INF3580 – Semantic Technologies – Spring 2010

Lecture 14: Presenting Relational Databases as RDF

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Today's Plan

1. From Relational DBs to RDF
2. The D2R/D2RQ System
3. Customizing Mappings
4. Reasoning about Databases
5. Conclusion

Outline

Relational Database Management Systems

- "Relational" databases introduced in 1970

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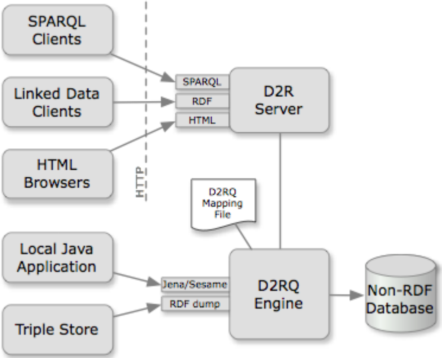
  - Drawback: need to keep "old-fashioned" DB backend

Outline

D2R/D2RQ

- Allows to treat relational databases as RDF



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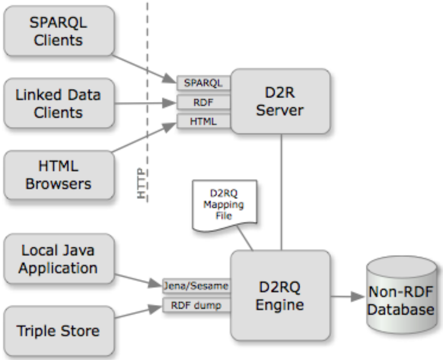

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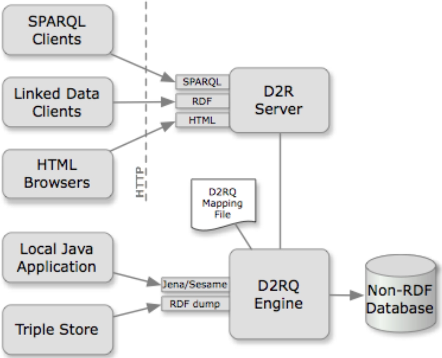

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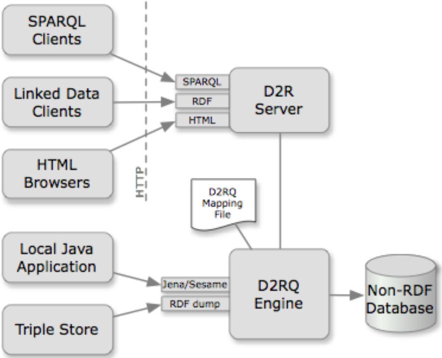

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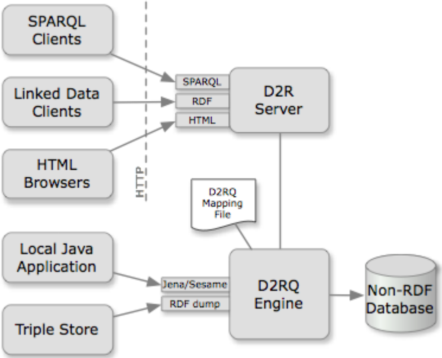
- Also on-demand RDF/HTML pages following LOD protocol



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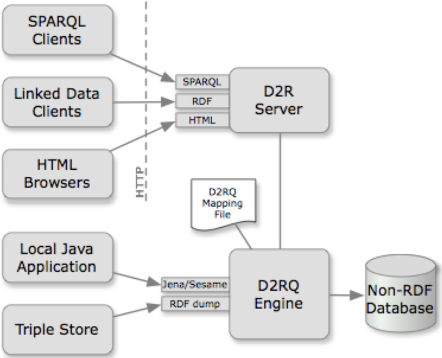

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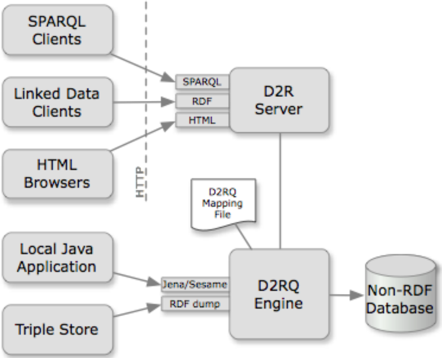

