2        ex:price 4 .
                rdf:type ex:Wine.
ex:wine3        ex:price "n/a";
                rdf:type ex:Wine.
```

Results:

?T	?C
Softdrink	1
Beer	1
Wine	3

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4. Subqueries

- How to create new triples that concatenate first name and last name?
- Possible with SELECT sub-queries or BIND

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX fn: <http://www.w3.org/2005/xpath-functions#>

CONSTRUCT{ ?P foaf:name ?FullName }
WHERE {
  SELECT ?P ( fn:concat(?F, " ", ?L) AS ?FullName )
  WHERE { ?P foaf:firstName ?F ; foaf:lastName ?L. }
}
```

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4. Subqueries

- How to create new triples that concatenate first name and last name?
- Possible with SELECT sub-queries or BIND

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX fn: <http://www.w3.org/2005/xpath-functions#>

CONSTRUCT{ ?P foaf:name ?FullName }
WHERE {
  ?P foaf:firstName ?F ; foaf:lastName ?L.
  BIND ( fn:concat(?F, " ", ?L) AS ?FullName )
}
```

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5. Property Path expressions

Arbitrary Length paths, Concatenate property paths, etc.
E.g. names of people Tim Berners-Lee transitively co-authored papers with…

```
SELECT DISTINCT ?N
 WHERE {<http://dblp…/Tim_Berners-Lee>
        (^foaf:maker/foaf:maker)+/foaf:name ?N
       }
```

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Path expressions full list of operators

- elt … Path Element

Syntax Form	Matches
uri	A URI or a prefixed name. A path of length one.
^elt	Inverse path (object to subject).
!uri or *!(uri$_1$/ ...|uri$_n$)*	Negated property set. A URI which is not one of *uri$_i$*
!^uri and *!(uri$_1$/ ...|uri$_j$|^uri$_{j+1}$/ ...|^uri$_n$)*	Negated property set. A URI which is not one of *uri$_i$*, nor uri$_{j+1}$...^uri$_n$ as reverse paths
(elt)	A group path *elt*, brackets control precedence.
elt1 / elt2	A sequence path of *elt1*, followed by *elt2*
elt1 | elt2	A alternative path of *elt1*, or *elt2* (all possibilities are tried).
*elt**	A path of zero or more occurrences of *elt*.
elt+	A path of one or more occurrences of *elt*.
elt?	A path of zero or one *elt*.

- Recent discussion about semantics (counting vs. non-counting) see also [Arenas, Conca, Pérez, WWW2012 *(research track)*] and [Losemann, Martens, PODS2012, forthcoming]

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6. Updates

SQL has not only a query language, but also a Data manipulation language.
→SPARQL Update to fill this gap:

```
PREFIX ex: <http://example.org/>
DELETE { ?Item ex:price ?Pr }
INSERT { ?Item ex:price ?NewPr }
WHERE { ?Item ex:price ?Pr
        BIND (?Pr * 1.1 AS ?NewPr ) }
```

→ Allows to change/update an RDF Store from outside, again via standard HTTP protocol.

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Implementations of SPARQL 1.1:

Some current (partial) SPARQL1.1 implementations:

ARQ

- http://sourceforge.net/projects/jena/
- http://sparql.org/sparql.html

OpenAnzo

- http://www.openanzo.org/

Perl RDF

- http://github.com/kasei/perlrdf/

Corese

- http://www-sop.inria.fr/teams/edelweiss/wiki/wakka.php?wiki=CoreseDownloads

etc.

Others probably forthcoming…

Many SPARQL1.0 endpoints around

- Dbpedia: http://dbpedia.org/snorql/
- DBLP: http://dblp.l3s.de/d2r/snorql/
- Etc.

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Tutorial Overview

Session 1

XQuery Overview – Sherif

SPARQL Overview – Axel

XSPARQL: a combined language – Axel

Session 2

XQuery implementations – Sherif

SPARQL implementations – Sherif

XSPARQL implementations – Axel

(optional) Compression formats for XML+RDF: EXI+HDT – Sherif

Q/A - Discussion

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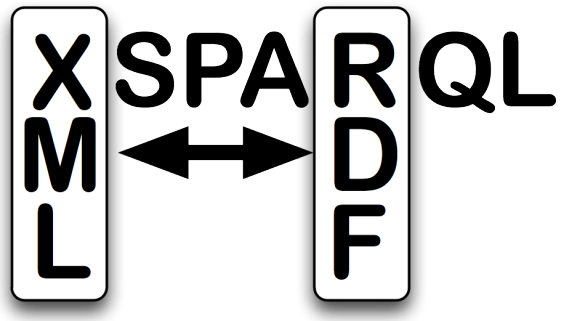
XSPARQL

Idea: One approach to conveniently query XML and RDF side-by-side: XSPARQL



- Transformation language
- Consume and generate XML and RDF
- Syntactic extension of XQuery, ie.
  XSPARQL = XQuery + SPARQL

XSPARQL: Syntax overview (I)

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Prefix declarations

P	`declare namespace` *prefix*`="`*namespace-URI*`"` or `prefix` *prefix*: <*namespace-URI*>

Body:

Data Input (XML or RDF)

F L W O	`for` *var* [`at` *posVar*] `in` *FLOWR' expression* `let` *var* := *FLWOR' expression* `where` *FLWOR' expression* `order by` *FLWOR' expression*
F' D W M	`for` *varlist* [`at` *posVar*] `from` / `from named` (<*dataset-URI*> or *FLWOR' expr.*) `where` { *pattern* } `order by` *expression* `limit` *integer* > 0 `offset` *integer* > 0

or

Data Output (XML or RDF)

C	`construct` { *template (with nested FLWOR' expressions)* }
R	`return` *XML+ nested FLWOR' expressions*

or

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XSPARQL Syntax overview (II)

XQuery or SPARQL prefix declarations

Any XQuery query

SPARQLFOR Clause represents a SPARQL query

construct allows to create RDF

P	`declare namespace` *prefix="namespace-URI"* `or prefix` *prefix*: <*namespace-URI*>	
F L W O	`for` *var* [`at` *posVar*] `in` *FLOWR' expression* `let` *var* := *FLWOR' expression* `where` *FLWOR' expression* `order by` *FLWOR' expression*	or
F' D W M	`for` *varlist* [`at` *posVar*] `from` / `from named` (<*dataset-URI*> or *FLWOR' expr.*) `where` { *pattern* } `order by` *expression* `limit` *integer* > 0 `offset` *integer* > 0	
C	`construct` { *template (with nested FLWOR' expressions)* }	or
R	`return` *XML+ nested FLWOR' expressions*	

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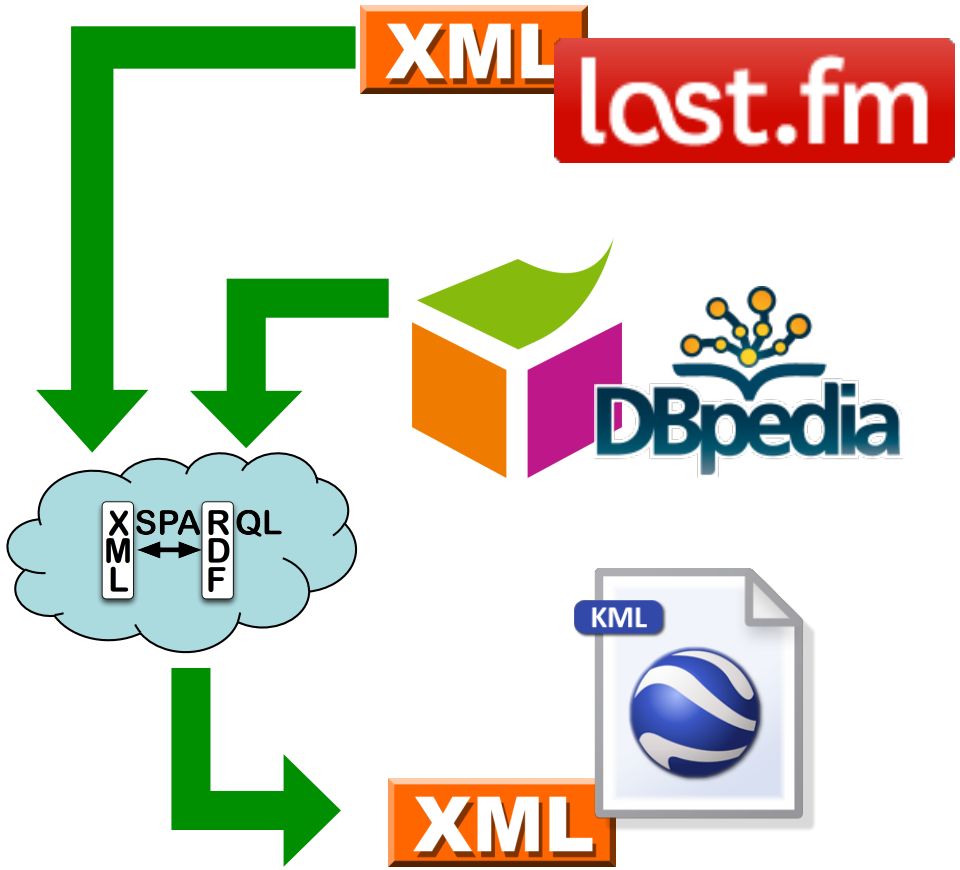
Use case



XSPARQL: Convert XML to RDF

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Query:

Convert Last.fm top artists of a user into RDF

