
# RDF and XML: Towards a Unified Query Layer

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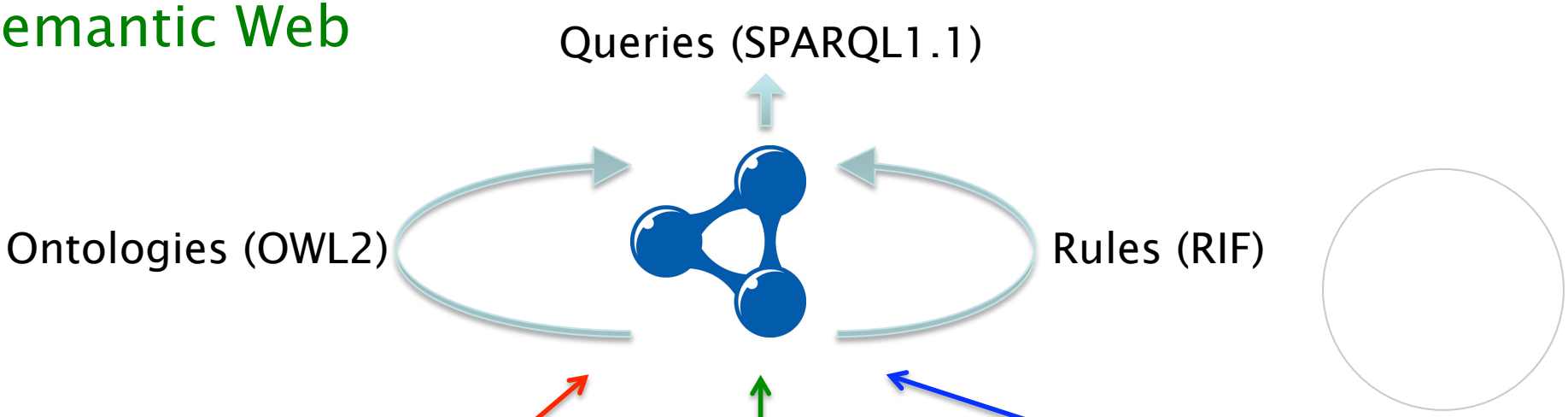
**(supporters of the W3C member submission)**


# Semantic Data Access…
# … that would be the vision

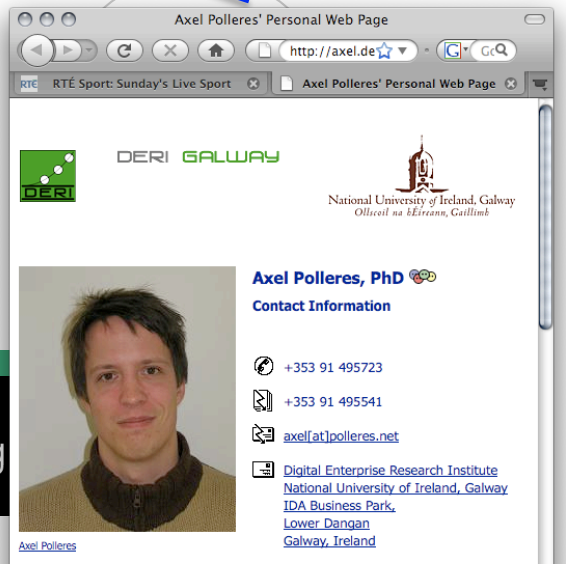


- RDF: common simple Data format underlying the Semantic Web




| id | FNAME | LNAME | AGE |
|---|---|---|---|
| 1 | Bob | McBob | 42 |
| 2 | John | Johnson | 24 |
| 3 | Steve | Smith | 38 |

```
<s1:messages>
 <s1:msg id="m1" format="bin">
  <s1:sendername>3PO</s1:sendername>
  <s1:receivername>R2D2<s1:receivername>
  <s1:payload>0111010001</s1:payload>
 </s1:msg>
<s1:msg id="m2" format="text">
  <s1:sendername>Obiwan</s1:sendername>
  <s1:receivername>Luke<s1:receivername>
  <s1:payload>Use the force</s1:payload>
 </s1:msg>
<s1:messages>
```



