RDF and Relational Databases

Mapping Relational data to RDF

Suppose we have data in a relational database that we want to export as RDF

1. Choose an RDF vocabulary to represent the data
2. Define a mapping from the relational tables to RDF

Then either:

a) Materialize the RDF triples from the database using the mappings

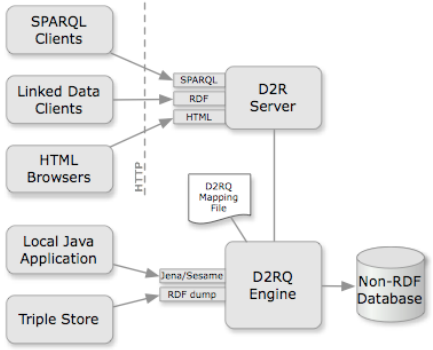
b) Use a server to dynamically access the relational data given a SPARQL query

c) Use a DBMS that directly supports RDF (e.g., Oracle 11g, DB2)

D2RQ

- D2RQ exposes relational data as RDF
- see http://d2rq.org/

- *D2RQ mapping language file* describes the relation between ontology and RDB
- *D2R server* provides HTML and linked data views and a SPARQL 1.1 endpoint
- *D2RQ engine* uses mappings to rewrite Jena & Sesame API calls to SQL queries and generates RDF dumps in various formats



D2RQ Features

- Browsing database contents: Web interface for navigation through the RDF contents for people
- Resolvable URIs: D2R Server assigns a resolvable URI to each entity in the database
- Content negotiation: HTML & RDF versions share URIs; HTTP content negotiation fixes version
- SPARQL: Both an endpoint & explorer provided
- BLOBs andCLOBs: Support for serving up values as files (e.g., PDFs, images)
- Not surprisingly, no inferencing

D2RQ Mapping Language

- The mapping is defined in RDF
- D2RQ can generate a default mapping using a standard heuristic
  - Each database table has information about one type of thing
  - Each row in a table represents one object
  - The first column is the key => defines the object
  - The other columns represent properties
- You can edit the default mapping or create your own by hand

A simple database

```
mysql> use lab; show tables;
+---------------+
| Tables_in_lab |
+---------------+
| people        |
+---------------+
mysql> desc people;
+--------+-------------+------+-----+---------+-------+
| Field  | Type        | Null | Key | Default | Extra |
+--------+-------------+------+-----+---------+-------+
| Name   | varchar(50) | NO   | PRI |         |       |
| Age    | int(11)     | YES  |     | NULL    |       |
| Mobile | varchar(50) | YES  |     | NULL    |       |
+--------+-------------+------+-----+---------+-------+
mysql> select * from people;
+---------------+------+--------------+
| Name          | Age  | Mobile       |
+---------------+------+--------------+
| Al Turing     |   32 | 443-253-3863 |
| Don Knuth     |   25 | 410-228-6282 |
| Chuck Babbage |   38 | 410-499-1282 |
+---------------+------+--------------+
```

The default model

- The *people table* has info of things of type people *<http://ebiq.org/o/labvocab/resource/people>*
- Each row in the table has information about one instance of a person
- The first column is the key and is used both
  - As the identifier for a person instance *<http://localhost/people/Chuck_Babbage>*
  - For the rdf:label for a person instance
- Properties of a person are: name, age & mobile <http://ebiq.org/o/labvocab/resource/people_Age>

The database table

```
mysql> use lab; show tables;
+---------------+
| Tables_in_lab |
+---------------+
| people        |
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+--------+-------------+------+-----+---------+-------+
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| Age    | int(11)     | YES  |     | NULL    |       |
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+--------+-------------+------+-----+---------+-------+
mysql> select * from people;
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+---------------+------+--------------+
```

Generating RDF mappings

- D2RQ can generate a default mapping directly from the database

```
% generate-mapping –u demo –p demo \
    -b http://ebiq.org/o/lab  \
    'jdbc:mysql://127.0.0.1/lab'
```

- The –b arg is the base url for the RDF vocabulary used in publishing the table
- The last argument is the string that JDBC uses to reference he database table
- The resulting mapping can be edited as desired

