Bring Graph Analysis to Relational and Hadoop Data

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Program Agenda with Highlight

1. Graph Data Management and Analysis: Usage & Use Cases
2. Oracle Big Data Spatial and Graph
3. In Memory Analyst (PGX)
4. What’s New
5. Demos
Relational Model vs. Property Graph Model

• Relational Model

• Graph Model

Courtesy: Tom Sawyer 2016
The Property Graph Data Model

- A set of vertices (or nodes)
  - each vertex has a unique identifier.
  - each vertex has a set of in/out edges.
  - each vertex has a collection of key-value properties.

- A set of edges (or links)
  - each edge has a unique identifier.
  - each edge has a head/tail vertex.
  - each edge has a label denoting type of relationship between two vertices.
  - each edge has a collection of key-value properties.

https://github.com/tinkerpop/blueprints/wiki/Property-Graph-Model
How graph analysis enhances business intelligence

• Answers from **Tabular Aggregation**
  – Who spends the most?
  – Who buys the highest margin goods?
  – Who is most consistently a top contributor?

Tabular questions:
Well-suited to SQL-like tools

• Answers from **Graph Connectivity**
  – Who’s most influential?
  – Which supplier do I depend on the most?
  – What is the right product mix for millennials?

Graph questions:
We need something different!
How is graph analysis important to business?

• What **patterns** are there in fraudulent behavior?
• Which supplier am I **most dependent upon**?
• Who is the most **influential customer**?
• Do my products appeal to certain **communities**?
• What targeted products or services do I **recommend** to customers?
Graph Use Case Scenarios

• Fraud detection
  – Find parties in insurance data who are on both sides of multiple claims, who live near each other

• Internet of Things
  – Manage graph of interconnected devices and predict the effect of an disruptions across network

• Cyber Security
  – Find entry points and affected machines

• Border Control
  – Analyze flight histories of a suspicious passenger. Indentify his co-travelers, co-traveler’s co-travelers, ...
Graph Analysis in Business

- **Product Recommendation**: Recommend the most similar item purchased by similar people

- **Influencer Identification**: Find out people that are central in the given network – e.g. influencer marketing

- **Community Detection**: Identify group of people that are close to each other – e.g. target group marketing

- **Graph Pattern Matching**: Find out all the sets of entities that match to the given pattern – e.g. fraud detection
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Oracle Big Data Spatial and Graph Property Graph Architecture

Graph Analytics

Parallel In-Memory Graph Analytics (PGX)

Access Layer

Apache Blueprints & Lucene/SolrCloud

Oracle Big Data Spatial and Graph

Apache HBase
Oracle NoSQL Database

Java APIs

REST/Web Service

Property graph formats supported

GraphML
GML
Graph-SON
Flat Files
CSV
Relational Data Sources

Java, Groovy, Python, ...

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Property Graph Workflow

• **Graph Data Management**
  – Transform and load relational data (or files) to a graph schema

• **Analysis and Exploration (in-memory analysis engine)**
  – Data scientists try different ideas (algorithms) on the data
  – Flexible, interactive, iterative, small-scale (sampled), ….

• **Production**
  – Operational queries and reporting
Graph Construction: Convert from Relational to Flat Files

• Two Key Java APIs:
  – OraclePropertyGraphUtils.convertRDBMSTable2OPV (E)
  – ColumnToAttrMapping

• Key Steps:
  – Column Mapping
  – Data Type Definition
  – Conversion

<table>
<thead>
<tr>
<th>EMPID</th>
<th>hasName</th>
<th>hasAge</th>
<th>hasSalary</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>Jean</td>
<td>20</td>
<td>120.0</td>
</tr>
<tr>
<td>102</td>
<td>Mary</td>
<td>21</td>
<td>50.0</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Example output .opv file

1101,name,1, Jean,, 1101, age, 2,, 20, 1101, salary, 4,, 120.0, 1102,name,1, Mary,, 1102, age, 2,, 21, 1102, salary, 4,, 50.0,
Data Access (APIs)

- Blueprints 2.3.0, Gremlin 2.3.0, Rexster 2.3.0
- Groovy shell for accessing property graph data
- REST APIs (through Rexster integration)
- PGQL (Property Graph Query Language)
Text Search through Apache Lucene/SolrCloud

• Integration with Apache Lucene & SolrCloud
• Support manual and auto indexing of Graph elements
  • Manual index:
    • oraclePropertyGraph.createIndex("my_index", Vertex.class);
    • indexVertices = oraclePropertyGraph.getIndex("my_index", Vertex.class);
    • indexVertices.put("key", "value", myVertex);
  • Auto Index
    • oraclePropertyGraph.createKeyIndex("name", Edge.class);
    • oraclePropertyGraph.getEdges("name", "*hello*world");
  • Enables queries to use syntax like "*oracle* or *graph*"
Support for Cytoscape Open Source Visualization
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Parallel In-Memory Graph Analyst

