# INF3580 – Semantic Technologies – Spring 2011

## Lecture 14: Publishing RDF Data on the Web

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# Today's Plan

1. Introduction
2. Linked Open Data
3. From Relational DBs to RDF
4. The D2R/D2RQ System
5. Mapping Files
6. Reasoning about Databases

# Outline

# RDF on the Web

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  - "Linked Open Data" (LOD)

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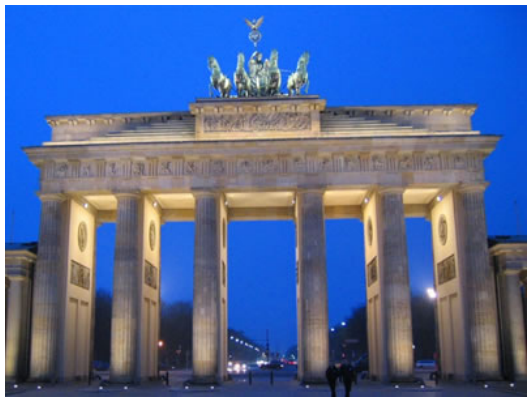
- From the RDF standpoint, all are OK
- In practice, software wants to locate information
  - Protocols like http, ftp, etc. are an advantage

# The Problem

- Need to differentiate between:
  - A web page or RDF file about Berlin
  - The city of Berlin
- e.g. the city was "created" around 1200...
- A URI for Berlin should not be an existing HTTP resource (why?)
- Need another way to retrieve information about a resource



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- Two W3C-recommended solutions:
  - The hash-namespace solution
  - The slash-namespace solution (aka HTTP 303 redirects)
- To fully understand them, we need to have a look at HTTP!

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  - Send:

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GET /martingi/ HTTP/1.1
User-Agent: Mozilla/5.0 (X11; U; Linux i686; ...
Accept: text/html,application/xhtml+xml,...
Accept-Language: no, en
Host: heim.ifi.uio.no
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- Other "methods": `HEAD`, `POST`, `PUT`,...

# HTTP (cont.)

- A typical response to the GET request:

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HTTP/1.1 200 OK
Date: Wed, 05 May 2010 14:15:24 GMT
Server: Apache/2.2.14 (Unix) ...
Content-Length: 14348
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<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01//EN"
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  - `303 See Other`

# Fragment identifiers

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```
@prefix myfoaf:  <http://.../martingi/foaf.rdf#>
myfoaf:me foaf:givenname "Martin" .
```

- This is known as a "hash namespace"

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Location:  http://www.oracle.com/
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```
GET / HTTP/1.1
Host:  www.oracle.com
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- Server at `www.oracle.com` responds:

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

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- Browser can now send a new request for that location:

```
GET /data/Oslo.xml HTTP/1.1
Accept: application/rdf+xml
```

- This time the server responds with the requested document:

```
HTTP/1.1 200 OK
Content-Type: application/rdf+xml
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- Also possible with hash namespaces, see `http://www.w3.org/TR/swbp-vocab-pub/`

# Example: dbpedia.org

- Requesting the URI `http://dbpedia.org/resource/Oslo`

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  - Client requests `http://dbpedia.org/page/Oslo`
  - Server sends HTML document:

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

# Example: dbpedia.org (cont.)

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```
HTTP/1.1 303 See Other
Location: http://dbpedia.org/data/Oslo.xml
```

  - Client requests `http://dbpedia.org/data/Oslo.xml`
  - Server sends RDF/XML document:

```
HTTP/1.1 200 OK
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# Outline

# Relational Database Management Systems

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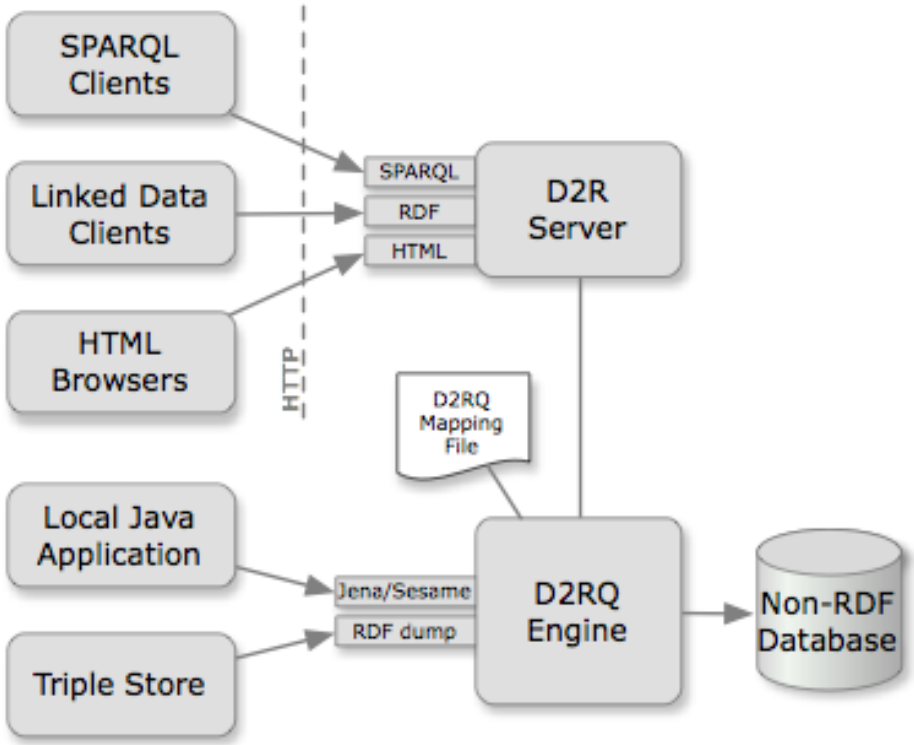
  - Data remains where it is, no duplication
  - Drawback: need to keep "old-fashioned" DB backend

# Outline

# D2R/D2RQ

- Allows to treat relational databases as RDF



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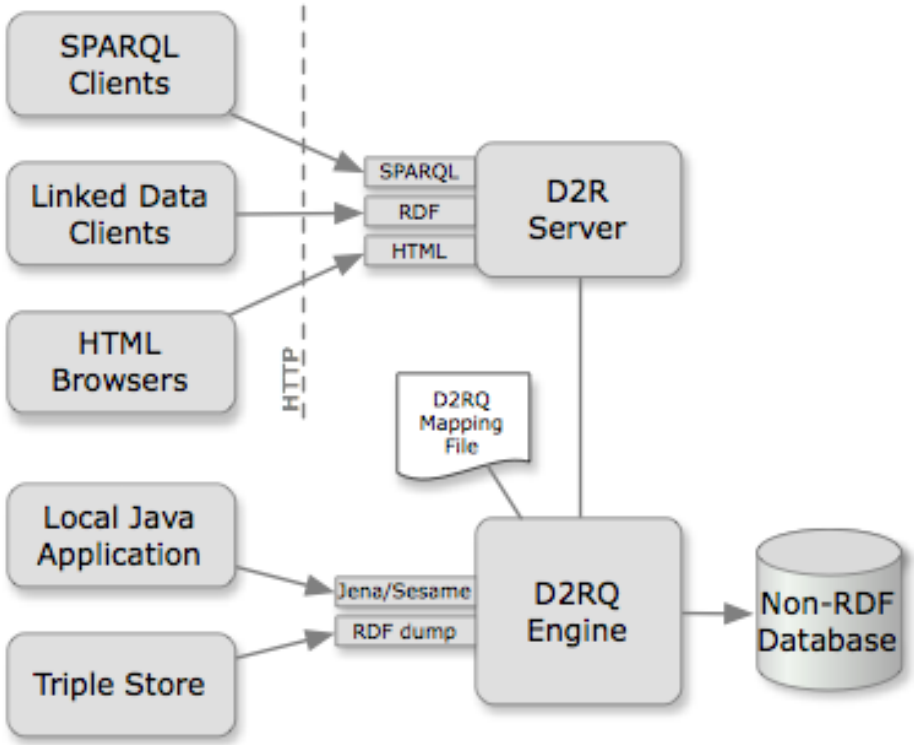

