

# Introduction to Graph Cloud Services, Database, and Analytics



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SAN FRANCISCO, CA

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October 2, 2017

# Safe Harbor Statement

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# Program Agenda

- 1 Product Introduction
- 2 Use Cases
- 3 Feature Overview
- 4 Demo
- 5 Mazda Example

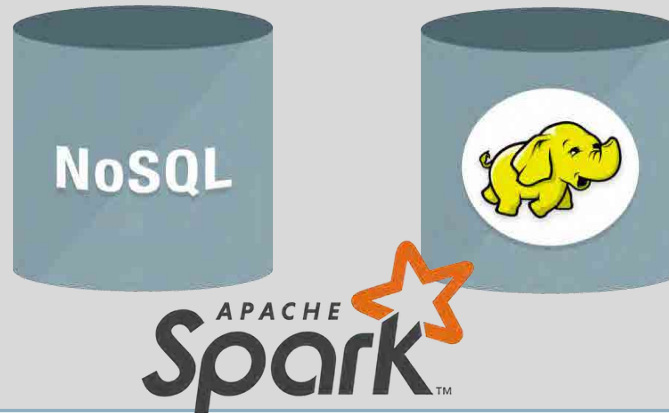
# Oracle's Spatial and Graph Strategy

## On Premise and Oracle Cloud

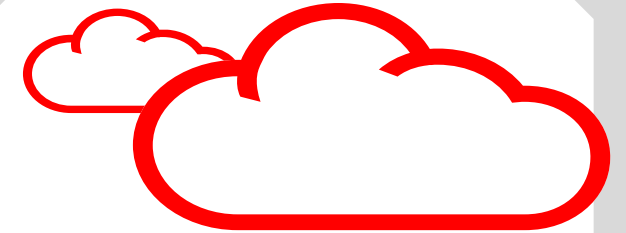
Oracle Database  
Spatial and Graph



Oracle Big Data Spatial and Graph



Spatial and Graph in  
Oracle Cloud



# Two Graph Data Models

Social Network  
Analysis

## Property Graph Model

- Path Analytics
- Social Network Analysis
- Entity analytics



- Financial
- Retail, Marketing
- Social Media
- Smart Manufacturing

Linked Data  
Semantic Web

## RDF Data Model

- Data federation
- Knowledge representation
- Semantic Web



- Life Sciences
- Health Care
- Publishing
- Finance

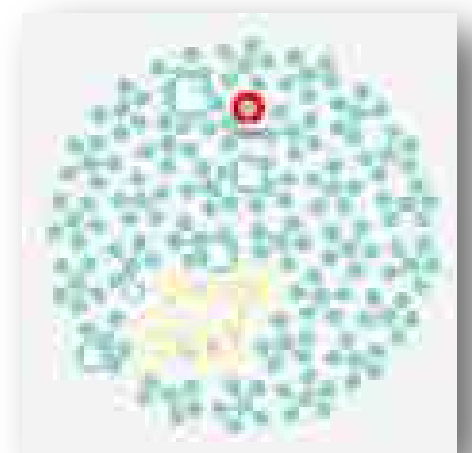
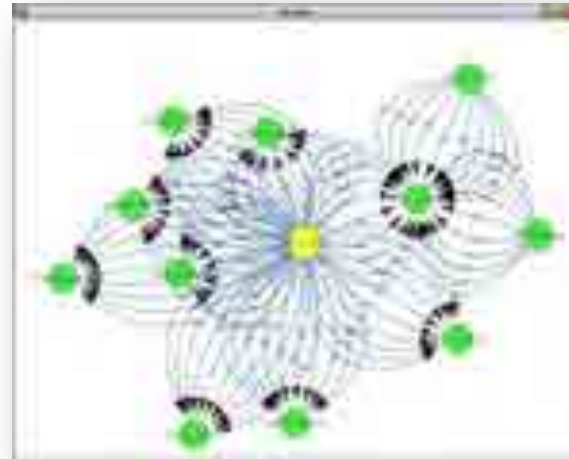
Use Case

Graph Model

Industry Domain

# Graph Database Features:

- Scalability and Performance
- Graph analytics
- Graph Visualization
- Graph Query Language
- Standard interfaces
- Integration with Machine Learning tools



*Courtesy Linkurious*



*Courtesy Tom Sawyer Perspectives*

# Graph Product Options

## Oracle Big Data Spatial and Graph

- Available for Big Data platform/BDCS
  - Hadoop, HBase, Oracle NoSQL
- Supported both on BDA and commodity hardware
  - CDH and Hortonworks
- Database connectivity through Big Data Connectors or Big Data SQL
- Included in Big Data Cloud Service

## Oracle Spatial and Graph (DB option)

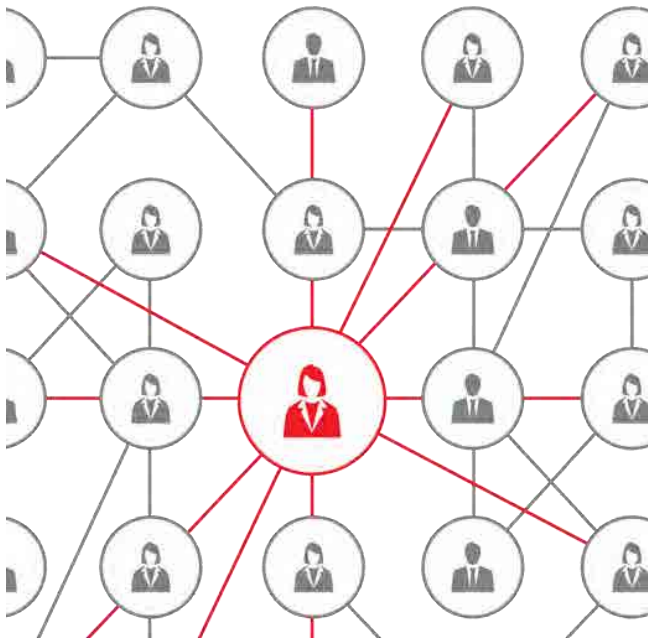
- Available with Oracle 12.2 / DBCS
- Using tables for graph persistence
- Graph views on relational data
- In-database graph analytics
  - Sparsification, shortest path, page rank, triangle counting, WCC, sub graphs
- SQL queries possible
- Included in Database Cloud Service