# Semantic Data Access…
# … that would be the vision



Queries

Ontologies

Rules

```
<emp:#1>        a          <emp:Employee>
<emp:#1>        <name>       “Bob McBob”.
…
<s1:3PO>        a          <s1:Agent>
<s1:3PO>        <name>       “3PO”.
<s1:3PO>        <sent>   <m1> .  <m1>     <format>     <binary>.
<s1:Obiwan>     a          <s1:Agent>
<s1:Obiwan>     <name>       “Obiwan Kenobi”.
<s1:Obiwan>     <sent>   <m2> .  <m2> <format> <text>.
…
<axel>          a          <Person>
<axel           <name>     “Axel Polleres”.
```

| id | FNAME | LNAME | AGE |
|---|---|---|---|
| 1 | Bob | McBob | 42 |
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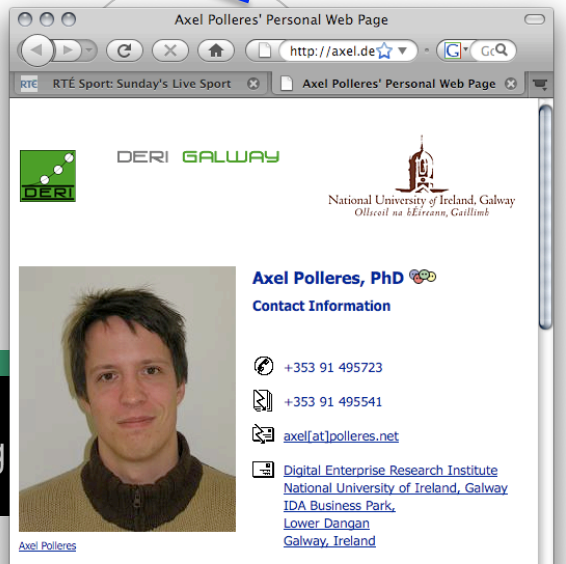
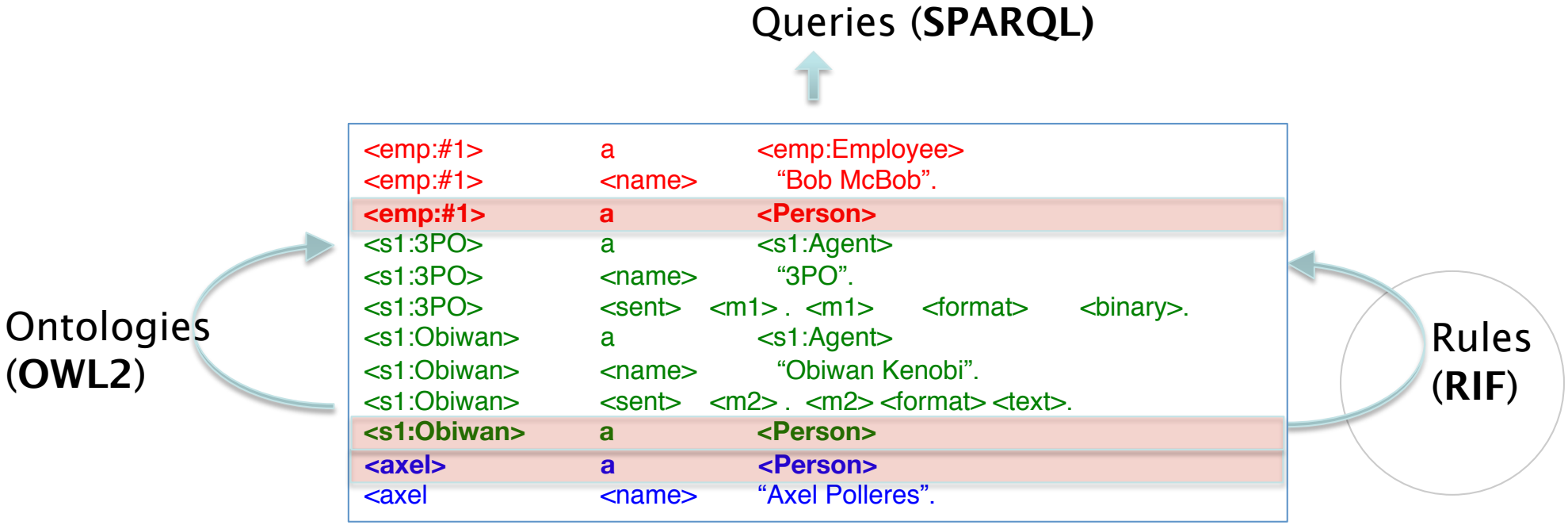
| 3 | Steve | Smith | 38 |

```
<s1:messages>
 <s1:msg id=“m1” format=“bin”>
  <s1:sendername>3PO</s1:sendername>
  <s1:receivername>R2D2<s1:receivername>
  <s1:payload>0111010001</s1:payload>
 </s1:msg>
<s1:msg id=“m2” format=“text”>
  <s1:sendername>Obiwan</s1:sendername>
  <s1:receivername>Luke<s1:receivername>
  <s1:payload>Use the force</s1:payload>
 </s1:msg>
<s1:messages>
```