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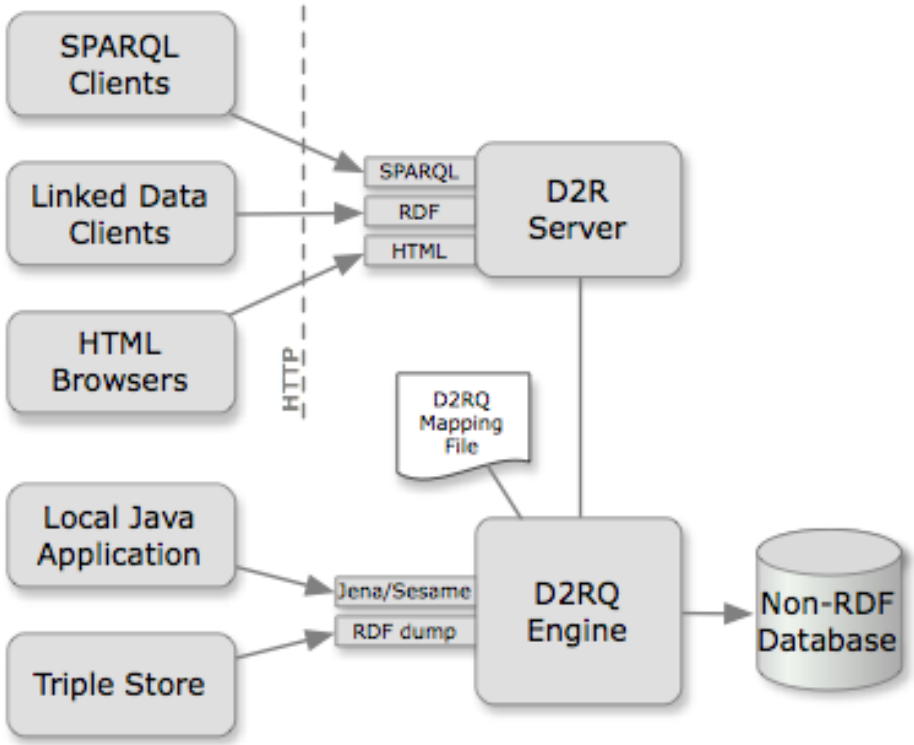

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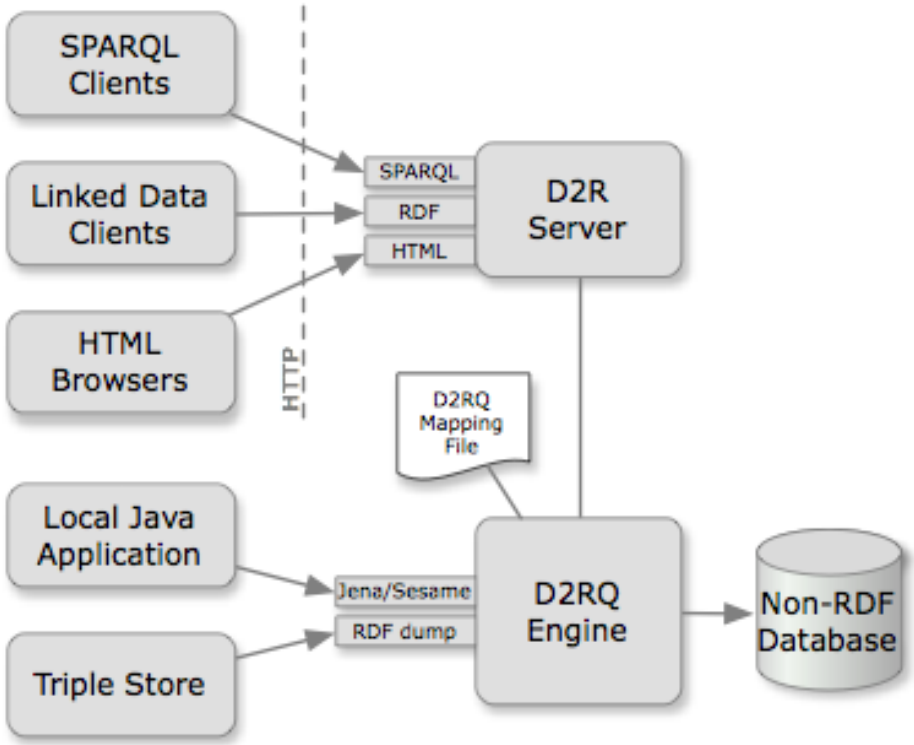

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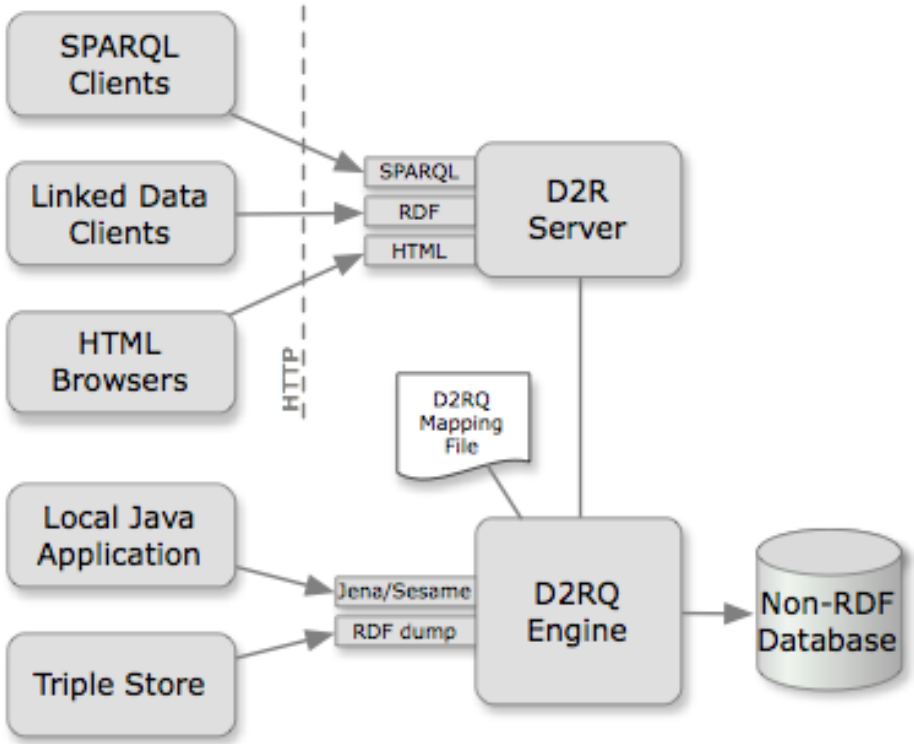
- Also on-demand RDF/HTML pages following LOD protocol