# Use Cases

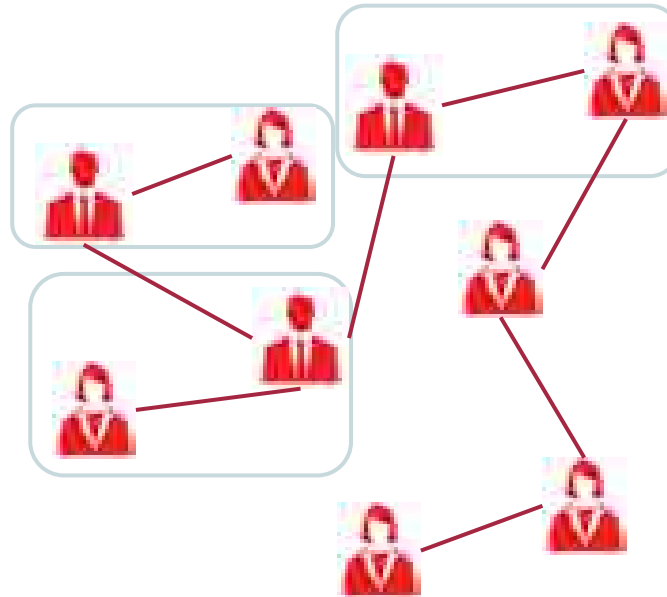


# Graph Analysis for Business Insight

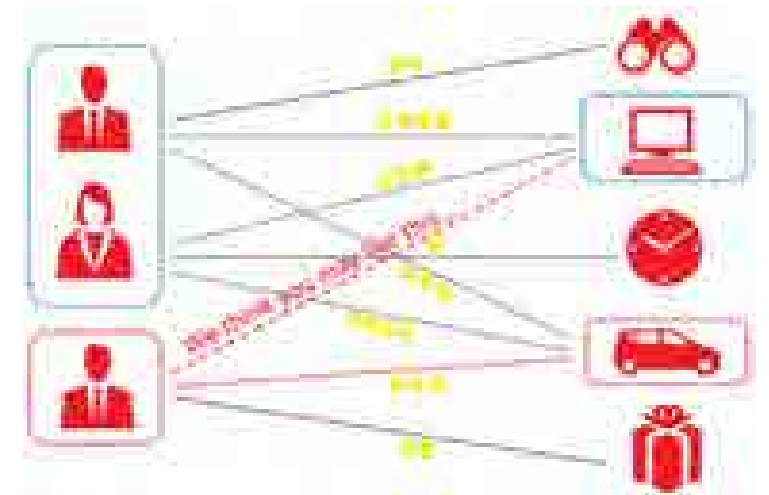
## Identify Influencers



## Discover Graph Patterns in Big Data

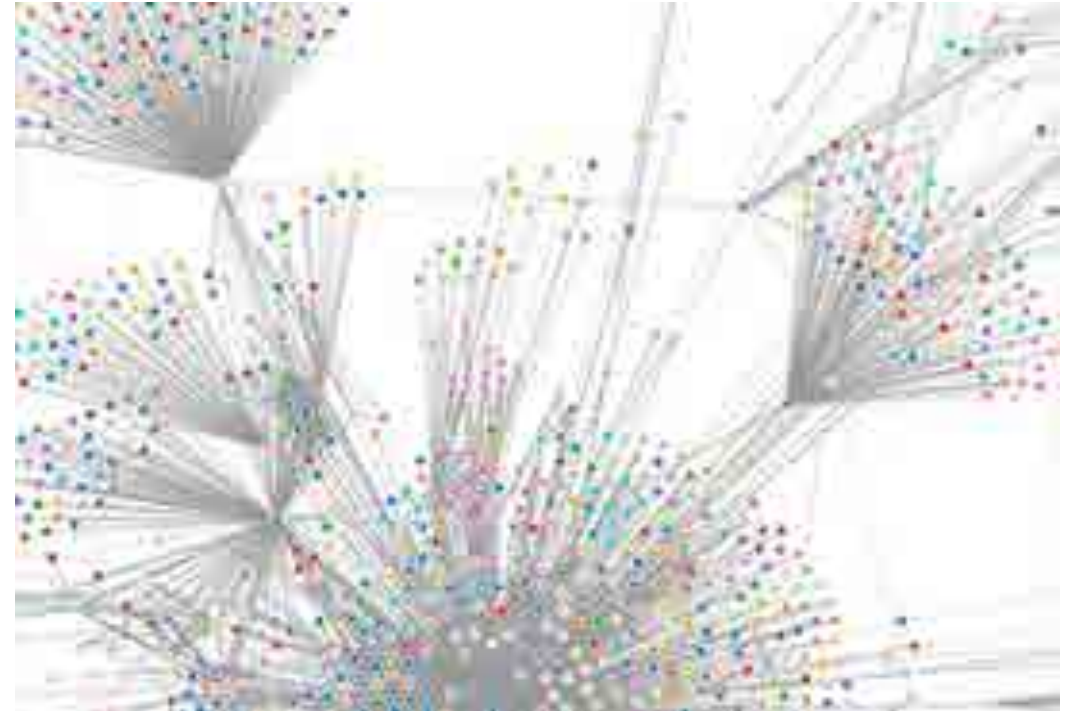


## Generate Recommendations



# Some Use Case Scenarios

- **Finance**
  - Customer 360, Fraud detection
- **Public Sector**
  - Tax Evasion, Crime network analysis
- **Retail**
  - Recommendation, sentiment analysis
- **Manufacturing**
  - Analyzing complex bill of materials (BoM)



# Financial Services

## Applying Graph Analysis To Improve Customer Service



- Model customer relationship to products, services, people, places.
- Analyze money customer's **flow** between non-bank to bank accounts
- Combine internal CRM data with enterprise and social media content
- Identify high-value customers across business divisions
- Enhance new product/service opportunities
- Provide Real-time recommendations

# Tax Fraud Analysis

## Chinese Province Tax Office

### Challenge:

- Modeling relationships between individuals and corporations
- Ingest documents, social media, web content, and publically available open data
- Create a ‘picture’ of the taxpayer network
  - Taxpayer relationship with other taxpayers
  - If a company structure, identify associated directors and shareholders in that company
  - Relationship between taxpayer’s and their associates’ financial affairs
  - Identify relevant intermediaries acting on behalf of taxpayer
- Explore tax evasion and fraud, trigger a formal case investigation



# Analyzing Blockchain Ledger Transactions

## Land Management, Banking, Public Services

- Distributed Ledgers being adopted in Finance, Public Sector
- Load and manage massive transactions from a distributed digital ledger
- Efficiently traverse a blockchain transaction graph
- Query and visualize – search for patterns of activity



# Public Security: Analyzing Criminal Networks

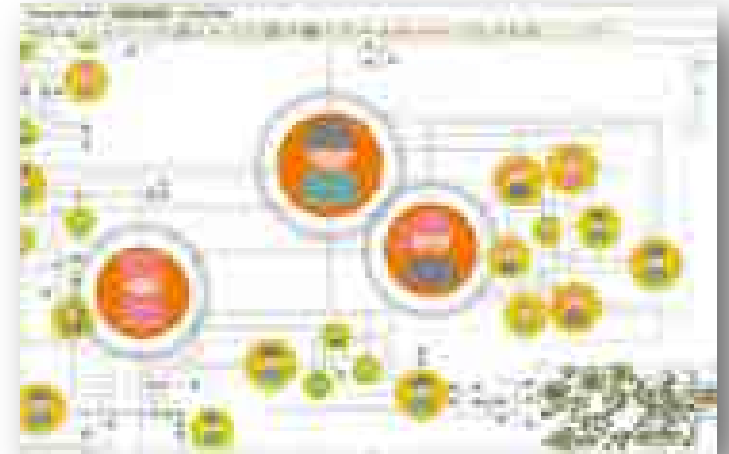
## Chinese Police Department

### Business Requirement

- Model relationships between known and suspected criminals
- Ingest documents, social media, web content, chat rooms, flight records, hotel stay registries, and publically available open datasets.

### How graph analysis solves the problem

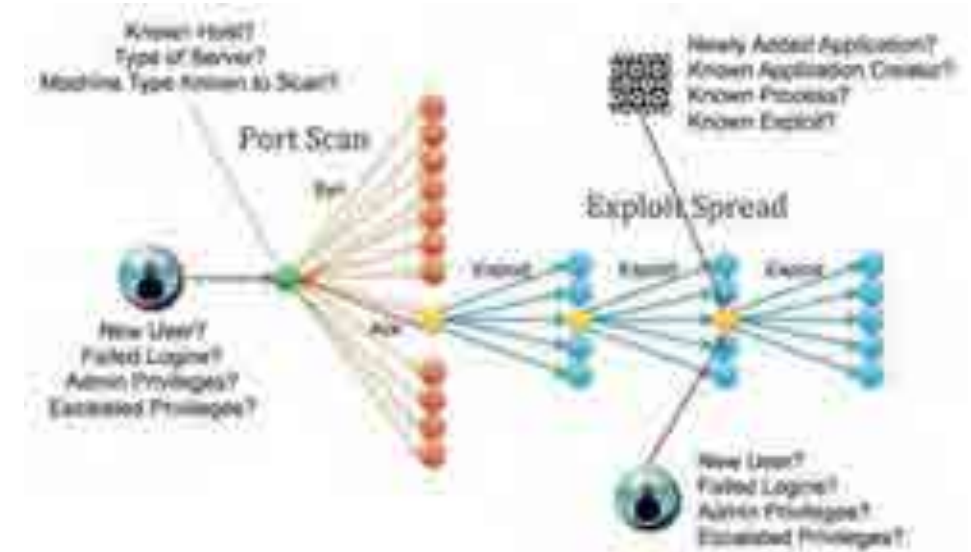
- Search for known individuals in web of content
- Analyze relationship with other criminals, travel history, addresses, employers
- Relationship between suspects and their financial affairs



*Courtesy Tom Sawyer Perspectives*

# IT Network Modeling & Monitoring

- Model cyber network topology as a Graph
- Identify CyberNetwork intrusions
  - Combine deep learning with graph analytics
- Visualize real-time state of CyberNetwork
- Analyze impact of component failure on an IoT system?
  - Reachability analysis: understand which routines, libraries, servers, routers are affected by a modification