# Semantic Data Access…
# … that would be the vision






- **Query (SPARQL)**: "Give me all Persons"

```
SELECT ?X WHERE { ?X a <Person> }
```

- **Ontologies (OWL2, DL)**: *"<emp:Employee> is a subclass of <Person>"*

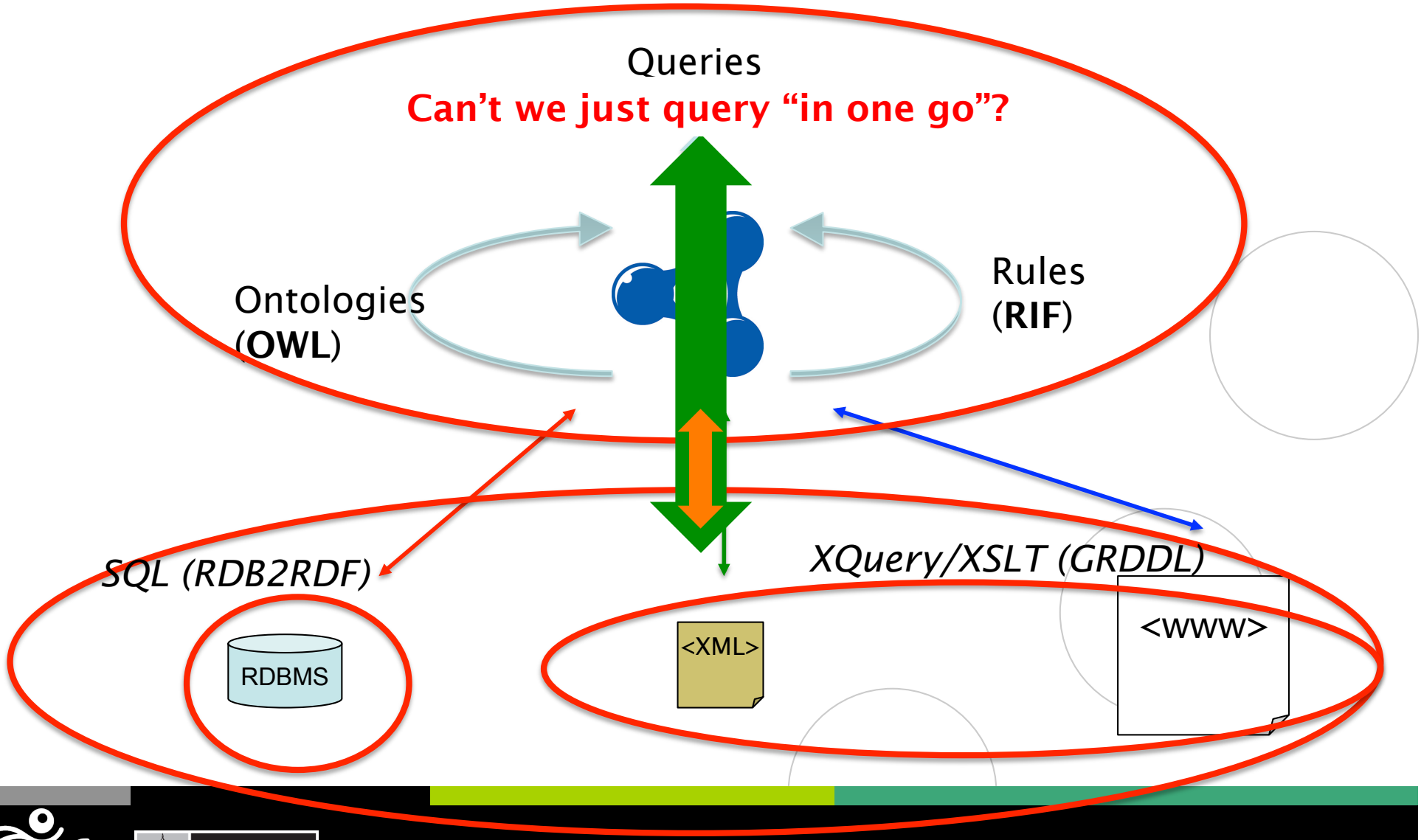
$$Employee \sqsubseteq Person$$

- **Rules (RIF, LP)**: "<s1:Agents> who never sent binary are Persons"

