# SHARD Triple-Store:

## Tools for Web-Scale SemWeb

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BBN Technologies

# Semantic Web / Graph Data

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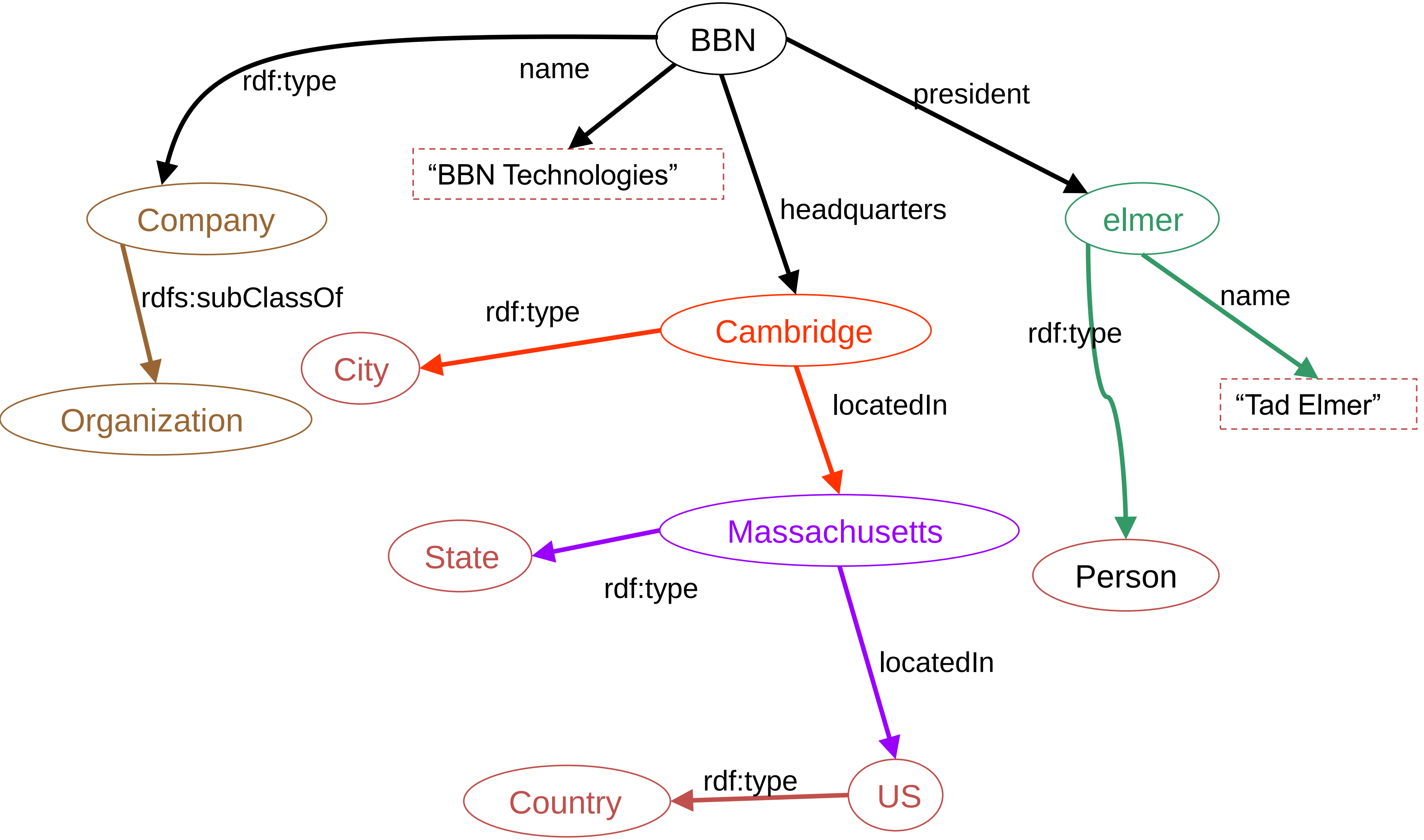
- Vision from Tim Berners-Lee at W3C.
- Create a web of data
  - Support use by intelligent agents.
  - Data described using ontologies.
  - Data represented as digraphs.
  - “Web 3.0.”
- Emerging commercially
  - Use by NYTimes, BBC, Pharma, …
  - Numerous startups.
  - Oracle, MySQL have SemWeb support.
- Government use…