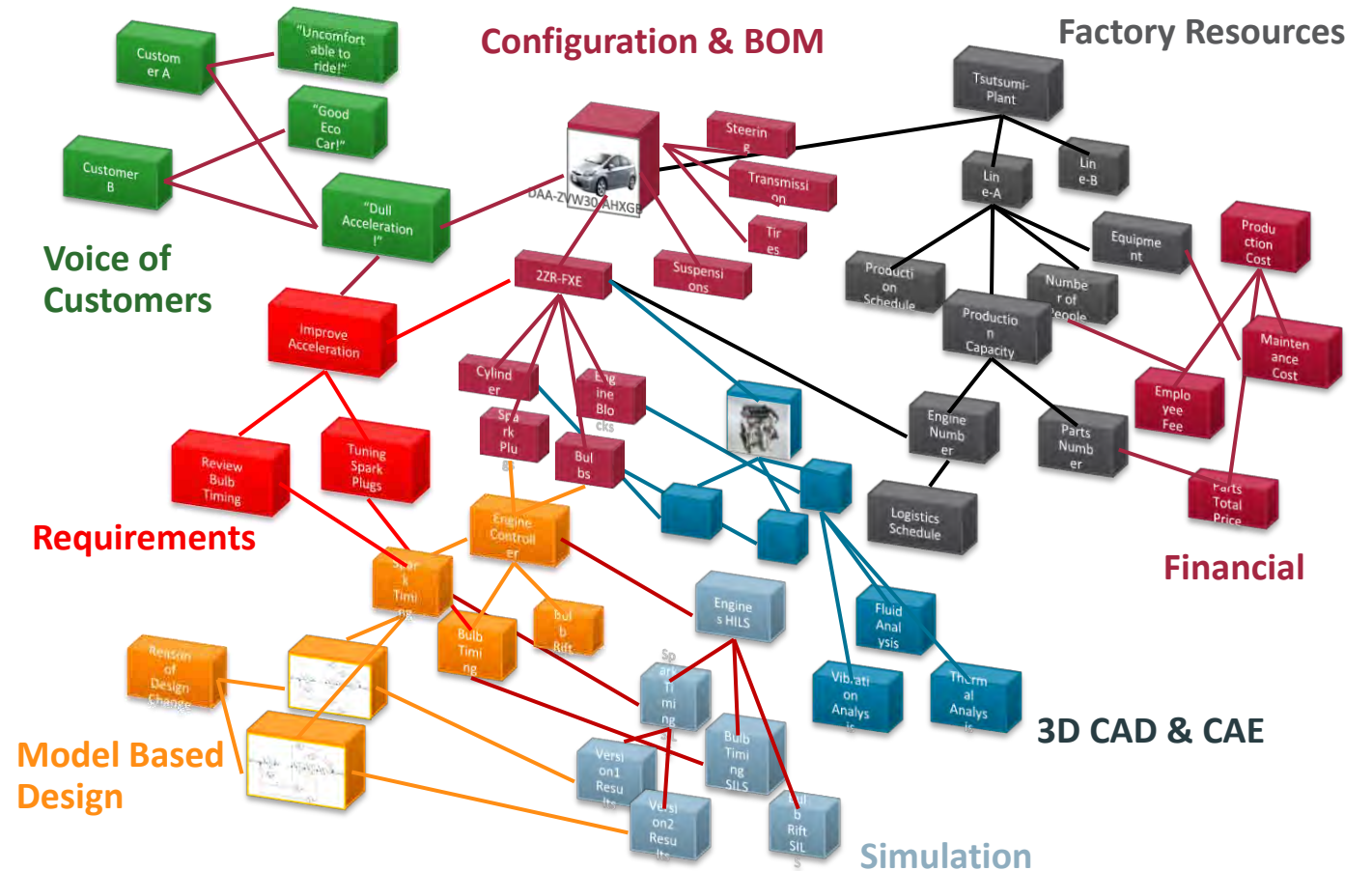


# Automotive Manufacturing

Support high variance, short innovation cycles of complex autos

## Graph View of Enterprise Data

- Unified graph representation of BoM, Configuration, CAE, Simulation...
- Generate “graph view” of relational data, or model instance data as graph
- Apply graph query and search across BoM and configuration models
- Apply graph analytics
- Scale to trillions of nodes and edges

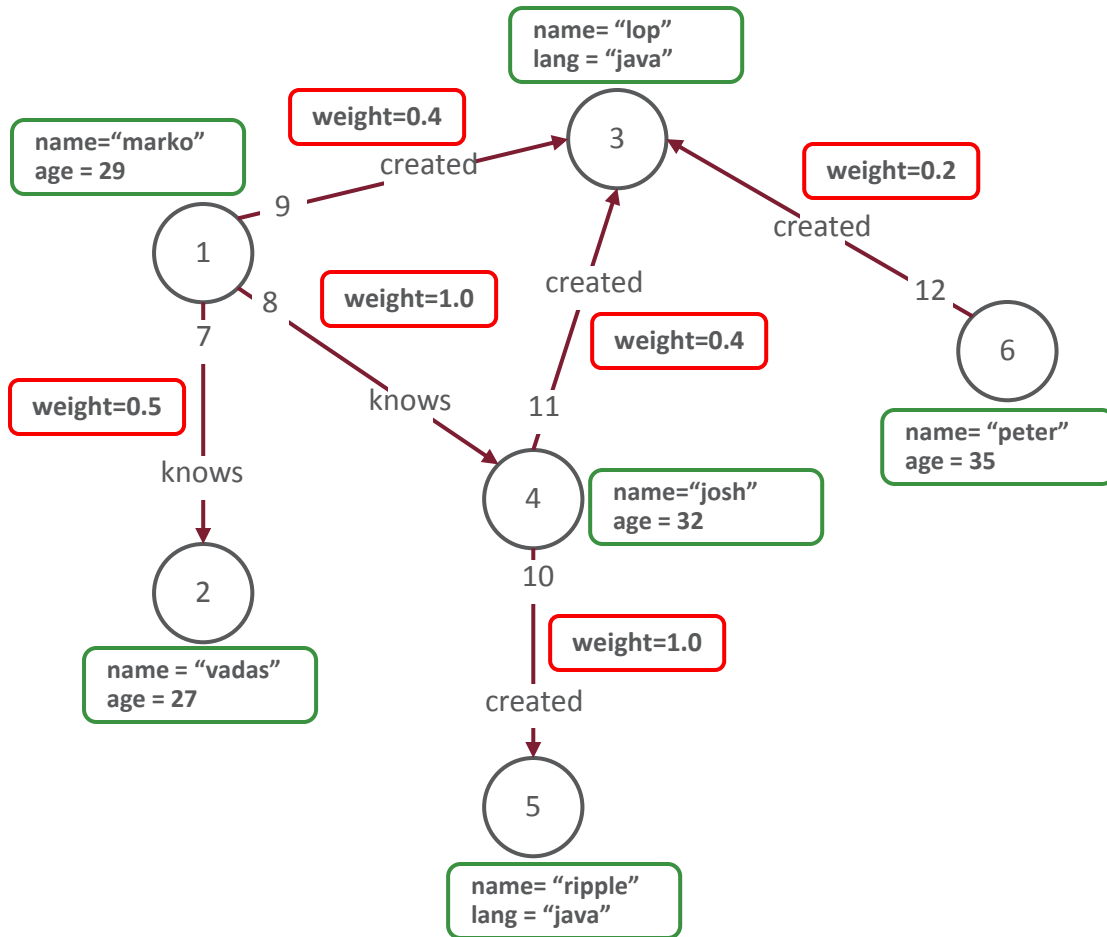




A man in a dark suit and tie is looking down at a tablet device he is holding. The background is a blurred office environment with windows and a desk. The text 'Feature Overview' is overlaid on the left side of the image.

# Feature Overview

# The Property Graph Data Model



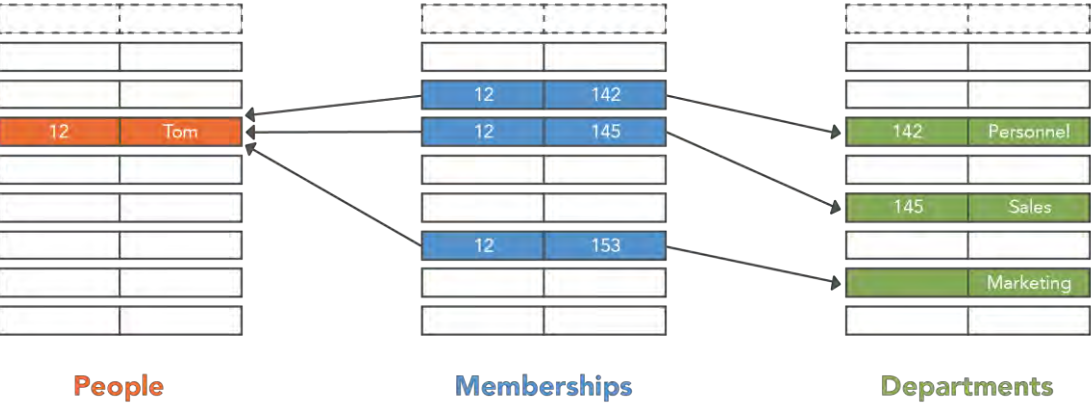
- A set of vertices (or nodes)
  - each vertex has a unique identifier.
  - each vertex has a set of in/out edges.
  - each vertex has a collection of **key-value** properties.
- A set of edges (or links)
  - each edge has a unique identifier.
  - each edge has a head/tail vertex.
  - each edge has a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

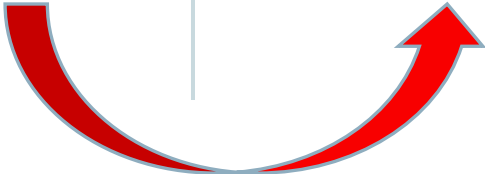
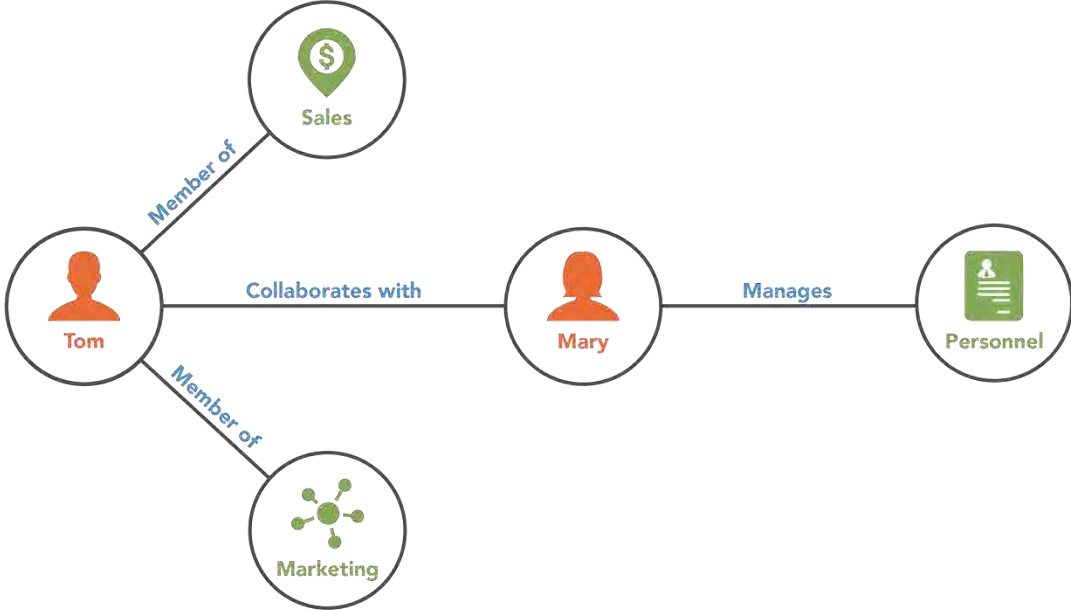