$$Person(x) :- Agent(x), \texttt{not } sent(x, "binary").$$

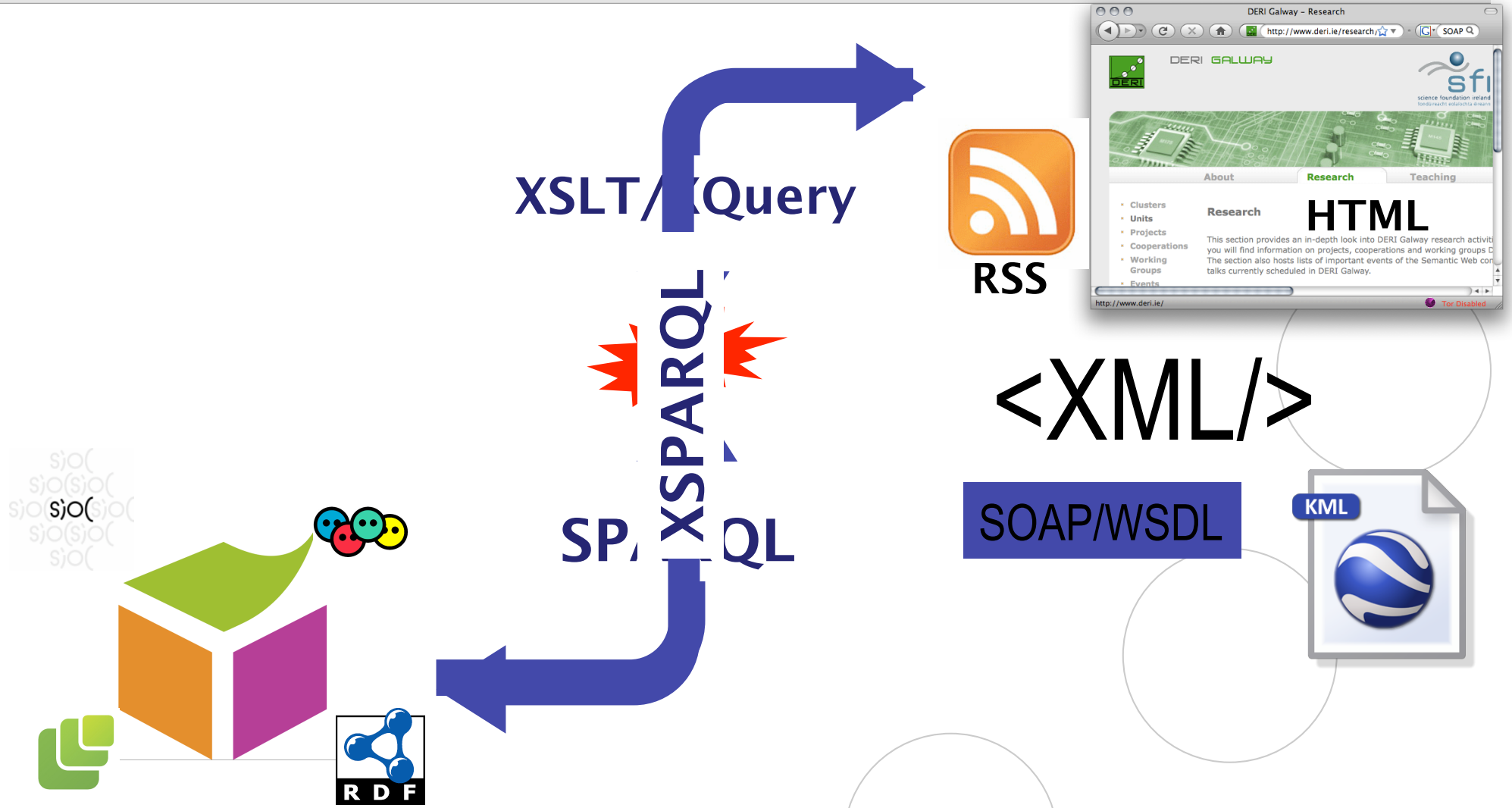
# Bridging Gaps to the data “below”:





# Our starting motivation (2008):





# Example:



relations.rdf

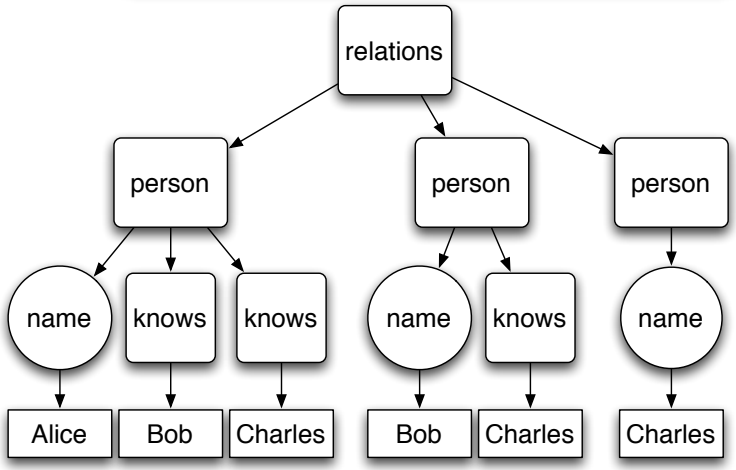
```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
_:b1 a foaf:Person;
     foaf:name "Alice";
     foaf:knows _:b2;
     foaf:knows _:b3.
_:b2 a foaf:Person; foaf:name "Bob";
     foaf:knows _:b3.
_:b3 a foaf:Person; foaf:name "Charles".
```

