Mining Big Data with RDF Graph Technology:

Xavier Lopez, Ph.D. Director, Product Mgmt.
Zhe Wu, Ph.D. Consulting Member Technical Staff
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Program Agenda

- Big Data in Action
- Introducing Oracle Spatial and Graph
- Using RDF for Big Data and Mining
- Tools: Oracle and 3rd party
- Demo
- Summary
Big Data in Action

Analyse all your data, at once
Oracle In-Database Analytics Platform

Parallel Processing Engine

Oracle R Enterprise
Oracle Data Mining
Spatial Analytics
Graph Analytics
Oracle MapReduce
SQL Analytics

Data Layer
XML
Relational
OLAP
Spatial
Graph
RDF
Media
INTRODUCING

Oracle Spatial and Graph
Oracle Spatial option has been renamed to “Oracle Spatial and Graph”

- Highlights existing graph capabilities in Oracle Spatial
  - Network Data Model graph since Oracle 10gR1
  - RDF semantic graph since Oracle 10gR2

- Addresses increasing market demand for graph database capability
  - Social Network Graph database popularity
  - Multimodal and integrated transportation, utility and communications networks
Oracle Spatial and Graph option

Graph Features

• Network Data Model graph
  – Manages logical / spatial networks in database
  – Persists link/node structure, connectivity and direction
  – Supports constraints at link and node level
  – Logically partitioning network graphs for scalability

• RDF Semantic graph
  – Enterprise class RDF Graph Database
  – Scales to petabytes of triples – by exploiting Exadata, RAC, SQL*Loader, Parallelism, Label Security
  – W3C standards: RDFS, OWL2 RL, OWL2 EL, SPARQL 1.1, RDB2RDF, RDFa, SKOS
  – SQL, PL/SQL APIs and Java APIs (Jena/Sesame)
What is RDF?
Resource Description Framework

- Basic structure is a “triple”
  - [subject] ➔ [predicate] ➔ [object]
- RDF can be serialized into XML
  - Namespaces, for example
- Schemas need not be specified in advance
  - No schema changes to cope with foreign vocabularies
- RDF data is fully expressible as RDBMS data
  - RDBMS data is also fully expressible as RDF
How is RDF Used in the Enterprise?

- Enterprise metadata framework for enterprise data & public cloud
- Semantic terms link instance data with other resources and apps
- Linked resources enable interoperability between apps
USING RDF GRAPHS FOR MINING SOCIAL MEDIA
RDF Semantic Graph for Social Applications

- **Unified content metadata model for public clouds**
- **Validate semantic and structural consistency**

- **Find related content & relations by navigating connected entities**
- **“Reason” across entities**

- **Analyze content using integrated metadata**
  - Blogs, wikis, video
  - Calendars, IM, voice
Use Case: Social Media Analytics

Oracle RDF Semantic Graph

• Integrate, archive, analyze, and act on data in social media and public clouds
• Leverage enterprise content and domain vocabularies to provide context
• Developing better analysis and predictions from Big Data sources
RDF DATABASE FEATURES
Oracle Spatial and Graph Option

Graph Features:

Oracle RDF Semantic Graph

- Native RDF Database
- Supports SPARQL 1.1, SPARQL/SQL, GeoSPARQL
- Jena, Sesame, & Joseki Web Services
- W3C standards: RDFS, OWL 2 RL, OWL 2 EL, SKOS, RDF, RDB2RDF, SPARQL 1.1, RDFa
- Scales with hardware – petabytes of triples
- Works with OBIEE, Oracle BPM, Oracle Advanced Analytics
- Exploits: Exadata, RAC, Parallelism, Label Security

Conceptually, Semantic applications look at things as being represented as graphs, rather than tables.

In Oracle Database, we use Triples and Key relationships to represent nodes and links in the Graph.