# Relational Model vs. Graph Model

- Relational Model



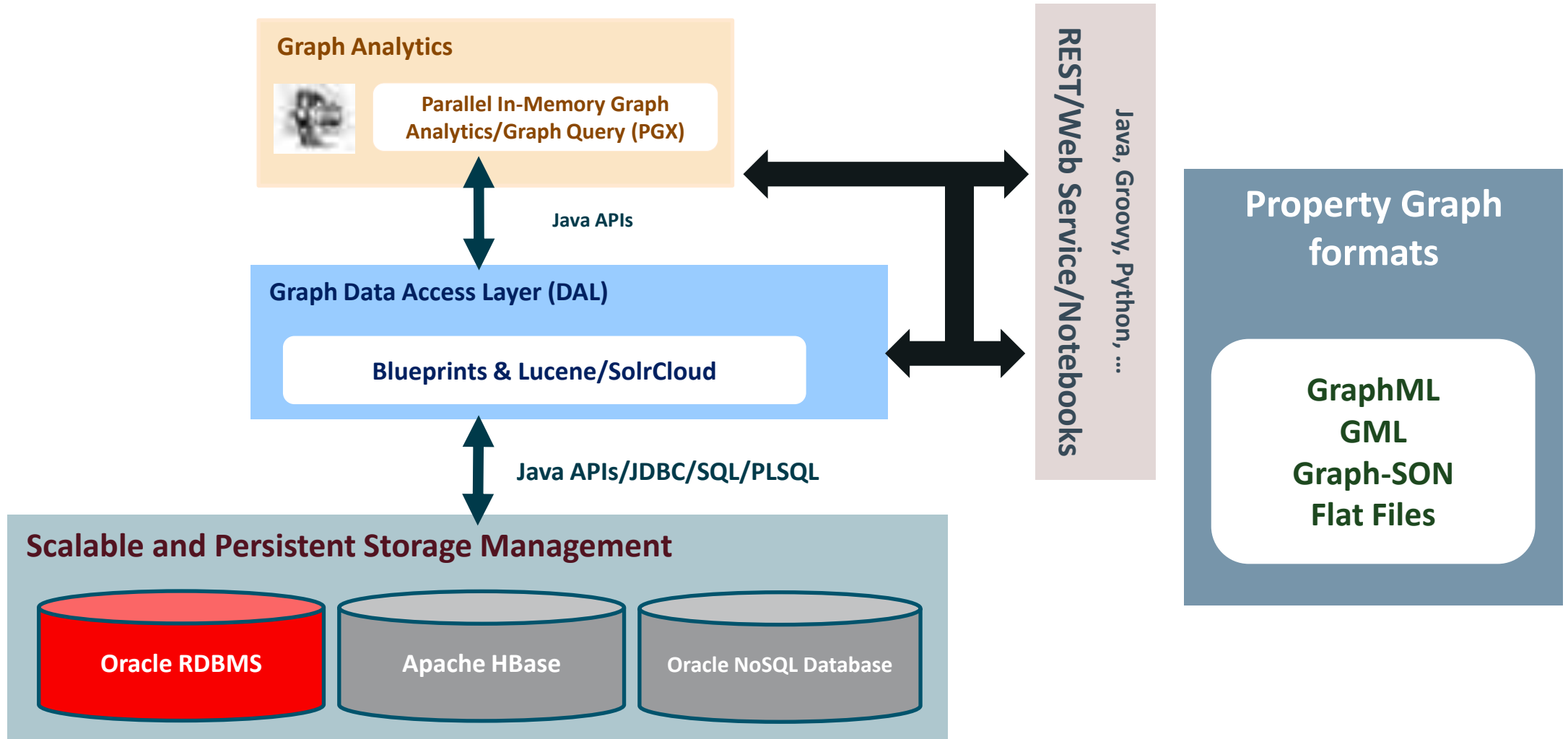
- Graph Model



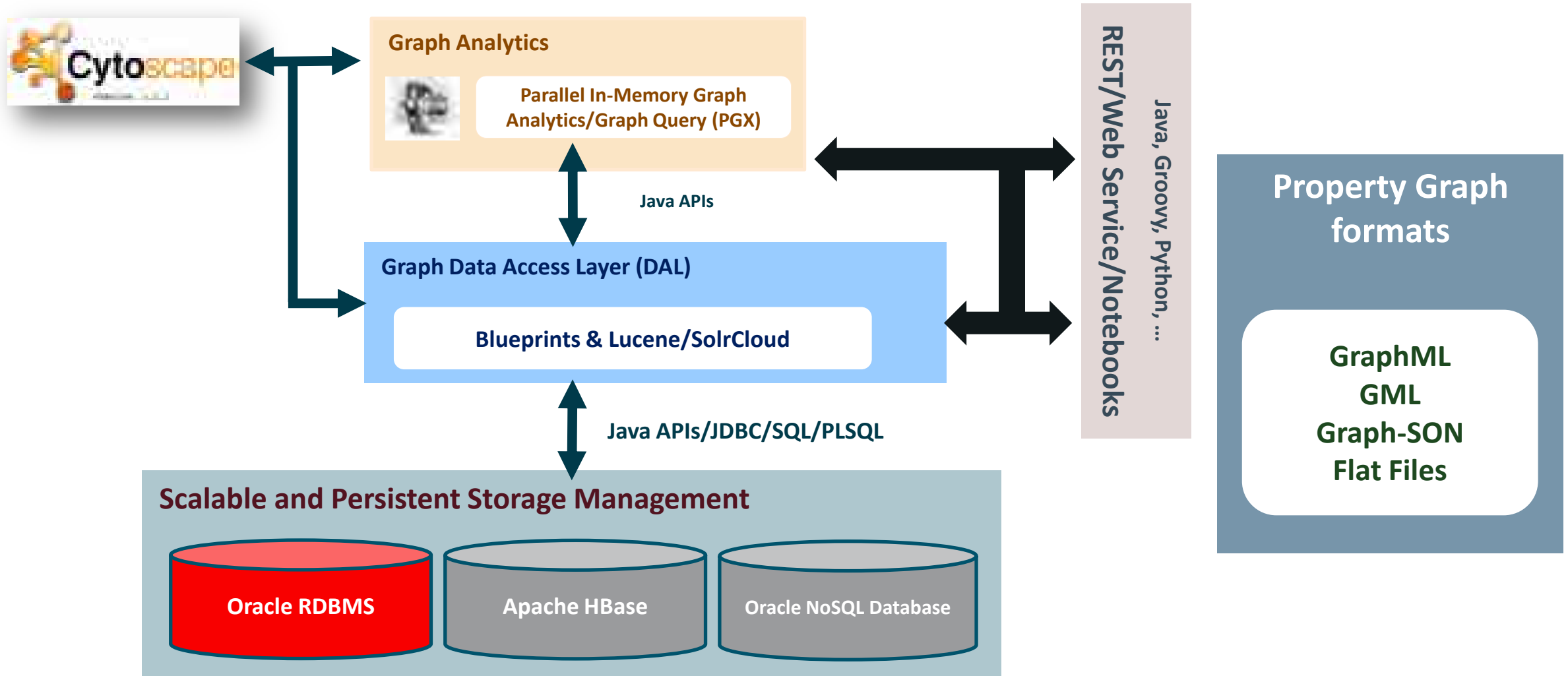
Courtesy: Tom Sawyer 2016



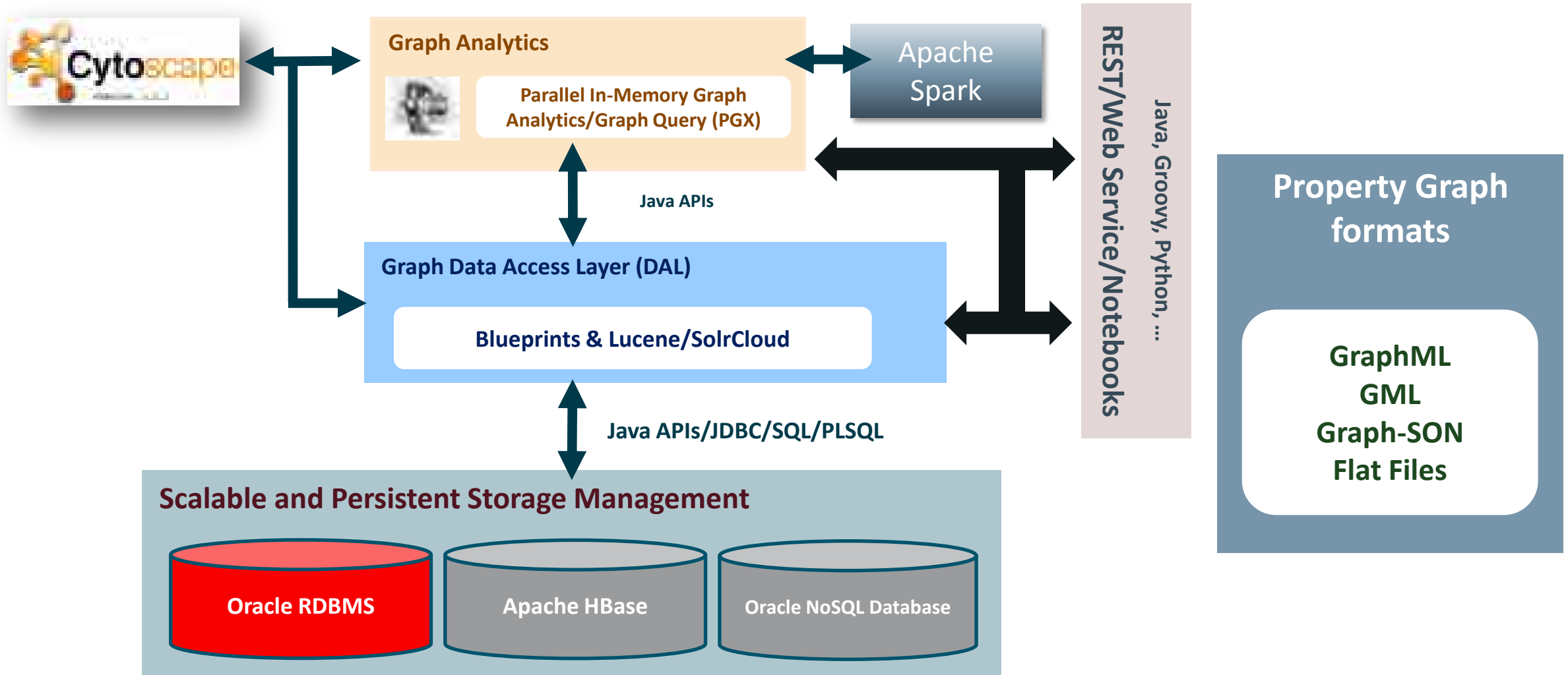
# Architecture of Property Graph Support