```
prefix lastfm: <http://xsparql.deri.org/lastfm#>

let $doc := "http://ws.audioscrobbler.com/2.0/?method=user.gettopartists"
for $artist in doc($doc)//artist
where $artist[@rank < 6]
construct { [] lastfm:topArtist {$artist//name};
             lastfm:artistRank {$artist//@rank} . }
```

Result:

```
@prefix lastfm: <http://xsparql.deri.org/lastfm#> .

[ lastfm:topArtist "Therion" ;  lastfm:artistRank "1" ] .
[ lastfm:topArtist "Nightwish" ;  lastfm:artistRank "2" ] .
[ lastfm:topArtist "Blind Guardian" ;  lastfm:artistRank "3" ] .
[ lastfm:topArtist "Rhapsody of Fire" ;  lastfm:artistRank "4" ] .
[ lastfm:topArtist "Iced Earth" ;  lastfm:artistRank "5" ] .
```

XSPARQL construct generates valid Turtle RDF

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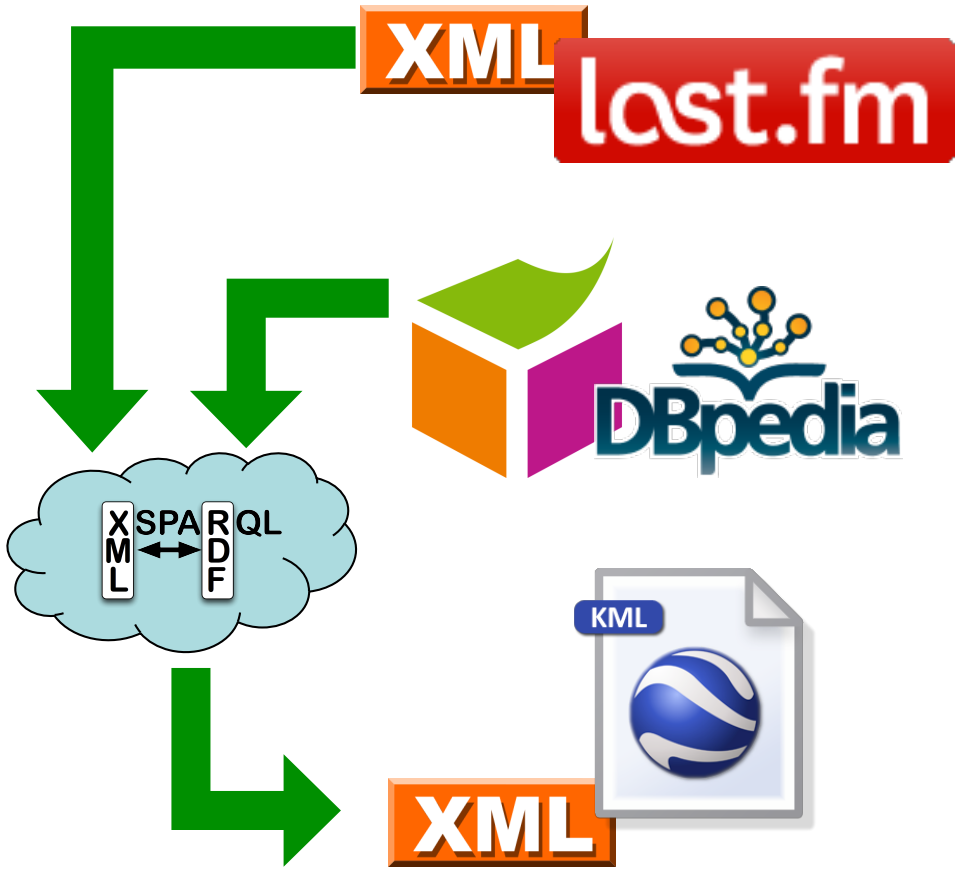
Use case



XSPARQL: Integrate RDF sources

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Query:

Retrieve the origin of an artist from DBPedia: Same as the SPARQL query

```
prefix dbprop: <http://dbpedia.org/property/>
prefix foaf:   <http://xmlns.com/foaf/0.1/>

construct { $artist foaf:based_near $origin }
from <http://dbpedia.org/resource/Nightwish>
where { $artist dbprop:origin $origin }
```

Issue: determining the artist identifiers

DBPedia does not have the map coordinates

GeoNames

XML

XSPARQL: Integrate RDF sources

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Query:

Retrieve the origin of an artist from DBPedia ***including map coordinates***