Image of graph with entities and relationships:

- Wells Fargo
- Now known as Wachovia
- Norwest
- Now known as
- First Union
- Now known as
- Crocker National
- First Nat Bank of Philadelphia
Support for Structured and Unstructured Data

- Integrated access to structured and RDF data
  - Join SPARQL results with relational data
  - Embed SPARQL query in SQL
  - Apply rich SQL operators (such as aggregates) on triples

- Semantic indexing (of unstructured content)
  - Generate RDF triples with 3rd party NLP and entity/concept extraction tools
  - Index generated RDF graph (1 named graph per doc)
  - Perform incremental updates of RDF graph as new documents entered

- Query text, spatial, temporal data using SPARQL
  -- GeoSPARQL
Performance and Scalability

- Scales to 100s of billions of triples (petabytes) and more
  - Scales linearly with Oracle database and hardware
  - No limitations as with other in-memory approaches

- Fast loading of triples
  - Incremental and bulk loading

- Parallelism is exploited
  - Load, Query, Inference

- Fast access by persisting asserted and inferred triples
Billions of Triples, Terabytes of Storage
High Performance and Scalability

• Lehigh Univ. Benchmark (25K) tested
  – 3.4 Billion triples in the model
  – 2.7 Billion triples inferred
  – Storage space including indexes: over 1 Terabytes
  – Load speed: 109 minutes on Sun M8000
  – Inference speed: 160 minutes
  – Query throughput: 0.5 Billion in 9 minutes
  – Sun M8000, 512GB RAM, 2TB Flash array, 128 Threads
  – Balanced hardware is key!
Leveraging Oracle and 3rd Party Tools

- Navigation and visualization
- Graph creation and manipulation
- Reporting and charting
- Exploring & analyzing
- Automated discovery (mining) & predictive analysis
Tools: Navigation and Visualization of Graphs

Cytoscape Graph Visualizer

Tom Sawyer’s Perspective

Open Source

Commercial Product
Tools: Reporting with Oracle BI EE

• Powerful BI dashboards
  – Visually appealing
  – 100% thin client

• Across all styles of analysis
  – R-OLAP, M-OLAP, Scorecards, Reporting, Collaboration, Actions

• Across all data sources
  – Federated data access
  – Share, collaborate, & publish
Tools: Statistical Graph Analytics
Oracle R Enterprise

- Open source language
- Statistical computing and chart for graph data
- Produces publication quality plots
- Highly extensible with open source R packages
Tools: Discovery & Predictive Analysis
Oracle Data Mining

<table>
<thead>
<tr>
<th>Problem Classification</th>
<th>Sample Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anomaly Detection</td>
<td>Given demographic data about a set of customers, identify customer purchasing behavior that is significantly different from the norm</td>
</tr>
<tr>
<td>Association Rules</td>
<td>Find the items that tend to be purchased together and specify their relationship – market basket analysis</td>
</tr>
<tr>
<td>Clustering</td>
<td>Segment demographic data into clusters and rank the probability that an individual will belong to a given cluster</td>
</tr>
<tr>
<td>Feature Extraction</td>
<td>Given demographic data about a set of customers, group the attributes into general characteristics of the customers</td>
</tr>
</tbody>
</table>
NEW FEATURES

Oracle Spatial and Graph
New functions in Oracle Database Release 12.1

- Open Geospatial Consortium (OGC) GeoSPARQL
- Native SPARQL 1.1 query support
  - 40+ new query functions/operators: IF, COALESCE, STRBEFORE, REPLACE, ABS,
  - Aggregates: COUNT, SUM, MIN, MAX, AVG, GROUP_CONCAT, SAMPLE
  - Subqueries
  - Value Assignment: BIND, GROUP BY Expressions, SELECT Expressions
  - Negation: NOT EXISTS, MINUS
  - Improved Path Searching with Property Paths

<table>
<thead>
<tr>
<th>On the fly inference: transitivity of rdfs:subClassOf</th>
<th>Social Networking: find all of John’s friends</th>
</tr>
</thead>
</table>
New functions in Oracle Database Release 12.1

- RDF views on relational tables (through RDB2RDF)
  - RDF views can be created on a set of relational tables and/or views
  - SPARQL queries access data from both a relational and RDF store
  - Allows filtering of data in a relational store based upon ontology
  - Support RDF view creation using
    - Direct Mapping: simple and straightforward to use
    - R2RML Mapping: customizations allowed
New functions in Oracle Database Release 12.1

• Inference
  – Native OWL 2 EL inference support
  – User defined inferencing
    • Allows generation of new RDF resources
    • Temporal reasoning, Spatial reasoning
    • Web service callouts
  – Ladder Based Inference
    • Fine grained security for inference graph
  – Performance optimization for user defined rules
  – Integration with TrOWL*, an external OWL 2 reasoner
    • TrOWL is a transformation based, tractable reasoner for OWL 2

* http://troll.eu/*
DEMO

Applying RDF Graph Analysis with:

• Oracle Advanced Analytics
• Oracle Business Intelligence EE
Demo Setup

• Demo 1: Using OBIEE on RDF
  • Data: Data.gov Finance Data in RDF format

• Demo 2: Using Oracle R Enterprise on RDF Data
  • Data: CIA World Factbook in RDF format
Demo 1: Using OBIEE on RDF Data

Architecture

- OBIEE
  - Business Intelligence

- SPARQL Gateway
  - Provide navigation, XML transformation

- Joseki Web Service
  - Provide standard compliant WS endpoint

- Jena Adapter
  - Provide Java APIs

- Oracle Database
  - Scalable, performant, secure RDBMS
  (Relational, XML, RDF, Spatial, Media, …)
Data.gov Finance Data in RDF: Graph Snippet
Data.gov Finance Data in RDF: SPARQL Query
### Data.gov Finance Data in RDF: Query Response

<table>
<thead>
<tr>
<th>Serial</th>
<th>Class Ticker</th>
<th>SERIES_NAME</th>
<th>CLASS_NAME</th>
<th>ZIP_CODE</th>
<th>STATE</th>
<th>CITY</th>
<th>ENTITY_ORG_TYPE</th>
<th>ADDRESS_1</th>
<th>ADDRESS_2</th>
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<tr>
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<td>KMXX</td>
<td>Kinetics Market Opportunities Fund</td>
<td>10523</td>
<td>NY</td>
<td>ELMSFORD</td>
<td>30</td>
<td>505 TAYLOR ROAD</td>
<td>SUITE 175</td>
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<td>ND Tax-Free Fund, Inc.</td>
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<td>ND</td>
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<td>58703</td>
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<tr>
<td>7</td>
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<td>31 WEST 52ND STREET</td>
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<tr>
<td>8</td>
<td>entry3726</td>
<td>VDEQX</td>
<td>Vanguard Diversified Equity Fund</td>
<td>19482</td>
<td>PA</td>
<td>VALLEY FORGE</td>
<td>30</td>
<td>PD BOX 2000 V26</td>
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<tr>
<td>9</td>
<td>entry7202</td>
<td>OCMUX</td>
<td>OCM MUTUAL OCM GOLD</td>
<td>90401</td>
<td>CA</td>
<td>SANTA MONICA</td>
<td>30</td>
<td>1299 OCEAN AVENUE</td>
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</table>


Finance Data: Transformed Response XML

```
<test>
  <row>
    <class_ticker> KMKT </class_ticker>
    <series_name> Kinetic Market Opportunities Fund </series_name>
    <class_name> Institutional Class </class_name>
    <zip_code> 10523 </zip_code>
    <state> NY </state>
    <city> ELMSFORD </city>
    <entity_org_type> 30 </entity_org_type>
    <address_1> 555 TAXIER ROAD </address_1>
    <address_2> SUITE 175 </address_2>
  </row>
</test>
```

This XML file does not appear to have any style information associated with it. The document tree is shown above.

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Finance Data: Feed XML Response to BI Tool
Finance Data: Visualizing RDF in OBIEE
Finance Data: Visualizing RDF in OBIEE (2)
Demo 2: Using Oracle R Enterprise on RDF
Semantic query that drives the demo

```
--
-- Semantic Query that drives the ORE Graphics and the ODM
--
create view CIA_WORLD_FACT as
  select name,
         to_number(brate) brate,
         to_number(drate) drate,
         to_number(leab) leab,
         to_number(imr) imr,
         to_number(nmr) nmr,
         to_number(population) population,
         to_number(area) area
  from table(sem_match('{
    sem_models('worldfact'), null, null, null, null)
where brate is not null
  and drate is not null
```
Demo 2 ORE on RDF: Connect to Oracle DB

```r
> library(ORE)
Loading required package: OREbase
Loading required package: ROracle
Loading required package: DBI
Attaching package: 'OREbase'
The following object(s) are masked from 'package:base':
cbind, data.frame, eval, interaction, order, paste, pmax, pmin,
rbind, table
Loading required package: OREstats
Loading required package: MASS
Loading required package: OREgraphics
Loading required package: OREeda
Loading required package: ORExml
> ore.connect("rquser","db12c","hqmsemperf1","RQUSER","1522")
> ore.attach()
> ore.sync()
> 
```
Demo 2 ORE on RDF: Data Summary

```
> summary(WORLD_FACT)

  NAME     BIRTH_RATE  DEATH_RATE  INF_MG  MIG_RATE
Afghanistan: 1 15.35 : 3 5.2 : 3 5.3 : 5 0 : 52
Albania    : 1 22.27 : 3 5.43 : 3 19.6 : 3 -0.34 : 3
Algeria    : 1 23.31 : 2 6.14 : 3 5.2 : 3 -0.73 : 2
American Samoa: 1 23.35 : 2 11.89 : 2 7 : 3 -1.5 : 2
Andorra    : 1 32.65 : 2 13.67 : 2 10 : 2 -2.92 : 2
Angola     : 1 9.75 : 2 13.88 : 2 11.2 : 2 (Other):158
(Other):214 (Other):206 (Other):205 (Other):202 NA's : 1

  POPULATION  AREA  LEC
10165059: 1 3 : 2 LONG :110
1023404: 1 340 : 2 MED : 84
10297 : 1 430 : 2 SHORT: 26
10298324: 1 5 : 2
1031600 : 1 620 : 2
10412219: 1 (Other):205 (Other):214 NA's : 5
```
Demo 2 ORE on RDF: R Graphics
Demo 2 ORE on RDF: R Graphics (2)
Summary