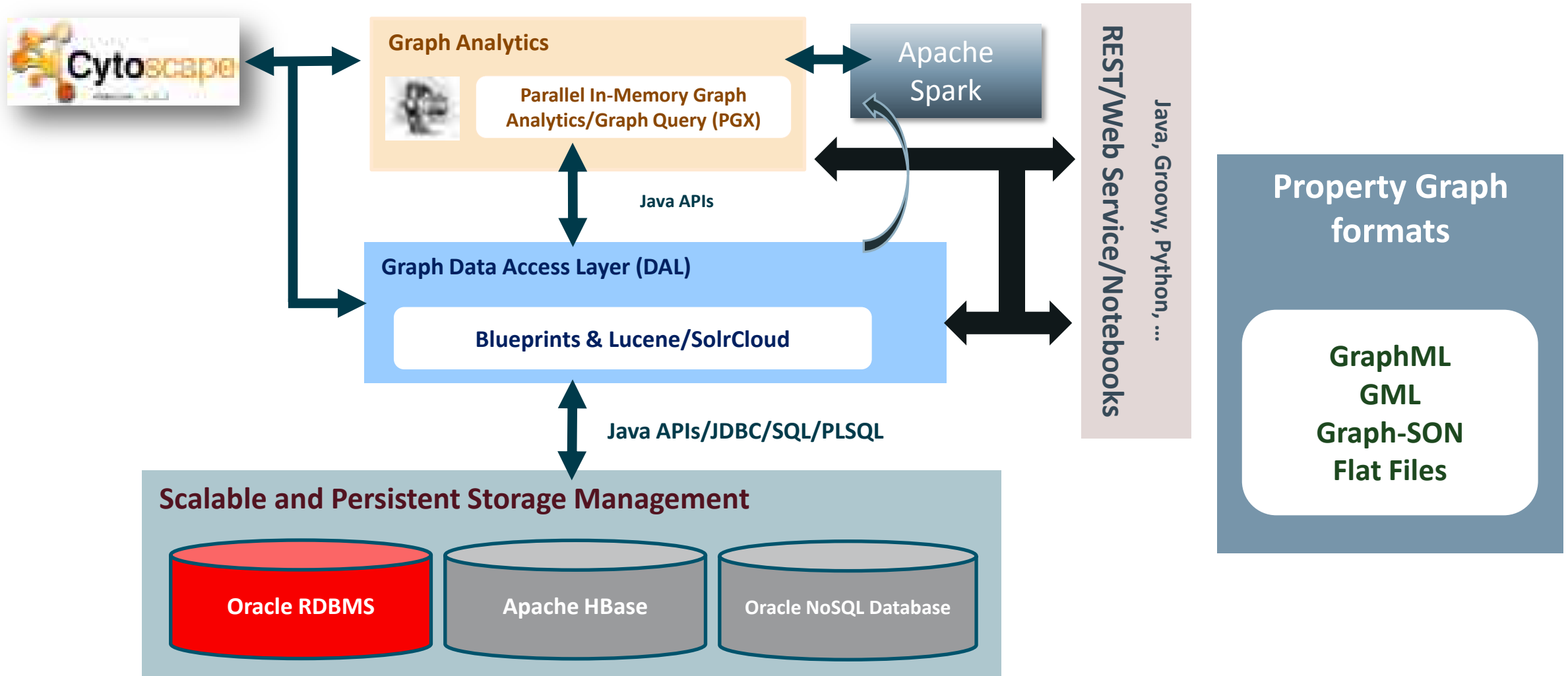
# Architecture of Property Graph Support



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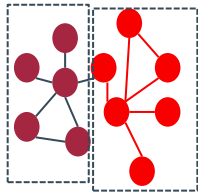
# Architecture of Property Graph Support



# Computational Analytics: Built-in Package

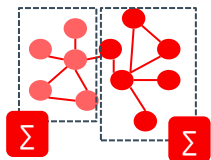
Rich set of built-in parallel graph algorithms

## Detecting Components and Communities



Tarjan's, Kosaraju's, Weakly Connected Components, Label Propagation (w/ variants), Soman and Narang's Spacification

## Evaluating Community Structures

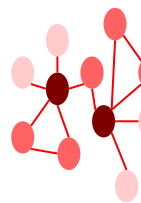


Conductance, Modularity, Clustering Coefficient (Triangle Counting), Adamic-Adar

## Link Prediction

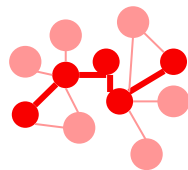
SALSA (Twitter's Who-to-follow)

## 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

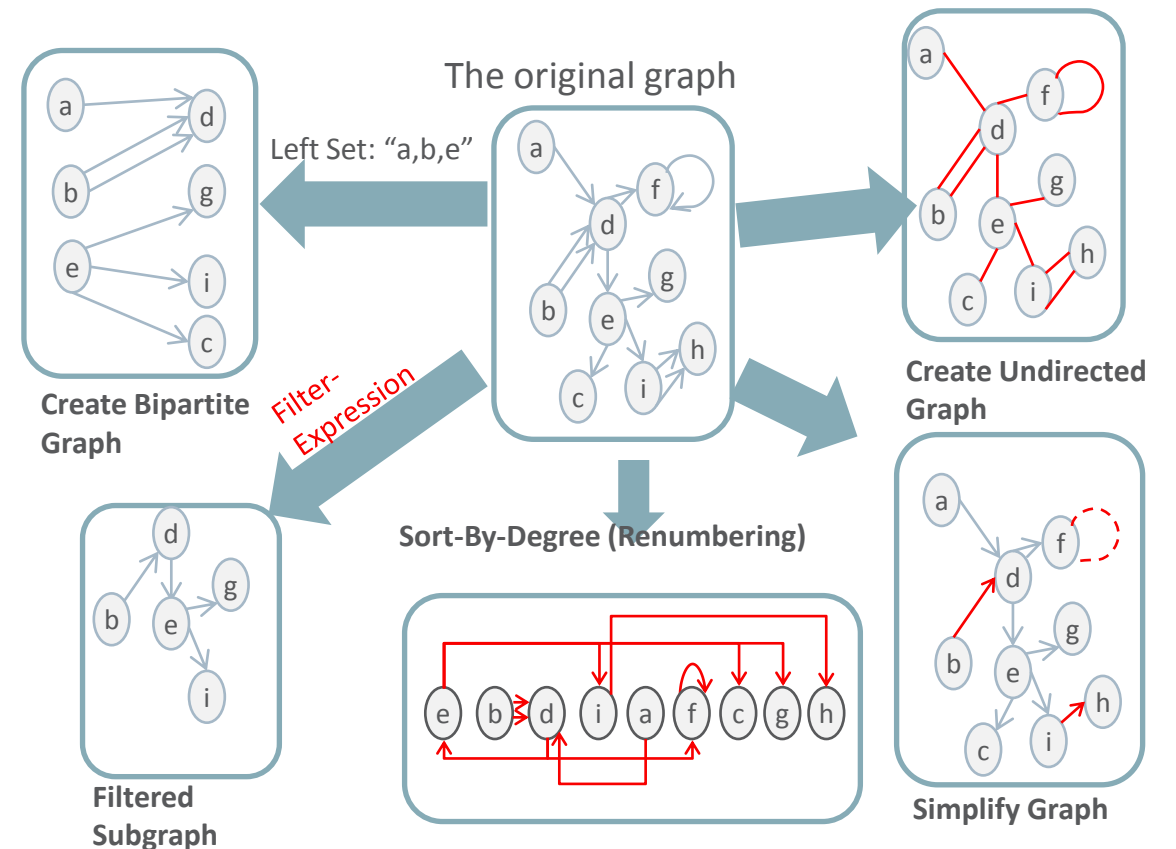


Hop-Distance (BFS), Dijkstra's, Bi-directional Dijkstra's, Bellman-Ford's

## Other Classics

Vertex Cover, Minimum Spanning-Tree (Prim's)