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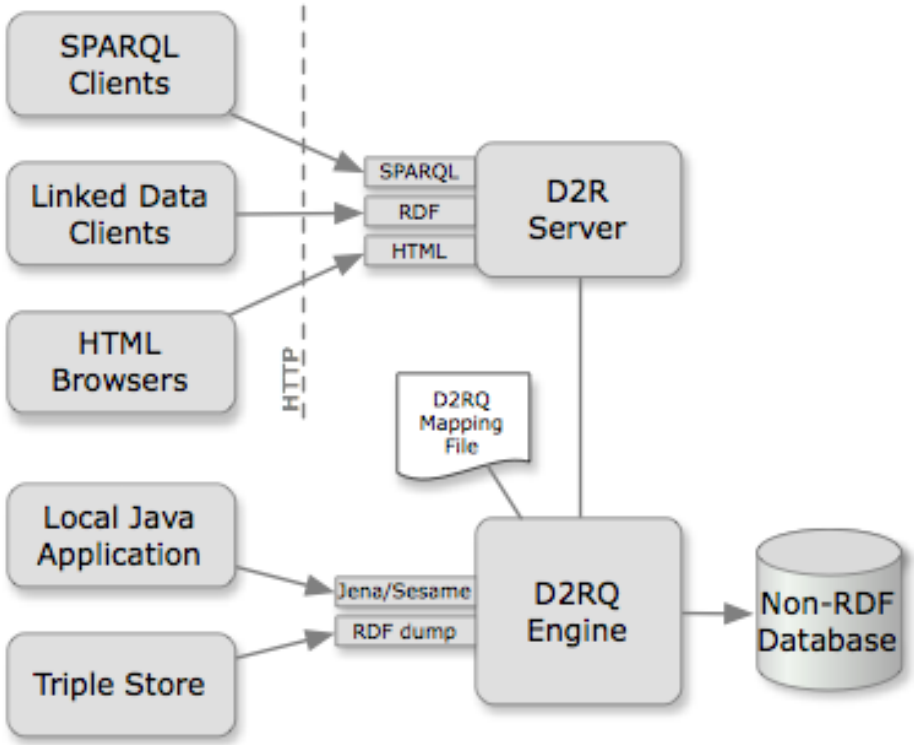

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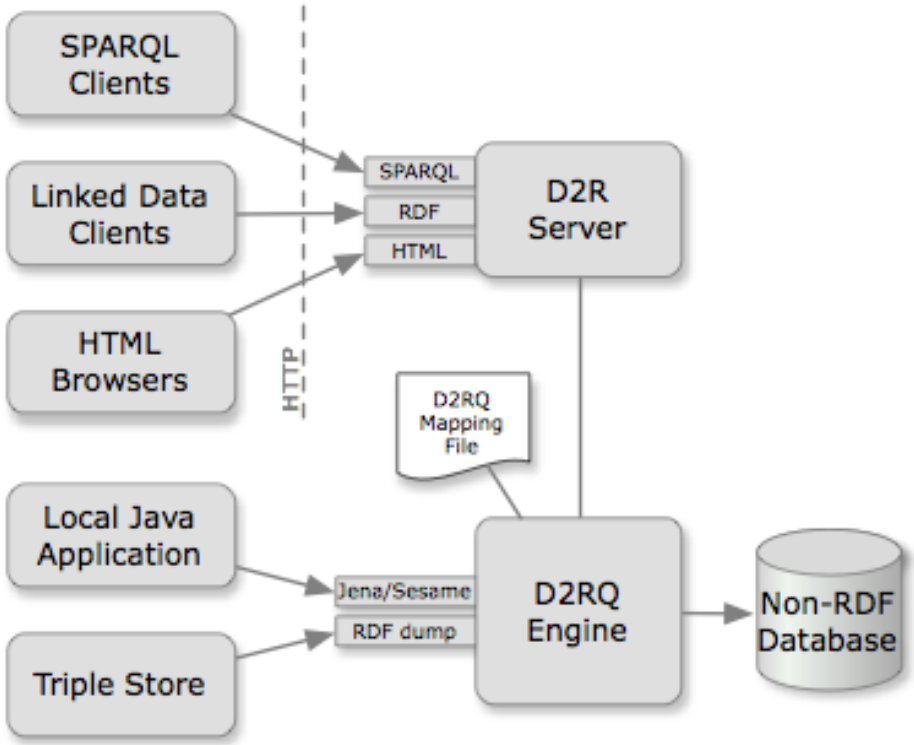
  - Table → Class



# D2RQ Engine

- Reads a "Mapping File"
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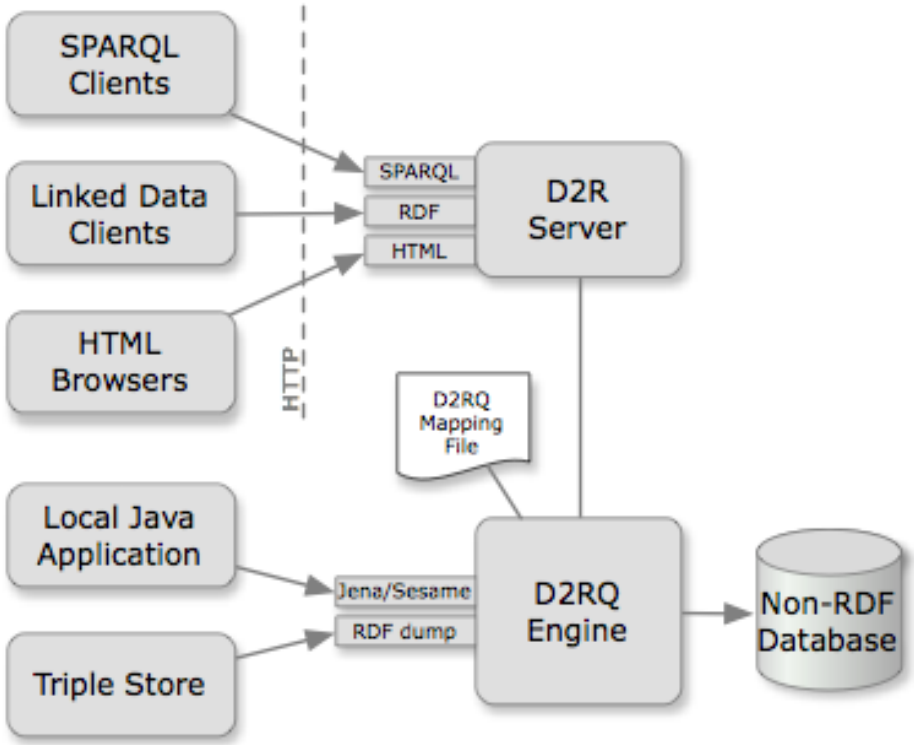
  - Row → Resource



