



Spatial and Graph Summit @

# ANALYTICS AND DATA SUMMIT 2019

All Analytics. All Data. No Nonsense.  
March 12-14, 2019

## Introduction to Graph Analytics and Oracle Cloud Service

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Oracle

 @SpatialHannes

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Oracle

 @JeanIhm

**Analytics and Data Summit 2019**

# Spatial and Graph Sessions

- 25+ Spatial and Graph related sessions
  - See **yellow** track on agenda
  - **Room 103** for most sessions
- **Tuesday:**
  - Morning: Graph technical sessions
  - Afternoon: Spatial technical sessions, Graph hands on lab
- **Wednesday:**
  - Morning: Spatial use cases
  - Afternoon: Graph use cases & Spatial sessions for developers
- **Thursday:**
  - Morning: Graph tech sessions & use cases (RDF & property graph)
  - Afternoon: Spatial - analytics & big data focus



[REGISTER](#)

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Tuesday, March 12

10:10am

• Introduction to Graph Analytics and Oracle Graph Cloud Service  
Hans Viehmann • Jean Ihm • Korbi Schmid

11:15am

• Graph Cloud Preview: How to Analyze Data Warehouse Data as a Graph  
Korbi Schmid • Jayant Sharma

1:10pm

• Oracle Spatial Studio: Self Service Spatial Visualization and Analysis  
Carol Palmer • Siva Ravada



## Safe Harbor Statement

The following is intended to outline our general product direction. It is intended for information purposes only, and may not be incorporated into any contract. It is not a commitment to deliver any material, code, or functionality, and should not be relied upon in making purchasing decisions. The development, release, timing, and pricing of any features or functionality described for Oracle's products may change and remains at the sole discretion of Oracle Corporation.

# Program Agenda

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

# Graph – an important growth area for data & analytics

## Gartner Identifies Top 10 Data and Analytics Technology Trends for 2019



### Trend No. 5: Graph

Graph analytics is a set of analytic techniques that allows for the exploration of relationships between entities of interest such as organizations, people and transactions.




The application of graph processing and graph DBMSs will grow at 100 percent annually through 2022 to continuously accelerate data preparation and enable more complex and adaptive data science.

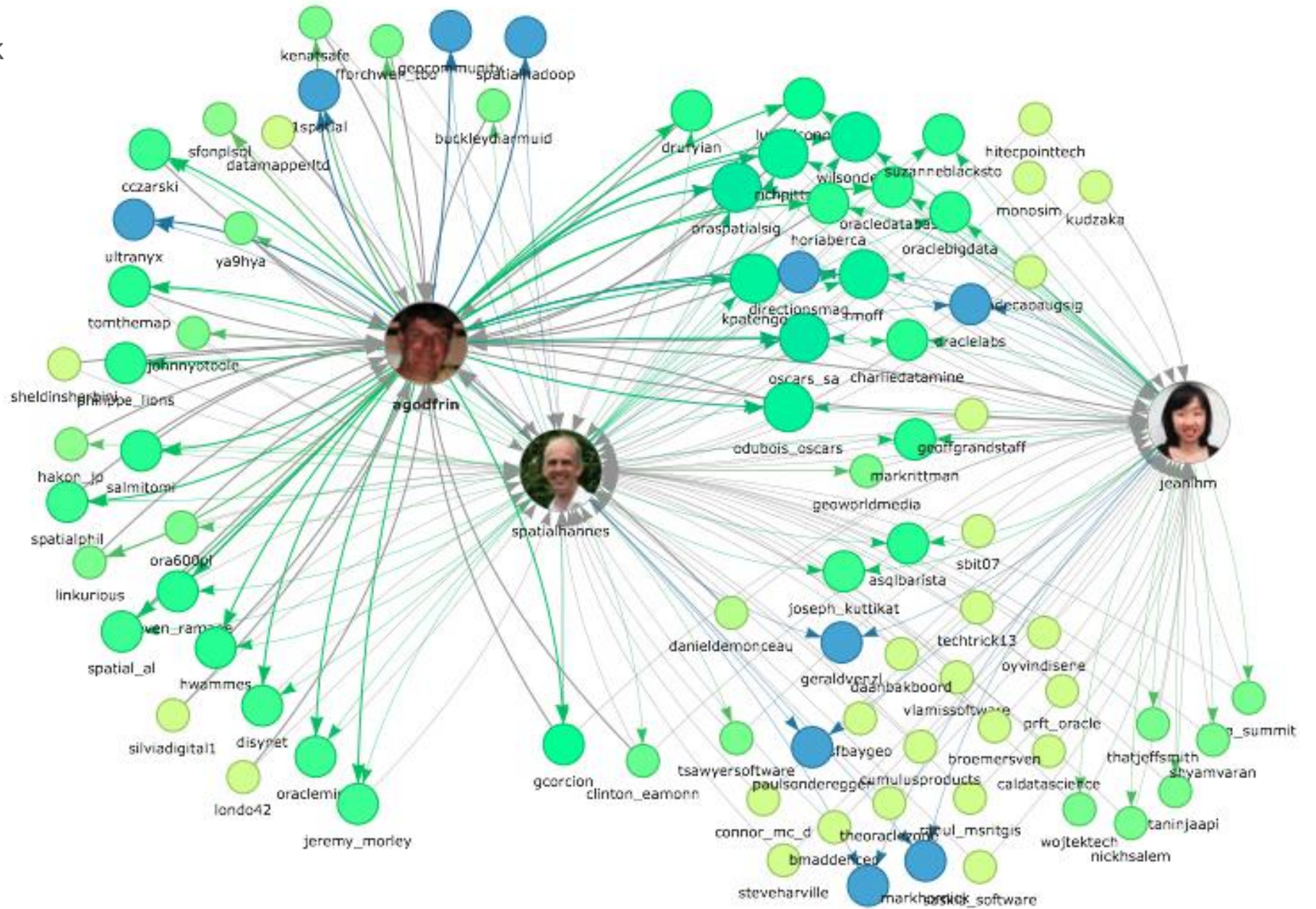
Graph data stores can efficiently model, explore and query data with complex interrelationships across data silos, but the need for specialized skills has limited their adoption to date, according to Gartner.