# Object Graph Example



# SemWeb Layer Cake

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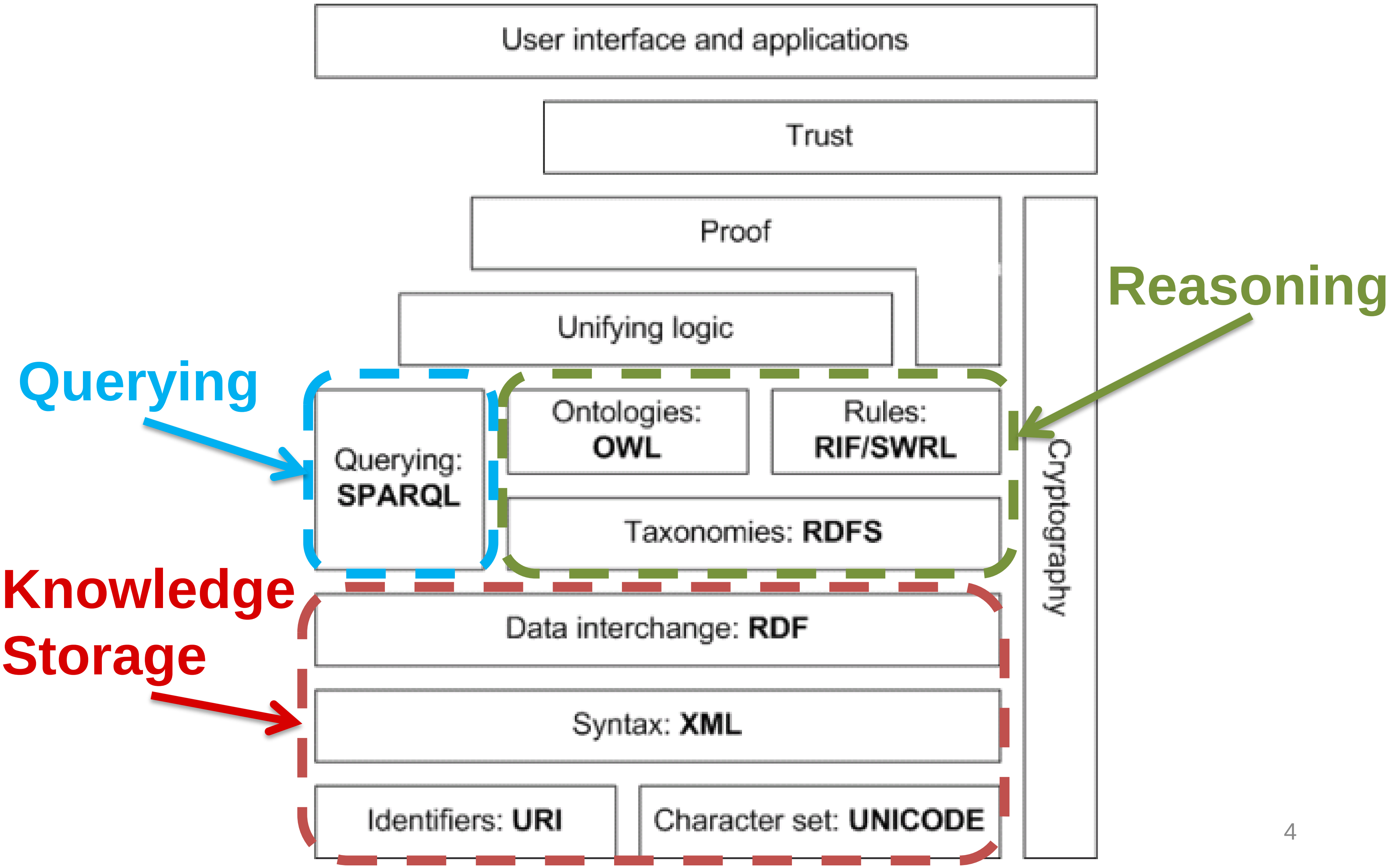

