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Developing GeoSPARQL Applications with Oracle Spatial and Graph

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Agenda

1. GeoSPARQL Overview
2. Implementation in Oracle
3. Demonstration with Oracle 12c

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OGC GeoSPARQL

- GeoSPARQL – A Geographic Query Language for RDF Data
  - OGC Standard (document 11-052r4)
  - Published in June 2012
  - Submitting Organizations

Australian Government Bureau of Meteorology

Bentley

CSIRO

GeoConnections

Defence Geospatial Information Working Group

USGS science for a changing world

interactive instruments

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Ordnance Survey

Raytheon

Traverse Technologies, Inc.

SPARQL Query

RDF Data

```
:res1 rdf:type   :House .
:res1 :baths     "2.5"^^xsd:decimal .
:res1 :bedrooms  "3"^^xsd:decimal .

:res2 rdf:type   :Condo .
:res2 :baths     "2"^^xsd:decimal .
:res2 :bedrooms  "2"^^xsd:decimal .

:res3 rdf:type   :House
:res3 :baths     "1.5"^^xsd:decimal .
:res3 :bedrooms  "3"^^xsd:decimal .
```

SPARQL Query

```
SELECT ?r ?ba ?br
WHERE { ?r rdf:type :House .
        ?r :baths ?ba .
        ?r :bedrooms ?br }
```

Result Bindings

```
?r    | ?ba   | ?br
===================
:res1 | "2.5" | "3"
:res3 | "1.5" | "3"
```

SPARQL Query

RDF Data

```
:res1 rdf:type   :House .
:res1 :baths     "2.5"^^xsd:decimal .
:res1 :bedrooms  "3"^^xsd:decimal .

:res2 rdf:type   :Condo .
:res2 :baths     "2"^^xsd:decimal .
:res2 :bedrooms  "2"^^xsd:decimal .

:res3 rdf:type   :House
:res3 :baths     "1.5"^^xsd:decimal .
:res3 :bedrooms  "3"^^xsd:decimal .
```

SPARQL Query

```
SELECT ?r ?ba ?br
WHERE { ?r rdf:type :House .
        ?r :baths ?ba .
        ?r :bedrooms ?br
        FILTER (?ba > 2) }
```

Result Bindings

```
?r    | ?ba   | ?br
===================
:res1 | "2.5" | "3"
```

Spatial SPARQL QUERY

Spatial RDF Data

This is what GeoSPARQL standardizes

```
:res1   rdf:type          :House .
:res1   :baths            "2.5"^^xsd:decimal .
:res1   :bedrooms         "3"^^xsd:decimal .
:res1   ogc:hasGeometry   :geom1 .
:geom1  ogc:asWKT         "POINT(-122.25 37.46)"^^ogc:wktLiteral .

:res3   rdf:type          :House
:res3   :baths            "1.5"^^xsd:decimal .
:res3   :bedrooms         "3"^^xsd:decimal .
:res3   ogc:hasGeometry   :geom3 .
:geom3  ogc:asWKT         "POINT(-122.24 37.47)"^^ogc:wktLiteral .
```

Vocabulary & Datatypes

Find houses within a search polygon

GeoSPARQL Query

Extension Functions

```
SELECT ?r ?ba ?br
WHERE { ?r rdf:type :House . ?r :baths ?ba . ?r :bedrooms ?br .
        ?r ogc:hasGeometry ?g . ?g ogc:asWKT ?wkt
        FILTER(ogcf:sfWithin(?wkt, "POLYGON(…)"^^ogc:wktLiteral)) }
```

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Details of ogc:WTKLiteral

All RDFS Literals of type ogc:wktLiteral shall consist of an optional IRI identifying the spatial reference system followed by Simple Features Well Known Text (WKT) describing a geometric value [ISO 19125-1].

```
"<http://www.opengis.net/def/crs/OGC/1.3/CRS84>
 POINT(-122.4192 37.7793)"^^ogc:wktLiteral
```

WGS84 longitude – latitude is the default CRS

```
"POINT(-122.4192 37.7793)"^^ogc:wktLiteral
```

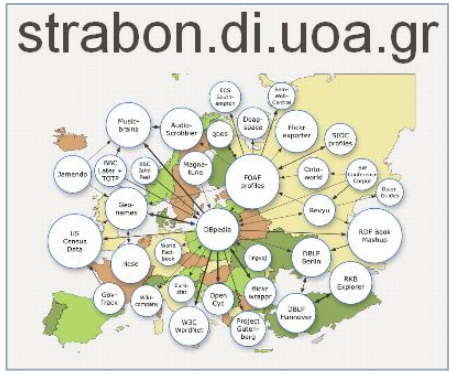
European Petroleum Survey Group (EPSG) maintains a set of CRS identifiers.