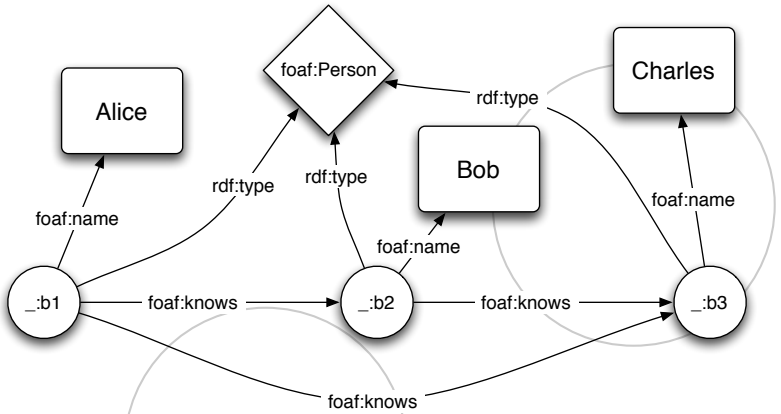
Lowering

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>
```

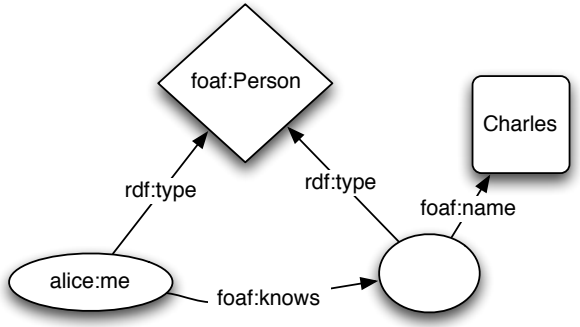


# So, why are XSLT, XQuery not enough?



- Because RDF ≠ RDF/XML !!!




1) many different RDF/XML representations…

```
<rdf:RDF xmlns:foaf="http://xmlns.com/foaf/0.1/"
         xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
   <foaf:Person rdf:about="alice/me">
      <foaf:knows>
         <foaf:Person foaf:name="Charles"/>
      </foaf:knows>
   </foaf:Person>
</rdf:RDF>
```

```
<rdf:RDF xmlns:foaf="http://xmlns.com/foaf/0.1/"
         xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
   <rdf:Description rdf:nodeID="x">
      <rdf:type rdf:resource="http://xmlns.com/foaf/0.1/Person"/>
      <foaf:name>Charles</foaf:name>
   </rdf:Description>
   <rdf:Description rdf:about="alice/me">
      <rdf:type rdf:resource="http://xmlns.com/foaf/0.1/Person"/>
      <foaf:knows rdf:nodeID="x"/>
   </rdf:Description>
</rdf:RDF>
```

```
<rdf:RDF xmlns:foaf="http://xmlns.com/foaf/0.1/"
         xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
   <rdf:Description rdf:about="alice/me">
      <foaf:knows rdf:nodeID="x"/>
   </rdf:Description>
   <rdf:Description rdf:about="alice/me">
      <rdf:type rdf:resource="http://xmlns.com/foaf/0.1/Person"/>
   </rdf:Description>
   <rdf:Description rdf:nodeID="x">
      <foaf:name>Charles</foaf:name>
   </rdf:Description>
   <rdf:Description rdf:nodeID="x">
      <rdf:type rdf:resource="http://xmlns.com/foaf/0.1/Person"/>
   </rdf:Description>
</rdf:RDF>
```

2) … and actually a lot of RDF data residing in RDF stores, accessible via SPARQL endpoints already, rather than in RDF/XML

# Our approach: XSPARQL (W3C submission)



- New query language… but don't reinvent!

XQuery + SPARQL = **XSPARQL**

| | | | |
|---|---|---|---|
| Prolog: | **P** | `declare namespace` *prefix*`="`*namespace-URI*`"`<br>or `prefix` *prefix*: <*namespace-URI*> | |
| Body: | **F** | `for` *var* `in` *XPath-expression* | |
| | **L** | `let` *var* := *XPath-expression* | |
| | **W** | `where` *XPath-expression* | |
| | **O** | `order by` *expression* | **or** |
| | **F'** | `for` *varlist* | |
| | **D** | `from` / `from named` <*dataset-URI*> | |
| | **W** | `where` {*pattern* } | |
| | **M** | `order by` *expression* | |
| | | `limit` *integer* $> 0$ | |
| | | `offset` *integer* $> 0$ | |
| Head: | **C** | `construct`<br>{ *template (with nested XSPARQL)* } | **or** |
| | **R** | `return` *XML + nested XSPARQL* | |

# 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