... and parallel graph mutation operations





# Graph Analysis Algorithms can be very hard to code ...

**BDSG and OSG Property Graph comes with 40+ pre-built algorithms**

- Example: Find the size of the 2-hop network of vertices (Gremlin+Python)

```
sum([v.query() \
     .direction(blueprints.Direction.OUT).count() \
     for v in OPGIterator(v0.query() \
     .direction(blueprints.Direction.OUT) \
     .vertices().iterator())])
```

- Single API call instead
  - Analysis in memory, in parallel
- Results can be persisted in Graph store and accessed from Oracle Database
  - Big Data SQL, Connectors

# Text Search through Apache Lucene/SolrCloud



## Why?

- Contribute to the performance of graph traversal queries
- Constrained to be uniform in type among the indexed elements (vertices or edges)

## Automatic Indexes

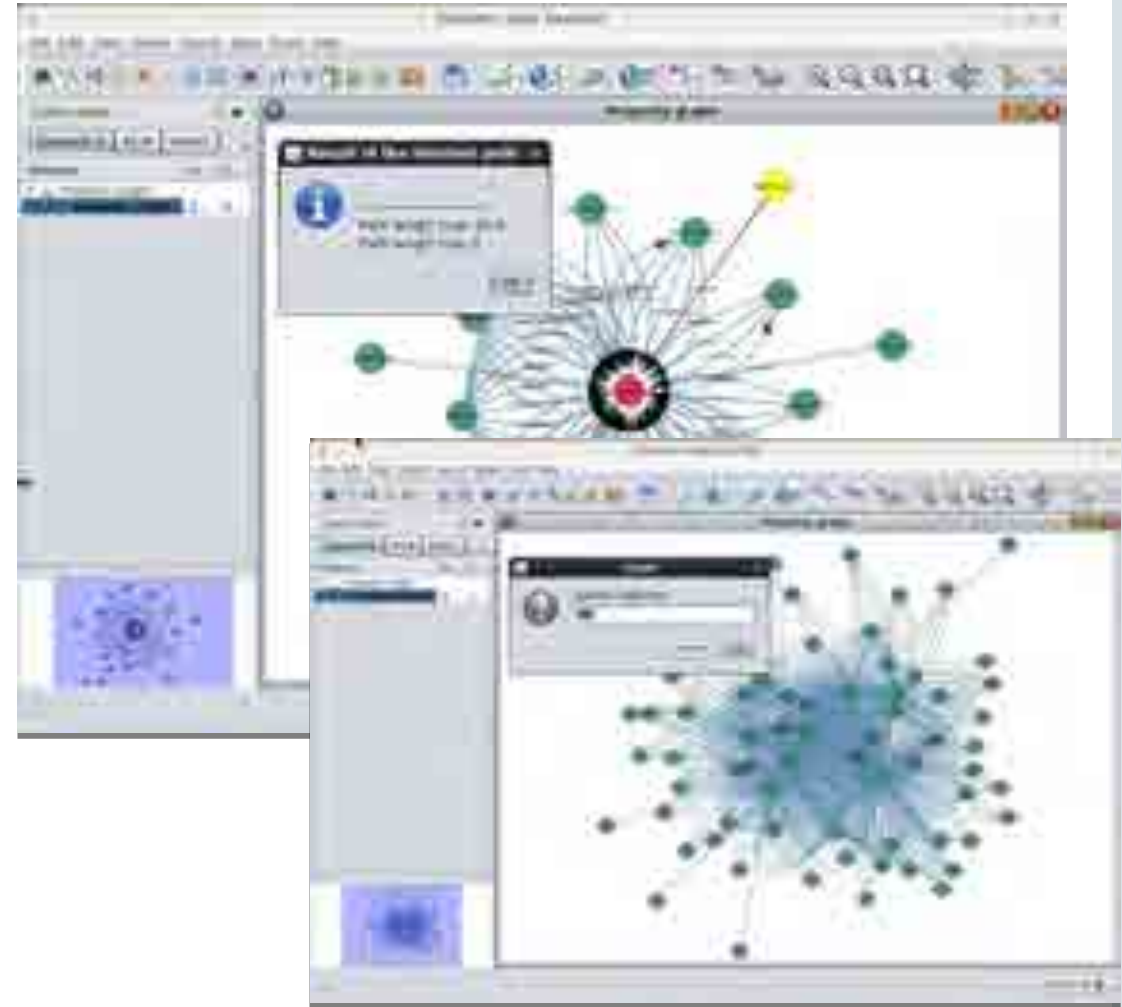
- Automatic update based on a subset of property keys
- Avoid linear scan to access an element by key/value

## Manual Indexes

- Maintained by users
- Fasten up text searches by a particular key/value pair
- Sub-graphs based on a set of (existing or temporary) properties

# Visualizing Property Graphs (with Cytoscape)

- Cytoscape supports Property Graph
- Connects to Oracle Database, Oracle NoSQL Database, or Apache HBase
- Runs Page Rank, Clustering, Shortest Path, etc
- Alternative to command-line for in-memory analytics once base graph created



# Additional Graph Visualization Partners

TomSawyer, Cambridge Intelligence, Linkurios, Vis.js,...



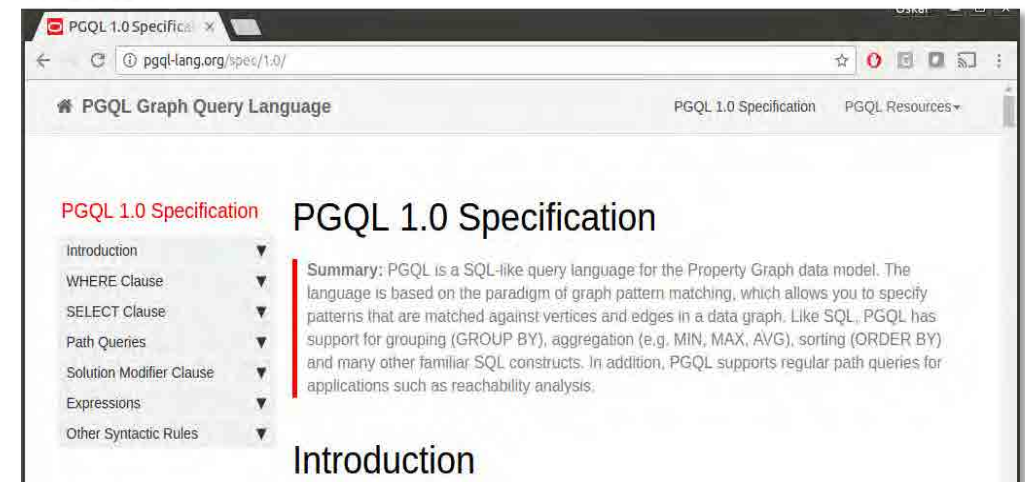
# Pattern matching using PGQL

- SQL-like syntax but with graph pattern description and property access
  - Interactive (real-time) analysis
  - Supporting aggregates, comparison, such as max, min, order by, group by
- Finding a given pattern in graph
  - Fraud detection
  - Anomaly detection
  - Subgraph extraction
  - ...

- Proposed for standardization by Oracle
  - Specification available on-line
  - Open-sourced front-end (i.e. parser)



<https://github.com/oracle/pgql-lang>



# Zeppelin Frontend

- Apache Zeppelin
  - **Multi-purpose notebook** for data analysis and visualization
  - Enables to embed interactive execution inside Browsers
  - Renders execution results with plots and tables within Browsers
- PGX provides a hook (interpreter) for Zeppelin integration