The Default D2RQ mapping

```
@prefix ...
Map:database a d2rq:Database;
  d2rq:jdbcDriver "com.mysql.jdbc.Driver";
  d2rq:jdbcDSN "jdbc:mysql://127.0.0.1/lab";
  d2rq:username "demo";
  d2rq:password "demo";
  jdbc:autoReconnect "true";
  jdbc:zeroDateTimeBehavior "convertToNull"; .
map:people a d2rq:ClassMap;
  d2rq:dataStorage map:database;
  d2rq:uriPattern "people/@@people.Name|
urlify@@";
  d2rq:class vocab:people;
  d2rq:classDefinitionLabel "people"; .
map:people__label a d2rq:PropertyBridge;
  d2rq:belongsToClassMap map:people;
  d2rq:property rdfs:label;
  d2rq:pattern "people #@@people.Name@@";.
```

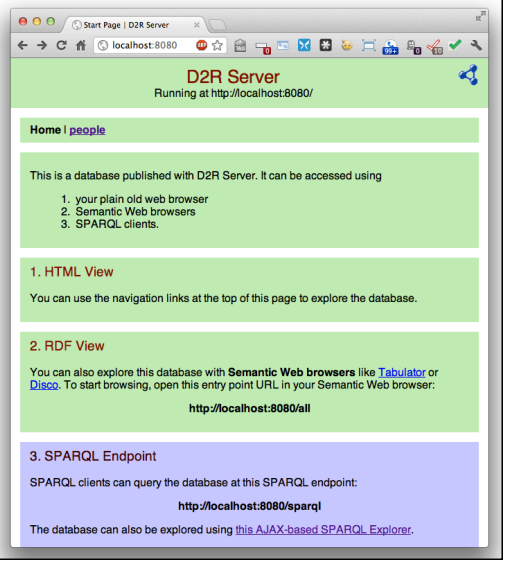
```
map:people_Name a d2rq:PropertyBridge;
  d2rq:belongsToClassMap map:people;
  d2rq:property vocab:people_Name;
  d2rq:propertyDefinitionLabel "people Name";
  d2rq:column "people.Name"; .
map:people_Age a d2rq:PropertyBridge;
  d2rq:belongsToClassMap map:people;
  d2rq:property vocab:people_Age;
  d2rq:propertyDefinitionLabel "people Age";
  d2rq:column "people.Age";
  d2rq:datatype xsd:int; .
map:people_Mobile a d2rq:PropertyBridge;
  d2rq:belongsToClassMap map:people;
  d2rq:property vocab:people_Mobile;
  d2rq:propertyDefinitionLabel "people Mobile";
  d2rq:column "people.Mobile"; .
```

Run the D2RQ Server

```
d2r-server -p 8080 ../mapping-lab.n3
```

Access via D2R server

- Explore via HTML
- Via SPARQL endpoint



Access via D2R server

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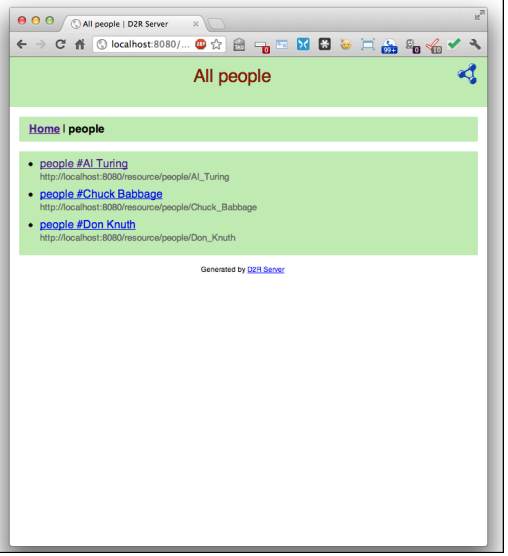
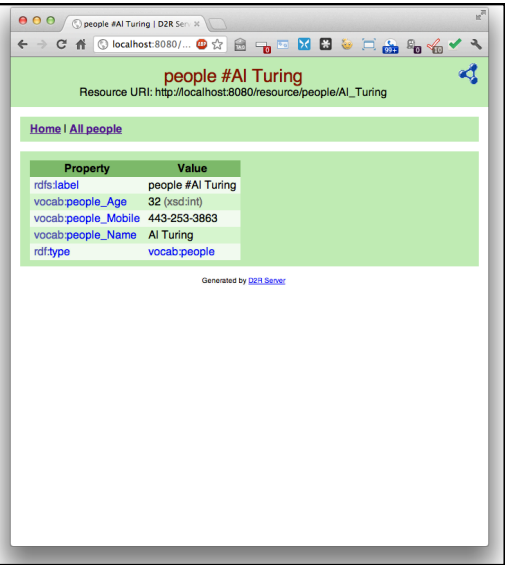
- Via SPARQL endpoint