```
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" .
…
```

# Implementation and semantics:

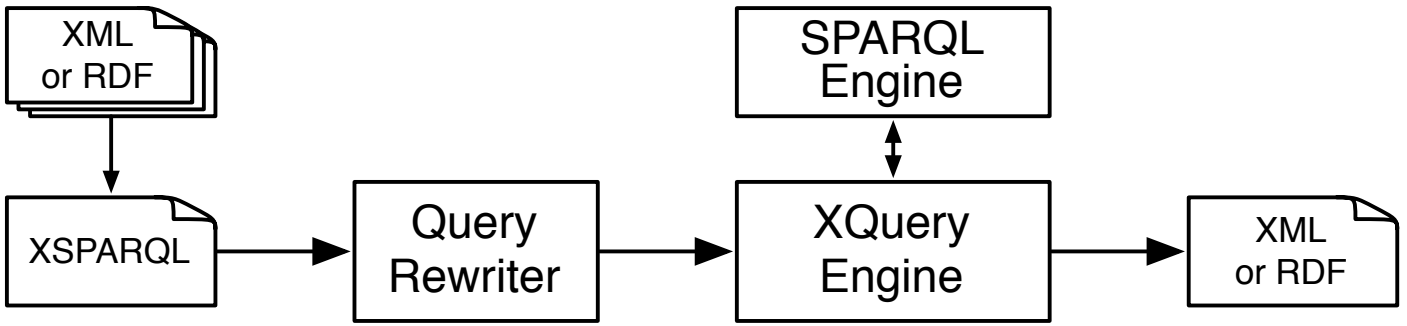



- Formal Semantics (XSPARQL1.0):
  - Based on XQuery formal Semantics
  - Can be implemented based on rewriting to XQuery
- Challenges/Limitations:
  - Nesting, scope of RDF dataset…
  - different “type systems” of RDF/XML (sequences)
  - adding ontological inference (to resolve heterogeneities)
  - We are working on this in XSPARQL1.1!

# Formal Semantics:



- Initial idea (and formalised in XSPARQL1.0):
  - extension of the XQuery semantics by plugging in SPARQL semantics in a modular way




  - Rewriting algorithm is defined for embedding XSPARQL into native XQuery plus interleaved calls to a SPARQL endpoint

# Rewriting XSPARQL to XQuery…




```
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_result at $aux_result_pos
                    in doc($aux_query)//sparql_result:result
let $P_Node :=
let $N_Node :=
let $F_Node :=
let $N := dat
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.

# Formalisation



- Current formalisation embeds rewriting in the functional semantics of XQuery:
  [http://xsparql.deri.org/spec/xsparql-semantics.html#id:flwor-expressions](http://xsparql.deri.org/spec/xsparql-semantics.html#id:flwor-expressions)

mapping rules $[\cdot]_{Expr'}$ inherit from the definitions of XQuery's $[\cdot]_{Expr}$

$$\left[\begin{array}{l}\texttt{for } \$VarName_1 \ldots \$VarName_n\ DatasetClause\ \texttt{where} \\ GroupGraphPattern\ SolutionModifier\ ReturnClause\end{array}\right]_{Expr'}$$

$$==$$

$$\left\lceil \texttt{let } \$\_aux\_queryresult := \left[\begin{array}{l}VarName_1 \ldots VarName_n\ DatasetClause \\ \texttt{where } GroupGraphPattern\ SolutionModifier\end{array}\right]_{SparqlQuery} \right\rceil$$

$$\left[\begin{array}{l}\$VarName_1 \ldots \$VarName_n\ DatasetClause \\ \texttt{where } GroupGraphPattern\ SolutionModifier\end{array}\right]_{SparqlQuery}$$