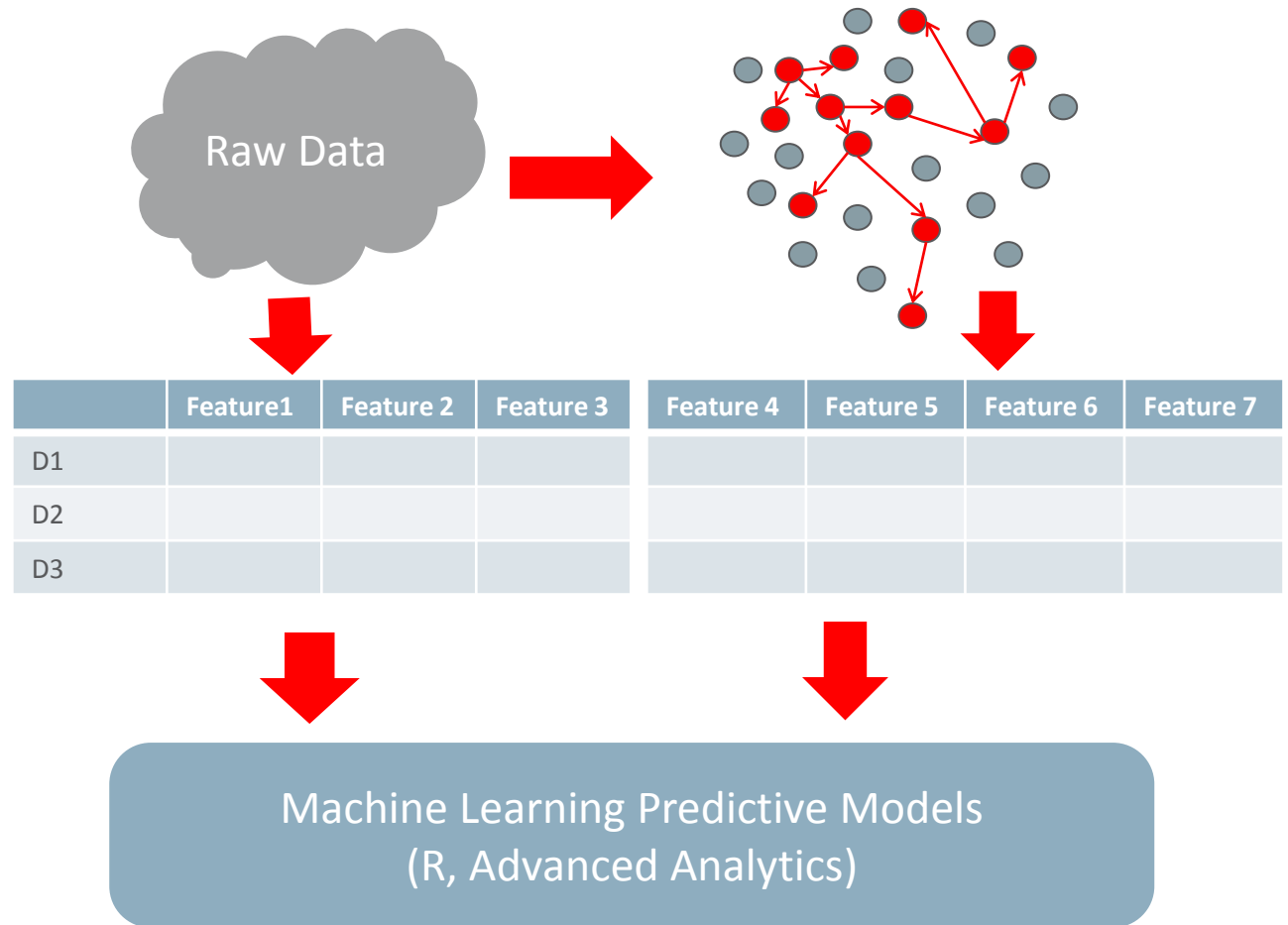
# Interacting with the Graph

- Access through APIs
  - Implementation of Apache Tinkerpop Blueprints APIs
  - Based on Java, REST plus SolR Cloud/Lucene support for text search
  - SQL/PLSQL for property graph functions in Oracle Database
- Scripting
  - Groovy, Python, Javascript, ...
  - Zeppelin integration, Javascript (Node.js) language binding
- Graphical UIs
  - Cytoscape, plug-in available for BDSG
  - Commercial Tools such as TomSawyer Perspectives, Ogma



# Enhancing ML and Data Analytics with Graphs

- Graph analysis can enhance the quality of ML and data analytics
- Graph representation helps discover hidden information about the data
  - Multi-hop relationship between data entities
- This can be used to further improve predictive models in R, Advanced Analytics, machine learning





# Distributed Graph Analysis Engine

## Handling extremely large graphs



- Oracle Big Data Spatial and Graph uses very compact graph representation
  - Can fit graph with ~23bn edges into one BDA node
- Distributed implementation scales beyond this
  - Processing even larger graphs with several machines in a cluster (scale-out)
  - Interconnected through fast network (Ethernet or, ideally, Infiniband)
- Integrated with YARN for resource management
  - Same client interface, but not all APIs implemented yet
- Again, much faster than other implementations
  - Comprehensive performance comparison with GraphX, GraphLab

Demo

# We Have Many Property Graph Demos

Demo booth at Moscone West SOA 127 (**Oracle's Graph Database**)

Fraud Detection

Graph  
Construction

Notebooks

Deep Learning  
Integration

Graph Studio

Network Intrusion  
Detection

Bitcoin/Blockchain

Recommender  
System

Graph  
Visualization

# Mazda Example

# Who Is MAZDA... ?



1920 Founded as 『Toyo Cork Kogyo Co., Ltd

1927 Renamed as 『Toyo Kogyo Co., Ltd

1929 Started the production of motorcycle

1984 Renamed as 『Mazda Motor Corporation

2020 Centennial anniversary



Sales price was around \$3.5 ~ \$3.8 then.



1931 Three-wheeler truck



1960 Mazda R360

(The very first passenger vehicle)

# Corporate Profile



<b>Company name</b>	Mazda Motor Corporation
<b>Founded</b>	January 30, 1920
<b>Headquarters</b>	Hiroshima / Japan
<b>Revenue</b>	\$30 Billion (FYE Mar 2017)
<b>Retail Volume</b>	1.5 million units (same FY as above)
<b>Number of employees</b>	48,749 (consolidated) (same FY as above)
<b>R&amp;D center</b>	5 locations (Hiroshima, Yokohama, US, Germany, China)
<b>Production Site</b>	3 factories in Japan Hiroshima Plant (Head Office, Ujina), Hofu Plant (Nishinoura, Nakanoseki), 7 factories overseas China, Thailand, Mexico, Vietnam, Malaysia, Russia

# Mazda Plant



# Mazda Plant





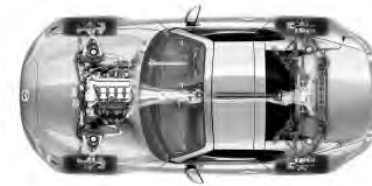
# Mazda's Problem



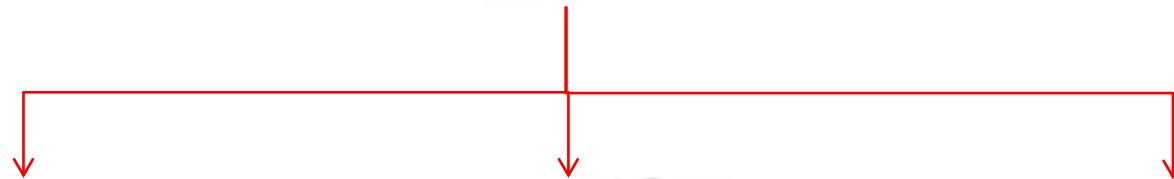
Imagine

Auto Manufacturer

Vehicle



Vehicle



Parts  
(constructed by  
small parts)

# Mazda's Problem

## Data Structure



### Relational ?

Many Business Domain

Finance  
Sale / Marketing  
Production  
Bill Of Materials  
...

### Graph ?

Which Data Structure is better for each Data ?

# Mazda's PoC



	May 8	15	22	29	June 5	12	19	26	July 3	10	17	24	31	Aug 7	21	28	Sep 4	11	18	25	Oct 2	9	16	23	30	Nov 6	13	20	27	Dec 4	11	18	
Ite0	Active																																
Ite1		Active	Active	Active																													
Ite2					Active	Active	Active																										
Ite3								Active	Active	Active	Active	Active																					
Ite4													Active	Active	Active	Active	Active																
Ite5																		Active	Active	Active	Active	Active											
Ite6																							Active	Active	Active	Active	Active						
Ite7																													Active	Active	Active	Active	Active



# Mazda's PoC (4<sup>th</sup> Stage)

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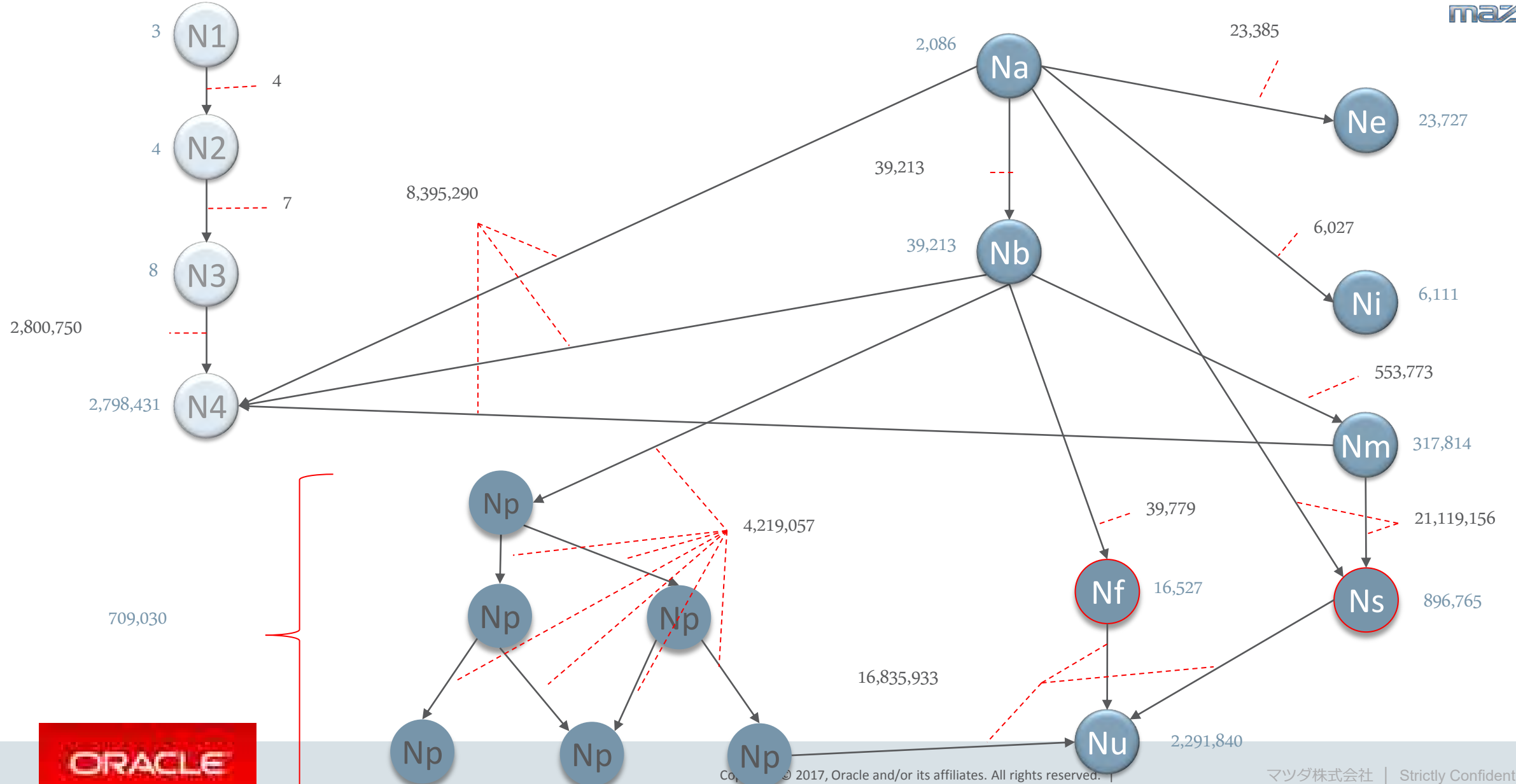