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- Reads a "Mapping File"
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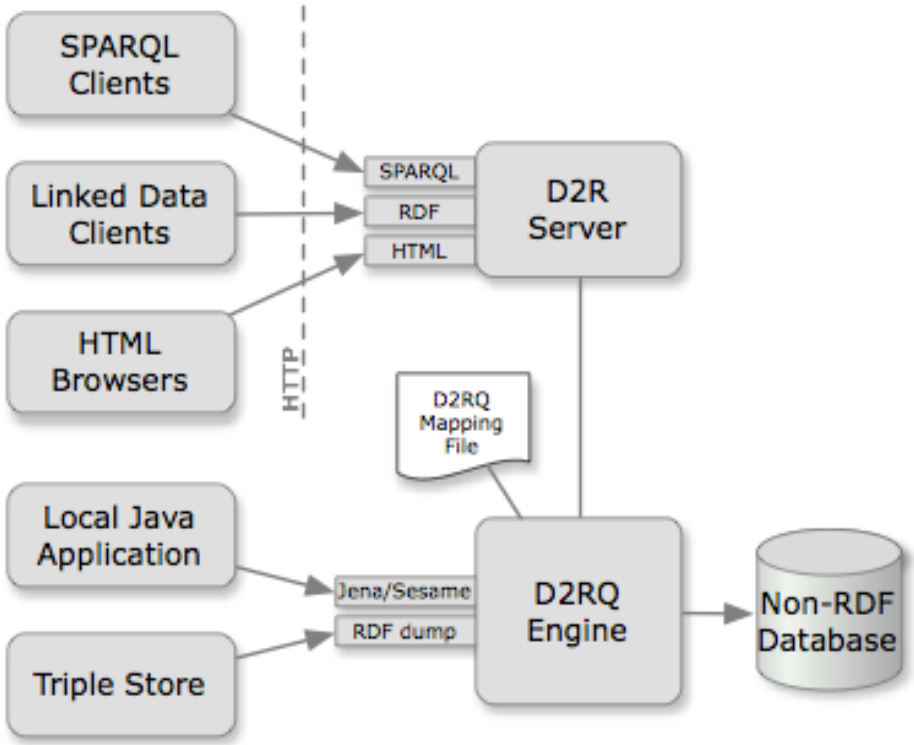
  - Column → Property



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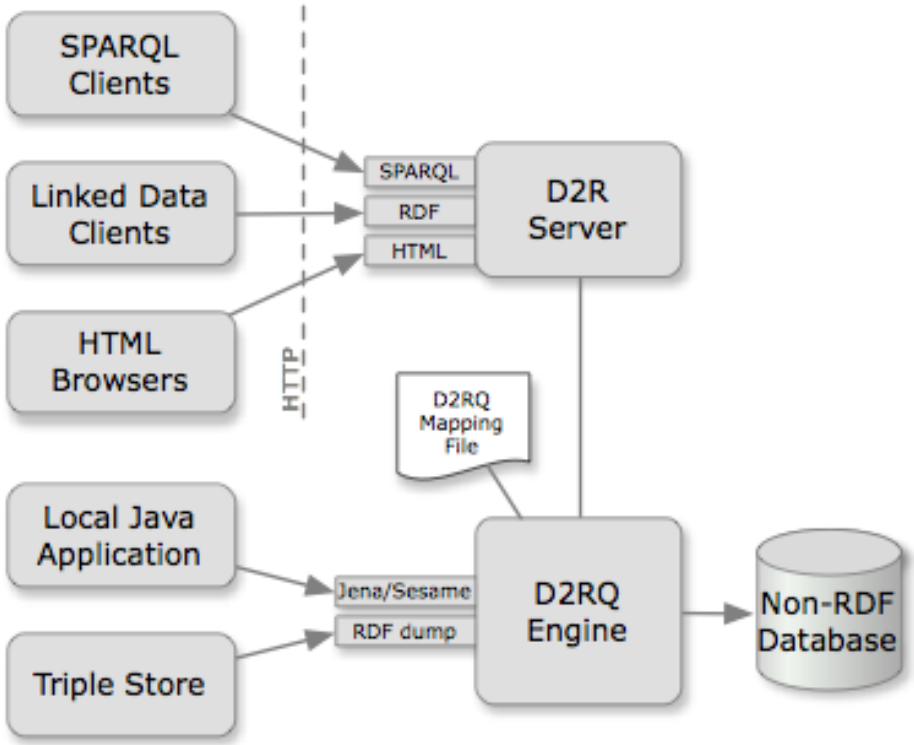
  - RDF-encoded



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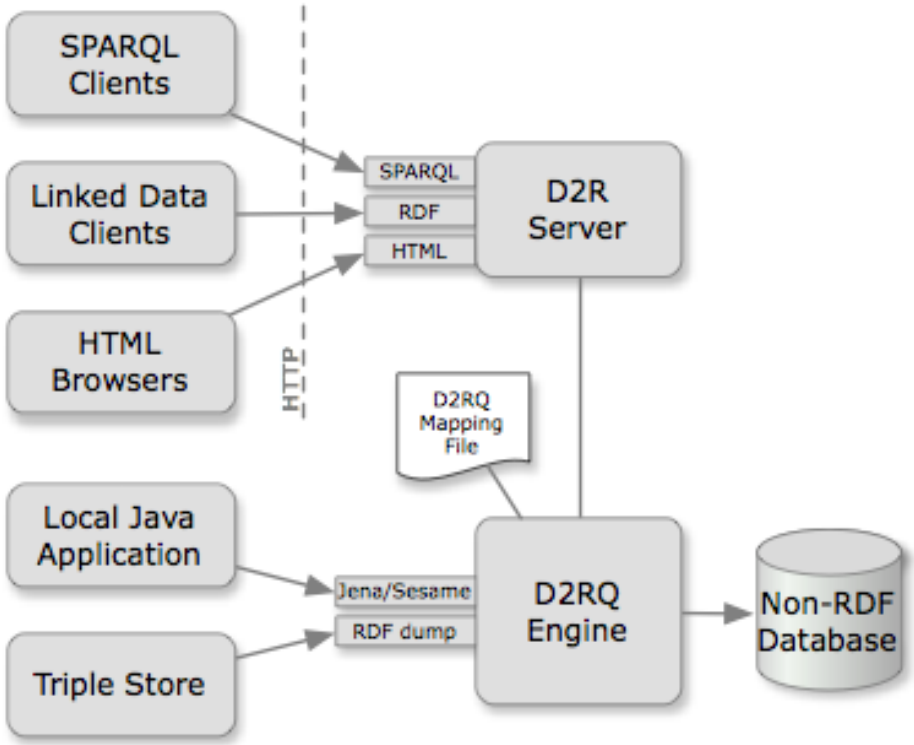
- Translates SPARQL to SQL



