Multi-agent and Semantic Web Systems: Linked Open Data

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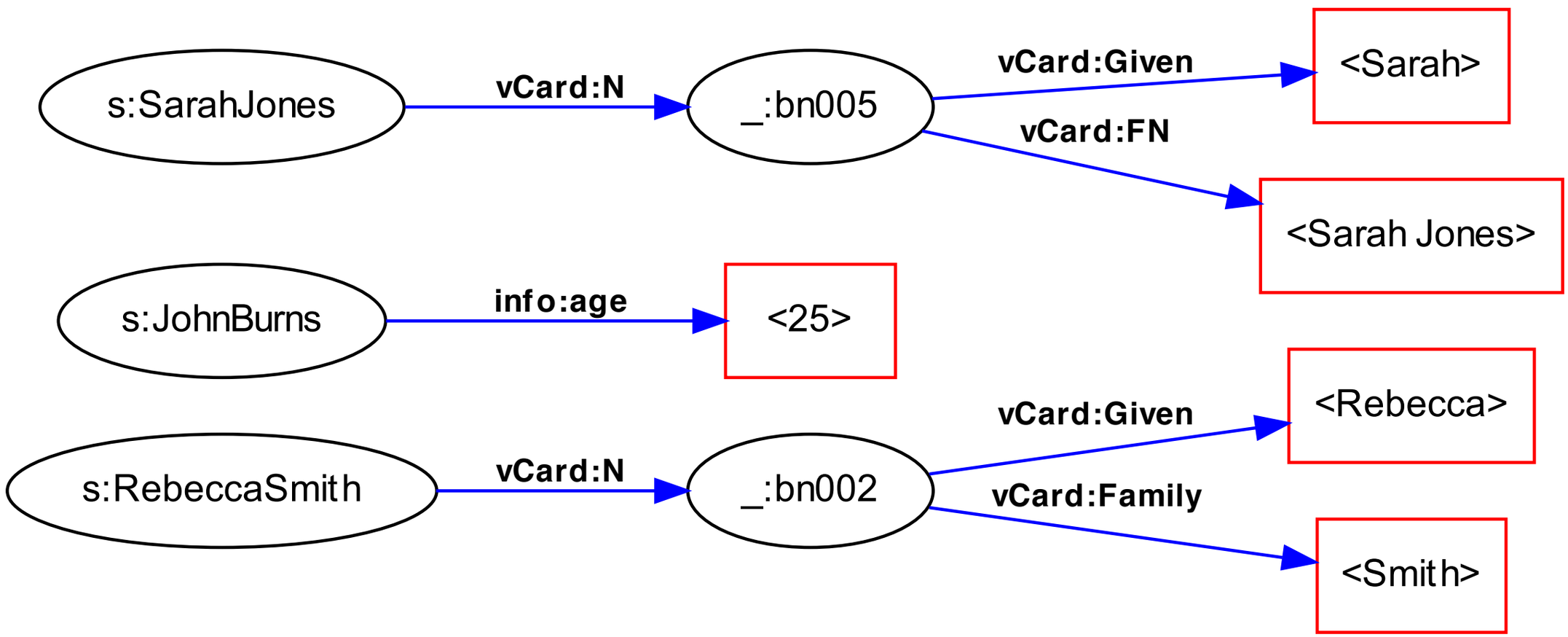
Jena Vcard 1: Triples

N3 Triples

```
@prefix vCard:   <http://www.w3.org/2001/vcard-rdf/3.0#> .
@prefix info:    <http://somewhere/peopleInfo#> .
@prefix s:       <http://somewhere/> .

s:RebeccaSmith
      vCard:N [ vCard:Family ”Smith” ;
                vCard:Given ”Rebecca”
              ] .
s:SarahJones
      vCard:N [ vCard:FN ”Sarah Jones” ;
                vCard:Given ”Sarah” ] .
s:JohnBurns
      info:age 25 .
```