GeoSPARQL Spatial Function Library

- Topological Relations
  - `ogcf:relate, ogcf:sfContains, ogcf:sfCrosses, ogcf:sfDisjoint, ogcf:sfEquals, ogcf:sfIntersects, ogcf:sfOverlaps, ogcf:sfTouches, ogcf:sfWithin`
- Distance-based Operations
  - `ogcf:distance, ogcf:buffer`
- Geometry Operations
  - `ogcf:boundary, ogcf:convexHull, ogcf:envelope, ogcf:getSRID,`
- Geometry-Geometry Operations
  - `ogcf:difference, ogcf:intersection, ogcf:symDifference, ogcf:union`

Implementations

Raytheon
Parliament™



ORACLE DATABASE 12c

OPEN SAHARA | uSeekM

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GeoSPARQL Support in Oracle

- Oracle Spatial and Graph supports the following conformance classes for GeoSPARQL
  - Core
  - Topology Vocabulary Extension (Simple Features)
  - Geometry Extension (WKT, 1.2.0)
  - Geometry Topology Extension (Simple Features, WKT, 1.2.0)
  - RDFS Entailment Extension (Simple Features, WKT, 1.2.0)

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OGC wktLiteral Datatype

- Optional leading Spatial Reference System URI followed by OGC WKT geometry string.
  <http://xmlns.oracle.com/rdf/geo/srid/{srid}>
- WGS 84 Longitude, Latitude is the default SRS (assumed if SRS URI is absent)

```
SRS: WGS84 Longitude, Latitude
"POINT(-122.4192 37.7793)"^^ogc:wktLiteral

SRS: NAD27 Longitude, Latitude
"<http://xmlns.oracle.com/rdf/geo/srid/8260>
                 POINT(-122.4181 37.7793)"^^ogc:wktLiteral
```

What Types of Spatial Data are Supported?

- Spatial Reference Systems
  - Built-in support for 1000's of SRS
  - Plus you can define your own
  - Coordinate system transformations applied transparently during indexing and query
- Geometry Types
  - Support OGC Simple Features geometry types
    - Point, Line, Polygon
    - Multi-Point, Multi-Line, Multi-Polygon
    - Geometry Collection
  - Up to 500,000 vertices per Geometry