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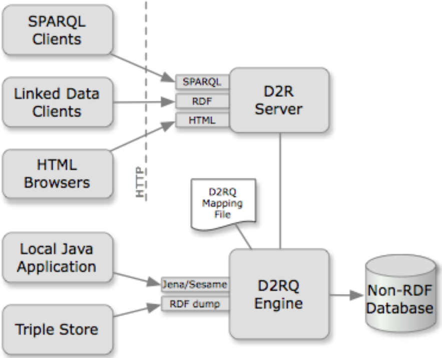

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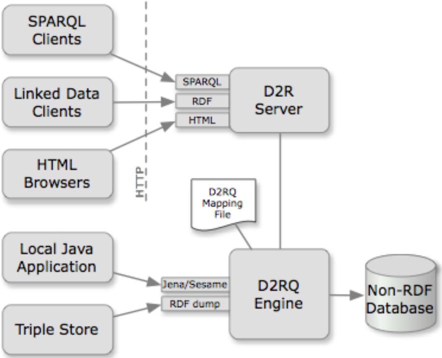

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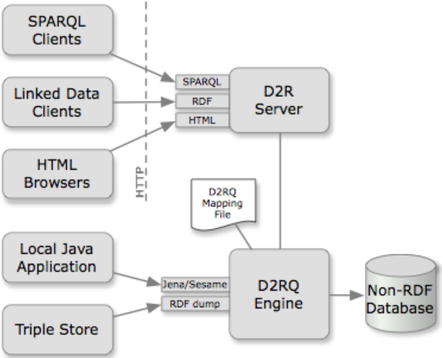

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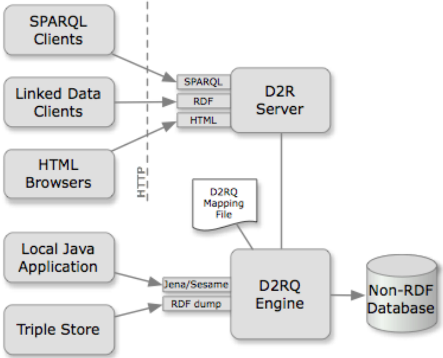

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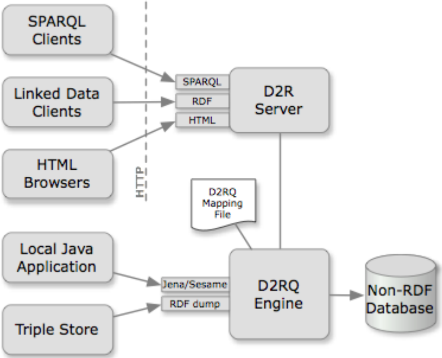

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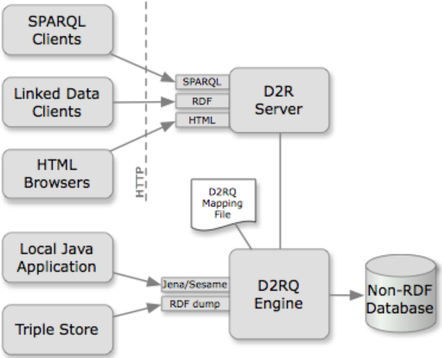

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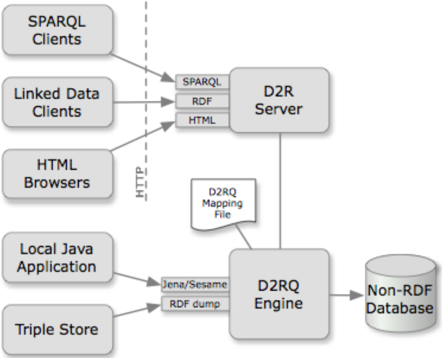
- Can also export whole DB