Jena VCard 1: Graph



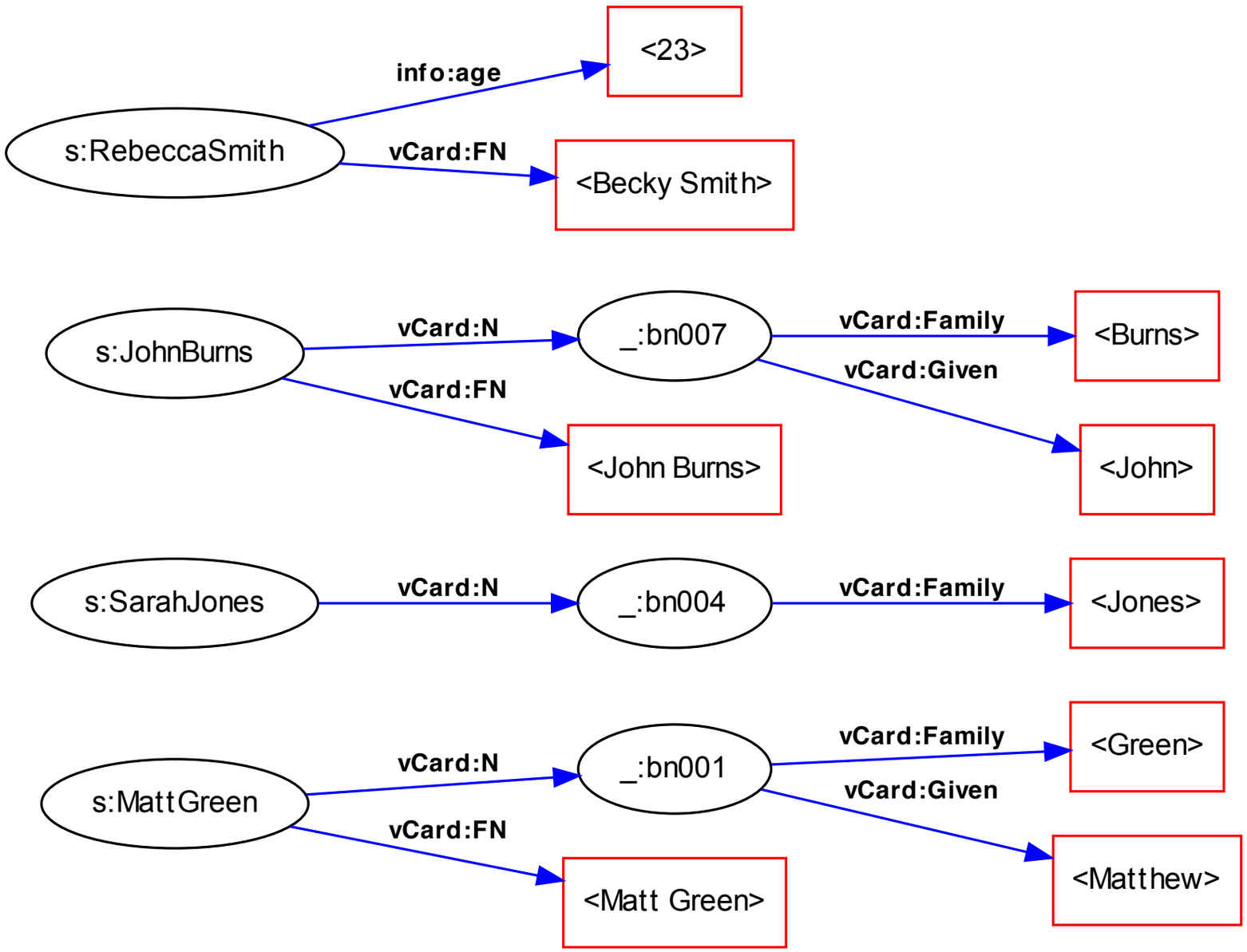
Jena VCard 2: Triples

N3 Triples

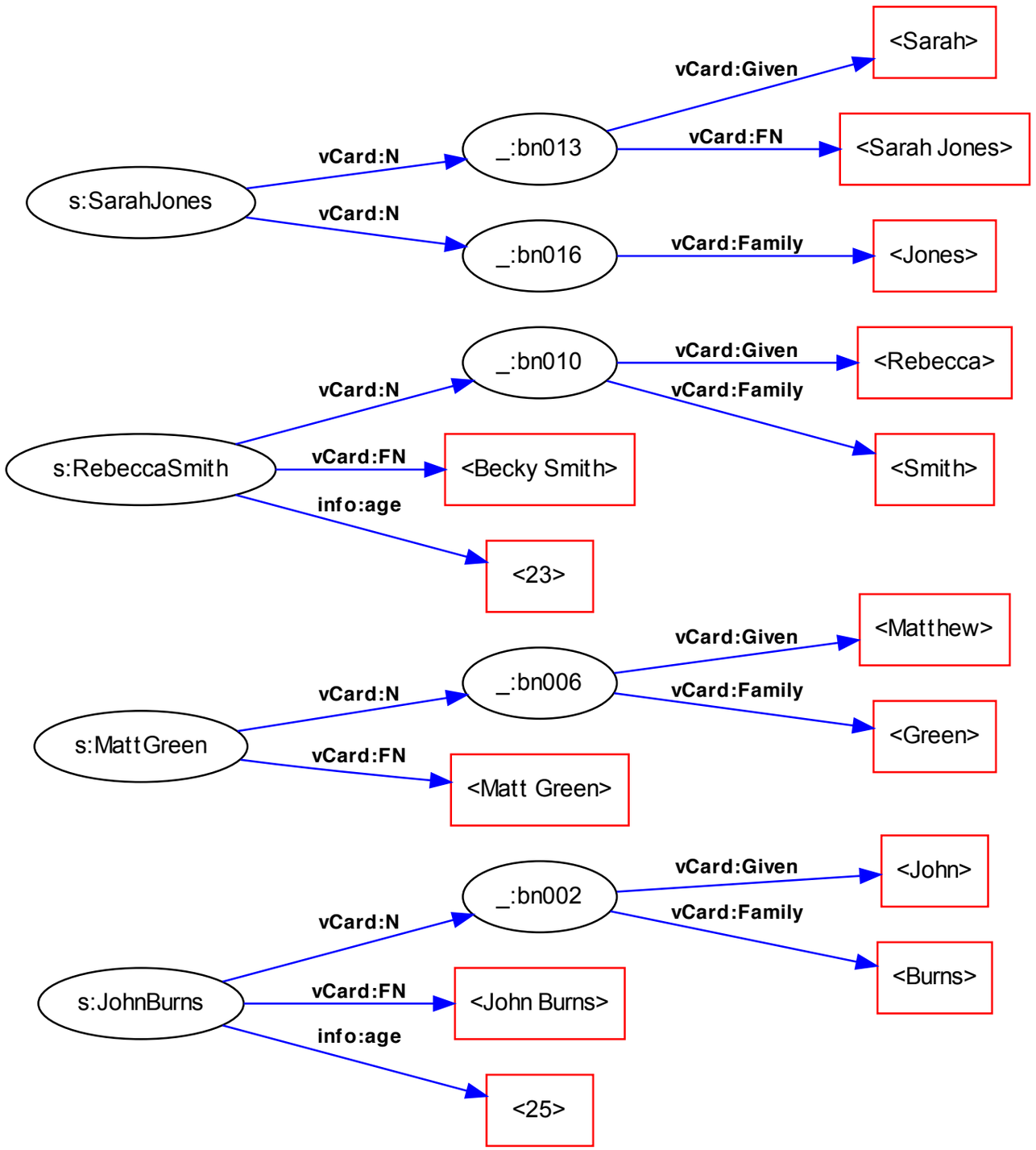
```
@prefix vCard:   <http://www.w3.org/2001/vcard-rdf/3.0#> .
@prefix info:    <http://somewhere/peopleInfo#> .
@prefix s:       <http://somewhere/> .

s:RebeccaSmith
      info:age 23 ;
      vCard:FN ”Becky Smith” .
s:MattGreen
      vCard:FN ”Matt Green” ;
      vCard:N [ vCard:Family ”Green” ;
                vCard:Given ”Matthew”] .
s:SarahJones
      vCard:N [ vCard:Family ”Jones” ] .
s:JohnBurns
      vCard:FN ”John Burns” ;
      vCard:N [ vCard:Family ”Burns” ;
                vCard:Given ”John” ] .
```