```
prefix wgs84_pos: <http://www.w3.org/2003/01/geo/wgs84_pos#>
prefix dbprop: <http://dbpedia.org/property/>

for * from <http://dbpedia.org/resource/Nightwish>
where { $artist dbprop:origin $origin }
return
let $hometown :=
  fn:concat("http://api.geonames.org/search?type=rdf&q=",fn:encode-for-uri($origin))
for * from $hometown
where { [] wgs84_pos:lat $lat; wgs84_pos:long $long }
limit 1
construct { $artist wgs84_pos:lat $lat; wgs84_pos:long $long }
```

DBPedia does not have the map coordinates

GeoNames

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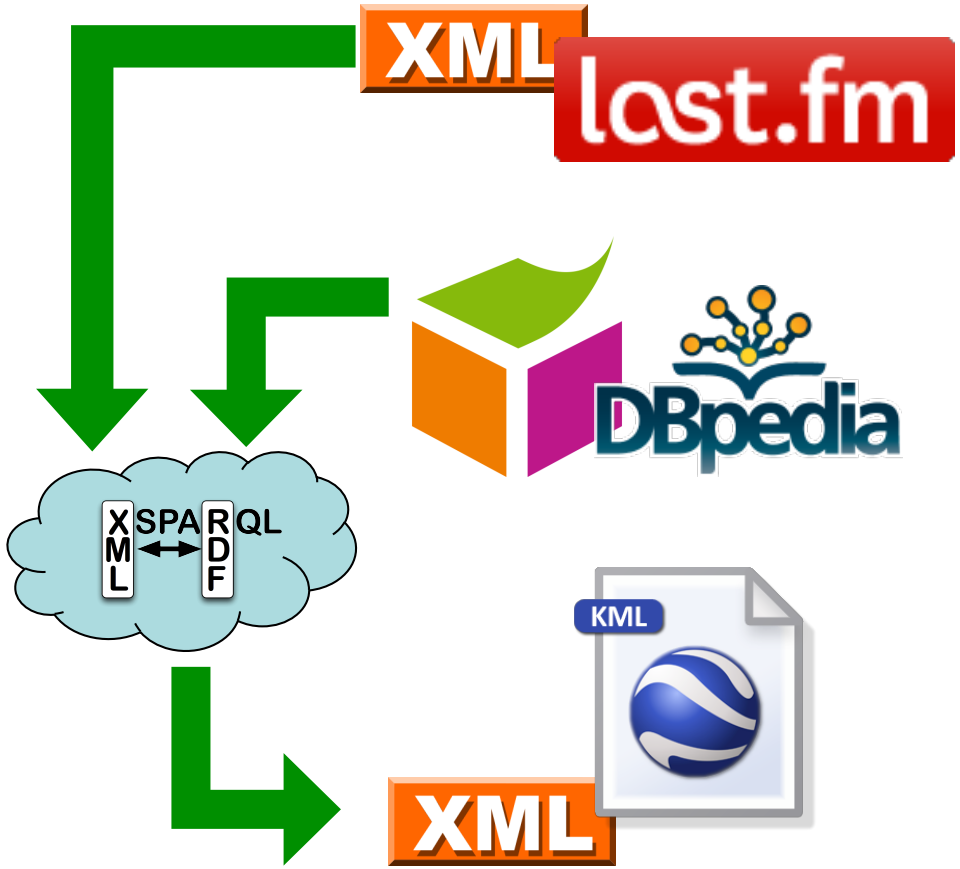
Use case



Output: KML XML format

```
<kml xmlns="http://www.opengis.net/kml/2.2">
   <Document>
      <Placemark>
         <name>Hometown of Nightwish</name>
         <Point>
            <coordinates>
              30.15,62.1,0
            </coordinates>
         </Point>
      </Placemark>
 </Document>
</kml>
```

KML format:

- root element: “kml”, then “Document”
- sequence of “Placemark”
- Each “Placemark” contains:
  - “Name” element
  - “Point” element with the “coordinates”

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XSPARQL: Putting it all together

Query: Display top artists origin in a map