- Oracle brings enterprise-class RDF semantic graph data management
- Scalable, Secure, and High Performance: load, query, inference features
- Supports W3C Semantic Standards
- Works with structured and unstructured data
- Enterprise-class Oracle tools can now mine insight from semantic data
  - OBIEE
  - Oracle Data Mining
  - Oracle R Enterprise
- Supported by leading 3rd party semantics tools
For More Information

Oracle RDF

Xavier.Lopez@oracle.com
Alan.Wu@oracle.com
oracle.com
# Oracle Spatial and Graph at OOW 2012 Sessions

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Title</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday, Sept 30</td>
<td>User Group Forum: Oracle Business Intelligence 11g Maps: Making Yourself Spatially Aware</td>
<td>Moscone West - 2006</td>
</tr>
<tr>
<td>Monday, Oct 1</td>
<td>General Session: What’s Next for Oracle Database?</td>
<td>Moscone North – Hall D</td>
</tr>
<tr>
<td>10:45am-11:45am</td>
<td>Conference Session: Mining Big Data with RDF Graph Technology: Discovering What You Didn’t Know</td>
<td>Moscone South – 200</td>
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<tr>
<td>3:15pm-4:15pm</td>
<td>General Session: Building and Managing a Private Oracle Database Cloud</td>
<td>Moscone South – 103</td>
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<tr>
<td>7:15pm-8:00pm</td>
<td>BOF: Adding Maps and Location to Analytic Applications: Real-World Experiences</td>
<td>Marriott Marquis – Club Room</td>
</tr>
</tbody>
</table>
# Oracle Spatial and Graph at OOW 2012 Sessions

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Title</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuesday, Oct 2</td>
<td><strong>JavaOne Session: Leveraging W3C Linked Data for Loosely Coupled Application Integrations</strong></td>
<td>Parc 55 - Embarcadero</td>
</tr>
<tr>
<td>8:30am-9:30am</td>
<td><strong>Conference Session: Oracle Spatial and Graph: Faster, Bigger, Better 2-D and 3-D Spatial Solutions</strong></td>
<td>Moscone South - 306</td>
</tr>
<tr>
<td>10:15am-11:15am</td>
<td><strong>Conference Session: Integrating Oracle Database with a Social Network</strong></td>
<td>Marriott Marquis – Foothill F</td>
</tr>
<tr>
<td>Wednesday, Oct 3</td>
<td><strong>Oracle Exadata, Oracle Exalogic, Oracle Exalytics, and Big Data Solutions in the Public Sector (Features panelists from US Census Bureau, New York City)</strong></td>
<td>Westin San Francisco - City</td>
</tr>
<tr>
<td>11:45am - 12:45pm</td>
<td><strong>Conference Session: Mash Up All Things Location with Android, iPad, HTML5 Web Maps, and Spatial</strong></td>
<td>Marriott Marquis – Club Room</td>
</tr>
</tbody>
</table>
Oracle Spatial and Graph at OOW 2012 Test Fest

- Special offer – Get certified on Oracle Spatial onsite!
  Test Fest @ Oracle PartnerNetwork Exchange
  Free for OPN Exchange participants