Jena VCard 2: Graph



Jena VCard Merged: Graph



Jena VCard: Merged

- Note problem with trying to merge blank nodes.
- rdfcat is one way of merging:

```
rdfcat file1 file2 > mergedfile
```

- Visualization:
  - IsaViz (www.w3.org/2001/11/IsaViz/) — also does merging
  - Protegé (uses Graphviz)
  - RDFS Explorer http://xml.mfd-consult.dk/ws/2003/01/rdfs/

Query

N3 Triples

```
PREFIX info:         <http://somewhere/peopleInfo#>
PREFIX vcard:       <http://www.w3.org/2001/vcard-rdf/3.0#>

SELECT ?name ?age
WHERE
{
    ?person vcard:FN  ?name .
    ?person info:age ?age .
}
```

Query

Results

```
-----------------------
| name           | age |
=======================
| "John Burns"   | 25  |
| "Becky Smith"  | 23  |
-----------------------
```

- This query only returns people for whom we have age information.
- What if we want to return people and also ages just when it is available?

Query

Results

```
-----------------------
| name           | age |
=======================
| "John Burns"   | 25  |
| "Becky Smith"  | 23  |
-----------------------
```

- This query only returns people for whom we have age information.
- What if we want to return people and also ages just when it is available?
- Use the `OPTIONAL` keyword.

Query

N3 Triples

```
PREFIX info:        <http://somewhere/peopleInfo#>
PREFIX vcard:      <http://www.w3.org/2001/vcard-rdf/3.0#>

SELECT ?name ?age
WHERE
{
    ?person vcard:FN  ?name .
    OPTIONAL { ?person info:age ?age }
}
```

Query

Results

```
----------------------
| name           | age |
======================
| "John Burns"   | 25  |
| "Matt Green"   |     |
| "Becky Smith"  | 23  |
| "Sarah Jones"  |     |
----------------------
```

- RDF is semi-structured data

- `OPTIONAL` gives SPARQL the ability not to fail a query when specific data does not exist.

Linked Data Principles

- Use URIs as names for things.
- Use HTTP URIs, so that people can look up those names
- When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL)
- Include links to other URIs, so that they can discover more things.

Why HTTP URIs?

- Globally unique names can be created in a decentralised fashion by domain name owners; no central naming authority is required.

- Not just a name, but a means of accessing information describing the identified entity.

URIs

Homepage of School of Informatics

`http://www.inf.ed.ac.uk`

Homepage of Ewan Klein

`http://www.inf.ed.ac.uk/people/staff/Ewan_Klein.html`

- These URIs point to web documents - or in the terminology of WebArch, information resources.
  - by definition, all its essential characteristics can be conveyed in a message
- Web clients request a representation of a resource
- One and the same resource might have different representations; e.g., text in English, Greek, Chinese, etc.

Content Negotiation

- HTTP clients send HTTP headers with each request to indicate what kinds of documents they prefer
- Servers inspect headers and select an appropriate response.
- Client can say prefers language X over Y.
- Or prefers RDF over HTML

Header of GET request

```
GET /people/staff/Ewan_Klein.html HTTP/1.1
Host: www.inf.ed.ac.uk
Accept: text/html, application/xhtml+xml
Accept-Language: en, gr, cn
```

Server Response

```
HTTP/1.1 200 OK
Content-Type: text/html
Content-Language: gr
```

URIs for Things

- We need mechanisms to ensure that when URIs are dereferenced,
  - real-world objects are not confused with documents that describe them, and
  - humans as well as machines can retrieve appropriate representations.

- Two strategies for deferencing URIs for real world objects:
  - 303 URIs
  - hash URIs

Solution 1: 303 (See other) URIs

- Server should not return a `200 OK` for a real-world object URI — it doesn't have a representation of the resource.