```
prefix dbprop: <http://dbpedia.org/property/>

<kml><Document>{
let $doc := "http://ws.audioscrobbler.com/2.0/?method=user.gettopartists"
for $artist in doc($doc)//artist
return let $artistName := fn:data($artist//name)
  let $uri := fn:concat("http://dbpedia.org/resource/", $artistName)
  for $origin from $uri
  where { [] dbprop:origin $origin }
  return
   let $hometown := fn:concat("http://api.geonames.org/search?type=rdf&q=",
                    fn:encode-for-uri($origin))
   for * from $hometown
   where { [] wgs84_pos:lat $lat; wgs84_pos:long $long }
   limit 1
   return <Placemark>
            <name>{fn:concat("Hometown of ", $artistName)}</name>
            <Point><coordinates>{fn:concat($long, ",", $lat, ",0")}
            </coordinates></Point>
           </Placemark>
}</Document></kml>
```

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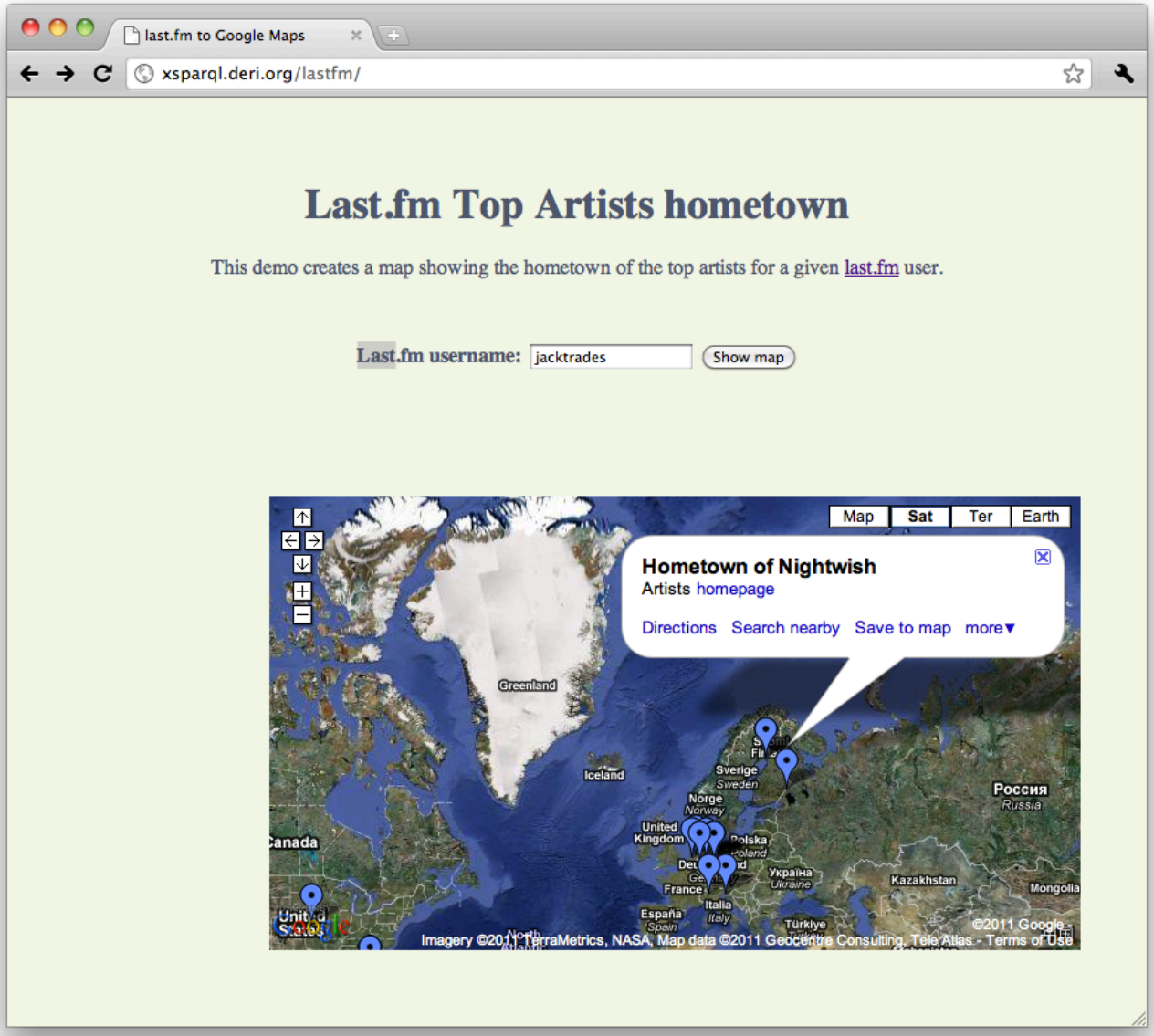
XSPARQL: Demo

http://xsparql.deri.org/lastfm



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XSPARQL: more examples

XSPARQL: Convert FOAF to KML

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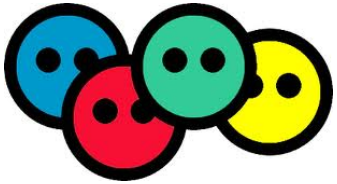

RDF (FOAF) data representing your location … *in different ways*

Show this information in a Google Map embedded in your webpage

Demo at: http://xsparql.deri.org/foaf2kml/

XSPARQL: Convert FOAF to KML

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```
 <foaf:based_near>                    http://nunolopes.org/foaf.rdf
      <geo:Point>
        <geo:lat>53.289881</geo:lat><geo:long>-9.073849</geo:long>
      </geo:Point>
    </foaf:based_near>
```

Display location in Google Maps based on your FOAF file

```
prefix foaf: <http://xmlns.com/foaf/0.1/>
prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#>

<kml xmlns="http://www.opengis.net/kml/2.2">{
 for $name $long $lat
 from <http://nunolopes.org/foaf.rdf>
 where { $person a foaf:Person; foaf:name $name;
         foaf:based_near [ a geo:Point; geo:long $long;
                           geo:lat $lat ] }
return <Placemark>
         <name>{fn:concat("Location of ", $name)}</name>
         <Point>
           <coordinates>{fn:concat($long, ",", $lat, ",0")}
           </coordinates>
         </Point>
       </Placemark>
}</kml>
```

XSPARQL: Convert FOAF to KML

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Different location representation in different foaf files…

http://polleres.net/foaf.rdf

```
<foaf:based_near rdf:resource="http://dbpedia.org/resource/Galway"/>
```

```
prefix foaf: <http://xmlns.com/foaf/0.1/>
prefix georss: <http://www.georss.org/georss/>

<kml><Document>{
  for * from <http://polleres.net/foaf.rdf>
  where { $person a foaf:Person; foaf:name $name;
          foaf:based_near $point. }
  return for * from $point
         where { $c georss:point $latLong }
         return let $coordinates := fn:tokenize($latLong, " ")
            let $lat1 := $coordinates[1]
            let $long1 := $coordinates[2]
            return <Placemark>
              <name>{fn:concat("Location of ", $name)}</name>
                <Point><coordinates>{fn:concat($long1, ",", $lat1, ",0")}
             </coordinates></Point>
            </Placemark>
}</Document></kml>
```

We can handle different representations of locations in the FOAF files

XSPARQL: Convert FOAF to KML

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you can cater for different representations in one query…

http://polleres.net/foaf.rdf

```
<foaf:based_near rdf:resource="http://dbpedia.org/resource/Galway"/>
```

http://nunolopes.org/foaf.rdf

```
<foaf:based_near>
     <geo:Point>
       <geo:lat>53.289881</geo:lat><geo:long>-9.073849</geo:long>
     </geo:Point>
   </foaf:based_near>
```

- Previous 2 queries can be easily combined into one… see:
  http://xsparql.deri.org/foaf2kml/foaf2kml.xsparql

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Obtaining locations in RDF

- Update or enhance your FOAF file with your current location based on a Google Maps search:

```
prefix foaf: <http://xmlns.com/foaf/0.1/>
prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#>
prefix kml: <http://earth.google.com/kml/2.0>

let $loc := "Hilton San Francisco Union Square, San Francisco, CA"
for $place in doc(fn:concat("http://maps.google.com/?q=",
                  fn:encode-for-uri($loc),
                  ”&num=1&output=kml"))
let $geo := fn:tokenize($place//kml:coordinates, ",")
construct { <nunolopes> foaf:based_near [ geo:long {$geo[1]};
                                          geo:lat {$geo[2]} ] }
```

Find the location in Google Maps and get the result as KML

Result:

```
@prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix kml: <http://earth.google.com/kml/2.0> .

<nunolopes> foaf:based_near [ geo:long "-122.411116" ;
                              geo:lat "37.786000" ] .
```