Graph analytics will grow in the next few years due to the need to ask complex questions across complex data, which is not always practical or even possible at scale using SQL queries.

*Source: Gartner press release, 2/18/2019, [www.gartner.com/en/newsroom/press-releases/2019-02-18-gartner-identifies-top-10-data-and-analytics-technolo](http://www.gartner.com/en/newsroom/press-releases/2019-02-18-gartner-identifies-top-10-data-and-analytics-technolo)*



-  Following, no follow back
-  Follower, no follow back
-  Follow each other



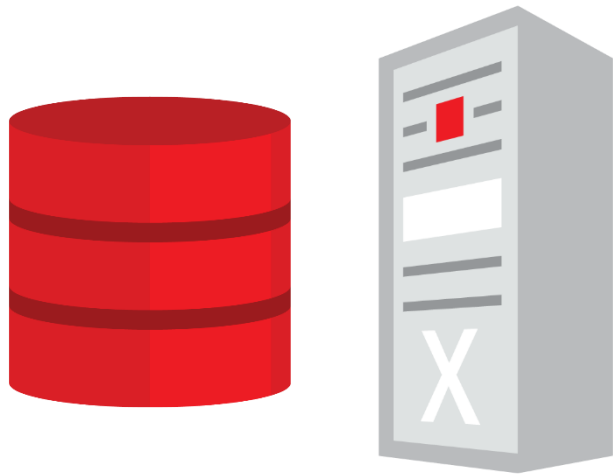
<https://twitter.jeffprod.com>



# Oracle's Spatial and Graph Strategy

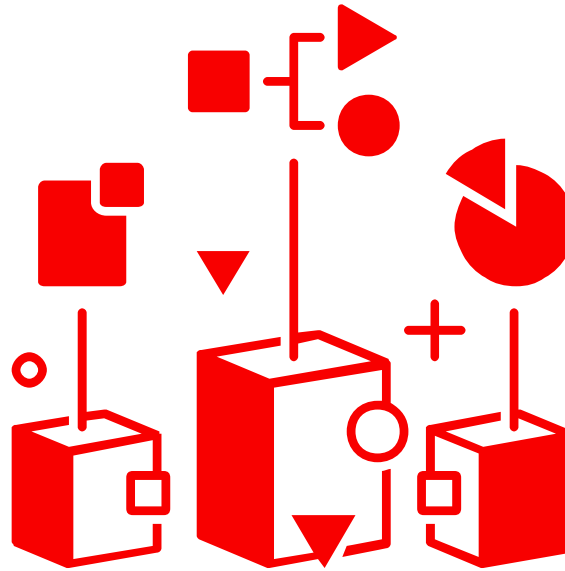
Enabling Spatial and Graph use cases on every platform