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday – Thursday exam times</td>
<td>Test Fest @ OPN Exchange – Certification Testing onsite for Oracle Spatial and many other Oracle technologies</td>
<td>Marriott Marquis, Juniper Room</td>
</tr>
<tr>
<td>available (2 hour slots)</td>
<td>• Pre-register for an exam slot at <a href="http://www.oracle.com/opnexchange/learn/test-fest">http://www.oracle.com/opnexchange/learn/test-fest</a></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Walk-ins available on a first-come, first-served basis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Proof of OPN membership and PearsonVue ID required</td>
<td></td>
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## Oracle Spatial and Graph at OOW 2012 Demos

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Demo</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Monday-Wednesday</td>
<td>Spatial Capabilities in Oracle Spatial and Graph</td>
<td>Moscone South, Left S-059</td>
</tr>
<tr>
<td>Monday-Wednesday</td>
<td>Semantic RDF Graph Technologies in Oracle Spatial and Graph</td>
<td>Moscone South, Left S-060</td>
</tr>
<tr>
<td>Monday-Wednesday</td>
<td>Empowering Business to Drive Process Modeling</td>
<td>Moscone South, Right S-234</td>
</tr>
<tr>
<td>Monday-Wednesday</td>
<td>Oracle Event Processing</td>
<td>Moscone South, Right S-230</td>
</tr>
<tr>
<td>Monday -Thursday</td>
<td>Analyze Big Data</td>
<td>Moscone North, Upper Lobby – N-013</td>
</tr>
</tbody>
</table>
Oracle Spatial and Graph option

Graph Features – RDF Semantic Graph

- Represents Graph relationships as triples in compressed, partitioned tables
- Supports quads/named graphs
- RDFS, OWL and user-defined inferencing, Parallel execution and incremental modes
- Kernel and SQL-layer enhancements for optimized indexing and access of triple data
- Partitioning and local indexing by application table
- Support for Oracle Exadata, RAC, SQL*Loader direct path load, Parallelism, Oracle Label Security

- Support for SPARQL and mixed SPARQL and SQL queries
- Patented Table Function Rewrite converts SPARQL to SQL
- Packaged with enhanced Open Source Tools: Jena, Sesame, Joseki Web Services
- W3C standards RDF, RDFS, OWL2 RL, OWL2EL, SKOS, RDB2RDF, RDFa
- Scales to 100's of billions of triples
- Access from OBI EE, Oracle BPM, Oracle Advanced Analytic (R and ODM) through Oracle’s SPARQL gateway
Key Features of Oracle RDF Semantic Graph

- **W3C Compliant Semantic Database**
  - RDF, RDFS, OWL 2, SKOS, SPARQL, …

- **SPARQL Query**
  - Query execution planning for optimal performance
  - Allow multiple RDF graphs in SPARQL queries

- **Inferencing**
  - Pre-computed inferences (forward chaining)
  - Incorporates higher order logic and user defined rules
  - Supports incremental inferencing for higher availability

- **Jena Adapter for easy loading, querying and inferencing**

- **Security: Fine-Grained Access Control (for each triple)**
RDF Semantic Graph New Features

- **Named Graph:**
  - Scalable, meaningfully grouping of triples simplifies development
  - Reduces the cost / improves performance of load/query/inference

- **RDF Views on Relational Tables**
  - No duplication of data and storage
  - Simplifies semantic discovery workflows on relational schema and RDF graphs

- **Analytic operations and tools:**
  - Supports SPARQL 1.1 Path Expressions,
  - Derives more info faster w/ graph analytics, Oracle Advanced Analytics, Oracle R Enterprise
  - User-provided inference gives users more ctrl over functions & optimization of inference process and results generated.
RDF Semantic Graph New Features

- Document Indexing Performance Enhancements
  - Efficient processing of large document workloads, faster document operations with partitioning, parallel loading of entities extracted from documents

- XML Schema, Text and Spatial Data Types:
  - Filter queries written in SPARQL or SQL with XML schema, text, spatial attributes.
  - Faster, more selective queries using keywords, geography/distance, XML types.

- W3C and OGC Standards, Open Source
  - Conforms to the latest W3C and OGC standards open source frameworks
  - 45% improvement in query performance with Jena Adapter mid-tier caching
  - Scalable querying of distributed SPARQL endpoints.
Use Case: Aligning Unstructured Content

Oracle Big Data Appliance
(Extract and annotate text as RDF)

Unstructured Documents

Bulk Load RDF triples

Oracle RDF Semantic Graph

RDF Models

Oracle Advanced Analytics

InfiniBand

Stream | Acquire | Organize | Analyze & Visualize