Ontology Documentation in HTML

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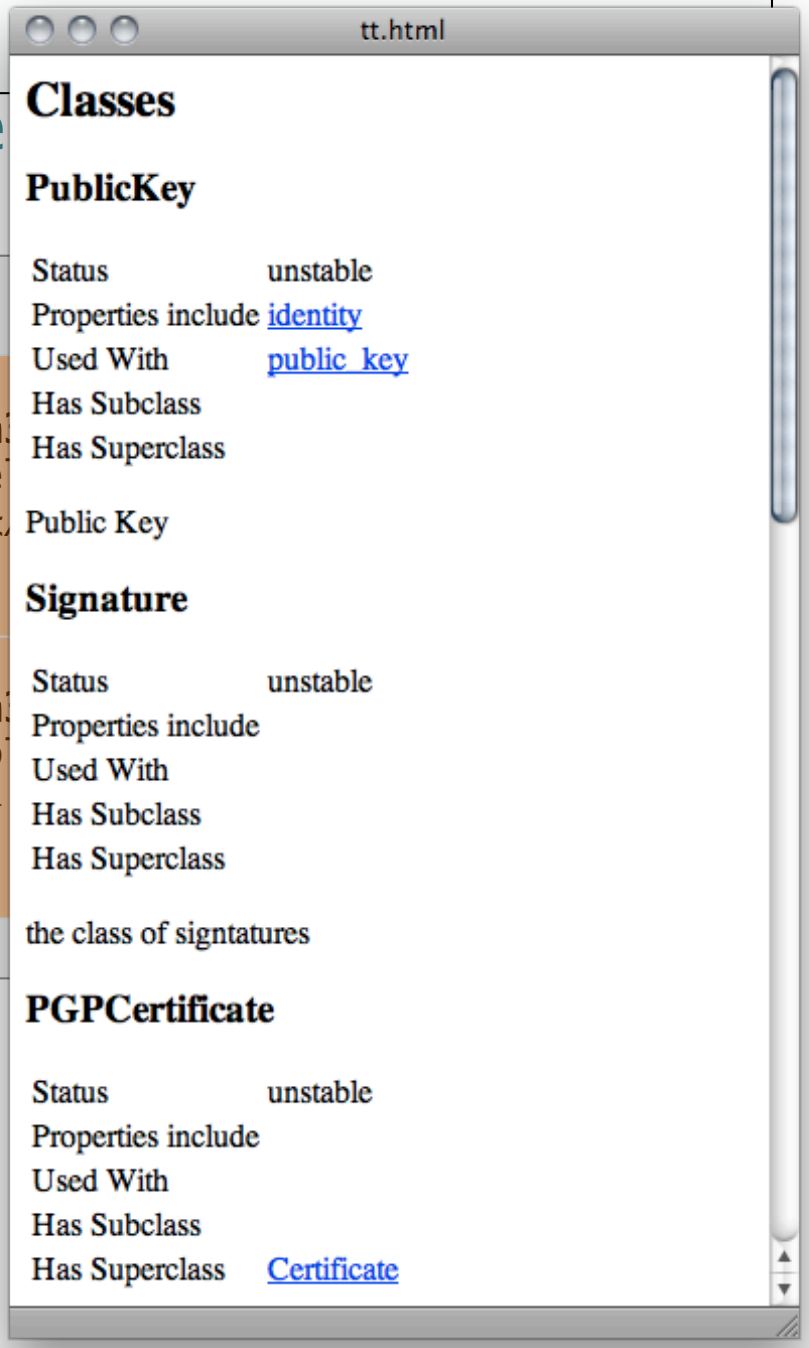
- Given an ontology you can gene
  XHTML describing it…

```
<html><head></head>
<body>
<h2>Classes</h2>{
  for * from <http://www.w3.org/ns/auth/cert.n
  where { $class a owl:Class; rdfs:label $labe
  } return  <div name="{$label}"><h3>{$label}</
             <p>{$comment}</p>
            </div>}
<h2>Properties</h2>{
  for * from <http://www.w3.org/ns/auth/cert.n
  where { $prop a rdf:Property; rdfs:label $lb
  } return  <div name="{$lbl}"><h3>{$lbl}</h3>
             <p>{$commnt}</p>
            </div>}
</body></html>
```



Use case and query by Henry Story

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XSPARQL vs. SPARQL for “pure RDF” queries

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Extending SPARQL1.0: Computing values

Computing values is not possible in SPARQL 1.0:

```
prefix foaf: <http://xmlns.com/foaf/0.1/>
prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#>
prefix : <http://xsparql.deri.org/geo#>

construct { $person :latLong $lat; :latLong $long }
from <http://nunolopes.org/foaf.rdf>
where { $person a foaf:Person; foaf:name $name;
        foaf:based_near [ geo:long $long;
                          geo:lat $lat ] }
```

While XSPARQL allows to use all the XPath functions:

```
prefix foaf: <http://xmlns.com/foaf/0.1/>
prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#>
prefix : <http://xsparql.deri.org/geo#>

construct { $person :latLong {fn:concat($lat, " ", $long}}
from <http://nunolopes.org/foaf.rdf>
where { $person a foaf:Person; foaf:name $name;
        foaf:based_near [ geo:long $long;
                          geo:lat $lat ] }
```

Note: SPARQL1.1 allow that (BIND)

Federated Queries in SPARQL1.1

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Find which persons in DBPedia have the same birthday as Axel (foaf-file):

SPARQL 1.1 has new feature SERVICE to query remote endpoints

```
PREFIX dbpedia2: <http://dbpedia.org/property/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?N ?MyB
FROM <http://polleres.net/foaf.rdf>
{ [ foaf:birthday ?MyB ].

  SERVICE <http://dbpedia.org/sparql> { SELECT ?N WHERE {
    [ dbpedia2:born ?B; foaf:name ?N ]. FILTER ( Regex(str(?B),str(?MyB)) ) } }
}
```

Doesn't work!!! **?MyB** unbound in SERVICE query

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Federated Queries in SPARQL1.1

Find which persons in DBPedia have the same birthday as Axel (foaf-file):

SPARQL 1.1 has new feature SERVICE to query remote endpoints

```
PREFIX dbpedia2: <http://dbpedia.org/property/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?N ?MyB
FROM <http://polleres.net/foaf.rdf>
{ [ foaf:birthday ?MyB ].

  SERVICE <http://dbpedia.org/sparql> { SELECT ?N WHERE {
    [ dbpedia2:born ?B; foaf:name ?N ]. } }

 FILTER ( Regex(Str(?B),str(?MyB)) )
}
```

Doesn't work either in practice ☹ as SERVICE endpoints often only returns limited results…

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Federated Queries

Find which persons in DBPedia have the same birthday as Axel (foaf-file):

In XSPARQL:

```
prefix dbprop: <http://dbpedia.org/property/>
prefix foaf: <http://xmlns.com/foaf/0.1/>
prefix : <http://xsparql.deri.org/bday#>

let $MyB := for * from <http://polleres.net/foaf.rdf>
            where { [ foaf:birthday $B ]. }
            return $B

for * from <http://dbpedia.org/> endpoint <http://dbpedia.org/sparql>
where { [ dbprop:born $B; foaf:name $N ].
          filter ( regex(str($B),str($MyB)) )  }
construct { :axel :sameBirthDayAs $N }
```

Specifies the endpoint to perform the query, similar to SERVICE in SPARQL1.1

Works! In XSPARQL bound values (**?MyDB**) are **injected** into the SPARQL subquery
→ More direct control over "query execution plan"