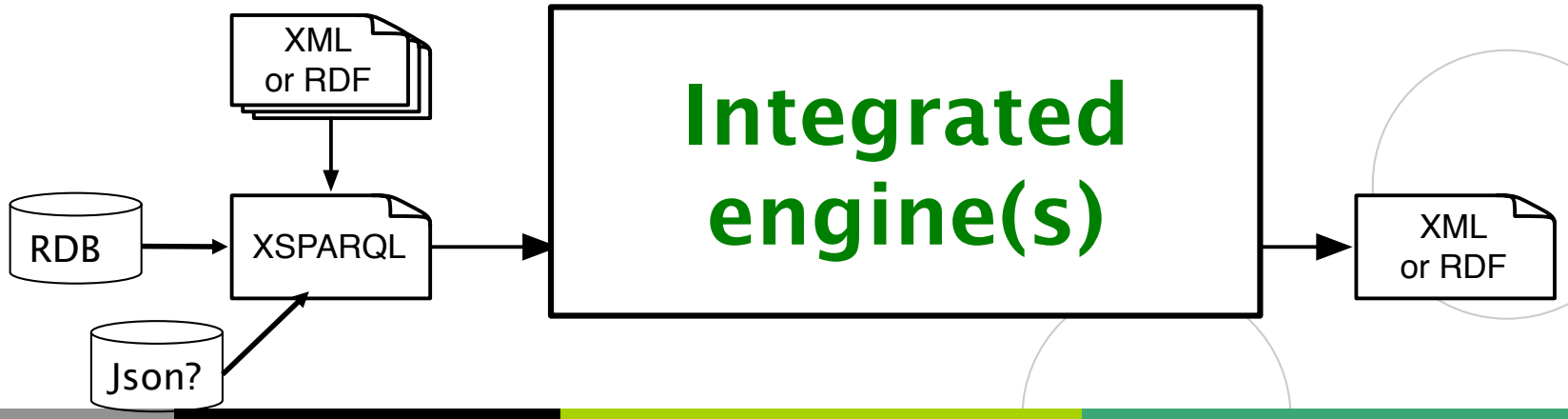
$$==$$

$$fs{:}sparql\left(\left[\begin{array}{l}\texttt{fs:serialize("SELECT } \$VarName_1 \ldots \$VarName_n\texttt{", } DatasetClause\texttt{, " where \{ ",} \\ \texttt{fs:serialize(} GroupGraphPattern\texttt{), " \} } SolutionModifier\texttt{")}\end{array}\right]_{Expr'}\right)$$

# Ongoing work/Outlook:



- Simple rewriting semantics has some limitations, which we are currently working on:
  - **Adding RDFS/OWL entailment(and other SPARQL1.1 features)**
  - **Integrate RDB Querying (SQL), Json, etc.**
  - **Optimisations**…
  - Nesting,scope of RDF dataset…
  - Different "type systems" of RDF/XML (sequences)…



# RDB Querying sketch



***Extract foaf:knows relations from a RDB with two tables: containing persons and their knows relations***

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

for p1.name as $x, p2.name as $y
from person as p1, person as p2, relation as r
where {  p1.name = r.person and
         p2.name = r.knows }