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Spatial Function Library

Standard OGC functions

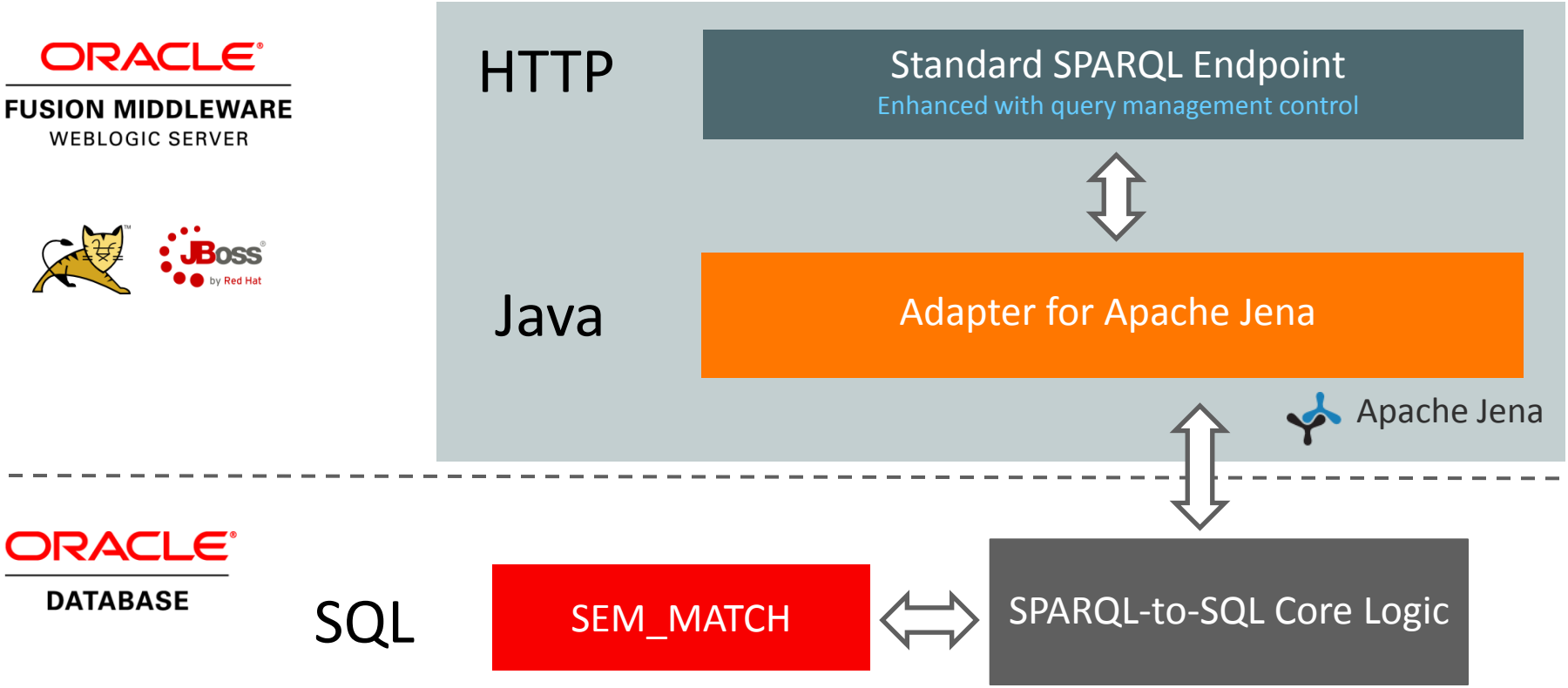
- Topological Relations
  - `ogcf:relate, ogcf:sfContains, ogcf:sfCrosses, ogcf:sfDisjoint, ogcf:sfEquals, ogcf:sfIntersects, ogcf:sfOverlaps, ogcf:sfTouches, ogcf:sfWithin`
- Distance-based Operations
  - `ogcf:distance, ogcf:buffer`
- Geometry Operations
  - `ogcf:boundary, ogcf:convexHull, ogcf:envelope, ogcf:getSRID,`
- Geometry-Geometry Operations
  - `ogcf:difference, ogcf:intersection, ogcf:symDifference, ogcf:union`

Spatial Function Library

Oracle Extensions

- Topological Relations
  - `orageo:relate`
- Distance-based Operations
  - `orageo:distance, orageo:withinDistance, orageo:buffer, orageo:nearestNeighbor`
- Geometry Operations
  - `orageo:area, orageo:length`
  - `orageo:centroid, orageo:mbr, orageo:convexHull`
- Geometry-Geometry Operations
  - `orageo:intersection, orageo:union, orageo:difference, orageo:xor`

SPARQL and SPARQL in SQL Query Architecture



Data Storage Tables

Unique key: PCSGM

RDF_LINK$

S (subj id)	P (pred id)	C (c. obj id)	G (graph id)	M (model id)
100	300	200		1

Partition P1

S (subj id)	P (pred id)	C (c. obj id)	G (graph id)	M (model id)

Partition P2

RDF_VALUE$

pkey

Unique key: Vpfx-Vtyp-Vsfx-Lit-Lang

val. id	vname_prefix	vname_suffix	value_type	Literal type	Lang type
100	http://xyz.com/	geom1	UR		
200	POINT(...)		TL	ogc:wktLiteral	
300	http://opengis..	asWKT	UR		

Spatial Index on ogc:wktLiteral Datatype

- Prepare for spatial querying by creating a spatial index for the ogc:wktLiteral datatype

```
SQL> exec sem_apis.add_datatype_index(
       'http://www.opengis.net/ont/geosparql#wktLiteral',
       options=>'TOLERANCE=0.1 SRID=8307
         DIMENSIONS=((LONGITUDE,-180,180)(LATITUDE,-90,90))');
```