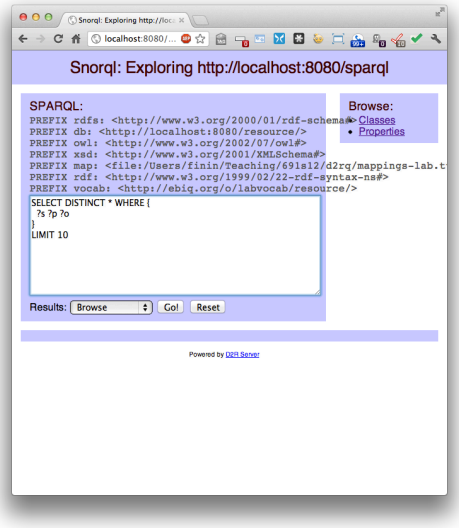
Access via D2R server

- Explore via HTML
- Via SPARQL endpoint



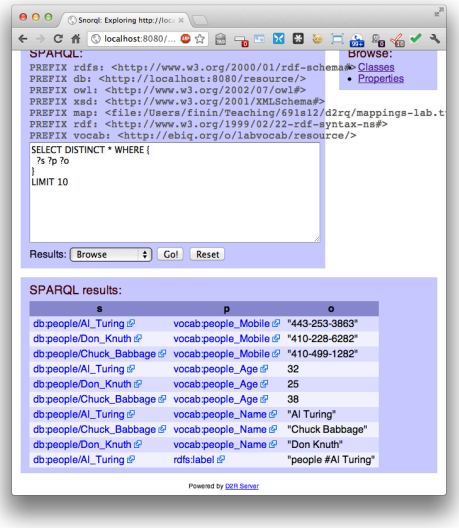
Access via D2R server

Via SPARQL endpoint



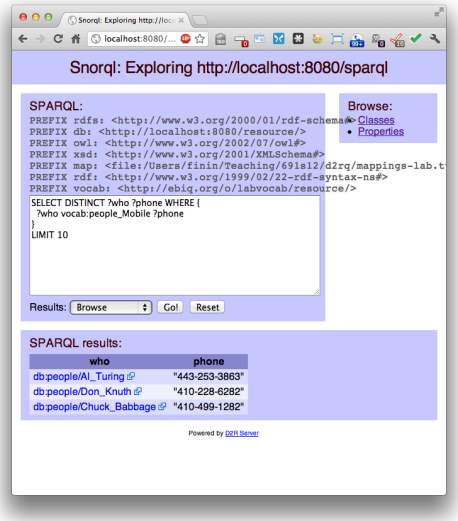
Access via D2R server

Via SPARQL endpoint



Access via D2R server

Via SPARQL endpoint



Content Negotiation

- D2RQ automatically recognizes URIs for
  - Entities (e.g., an RDF object like a class or instance) http://localhost:8080/resource/people/Al_Turing
  - RDF representations http://localhost:8080/data/people/Al_Turing
  - HTML representations http://localhost:8080/page/people/Al_Turing
- The HTTP protocol supports *content negotiation*
- A get request can specify what kind of content it wants, e.g., HTML or RDF

Resources and 303 redirects

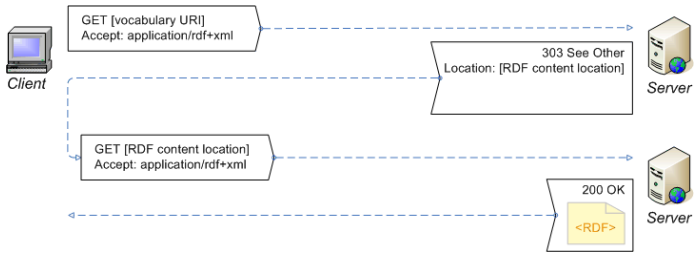
- Asking for a raw resource doesn't make sense – it's just an identifier
- But we can specify in the HTTP header what kind of content we want, e.g. HTML or RDF
- If client gets a 303 (redirect) it knows where to go
- For example:

% curl -H "Accept: text/html" http://localhost:8080/resource/people/Al_Turing
303 See Other: For a description of this item, see http://localhost:8080/page/people/Al_Turing

% curl -H "Accept: application/rdf+xml" http://localhost:8080/resource/people/Al_Turing
303 See Other: For a description of this item, see http://localhost:8080/data/people/Al_Turing

URIs should be de-referenceable

- Linked Data best practice says that LOD URIs should be dereferenceable
- Doing a GET on one should always yield useful information



Asking for RDF data

```
% curl http://localhost:8080/data/people/Al_Turing
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> . …
@prefix vocab:   <http://ebiq.org/o/labvocab/resource/> .
<http://localhost:8080/data/people/Al_Turing>
    rdfs:label "RDF Description of people #Al Turing" ;
    foaf:primaryTopic <http://localhost:8080/resource/people/Al_Turing> .
vocab:people
    rdfs:seeAlso <http://localhost:8080/sparql?query=DESCRIBE+%3Chttp%3A
%2F%2Febiq.org%2Fo%2Flabvocab%2Fresource%2Fpeople%3E> .
<http://localhost:8080/resource/people/Al_Turing>
    a       vocab:people ;
    rdfs:label "people #Al Turing" ;
    vocab:people_Age "32"^^xsd:int ;
    vocab:people_Mobile "443-253-3863" ;
    vocab:people_Name "Al Turing" .
```

Asking for HTML

```
% curl http://localhost:8080/page/people/Al_Turing
<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN" "http://
www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en" lang="en">
  <head>
    <title> people #Al Turing | D2R Server </title>
    <link rel="stylesheet" type="text/css" href="http://localhost:8080/snorql/
style.css" />
    <link rel="alternate" type="application/rdf+xml" href="http://localhost:8080/
data/people/Al_Turing?output=rdfxml" title="This page in RDF (XML)" />
    <link rel="alternate" type="text/rdf+n3" href="http://localhost:8080/data/people/
Al_Turing?output=n3" title="This page in RDF (N3)" />
  </head>
 …
```

The iswc example

- D2RQ comes with a partial example database and mapping for information about ISWC
  - Stop the server
  - d2r-server -p 8080 ../mapping-iswc.n3
  - Visit http://localhist:8080/

ISWC Database

- The ISWC database has partial information about the 2002? Iswc conference
- It's a richer schema going beyond the simple auto generated mapping
- http://sw.cs.technion.ac.il/d2rq/tutorial had detailed instructions on installing on your computer
- And sample queries you can run

```
mysql> use iswc; show tables;
+-------------------------+
| Tables_in_iswc          |
+-------------------------+
| conferences             |
| organizations           |
| papers                  |
| persons                 |
| rel_paper_topic         |
| rel_person_organization |
| rel_person_paper        |
| rel_person_topic        |
| topics                  |
+-------------------------+
9 rows in set (0.00 sec)
```

Generating RDF dumps

- Once the mapping is defined, use dump-rdf to for RDF dumps in various formats
- For example:

```
% dump-rdf -m ../mapping-iswc.n3 -f N3
```

Oracle Database Semantic Data Store

- Introduced in Oracle 10g, also in 11g
- An open and persisted RDF data model and analysis platform for semantic applications
- An RDF Data Model with inferencing (RDFS, OWL and user-defined rules)
- Performs SQL-based access to triples and inferred data
- Combines SQL query of relational data with RDF graphs and ontologies
- Scalable: supports large graphs (billion+ triples)
- Support for Special queries

RDB2RDF Working Group

- http://www.w3.org/2001/sw/rdb2rdf/
- Mission: standardize languages for mapping relational data and schemas into RDF and OWL
- It is developing two languages: R2RML and Direct Mapping
  - Direct mapping is like D2RQ's automatic schema
  - R2RML is the language for expressing custom mappings
- Preliminary recommendations for both were published in March, final recommended status expected in Summer 2012