# W3C Resource Description Framework (RDF)

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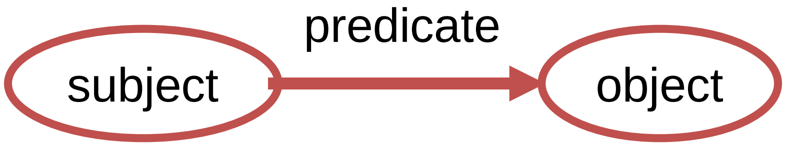
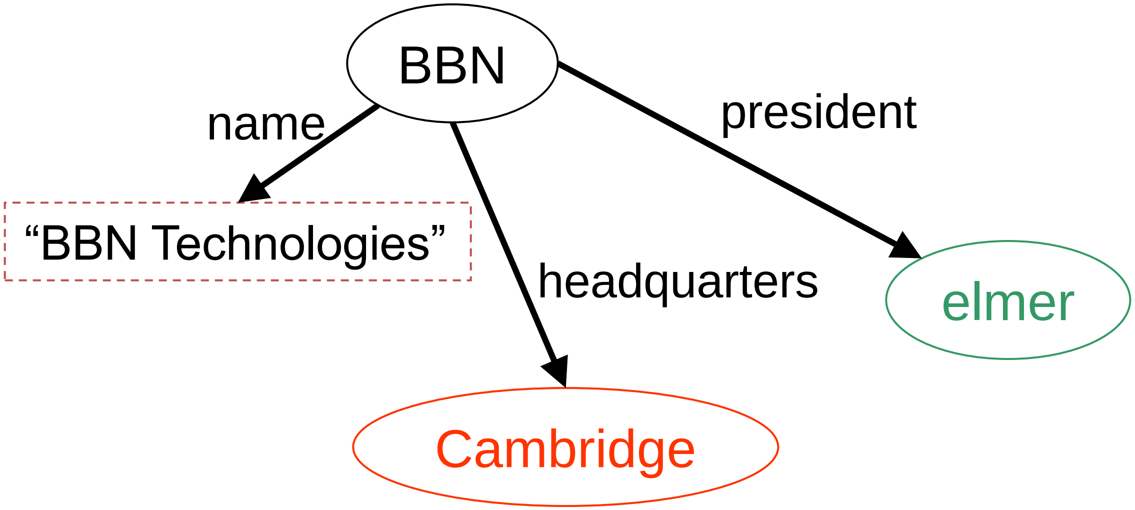


- RDF graph is made up of individual statements.
- Subject and predicate are Uniform Resource Identifiers (URIs).
- You can also make statements about statements (e.g. timestamp, confidence, etc.)