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Tutorial Overview

Session 1

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- SPARQL Overview – Axel
- XSPARQL: a combined language – Axel

Session 2

- **XQuery implementations** – Sherif
- **SPARQL implementations** – Sherif
- **XSPARQL implementations** – Axel

- **Q/A - future work, etc.** – Sherif,Axel

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End of session 1

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- **(optional) Compression formats for XML+RDF: EXI+HDT** – Sherif

Q/A Discussion

Switch to other slideset for details on XQuery

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Q/A - Discussion

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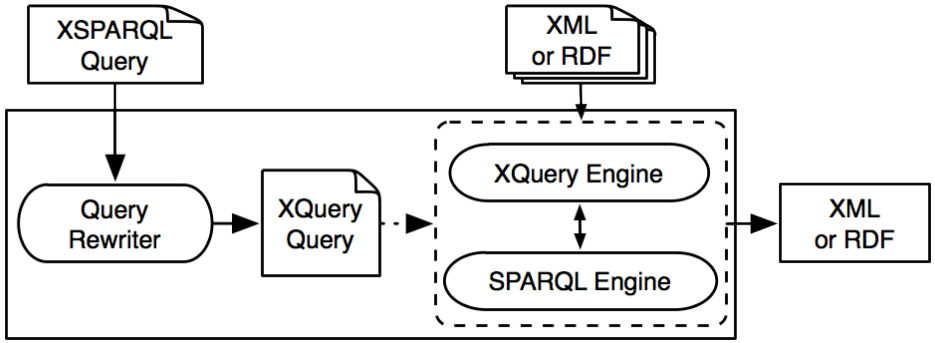
XSPARQL Implementation



- Each XSPARQL query is translated into an XQuery
- SPARQLForClauses are translated into SPARQL SELECT clauses
- Uses *off the shelf* components:
  - XQuery engine: Saxon
  - SPARQL engine: Jena / ARQ

Example:

relations.rdf

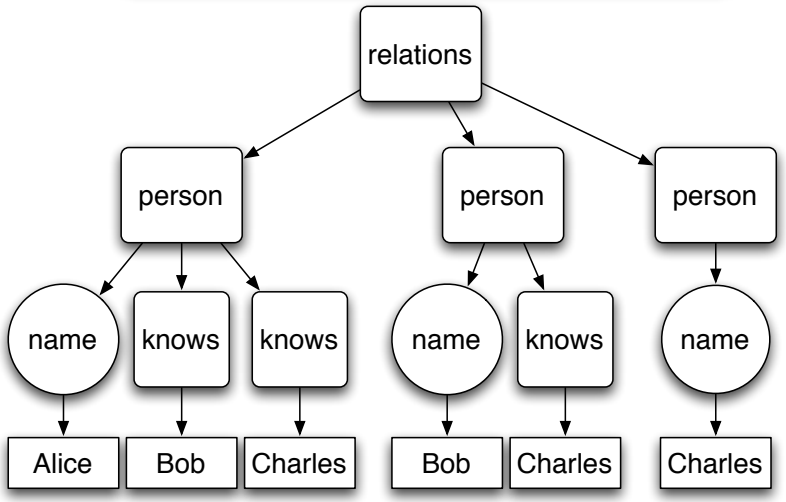
```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
_:b1 a foaf:Person;
     foaf:name "Alice";
     foaf:knows _:b2;
     foaf:knows _:b3.
_:b2 a foaf:Person; foaf:name "Bob";
     foaf:knows _:b3.
_:b3 a foaf:Person; foaf:name "Charles".
```

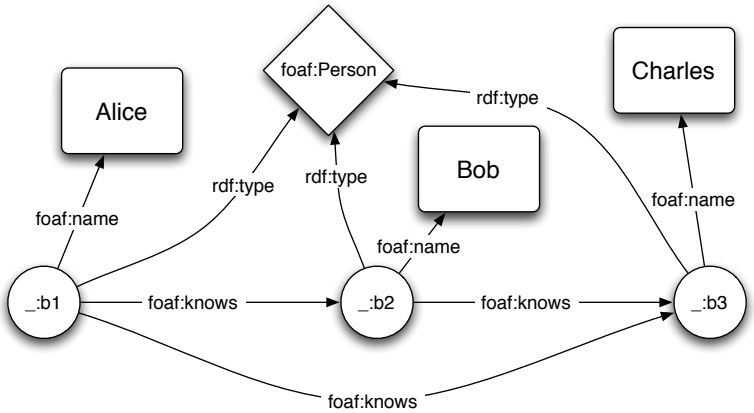
Lowering

Lifting

relations.xml

```
<relations>
  <person name="Alice">
    <knows>Bob</knows>
    <knows>Charles</knows>
  </person>
  <person name="Bob">
    <knows>Charles</knows>
  </person>
  <person name="Charles"/>
</relations>
```





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Example: Mapping from RDF to XML

```
<relations>
{ for $Person $Name
  from <relations.rdf>
  where { $Person foaf:name $Name }
  order by $Name
  return
      <person name="{$Name}">
      {for $FName
       from <relations.rdf>
       where {
            $Person foaf:knows $Friend .
            $Person foaf:name $Name .
            $Friend foaf:name $Fname }
       return <knows>{$FName}</knows>
    } </person>
}</relations>
```

```
<relations>
  <person name="Alice">
    <knows>Bob</knows>
    <knows>Charles</knows>
  </person>
  <person name="Bob">
    <knows>Charles</knows>
  </person>
  <person name="Charles"/>
</relations>
```

Example: Adding value generating functions to SPARQL (using XSPARQL to emulate a SPARQL1.1 feature)

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```
construct { :me foaf:knows _:b .
            _:b foaf:name {fn:concat("""",?N," ",?F,""")} }
from <MyAddrBookVCard.rdf>
where {
       ?ADDR vc:Given ?N .
       ?ADDR vc:Family ?F .
}
```

…

```
:me foaf:knows _:b1. _:b1 foaf:name "Peter Patel-Schneider" .
:me foaf:knows _:b2. _:b2 foaf:name "Stefan Decker" .
:me foaf:knows _:b3. _:b3 foaf:name "Thomas Eiter" .
```

…

XSPARQL Implementation 1.0
Rewriting XSPARQL to XQuery…

SIEMENS

```
construct { _:b foaf:name {fn:concat($N," ",$F)} } from
<vcard.rdf>
where { $P vc:Given $N . $P vc:Family $F . }
```