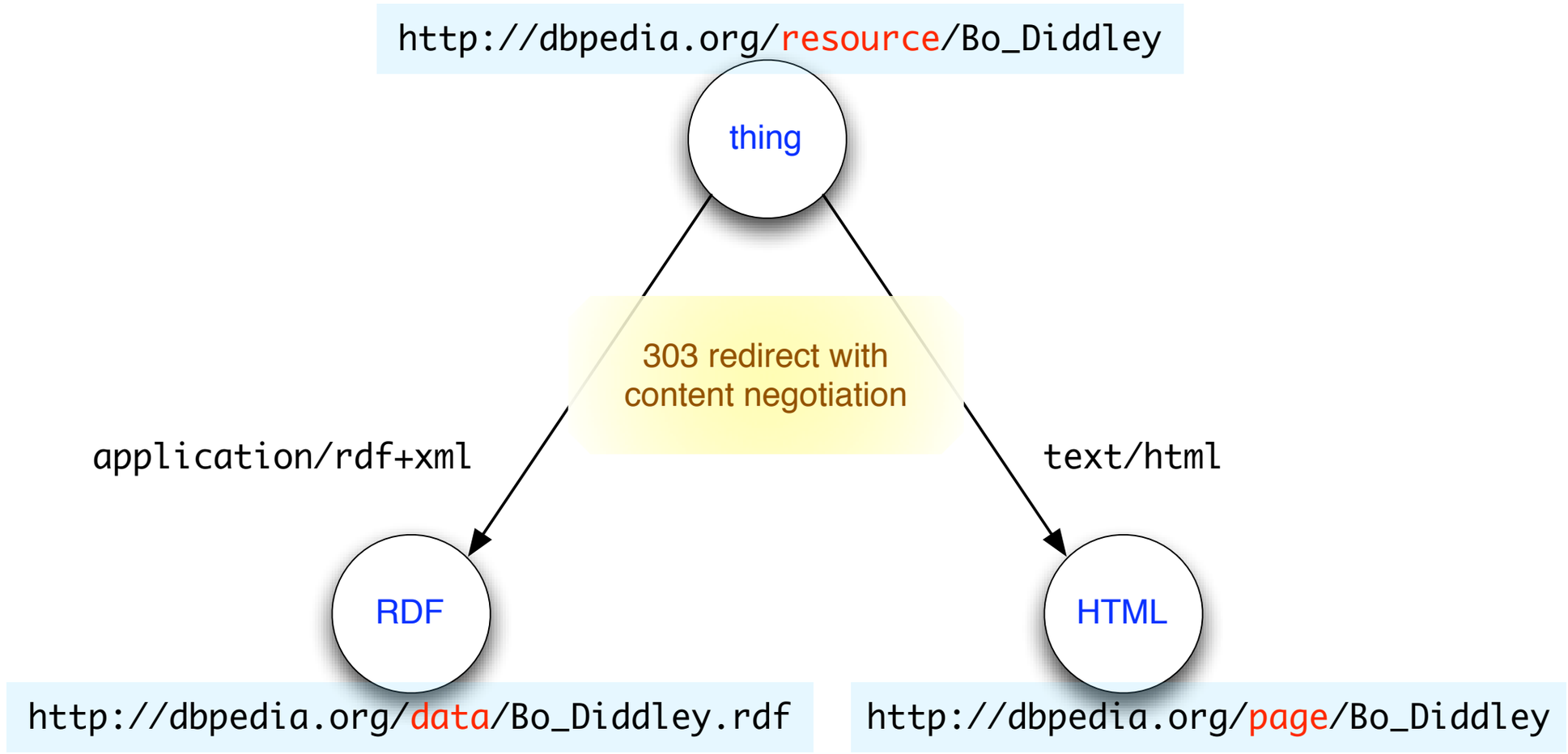
- Instead (cf. httpRange-14 resolution), server should send `303 See Other` plus the URI of a web document that describes the object; this is also called a 303 redirect

- Client then dereferences this new URI and gets a description of the resource.