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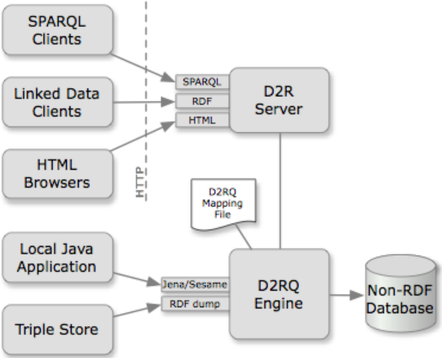

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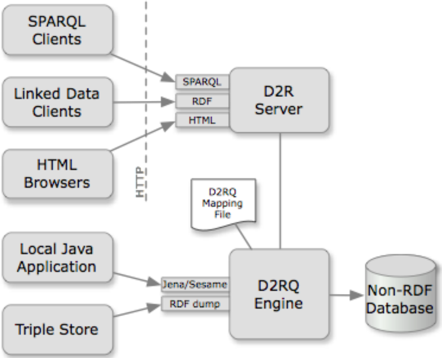

D2R Server

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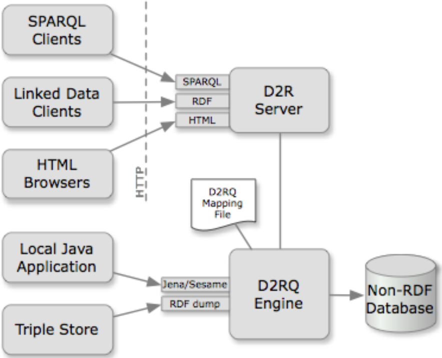
- Serves RDF as linked open data



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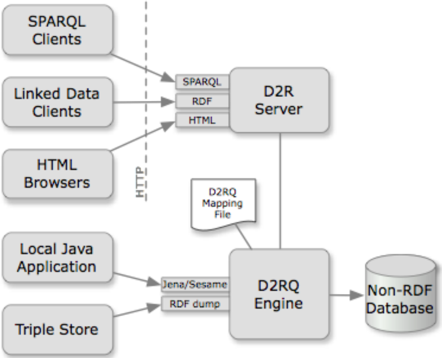

D2R Server

- Provides WWW-frontend
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- Serves RDF as linked open data
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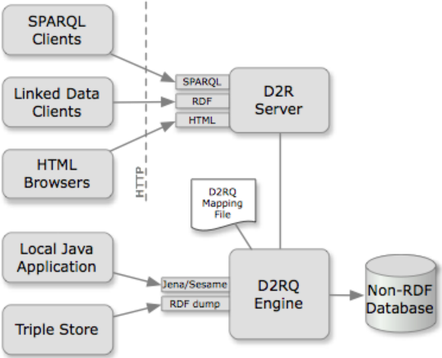
- All requests translated to SPARQL



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

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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	...
		...	

Example: World Database (cont.)

- Table City:

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

- Table Country:

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

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  - plus one `rdfs:label` for every resource
- Uses automatically generated class and property names

Generated RDF for Automatic Mapping

```
<http://.../City/2807> a vocab:City ;
         rdfs:label "City #2807" ;
         vocab:City_Name "Oslo" ;
         vocab:City_CountryCode "NOR" .

<http://.../Country/NOR> a vocab:Country ;
         rdfs:label "Country #NOR" ;
         vocab:Country_Name "Norway" ;
         vocab:Country_Continent "Europe" ;
         vocab:Country_Capital "2807"
```

- Only literals, no URI-links between Oslo and Norway
- No attempt to introduce a class for continents
- Solution: refine the generated mapping file manually

Outline

Where Classes Come From

- From the generated mapping file:

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map:City a d2rq:ClassMap ;
    d2rq:dataStorage map:database ;
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- give the RDFS class for those resources
- give the label for that class.

Resources for Continents

- Add to mapping file:

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- ...removing spaces from "North America", etc.