```
let $aux_query := fn:concat("http://localhost:2020/sparql?query=",
                            fn:encode-for-uri(
                  "select $P $N $F from <vcard.rdf>
                   where {$P vc:Given $N. $P vc:Family $F.}"))
for $aux_resu
                  in doc($aux_query)//sparql_result:result
let $P_Node :=                                  :binding[@name="P"]
let $N_Node :=                                  :binding[@name="N"]
let $F_Node := $aux_result/sparql_result:binding[@name="F"]
let $N := data($N_Node/*)let $N_NodeType := name($N_Node/*)
let $N_RDFTerm := local:rdf_term($N_NodeType,$N)
...
return ( fn:c                                              "),
          ( f                                              """) ), "." )
```

1. Encode SPARQL in HTTP call SELECT Query
2. Execute call, via fn:doc function
3. Collect results from SPARQL result format (XML)
4. `construct` becomes `return` that outputs triples (slightly simplified)

XSPARQL1.1

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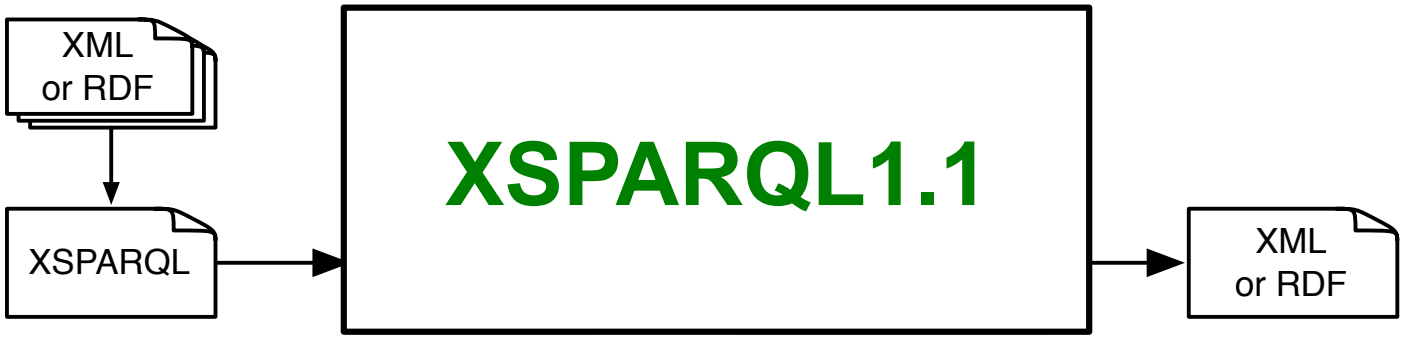
Simple rewriting semantics has some limitations:

- Call via Web Service/SPARQL Protocol interface is inefficient
- Nesting, scope of RDF dataset…
- Different “type systems” of RDF/XML (sequences), XSPARQL1.0 couldn’t bind RDF to a variable…
- Tightly integrated implementation enables optimisations…

→ These issues have been addressed in XSPARQL1.1

http://xsparql.sourceforge.net/

http://xsparql.deri.org/



XSPARQL Implementation 1.1
Rewriting XSPARQL to XQuery…

SIEMENS

```
construct { _:b foaf:name {fn:concat($N," ",$F)} } from
<vcard.rdf>
where { $P vc:Given $N . $P vc:Family $F . }
```

```
let $aux_results :=
        xsparql:sparqlQuery(
                "PREFIX foaf: PREFIX vc: SELECT $F $N $P
                 from where { $P vc:Given $N . $P vc:Family $F . } " )
for $aux_result at $aux_result_pos
                 in xsparql:sparqlResultsFromNode( $aux_result )
```

1. No fn:doc function or encoding into URL, directly call a native function **sparqlQuery**

```
let $F := xsparql:resultNode( $_aux_result0, "F" )
let $N := xsparql:resultNode( $_aux_result, "N" )
let $P := xsparql:resultNode( $aux_result, "P" ) ...
```

2. Collect variable bindings from result format encapsulated in new function

```
return (xsparql:_serialize( fn:concat("_:b",$aux_result_pos," foaf:name
"), ( fn:concat("""",$N_RDFTerm," ",$F_RDFTerm,"""") ), "." )
```

3. `construct` becomes `return` that outputs triples (slightly simplified)

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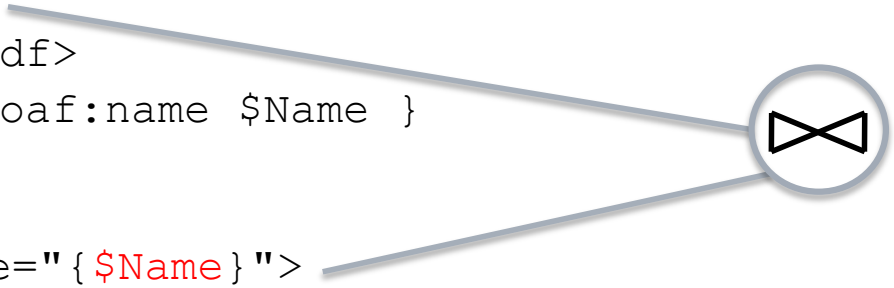
Nesting, scope of RDF dataset…

Remember the query from before…. We were slightly cheating:

```
<relations>
{ for $Person $Name
  from <relations.rdf>
  where { $Person foaf:name $Name }
  order by $Name
  return
        <person name="{$Name}">
        {for $FName
         from <relations.rdf>
         where {
                $Person foaf:knows $Friend .
                $Person foaf:name $Name .
                $Friend foaf:name $Fname }
         return <knows>{$FName}</knows>
     } </person>
}</relations>
```



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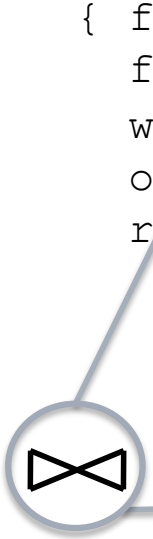
Nesting, scope of RDF dataset…

Remember the query from before…. This is what one would rather expect

```
<relations>
{ for $Person
  from <relations.rdf>
  where { $Person foaf:name $Name }
  order by $Name
  return
        <person name="{$Name}">
        {for $FName

         where {
                $Person foaf:knows $Friend .