Spatial Indexing

RDF_VALUE$ columns

Target SRS

Helper function to generate SDO_GEOMETRY objects

```
FUNCTION getV$GeometryVal (
  value_type          IN VARCHAR2
, vname_prefix        IN VARCHAR2
, vname_suffix        IN VARCHAR2
, literal_type        IN VARCHAR2
, language_type       IN VARCHAR2
, srid                IN NUMBER
) RETURN        MDSYS.SDO_GEOMETRY
```

RDF_VALUE$

val. id	vname_prefix	vname_suffix	value_type	Literal type	Lang type
100	http://xyz.com/	geom1	UR		
200	POINT(…)		TL	ogc:wktLiteral	
300	http://opengis..	asWKT	UR		

Spatial Indexing

ogcf:sfOverlaps(?geom, "POLYGON((…))")

1) Primary Filter → Function-based R-Tree Index (BBox)

2) Secondary Filter → getV$GeometryVal(value_type, vname_prefix, …)

RDF_VALUE$

val. id	vname_prefix	vname_suffix	value_type	Literal type	Lang type
100	http://xyz.com/	geom1	UR		
200	POINT(…)		TL	ogc:wktLiteral	
300	http://opengis..	asWKT	UR		

Spatial Query Execution

```
SELECT ?s ?l ?wkt
WHERE {
  ?s rdf:type lgd:Monument .
  ?s rdfs:label ?l .
  ?s geovocab:geometry ?geom .
  ?geom ogc:asWKT ?wkt .
  FILTER(
    ogcf:sfWithin(
      ?wkt,
      "POLYGON((-71.44 42.50,
                -71.42 42.40,
                -71.08 42.39,
                -71.03 42.56,
                -71.44 42.50))"^^ogc:wktLiteral))}
```

```
-----------------------------------------------------------------------
| Id  | Operation                                   | Name              |
-----------------------------------------------------------------------
|   0 | SELECT STATEMENT                            |                   |
|   1 |  NESTED LOOPS                               |                   |
|   2 |   NESTED LOOPS                              |                   |
|   3 |    VIEW                                     |                   |
|   4 |     NESTED LOOPS                            |                   |
|   5 |      NESTED LOOPS                           |                   |
|   6 |       NESTED LOOPS                          |                   |
|   7 |        NESTED LOOPS                         |                   |
|   8 |         TABLE ACCESS BY INDEX ROWID         | RDF_VALUE$        |
|*  9 |          DOMAIN INDEX (SEL: 0.100000 %)     | RDF_V$GEO_IDX     |
|  10 |         PARTITION LIST SINGLE               |                   |
|* 11 |          INDEX RANGE SCAN                   | RDF_LNK_CPSGM_IDX |
|  12 |        PARTITION LIST SINGLE                |                   |
|* 13 |         INDEX RANGE SCAN                    | RDF_LNK_CPSGM_IDX |
|  14 |       PARTITION LIST SINGLE                 |                   |
|* 15 |        INDEX RANGE SCAN                     | RDF_LNK_CPSGM_IDX |
|  16 |      PARTITION LIST SINGLE                  |                   |
|* 17 |       INDEX RANGE SCAN                      | RDF_LNK_PSCGM_IDX |
|  18 |    TABLE ACCESS BY INDEX ROWID              | RDF_VALUE$        |
|* 19 |     INDEX UNIQUE SCAN                       | C_PK_VID          |
|  20 |   TABLE ACCESS BY INDEX ROWID               | RDF_VALUE$        |
|* 21 |    INDEX UNIQUE SCAN                        | C_PK_VID          |
-----------------------------------------------------------------------
```

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Demonstration with Oracle 12c

ORACLE DATABASE 12c

ORACLE FUSION MIDDLEWARE

Oracle Big Data Lite VM
+
Spatial & Graph Support
+
Map Viewer

HistoricThing.node
4.1 Million Triples
268K Points (WGS 84)

Create semantic model → Bulk load into model → Create spatial index → Execute GeoSPARQL queries → Create Map Viewer layer

Integrated Cloud

Applications & Platform Services

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