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- ...generate a resource with URI `.../Continent/...`
- ...removing spaces from "North America", etc.
- E.g. `http://.../resource/Continent/North_America`

Where Properties Go To

- In original mapping file:

```
map:City_CountryCode a d2rq:PropertyBridge ;
    d2rq:belongsToClassMap map:City ;
    d2rq:property vocab:City_CountryCode ;
    d2rq:propertyDefinitionLabel "City CountryCode" ;
    d2rq:column "City.CountryCode" .
```

Where Properties Go To

- In original mapping file:

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map:City_CountryCode a d2rq:PropertyBridge ;
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- Identify a “property bridge”

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- give the predicate

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- give a label to the predicate

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```

- Identify a “property bridge”
- that adds properties to the resources described in `map:City`
- give the predicate
- give a label to the predicate
- the object is a *literal* taken from this column
- Also possible to define literals with patterns containing columns

Linking Cities to Countries

- Replace the previous property bridge with:

```
map:City_CountryCode a d2rq:PropertyBridge ;
    d2rq:belongsToClassMap map:City ;
    d2rq:property vocab:City_Country ;
    d2rq:propertyDefinitionLabel "City Country" ;
    d2rq:refersToClassMap map:Country ;
    d2rq:join "City.CountryCode=>Country.Code" .
```

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    d2rq:join "City.CountryCode=>Country.Code" .
```

- Foreign key: link to resource from another class map
- Say how columns for `map:City` correspond to those for `map:Country`

Linking Countries to Capitals

- Replace:

```
map:Country_Capital a d2rq:PropertyBridge;
    d2rq:belongsToClassMap map:Country;
    d2rq:property vocab:Country_Capital;
    d2rq:propertyDefinitionLabel "Country Capital";
    d2rq:column "Country.Capital" .
```

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```

- By:

```
map:Country_Capital a d2rq:PropertyBridge;
    d2rq:belongsToClassMap map:Country;
    d2rq:property vocab:capital;
    d2rq:propertyDefinitionLabel "Country Capital";
    d2rq:refersToClassMap map:City;
    d2rq:join "Country.Capital=>City.ID";
```

Resulting Graph

```
<http://.../City/2807> a vocab:City ;
         rdfs:label "City #2807" ;
         vocab:City_Name "Oslo" ;
         vocab:City_Country <http://.../Country/NOR> .

<http://.../Country/NOR> a vocab:Country ;
         rdfs:label "Country #NOR" ;
         vocab:Country_Name "Norway" ;
         vocab:Country_Continent "Europe" ;
         vocab:Country_Capital <http://.../City/2807> .
```

Linking to DBpedia

- Add property bridge:

```
map:Country_DBpedia a d2rq:PropertyBridge;
    d2rq:belongsToClassMap map:Country;
    d2rq:property owl:sameAs;
    d2rq:uriPattern
"http://dbpedia.org/resource/@@Country.Name|urlify@@" .
```

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    - DBpedia URI: `http://.../São_Tomé_and_Príncipe`

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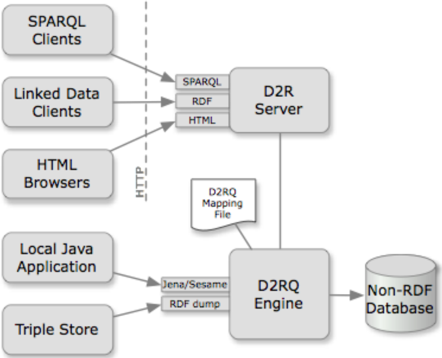
- Careful: Generating links like this often fails for some cases:
  - World DB country name: `Sao Tome and Principe`
  - DBpedia URI: `http://.../São_Tomé_and_Príncipe`
- Better in general to have a DB table with corresponding URIs

Outline

The Jena Adapter

- No direct way of adding reasoning to D2R



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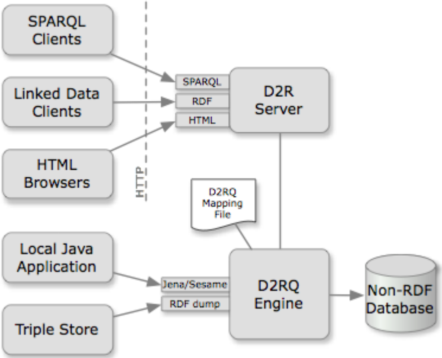

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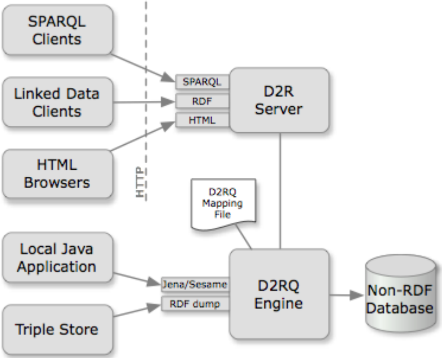
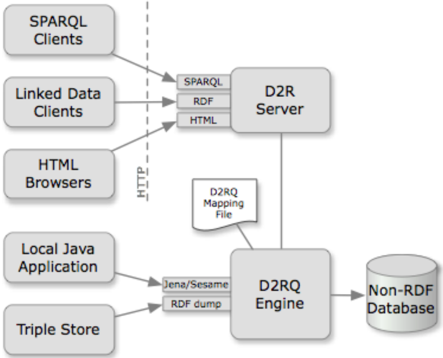


The Jena Adapter

- No direct way of adding reasoning to D2R
- An RDF view of a database can be made available as a Jena Model
- Requires mapping file and d2rq.jar
- Add reasoning to that model



The Jena Adapter: Example

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Model infm = ModelFactory.createRDFSModel(om, m);
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- Can use Jena query engine for SPARQL queries with reasoning

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Model infm = ModelFactory.createRDFSModel(om, m);
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- Asking `infm` for all objects of type `vocab:Place`...
- ...gives all cities...
- ...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.:

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

Forward Chaining vs. Backward Chaining

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- Backward Chaining:
  - Leave model as it is

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  - Queries can be answered using the expanded model
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  - Leave model as it is
  - Answer queries by applying rules “backwards”

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- Forward Chaining:
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  - Queries can be answered using the expanded model
- Backward Chaining:
  - Leave model as it is
  - Answer queries by applying rules “backwards”
  - A bit like Prolog!

Example for Forward Chaining

- Given triples:

```
:City rdfs:subClassOf :Place
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- Inferred triples:

```
:Oslo rdf:type :Place
:Place rdf:type rdfs:Class
:Place rdfs:subClassOf rdfs:Resource
...
```

Example for Forward Chaining

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  ...
  ```

- To answer x `rdf:type :Place`:
  - Simply look in model:
  - $x \rightarrow$ `:Oslo`

Example for Backward Chaining

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  - Look for direct occurrences: none

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  - E.g. $C \rightarrow$ `:City`, $x \rightarrow$ `:Oslo`

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- In general, need to backward-chain over many rules!

Example for Backward Chaining

- Given triples:

  `:City rdfs:subClassOf :Place`
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  - Look for instances of:
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    - x `rdf:type` C
  - 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

Forward	**Backward**
reason once	repeated computation
diffuse	goal-oriented
adds to data	data unchanged
much space	little space
expensive up-front	cheap up-front
fast queries	slow queries
possibly non-terminating expansion	possibly non-terminating backward chaining

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- "Hybrid" approaches possible, e.g. Jena RDFS reasoner
  - Forward chaining for sub-class/prop. hierarchy, ranges, domains
  - Backward chaining for `rdf:type`
- Forward chaining difficult for data in databases

Forward Chaining vs. Backward Chaining

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reason once	repeated computation
diffuse	goal-oriented
adds to data	data unchanged
much space	little space
expensive up-front	cheap up-front
fast queries	slow queries
possibly non-terminating expansion	possibly non-terminating backward chaining

- "Hybrid" approaches possible, e.g. Jena RDFS reasoner
  - Forward chaining for sub-class/prop. hierarchy, ranges, domains
  - Backward chaining for `rdf:type`
- Forward chaining difficult for data in databases
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  - Google for "QuOnto" for work on OWL QL/DL-Lite.

Outline

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- And many more!

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That's all Folks!