# RDF/XML

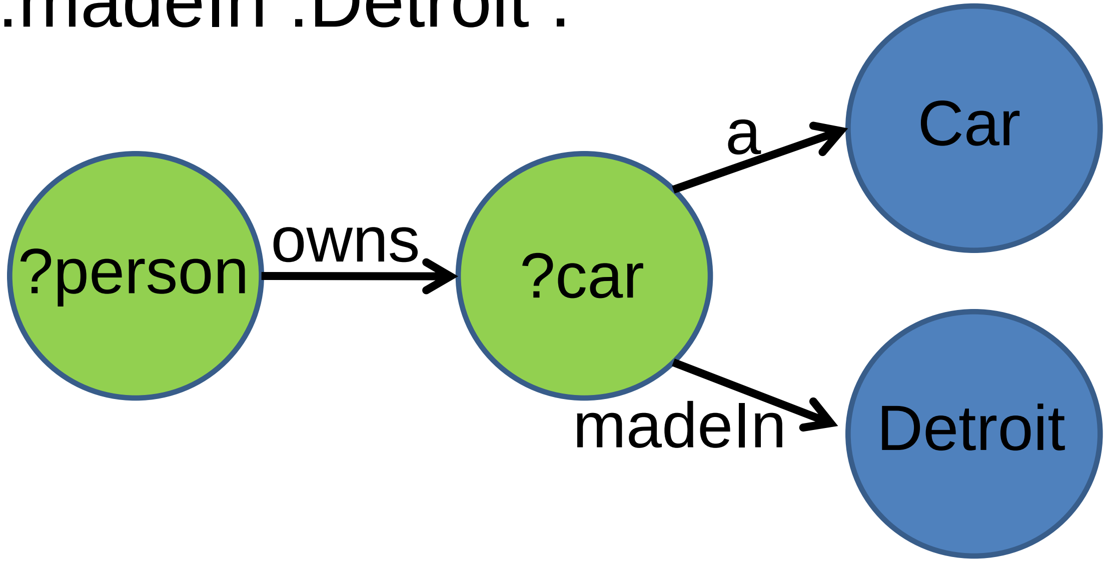
```
<rdf:RDF
  xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns="http://example.org/business-ont#">

  <Company rdf:ID="BBN">
    <name>BBN Technologies</name>
    <headquarters rdf:resource="http://www.state.ma.us/cities#Cambridge"/>
    <president rdf:resource="http://www.bbn.com/management#elmer"/>
  </Company>

</rdf:RDF>
```