- An in-memory, parallel framework for fast graph analytics
  - Read a graph from NoSQL or HBase
  - Handles analytic workloads while the data access layer handles transactional workloads
  - Supports multiple users/graphs
  - Dozens of graph analysis functions
Social Network Analysis Algorithms (1)

- Structure Evaluation
  - Conductance
  - countTriangles
  - inDegreeDistribution
  - outDegreeDistribution
  - partitionConductance
  - partitionModularity
  - sparsify
  - K-Core computes

- Community Detection
  - communitiesLabelPropagation

- Ranking
  - closenessCentralityUnitLength
  - degreeCentrality
  - eigenvectorCentrality
  - Hyperlink-Induced Topic Search (HITS)
  - inDegreeCentrality
  - nodeBetweennessCentrality
  - outDegreeCentrality
  - pagerank
  - personalizedPagerank
  - randomWalkWithRestart
  - approximatePagerank
  - weightedPagerank

K-Core computes
Social Network Analysis Algorithms (2)

**Pathfinding**
- fattestPath
- shortestPathBellmanFord
- shortestPathBellmanFordReverse
- shortestPathDijkstra
- shortestPathDijkstraBidirectional
- shortestPathFilteredDijkstra
- shortestPathFilteredDijkstraBidirectional
- shortestPathHopDist
- shortestPathHopDistReverse

**Recommendation**
- salsa
- personalizedSalsa
- whomToFollow

**Classic - Connected Components**
- sccKosaraju
- sccTarjan
- wcc
“No Coding” Graph Analysis

Degree Centrality

Page Rank

Betweenness Centrality

Community Detection

heroInfluence = analyst.inDegreeCentrality()

heroPR = analyst.pageRank().topK(15)

b = analyst.betweenness().topK(15)

comic_coms = analyst.communities()
Computational Analytics: Built-in Package

Rich set of built-in parallel graph algorithms

- Detecting Components and Communities
  - Tarjan’s, Kosaraju’s, Weakly Connected Components, Label Propagation (w/ variants), Soman and Narang’s Spacification

- Ranking and Walking
  - Pagerank, Personalized Pagerank, Betweenness Centrality (w/ variants), Closeness Centrality, Degree Centrality, Eigenvector Centrality, HITS, Random walking and sampling (w/ variants)

- Path-Finding
  - Hop-Distance (BFS), Dijkstra’s, Bi-directional Dijkstra’s, Bellman-Ford’s

- Evaluating Community Structures
  - Conductance, Modularity, Clustering Coefficient (Triangle Counting), Adamic-Adar

- Other Classics
  - Vertex Cover, Minimum Spanning-Tree (Prim’s)

... and parallel graph mutation operations

- Creating Bipartite Graph
  - The original graph
    - Left Set: “a,b,e”
    - Create Bipartite Graph
    - Filter-Expression
    - Sort-By-Degree (Renumbering)
    - Filtered Subgraph
  - Create Undirected Graph
  - Simplify Graph

- Link Prediction
  - SALSA (Twitter’s Who-to-follow)

- Link Prediction
  - Vertex Cover
  - Minimum Spanning-Tree (Prim’s)
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What’s New: Property Graph Features
Big Data Spatial and Graph 2.0

Faster, more powerful and scalable

- Integration with Apache Spark
- PGQL: Declarative Graph Query Language
- Distributed In-memory Graph Analysis
- Hortonworks 2.4; Apache Solr 5.2x
- Conversion of CSV & Relational data to Graph

- Vertex Label Support
- Node.js Client Support
- Many new SNA Algorithms
- Data type support: long, char, byte, short, spatial
- and many more…
Oracle Differentiators -- Graph

• **Complete, Supported, Graph Solution:**
  – **Storage:** NoSQL, Hbase, RDBMS back-ends
  – **Data Access:** Blueprints, Java, Property Graph Query Language (PGQL)
  – **Rich Graph Analytics:** 40 pre-built, in-memory graph algorithms

• **Scalable:**
  – Analyze 20-30 billion edge graph in memory on single BDA node
  – Persist extremely large graphs on disk

• **Security:** Secure NoSQL, Kerberos CDH

• **10-50x Faster** than graph analysis competitors
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Resources on Big Data Spatial and Graph

• Oracle Big Data Spatial and Graph on Oracle.com: www.oracle.com/database/big-data-spatial-and-graph

• OTN product page (white papers, software downloads, documentation, tutorials): www.oracle.com/technetwork/database/database-technologies/bigdata-spatialandgraph

• Oracle Big Data Lite Virtual Machine - a free sandbox to get started: www.oracle.com/technetwork/database/bigdata-appliance/oracle-bigdatalite-2104726.html

• Hands On Lab for Big Data Spatial: tinyurl.com/BDSG-HOL

• Blog – examples, tips & tricks: blogs.oracle.com/bigdataspatialgraph

• @OracleBigData, @SpatialHannes, @JeanIhm