Total number of Edges : 53,993,161  
Total number of Nodes : 7,099,473

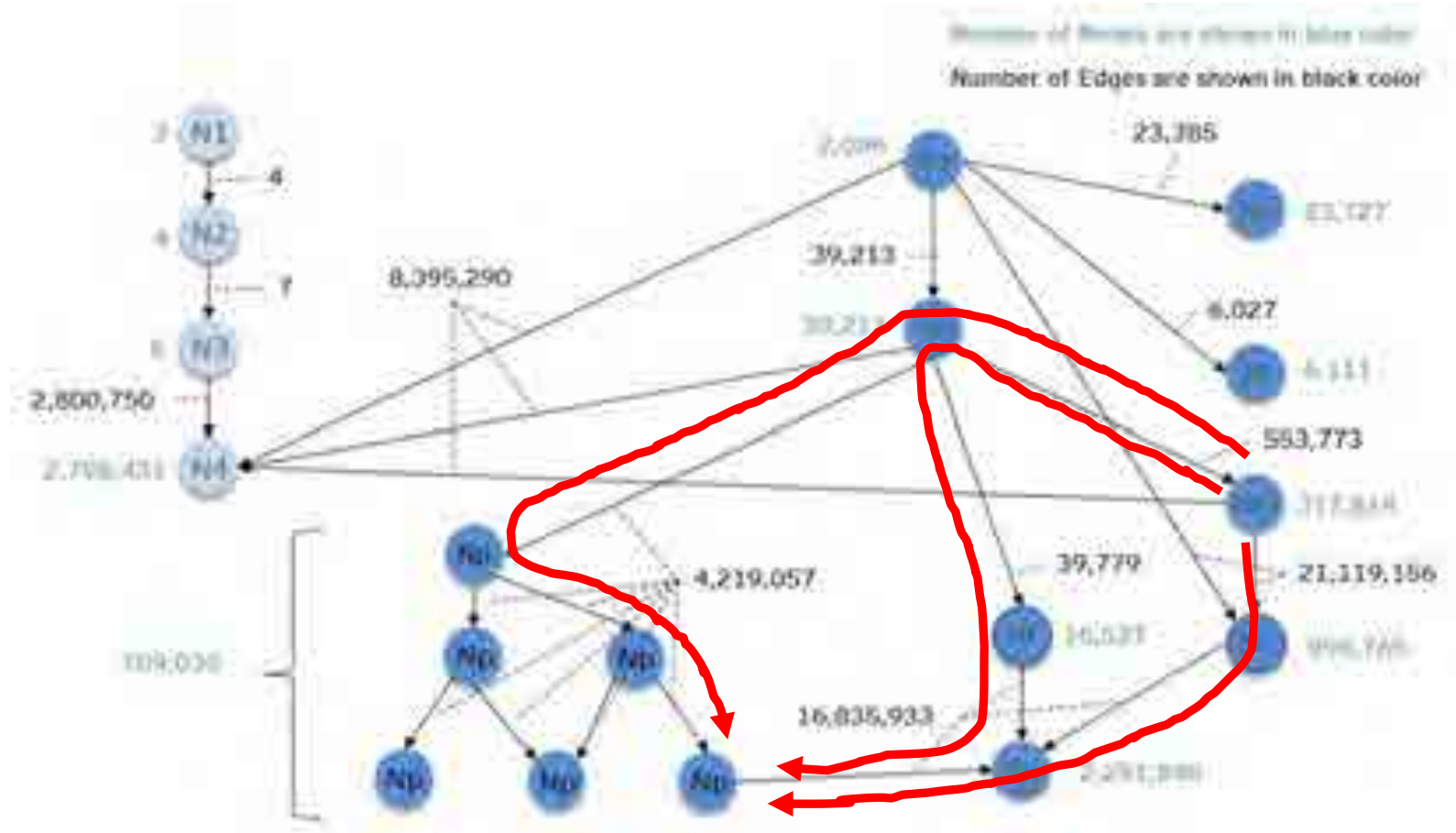
# Mazda's PoC (4<sup>th</sup> Stage)

Number of Nodes are shown in blue color

Number of Edges are shown in black color



# Performance (PGQL Query)



Nm	Num	Query time (ms)
aaaaaaaa	62	43
bbbbbbbb	66	51
cccccccc	78	46



# Summary (Current Result)

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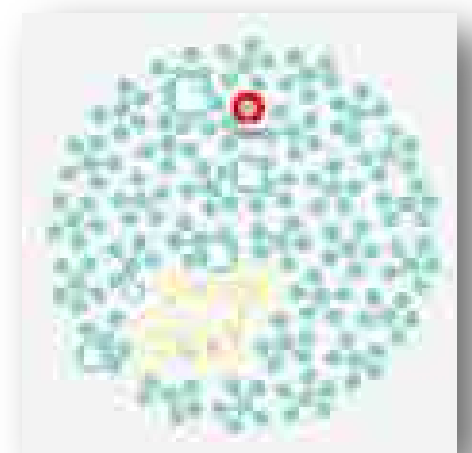
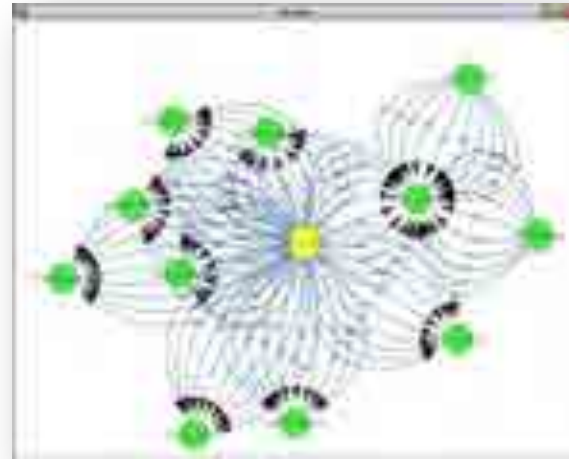


- Performance is Good !
- Issues: Refinement of complex PGQL queries
- Next Step: On going collaboration with Oracle Team
  - Oracle Japan, US Development, Oracle Labs

# Overview:

## Complete Graph Solution

- Distributed graph database
- Distributed in-memory analytics
- Graph Visualization
- Graph Query Language (PGQL)
- Standard interfaces
- Available on premise and Oracle Cloud



*Courtesy Linkurious*



*Courtesy Tom Sawyer Perspectives*



# Spatial and Graph at OOW 2017

[tinyurl.com/SpatialGraphOOW17](http://tinyurl.com/SpatialGraphOOW17)

## Spatial and Graph Sessions

Date/Time	Title	Location
<b>Monday, Oct. 2</b>		
2:15 pm - 3:00 pm	Leveraging the Power of Graph Analytics to Fight Financial Crimes [CON2495]	Park Central (Floor 2) – Metropolitan III
<b>Tuesday, Oct. 3</b>		
5:45 pm – 6:30 pm	Fake News, Trolls, Bots, and Money Laundering: Find the Truth with Graphs [CON6683]	Park Central - Franciscan I

## Spatial and Graph Demos

Date/Time	Title	Location
Monday - Wednesday	Oracle's Spatial Technologies for Database, Big Data, and the Cloud	Moscone West Exhibit Hall 1 <sup>st</sup> floor Oracle Cloud Platform > Analytics & Big Data, pod SOA 131
Monday - Wednesday	Oracle's Graph Database and Analytics for Database, Big Data, and the Cloud	Moscone West Exhibit Hall 1 <sup>st</sup> floor Oracle Cloud Platform > Analytics & Big Data, pod SOA 127



# ANALYTICS AND DATA SUMMIT 2018

All Analytics. All Data. No Nonsense.

March 20–22, 2018

We've changed our name! Formerly called the BIWA Summit with the Spatial and Graph Summit. Same great technical content—but new name!

[www.AnalyticsandDataSummit.org](http://www.AnalyticsandDataSummit.org)

**Call for speakers is now open with rolling acceptances.**

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