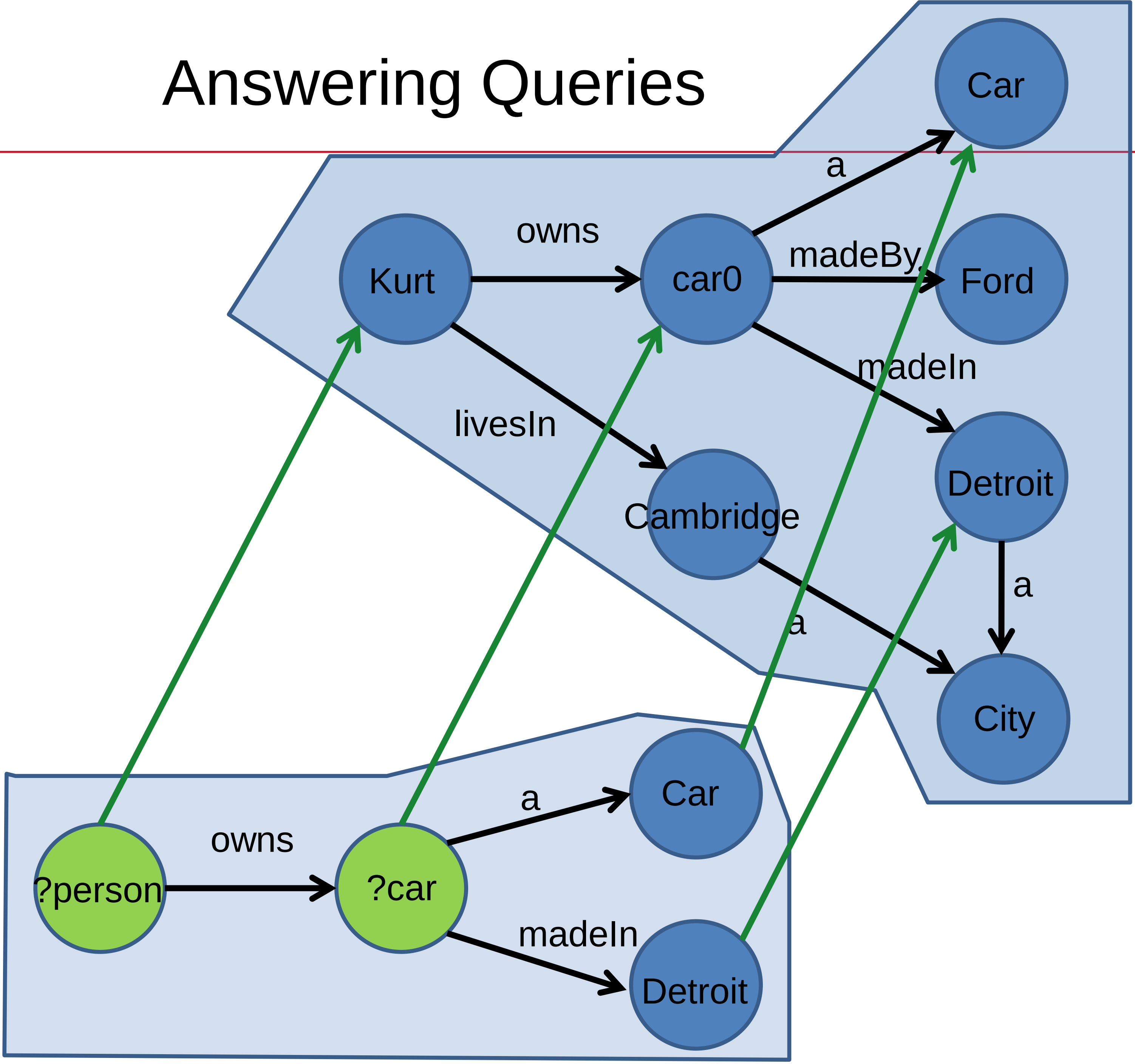
# SPARQL Query

All people who own a car made in Detroit:

```
SELECT ?person
WHERE  {
   ?person :owns ?car .
   ?car a :Car .
   ?car :madeIn :Detroit .
  }
```



# Answering Queries



# Sample of Triple-Stores

- Parliament by BBN (from DAPRA DAML.)
- OWLIM by OntoText (several versions.)
- Allegrograph from Franz.
- MySQL and Oracle Solutions.
- LarKC by DERI Galway.
- Mulgara.
- Hive- and Pig-based experimental triple-stores.
- Etc…

# Triple-Store Design Considerations

- Scalable – web-scale?
- High Assurance.
- Cost Effective – commodity hardware?
- Modular inferred data separation.
- Robustness.

- Considerations as endless as applications.

# Map-Reduce Triple-Store Proof of Concept

# SHARD Triple-Store Built on Hadoop

Prioritized goals:

- Commodity hardware, ONLY.
- Web scalable.
- Robust.