# D2RQ Engine

- Reads a "Mapping File"
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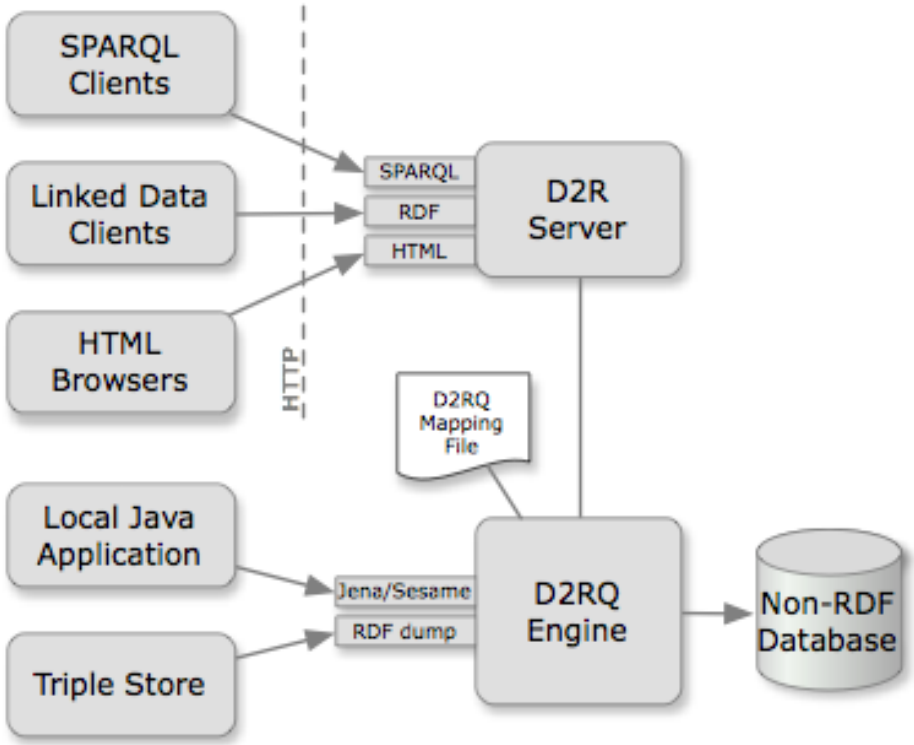
  - Column → Property
  - RDF-encoded
- Translates SPARQL to SQL
- Can also act as Jena Graph



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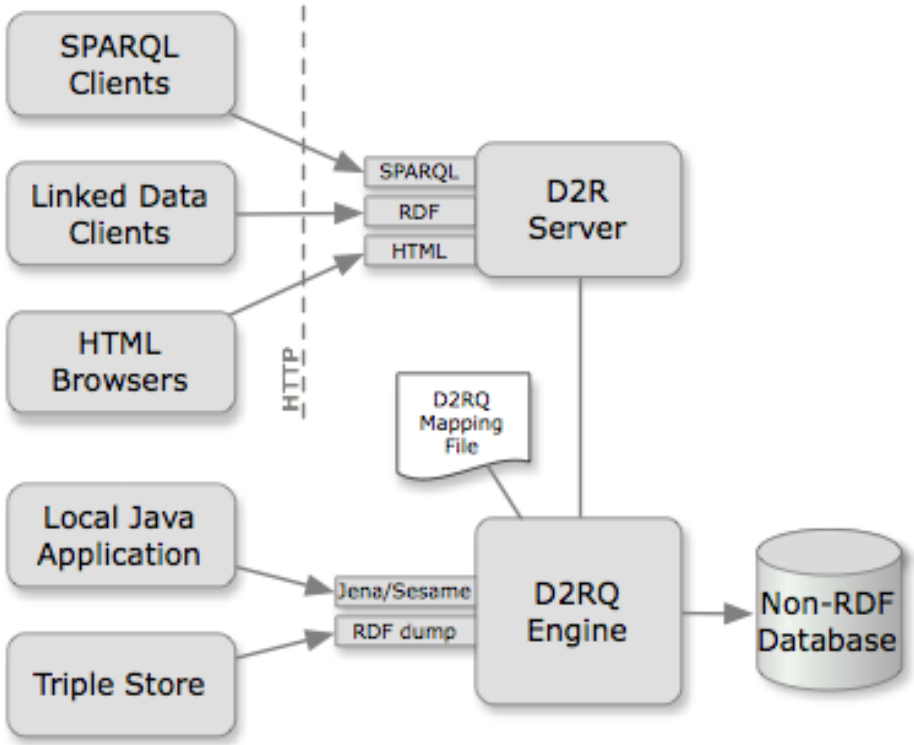

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  - Table → Class
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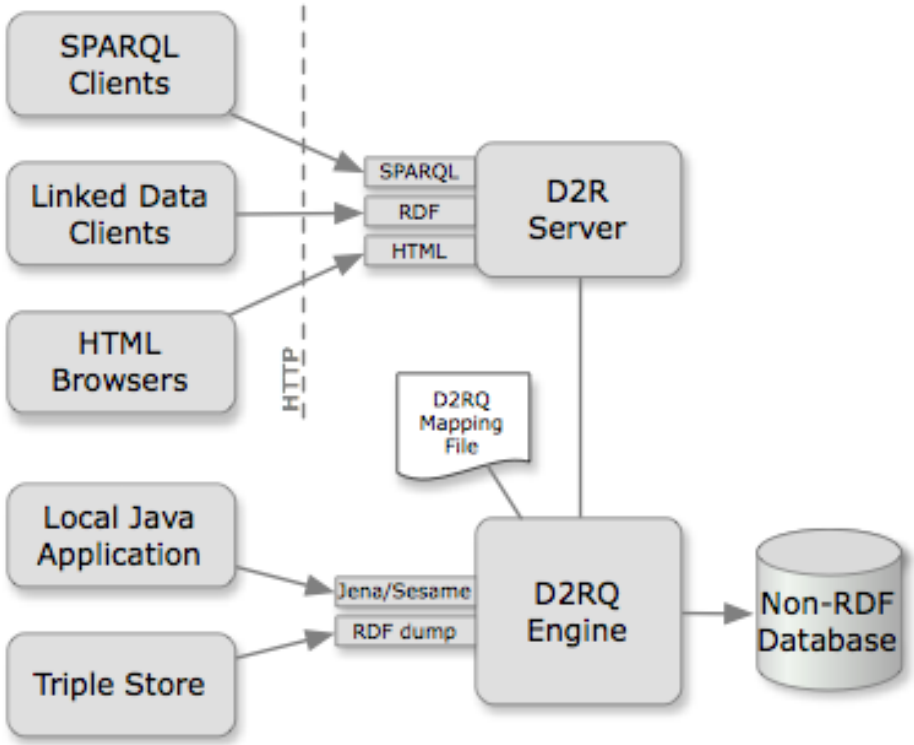
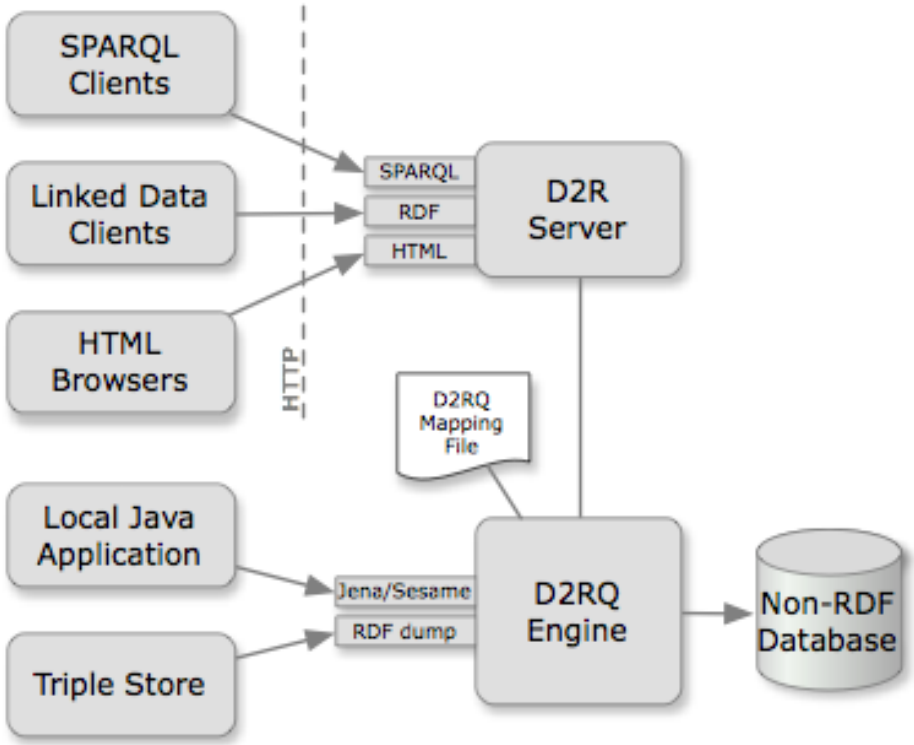
  - RDF-encoded
- Translates SPARQL to SQL
- Can also act as Jena Graph
- Or the Sesame equivalent
- Can also export whole DB



