Implemented Systems

Presenter: Manos Karpathiotakis
Outline

• Relational DBMS with a geospatial extension
• RDF stores with a geospatial component:
  – Research prototypes
  – Commercial systems
How does an RDBMS handle geometries? (1/2)

- Geometries are not explicitly handled by query language (SQL)
- Define datatypes that extend the SQL type system
  - Model geometries using Abstract Data Type (ADT)
  - Hide the structure of the data type to the user
    - The interface to an ADT is a list of operations
      - For spatial ADTs: Operations defined according to OGC Simple Features for SQL
      - Vendor-specific implementation irrelevant - extend SQL with geometric functionality independently of a specific representation/implementation
How does an RDBMS handle geometries? (2/2)

- Special indices needed for geometry data types
- Specialised query processing methods
Implemented Systems

• Will examine following aspects:
  – Data model
  – Query language
  – Functionality exposed
  – Coordinate Reference System support
  – Indexing Mechanisms
Research Prototypes

• Strabon
• Parliament
• Brodt et al.
• Perry
Strabon

- Storage and query evaluation module for stSPARQL
- Geometries represented using typed literals
  - WKT & GML serializations supported
- Spatial predicates represented as SPARQL functions
  - OGC-SFA, Egenhofer, RCC8 families exposed
  - Spatial aggregate functions
- Support for multiple coordinate reference systems

- GeoSPARQL support
  - Core
  - Geometry Extension
  - Geometry Topology Extension
Strabon - Implementation

Parliament

- Storage Engine
- Developed by Raytheon BBN Technologies (Dave Kolas)
- First implementation of GeoSPARQL
  - Geometries represented using typed literals
    - WKT & GML serializations supported
  - Three families of topological functions exposed
    - OGC-SFA
    - Egenhofer
    - RCC8
  - Multiple CRS support
Parliament - Implementation

- Rule engine included
- Paired with query processor
- R-tree used

Brodt et al.

- Built on top of RDF-3X
- Implemented at University of Stuttgart
- No formal definitions of data model and query language given
- Geometries expressed according to OGC-SFA
  - Typed Literals
  - WKT serialization supported
  - Expressed in WGS84
- Spatial predicates represented as SPARQL filter functions
  - OGC-SFA functionality exposed
Focus on spatial query processing and spatial indexing techniques for spatial selections
- e.g. "Retrieve features located inside a given polygon"

- Naive spatial selection operator
  - Placed in front of the execution plan which the planner returns

- Spatial index (R-Tree) implemented
  - Only utilized in spatial selections

Available upon request
Perry

- Built on top of Oracle 10g
- Implemented at Wright State University
- Implementation of SPARQL-ST
  - Upper-level ontology imposed
- Geometries expressed according to GeoRSS GML
- Spatial and temporal variables introduced
- Spatial and temporal filters used to filter results with spatiotemporal constraints
  - RCC8 calculus
  - Allen’s interval calculus
Perry

- Spatiotemporal operators implemented using Oracle's extensibility framework
  - Three spatial operators defined
- Strictly RDF concepts implemented using Oracle’s RDF storage and inferencing capabilities
- R-Tree used for indexing spatial objects

Available upon request
Commercial RDF Stores

- AllegroGraph
- OWLIM
- Virtuoso
- uSeekM
AllegroGraph

- Well-known RDF store, developed by Franz Inc.
- Two-dimensional point geometries
  - Cartesian / spherical coordinate systems supported
- GEO operator introduced for querying
  - Syntax similar to SPARQL’s GRAPH operator
  - Available operations:
    - Radius / Haversine (Buffer)
    - Bounding Box
    - Distance
- Linear Representation of data
  - X and Y ordinates of a point are combined into a single datum
- Distribution sweeping technique used for indexing
  - Strip-based index
• Semantic Repository, developed by Ontotext
• Two-dimensional point geometries supported
  – Expressed using W3C Geo Vocabulary
    • Point Geometries
    • WGS84
• Spatial predicates represented as property functions
  – Available operations:
    • Point-in-polygon
    • Buffer
    • Distance

• Implemented as a Storage and Inference Layer for Sesame
• Custom spatial index used
• Closed Source
  – Free version available for evaluation purposes
    (http://www.ontotext.com/owlim)
Virtuoso

- Multi-model data server, developed by OpenLink
- Two-dimensional point geometries
  - Typed literals
  - WKT serialization supported
  - Multiple CRS support
- Spatial predicates represented as functions
  - Subset of SQL/MM supported

- R-Tree used for indexing
- Spatial capabilities firstly included in Virtuoso 6.1
- Closed Source
    - Does not include the spatial capabilities extension
• Add-on library for Sesame-enabled semantic repositories, developed by OpenSahara
• Geometries expressed according to OGC-SFA
  – WKT serialization
  – Only WGS84 supported
• Spatial predicates represented as functions
  – OGC-SFA functionality exposed
  – Additional functions
    • e.g. shortestline(geometry,geometry)

• Implemented as a Storage and Inference Layer (SAIL) for Sesame
  – May be used with RDF stores that have a Sesame Repository/SAIL layer
• R-tree-over-GiST index used (provided by PostGIS)
• Open Source, Apache v2 License
• Available from https://dev.opensahara.com/projects/useekm
<table>
<thead>
<tr>
<th>System</th>
<th>Language</th>
<th>Index</th>
<th>Geometries</th>
<th>CRS support</th>
<th>Comments on Functionality</th>
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<td>R-tree-over-GiST</td>
<td>WKT / GML support</td>
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<td>• Egenhofer</td>
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<td>• RCC-8</td>
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<td>Brodt et al. (RDF-3X)</td>
<td>SPARQL</td>
<td>R-Tree</td>
<td>WKT support</td>
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<td>OGC-SFA</td>
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<td>• Bounding Box</td>
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<td>Virtuoso</td>
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Conclusions

- **Semantic Geospatial Systems:**
  - Research Prototypes
  - Commercial Systems

- **Next topic:** Applications of Linked Geospatial Data