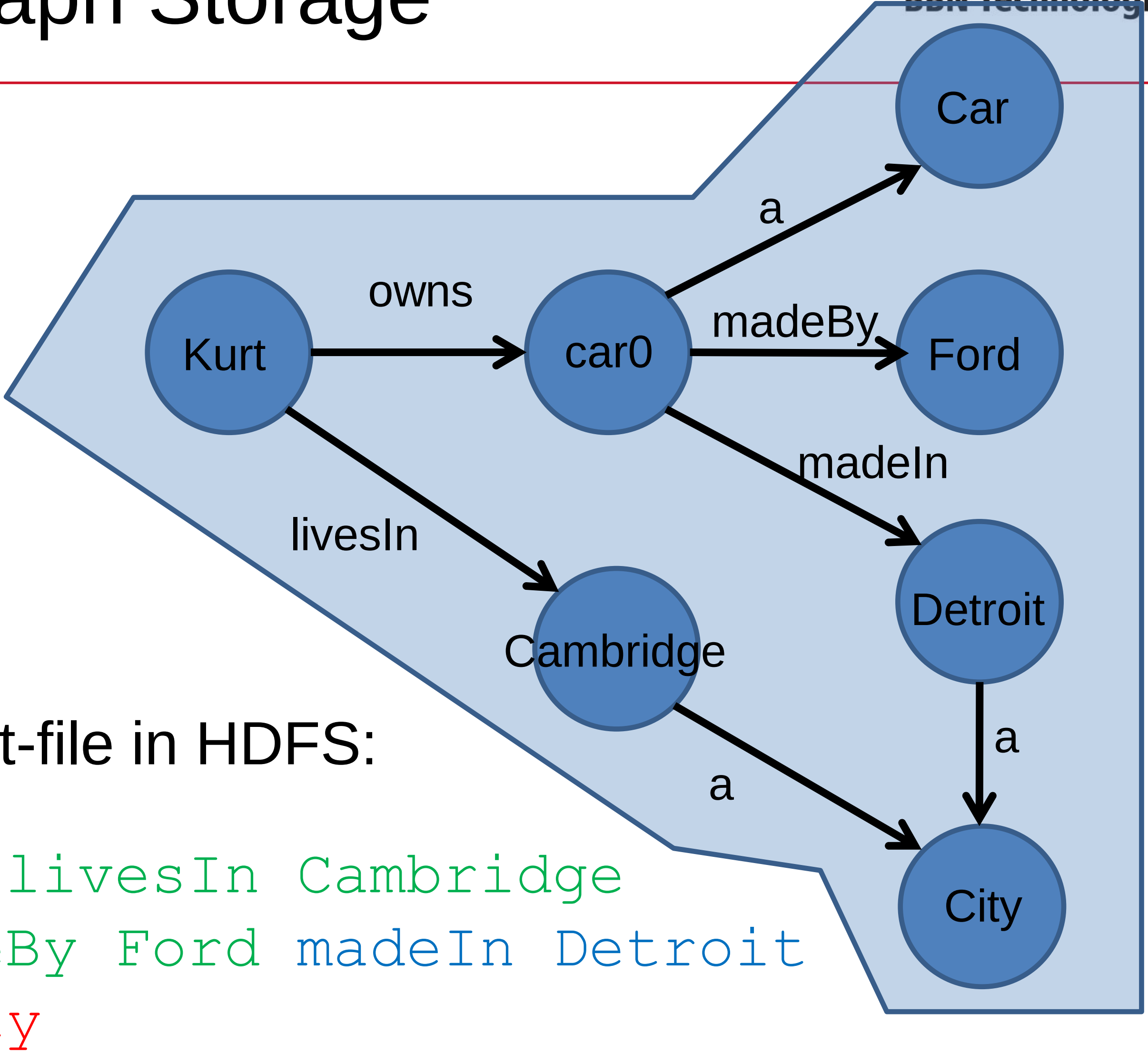
# More Specifically

- Cloud-based triple-store on HDFS.
  - Method calls at client.
  - Processing in cloud.
  - Move results to local machine.
- Massively scalable.
- SPARQL queries.
- Basic inferencing.

# Data Persistence Advice from SHARD

- Down to “bare metal” in HDFS for efficiency.
  - No Berkeley DB, no C-stores, …. Nothing.
- Simple data storage as flat files.
  - Lists of (predicate, object) pairs for every subject by line.
  - Ex: Kurt owns car0 livesin Cambridge
- Simple often really is better…

# HDFS Graph Storage



Graphs saved as flat-file in HDFS:

```
Kurt owns car0 livesIn Cambridge
Car0 a Car madeBy Ford madeIn Detroit
Cambridge a City
Detroit a City
```

# Query Processing

- BBN-developed query processor.
  - – Starting integration with “standard” interfaces
    - Jena, Sesame.
- SHARD supports “most” of SPARQL.
  - – Like most commercial triple-stores.
- Large performance improvements possible with improved query reordering.