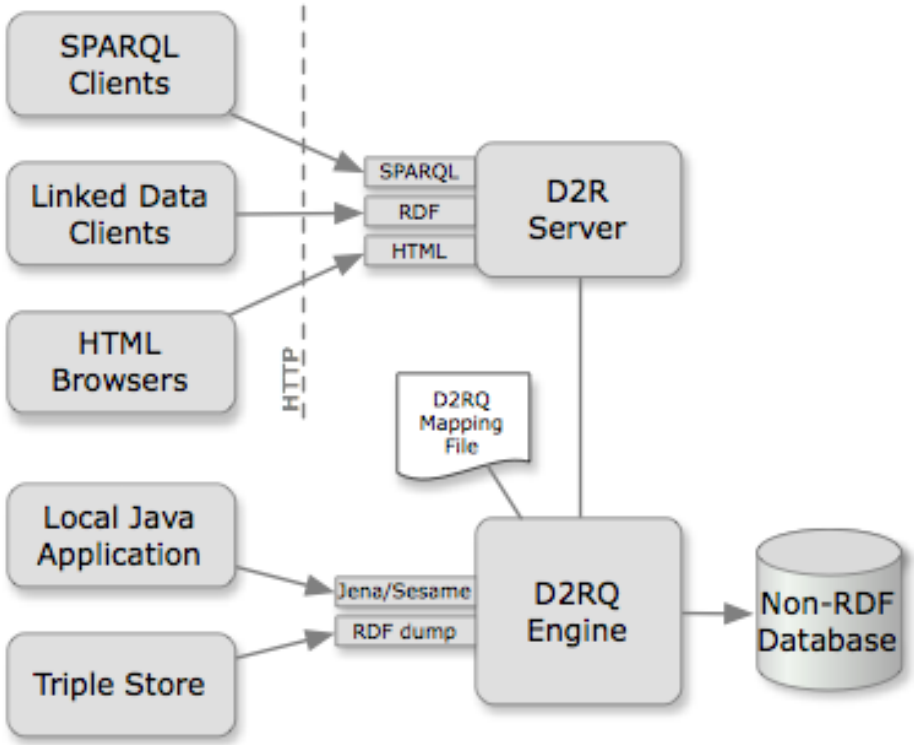
# D2R Server

- Provides WWW-frontend



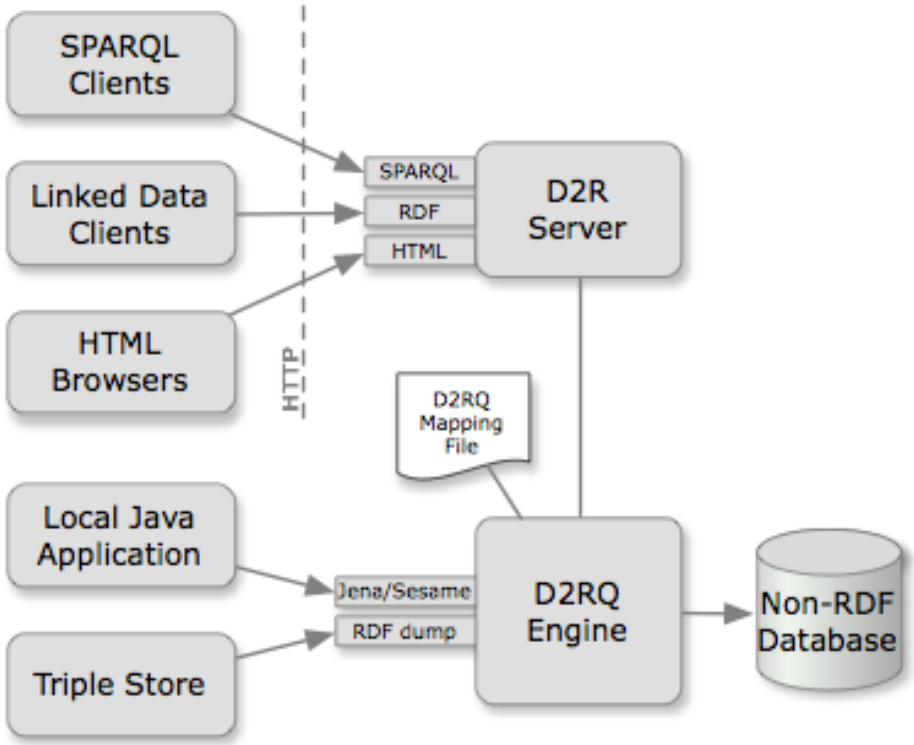
# D2R Server

- Provides WWW-frontend
- SPARQL Endpoint



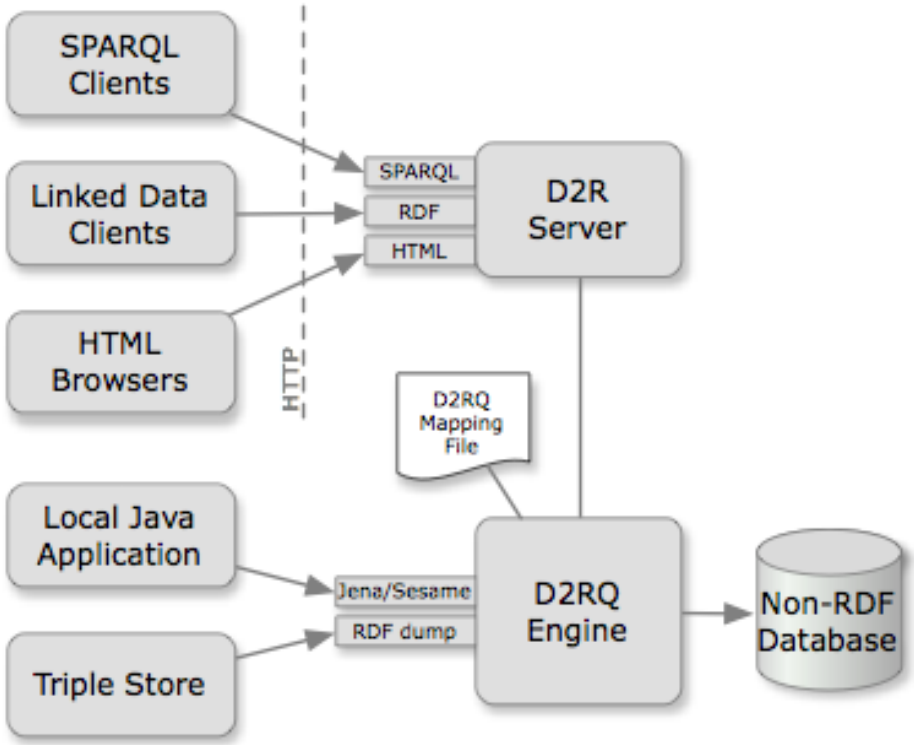
# D2R Server

- Provides WWW-frontend
- SPARQL Endpoint
- Serves RDF as linked open data



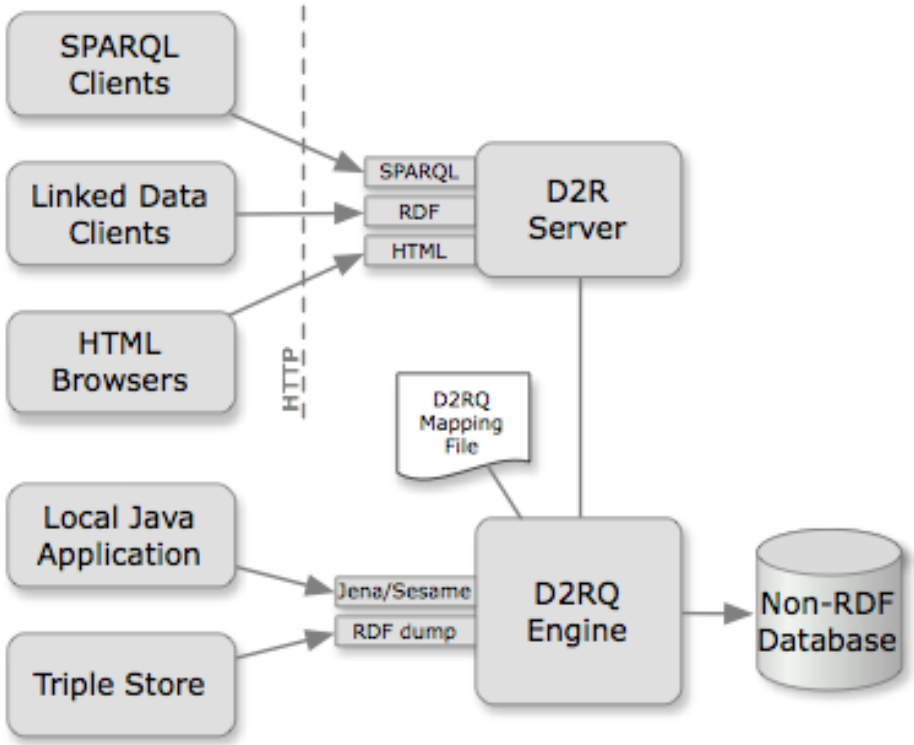
# D2R Server

- Provides WWW-frontend
- SPARQL Endpoint
- Serves RDF as linked open data
- Pages of data for HTTP browsers



# D2R Server

- Provides WWW-frontend
- SPARQL Endpoint
- Serves RDF as linked open data
- Pages of data for HTTP browsers
- All requests translated to SPARQL



# Example: World Database

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  - Capital: the City ID of the country's capital

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# Example: World Database (cont.)

- Table City:

| ID | Name | CountryCode | ... |
|---|---|---|---|
| | | ... | |
| 2806 | Kingston | NFK | ... |
| 2807 | Oslo | NOR | ... |
| 2808 | Bergen | NOR | ... |
| | | ... | |

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| | | ... | |

- Table Country:

| Code | Name | Continent | Capital | ... |
|---|---|---|---|---|
| | | ... | | |
| NLD | Netherlands | Europe | 5 | ... |
| NOR | Norway | Europe | 2807 | ... |
| NPL | Nepal | Asia | 2729 | ... |
| | | ... | | |

# Outline

# Where Classes Come From

- From a mapping file for the World database:

```
map:City a d2rq:ClassMap ;
    d2rq:dataStorage map:database ;
    d2rq:uriPattern "City/@@City.ID@@" ;
    d2rq:class vocab:City ;
    d2rq:classDefinitionLabel "City" .
```

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# Resources for Countries and Continents

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- E.g. `http://.../resource/Continent/North_America`

# Where Properties Go To

- A mapping for city names:

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- Also possible to define literals with patterns containing columns

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- From countries to capitals:

```
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    d2rq:property vocab:capital;
    d2rq:refersToClassMap map:City;
    d2rq:join "Country.Capital=>City.ID";
```