                $Friend foaf:name $Fname }
         return <knows>{$FName}</knows>
     } </person>
}</relations>
```



The nested query should be over the same Dataset as the outer query, bindings to bnodes should be preserved
Two separate, independent SPARQL calls don't work anymore

Solution in XSPARQL1.1:

Adjust Xquery's formal semantics:
We needed to add Dataset to the dynamic environment in the semantics.

Adjust implementation:
We needed a special SPARQL implementation that allows several calls to the same active graph.

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Different “type systems” of RDF/XML (e.g. sequences)…

Social Graph queries a la [1]: ***Give me all pairs of co-authors and their joint publications.***

```
prefix foaf: <http://xmlns.com/foaf/0.1/>
prefix dc:      <http://purl.org/dc/elements/1.1/>

let $ds := for *
from <http://dblp.l3s.de/d2r/resource/authors/Axel_Polleres>
where { $pub dc:creator [] }
construct {
           { for * from $pub where { $p dc:creator $o . }
            construct {$p dc:creator <{$o}>} } }

let $allauthors :=
distinct-values(for $o from $ds where {$p dc:creator $o}
order by $o
return $o)

for $auth at $auth_pos in $allauthors
 for $coauth in $allauthors[position() > $auth_pos]
    let $commonPubs := count(
     { for $pub from $ds where { $pub dc:creator $auth, $coauth } return $pub }
    )
where ($commonPubs > 0)
construct { [ :author1 $auth; :author2 $coauth; :commonPubs $commonPubs ] }
```

Assignment of graphs to variables needs new datatype RDFGraph

Nested CONSTRUCTs queries

Lists of RDFTerms needed new datatype RDFTerm

1. Mauro San Martín, Claudio Gutierrez: Representing, Querying and Transforming Social Networks with RDF/SPARQL. ESWC 2009: 293-307

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Optimisations

- E.g. dependent Join… i.e.

```
<relations>
{ for $Person $Name
  from <relations.rdf>
  where { $Person foaf:name $Name }
  order by $Name
  return
    <person name="{$Name}">
    {for $Fname
     where {
        $Person foaf:knows $Friend .
        $Friend foaf:name $Fname }
     return <knows>{$FName}</knows>
     } </person>
}</relations>
```

```
<relations>
{ let $aux := select $Person $Name $FName
  from <relations.rdf>
  where { $Person foaf:name $Name .
          $Person foaf:knows $Friend .
          $Friend foaf:name $Fname }

  for $Name in  $aux.Name
  return
    <person name="{$Name}">
    { for $FName in $aux.Fname
      where $aux.Name = $Name
      return <knows>{$FName}</knows>
     } </person>
}</relations>
```

Only one SPARQL query

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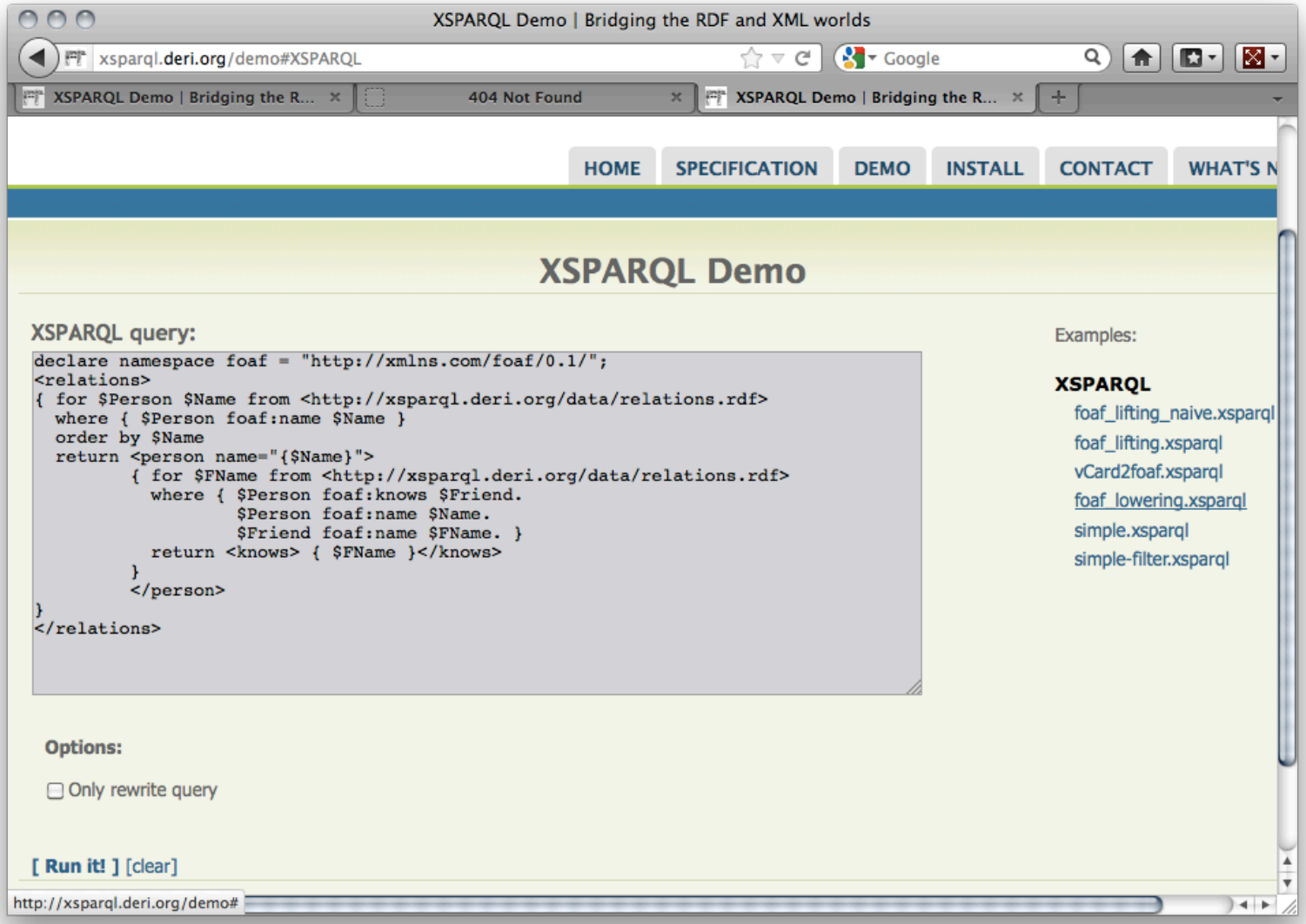
Test Queries and show rewriting…

http://xsparql.deri.org/demo



Details about XSPARQL1.1 semantics and implementation

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Check our Technical Report:

Stefan Bischof, Stefan Decker, Thomas Krennwallner, Nuno Lopes, Axel Polleres. **Mapping between RDF and XML with XSPARQL**. Technical Report 2011. http://www.deri.ie/fileadmin/documents/DERI-TR-2011-04-04.pdf

Next steps and Related works (regarding XSPARQL implementation):

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Next Steps:

• SPARQL1.1 compliance (so far only SPARQL1.0 supported)

Alternatives/Related works regarding possible implementations:

• S. Groppe, J. Groppe, V. Linnemann, D. Kukulenz, N. Hoeller, and C. Reinke, "Embedding SPARQL into XQuery/XSLT," in ACM SAC, 2008, pp. 2271–2278.

• T. Grust, M. Mayr, and J. Rittinger, "Let SQL drive the XQuery workhorse (XQuery join graph isolation)," in EDBT, 2010, pp. 147–158.

• Fischer P, Florescu D, Kaufmann M, Kossmann D (2011) Translating SPARQL and SQL to XQuery. In: XMLPrague'11, pp 81 – 98