# Iterative Query Response Construction

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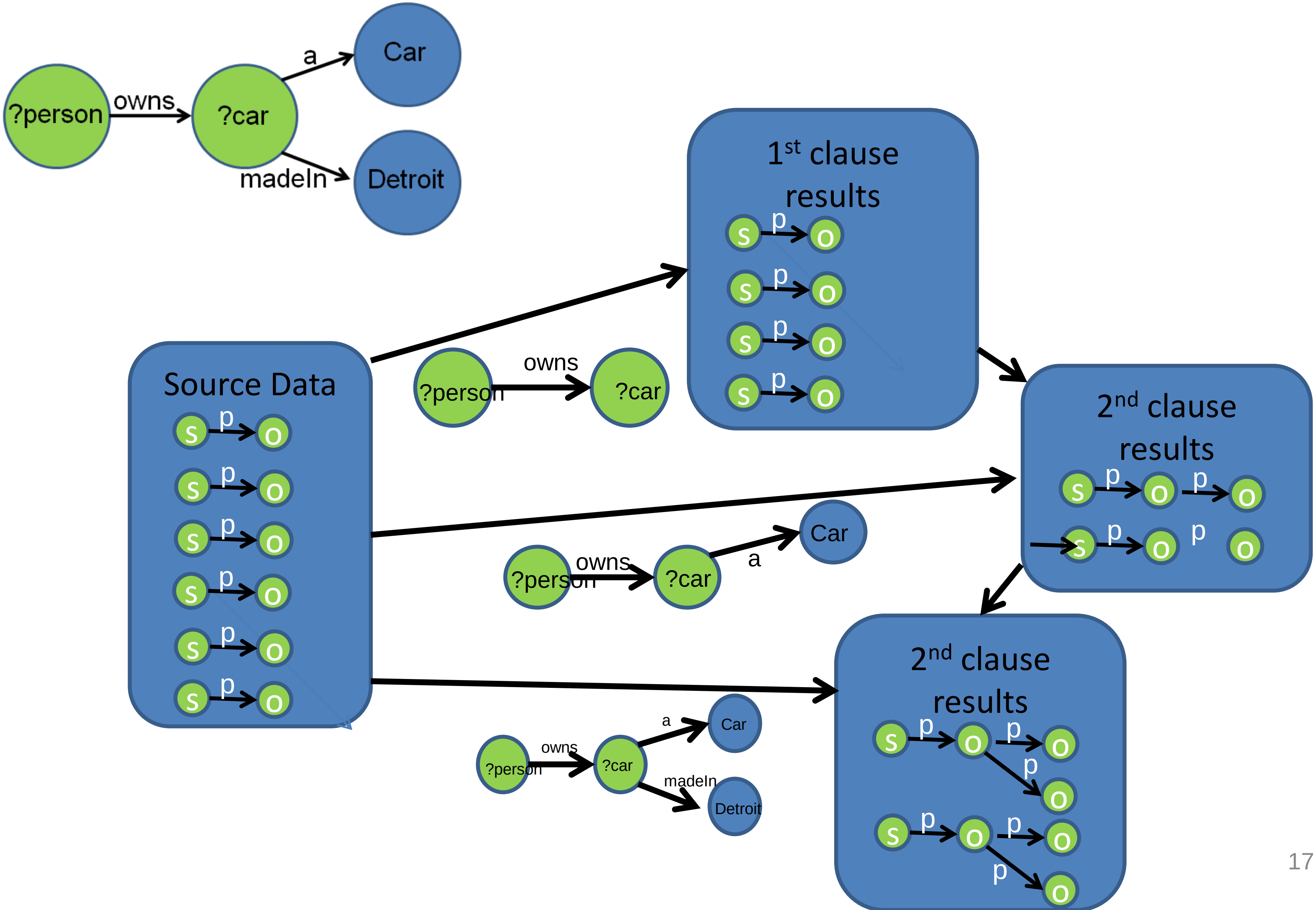

# Test Data

- Deployed code on Amazon EC2 cloud.
  - 19 XL nodes.
- 6000 LUBM university dataset.
  - Approximately 800 million edges in graph.
- In general, performed comparably to “industrial” monolithic triple-stores.

# SHARD Open-Source Release

- BSD license.
- Check:
  - My webpage
  - Sourceforge (SHARD-3store)

# More info?

- Tim Berners-Lee’s seminal SciAmerican article.
- W3C for “recommended” standards.
- Jena and Sesame frameworks.
- SemWebCentral for other open-source.

- Please come up and talk with me for more info!

# Thanks!
# Questions?

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# Performance Comparison

- Proof o' Concept: For 6000 universities (approx. 800 million triples):
  Query 1: 404 sec. (approx 0.1 hr.)
  Query 9: 740 sec. (approx 0.2 hr.)
  Query 14: 118 sec. (approx 0.03 hr.)
- Sesame+DAMLDB:
  Query 1: approx 0.1hr,
  Query 9: approx 1 hr
  Query 14: approx. 1 hr
- Jena+DAMLDB for 550 million triples:
  Query 1: approx 0.001 hr,
  Query 9: approx 1 hr
  Query 14: approx. 5 hr