DBPedia URIs for Real-world Objects

```
http://dbpedia.org/resource/Bo_Diddley [resource]
http://dbpedia.org/data/Bo_Diddley.rdf [RDF description]
http://dbpedia.org/page/Bo_Diddley [HTML description]
```

Solution 1: 303 (See other) URIs



Solution 1: Hash URIs

Server Response

`http://homepages.inf.ed.ac.uk/ewan/foaf.rdf #ehk`

- Use 'hash URIs' for non-document resources, i.e., add a fragment, indicated by #

- Following HTTP protocol, clients must strip off the fragments before sending request to server.

- So the URI with the fragment cannot be retrieved directly and cannot therefore identify a Web document.

- So hash URI can identify real-world objects without creating ambiguity.

Hash v 303

- Hash URIs reduce number of HTTP requests; *cf* `http://www.w3.org/TR/cooluris/#choosing` for arguments in favour.

- But all resources that share same hash URI dereference to same description document; can mean lots of redundant data is transmitted.

- 303 redirects can be configured separately for each resource.

- Some data publishers (e.g., `http://kasabi.com/doc/api/linked-data` don't support hash URIs).

5-★ Data


LINKED DATA
On the web, open licens
Machine-readable data
Non-proprietary format
RDF standards
Linked RDF
YOUR DATA 5 ★?

Is Your Data 5-★ ?

★	Data available on the web (in whatever format), but with an open licence
★ ★	Available as machine-readable structured data (e.g. Excel instead of image scan of a table)
★ ★ ★	as ★★ plus: Use non-proprietary data format (e.g. CSV instead of Excel)
★ ★ ★ ★	All the above plus: Use open standards from W3C (e.g. HTTP URIs) to identify things, so that people can point at your stuff
★ ★ ★ ★ ★	All the above, plus: Link your data to other people's data to provide context

RDF for Linked Data

RDF is standardly used for Linked Data. Advantages include:

- Easy to insert RDF links between data from different sources.
- Information from different sources can be combined by graph merging.
- Information using different schemas can be expressed in a single graph, i.e., by mixing different vocabularies.
- Data can be tightly or loosely structured.

Features of RDF that are avoided:

- Reification (hard to query with SPARQL)
- Collections and containers (ditto). Use multiple triples with same predicate instead.
- Blank nodes: makes merging less effective.

Kinds of Links

Relationship Links point at related things in other data sources. LD counterpart to outgoing hyperlinks in a web document. E.g., `foaf:based_near dbpedia:Edinburgh`

Identity Links point at URI aliases used by other data sources to identify the same real-world object or abstract concept.

Vocabulary Links point from data to the definitions of the vocabulary terms that are used to represent the data.

Identity Links

- Many different URIs used to refer to same real-world object.
- Standard mechanism for saying that two URI aliases refer to same object: `http://www.w3.org/2002/07/owl#sameAs`.
- Motivations for this approach:
  - Different aliases can be dereferenced to different description of same resource (AAA principle).
  - Can support provenance for LD consumers: trace back to who published the URI.
  - Having only one, canonical, URI for each object would require centralised naming authority, and act as barrier to spread of web of data.

Potential problems:

- Identity may be context dependent
- Facts vs. opinions

Summary

Stuff we looked at today:

- Adding RDFS schema information
- Graph merging
- Graph visualisation
- SPARQL OPTIONAL
- URIs for informational vs. real-world objects
- LOD principles for publishing data

Linked Data Summary

- Structured data is made available on web (i.e., open) in many formats: CSV, Excel, HTML Microdata (e.g., http://schema.org/), web APIs, PDF tables (shudder), ...

- Advantages of Linked Data:
  - A unifying data model (RDF)
  - A standardised data access mechanism (HTTP).
  - Hyperlink-based data discovery: links connect all Linked Data into a single global data space and enable Linked Data applications to discover new data sources at run-time.
  - Self-descriptive data: vocabulary definitions are recoverable like other data, and vocabulary terms can be linked to one another

Linked Data Summary

- Linked data adopts perspective of data integration.
- Not interested in reasoning aspect of Semantic Web.

http://blog.paulwalk.net/2009/11/11/linked-open-semantic/:

- Data can be open, while not being linked.
- Data can be linked, while not being open.
- Data which is both open and linked is increasingly viable.
- The Semantic Web can only function with data which is both open and linked.