# Resulting Graph

After adding similar mappings for country names and `inContinent`:

```
<http://.../City/2807> a vocab:City ;
        vocab:name "Oslo" ;
        vocab:inCountry <http://.../Country/NOR> .

<http://.../Country/NOR> a vocab:Country ;
        vocab:name "Norway" ;
        vocab:capital <http://.../City/2807> ;
        vocab:inContinent <http://.../Continent/Europe> .
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# Linking to DBpedia

- Add property bridge:

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  - World DB country name: `Sao Tome and Principe`
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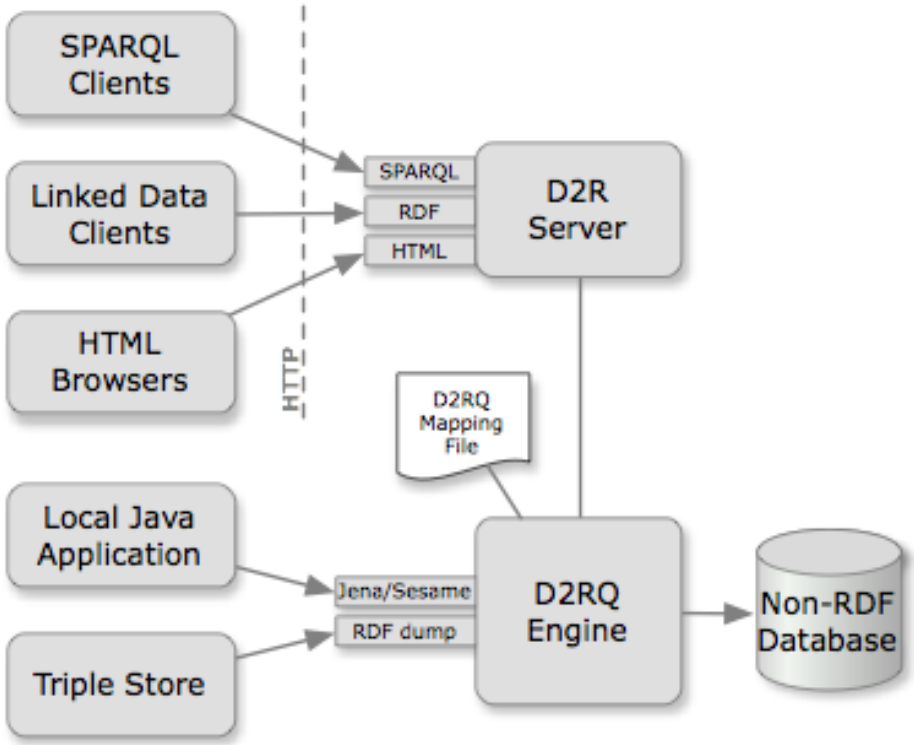
- Better in general to have a DB table with corresponding URIs

# Outline

# The Jena Adapter

- No direct way of adding reasoning to D2R



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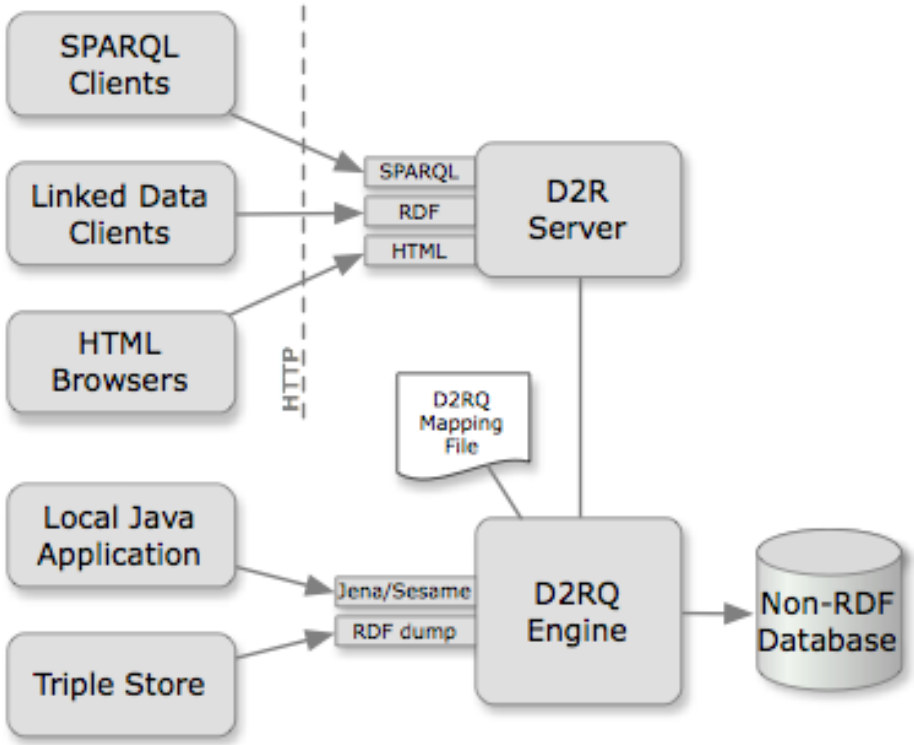

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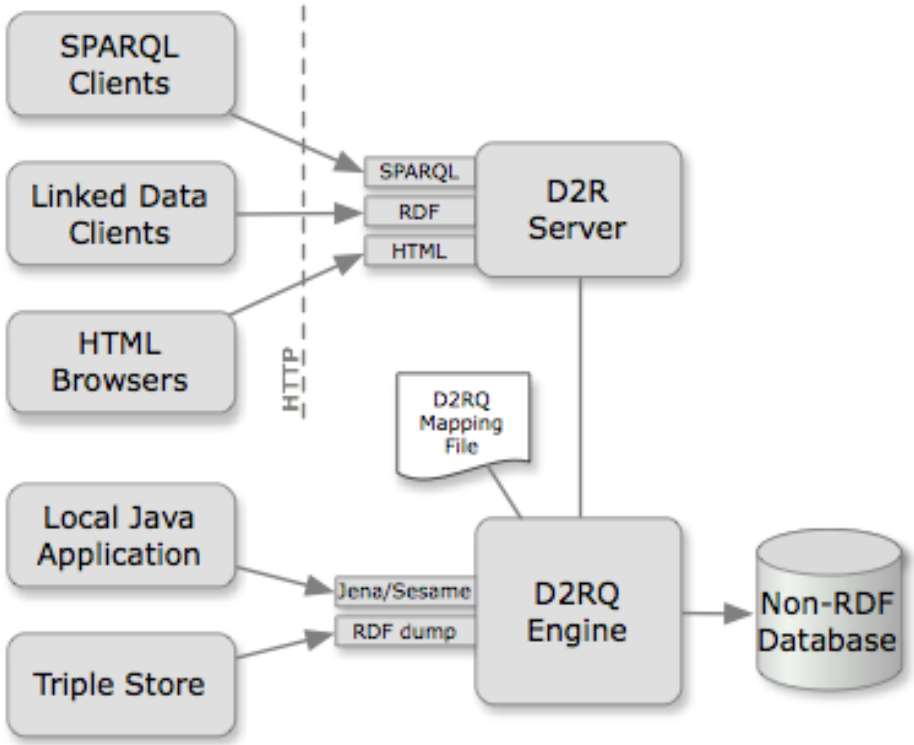

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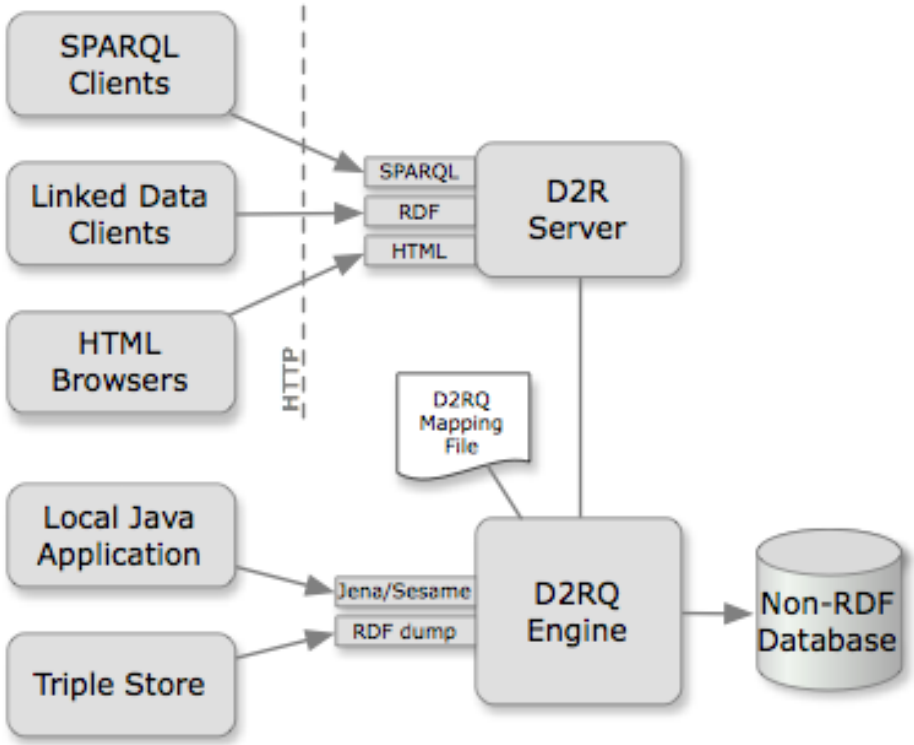

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- Asking `infm` for all objects of type `vocab:Place`...

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- ...and all countries!
- Can use Jena query engine for SPARQL queries with reasoning
- But does it still not read data into memory?

# Forward Chaining vs. Backward Chaining

- Given: reasoning rules, like e.g.:

$$\frac{x \texttt{ rdf:type } C \qquad C \texttt{ rdfs:subClassOf } D}{x \texttt{ rdf:type } D}$$

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- Backward Chaining:
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  - A bit like Prolog!

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- Given triples:

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:City rdfs:subClassOf :Place
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  - Simply look in model:
  - $x \rightarrow$ `:Oslo`

# Example of Backward Chaining

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# Example of Backward Chaining

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# Example of Backward Chaining

- Given triples:

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  - Look for direct occurrences: none

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# Example of Backward Chaining

- Given triples:

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  - E.g. $C \rightarrow$ `:City`, $x \rightarrow$ `:Oslo`
- In general, need to backward-chain over many rules!
  - E.g. $C$ `rdf:subClassOf :Place` could come from other rules

# Forward Chaining vs. Backward Chaining

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  - RDFS reasoner OK for databases
  - Pellet etc. in general not

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