construct { $x foaf:knows $y }
```

RDBForClause to specify input from RDB tables

SQL Where pattern

Output RDF (or XML)

- Use as an RDB2RDF exporter…

**Unified RDF/XML/RDB Query Layer = XSPARQL + RDB2RDF ?**

# Optimisations – Example:



- E.g. dependent Join… i.e.

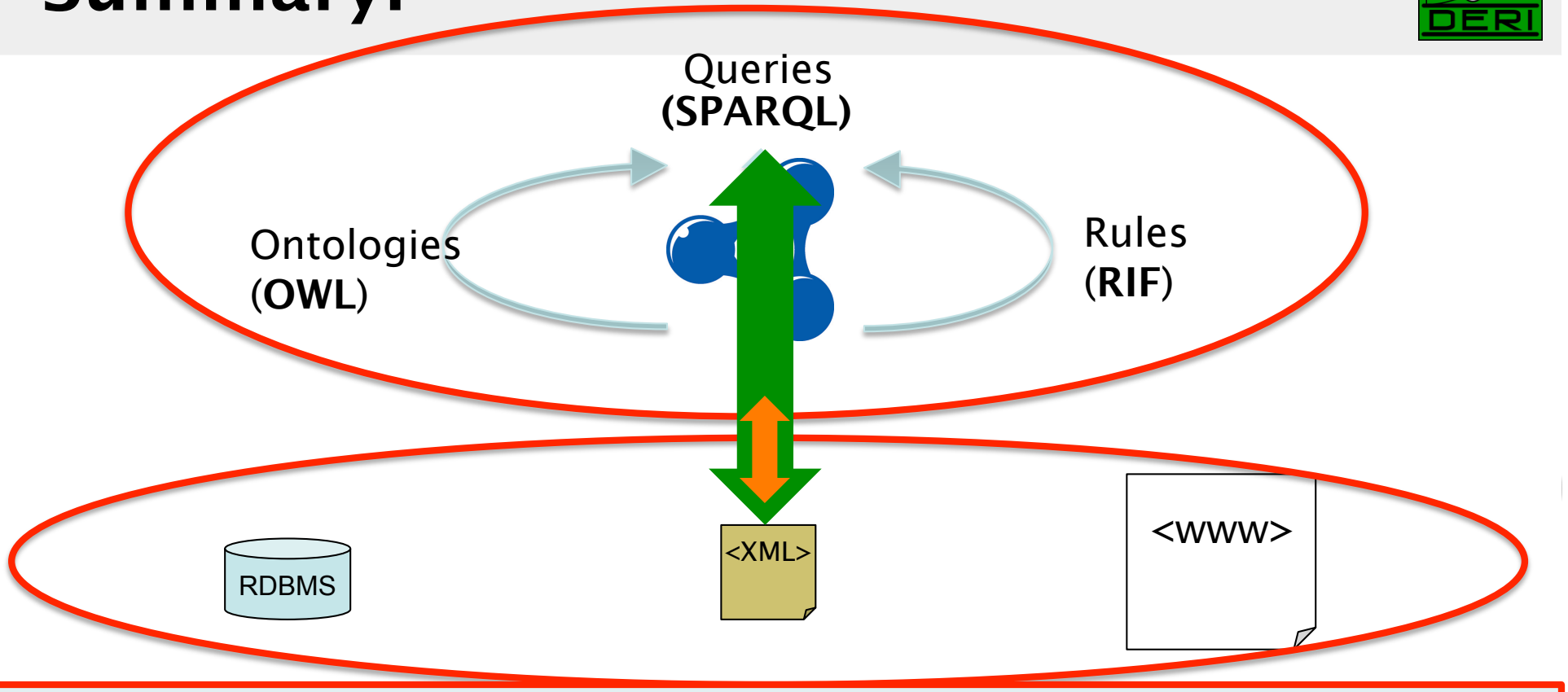
```
<relations>
{ for $Person $Name
  from <relations.rdf>
  where { $Person foaf:name $Name }
  order by $Name
  return
    <person name="{$Name}">
    {for $Fname
     where {
        $Person foaf:knows $Friend .
        $Friend foaf:name $Fname }
     return <knows>{$FName}</knows>
     } </person>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

# Summary:




One Unified RDF/XML/RDB Query Layer to combine XQuery+SPARQL+GRDDL+SQL ?

- Enable optimisation across layers
- query each source format in native language instead of multistep transformation via "narrow" interfaces (e.g. SPARQL→ SPARQL-Resuly/XML→ Xquery/XSLT)
- Enable declarative view (a la Relational Algebra for core fragment of the language)
- Tighter integration of various source formats that populate the (Semantic) Web
- This needs a cross-activity effort in W3C? Semantic Web + XML + others?

# 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>
```

# Nesting,scope of RDF dataset…



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

```
<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>
```

- 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:

- We need to add Dataset to the dynamic environment in the semantics.
- We need a special SPARQL implementation that allows several calls to the same active graph.

# 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 need new datatype RDFTerm

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

# Use: SIOC-2-RSS



- XSPARQL+SIOC enables **customised RSS export**:

```
<channel>
<title>
        {for $name
         from <http://www.johnbreslin.com/blog/index.php?sioc_type=site>
         where { [a sioc:Forum] sioc:name $name }
         return $name}
</title>
        {for $seeAlso
         from <http://www.johnbreslin.com/blog/index.php?sioc_type=site>
         where { [a sioc:Forum] sioc:container_of [rdfs:seeAlso $seeAlso] }
return <item>
                {for $title $descr $date
                 from $seeAlso
                 where { [a sioc:Post] dc:title $title ;
                                       sioc:content $descr;
                                       dcterms:created $date
                 return <title>$title</title>
                        <description>$descr</description>
                        <pubDate>$date</pubDate>}
```

RSS2.0

XSPARQL


*"Great stuff,... I have not seen any SIOC to RSS xslt examples or vice versa" (John Breslin, creator of SIOC)*

# Use: Generate KML from FOAF+Geo:

- XSPARQL+FOAF and GEO data enables **KML map data**:


```
<kml xmlns="http://www.opengis.net/kml/2.2">
{
for $person $name $long $lat
from <http://www.deri.ie/Stefan_Decker>
where { $person; foaf:name $name;
        foaf:based_near [ 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>
```

XML ↔ SPARQL ↔ RDF