Oracle Database  
Spatial and Graph Option



Exadata  
Non-Engineered Systems

Oracle Big Data  
Spatial and Graph



Big Data Appliance  
Commodity Hadoop  
Spark

Cloud  
Services



Database Cloud Service  
Exadata Cloud Service

# Two Graph Data Models

## Social Network Analysis

### Property Graph Model

- Path Analytics
- Social Network Analysis
- Entity analytics

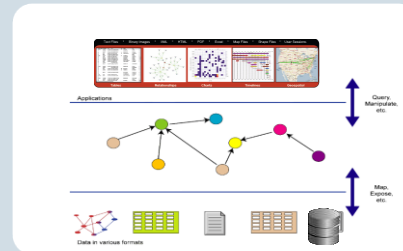


- Financial
- Retail, Marketing
- Social Media
- Smart Manufacturing

## Linked Data Knowledge Graphs

### RDF Data Model

- Data federation
- Knowledge representation



- Life Sciences
- Health Care
- Publishing
- Finance

Use Case

Graph Model

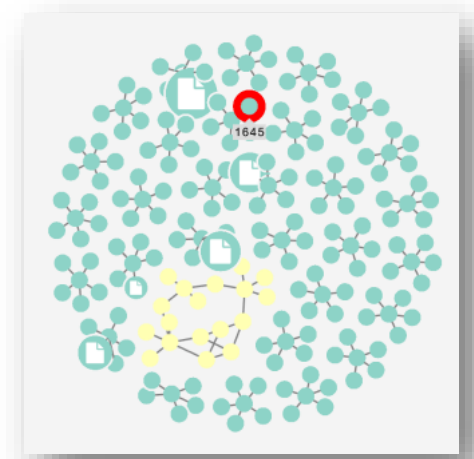
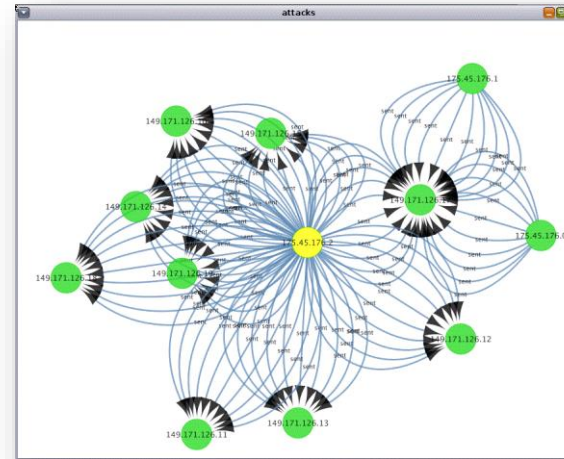
Industry Domain

**RDF Knowledge Graph Sessions:** Technical overview, use cases on Knowledge Graphs and BIM for Engineering (Bechtel) – Thursday 8:45 – 10:40am

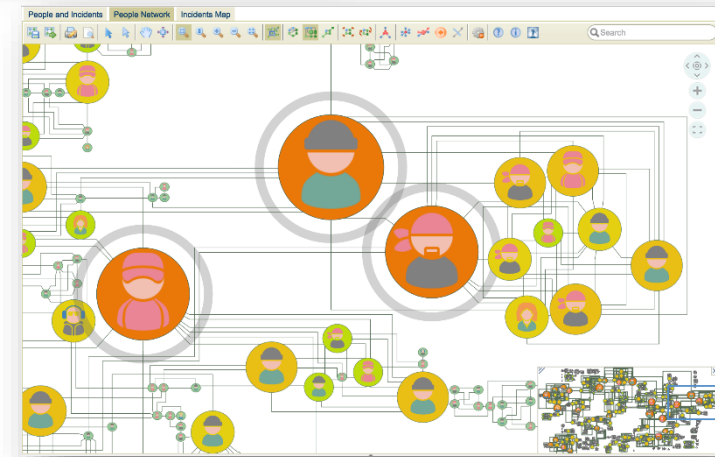


# Graph Database Features:

- Scalability, Performance, Security
- Graph Analytics
- Graph Query Language
- Graph Visualization
- Standard Interfaces
- Integration with Machine Learning tools



*Courtesy Linkurious*



*Courtesy Tom Sawyer Perspectives*

# Oracle Products Supporting Property Graphs

## Oracle Big Data Spatial and Graph

- Available for Big Data platform
- Supported both on BDA and commodity hardware
  - Cloudera Distribution for Hadoop
- Database connectivity through Big Data Connectors or Big Data SQL
- Part of Big Data Cloud Service

## Oracle Spatial and Graph (DB option)

- Available with Oracle 12.2 and above (EE)
- Using tables for graph persistence
- In-database graph analytics
  - Sparsification, shortest path, page rank, triangle counting, WCC, sub graph generation...
- SQL and PGQL queries possible
- Included in Database Cloud Services

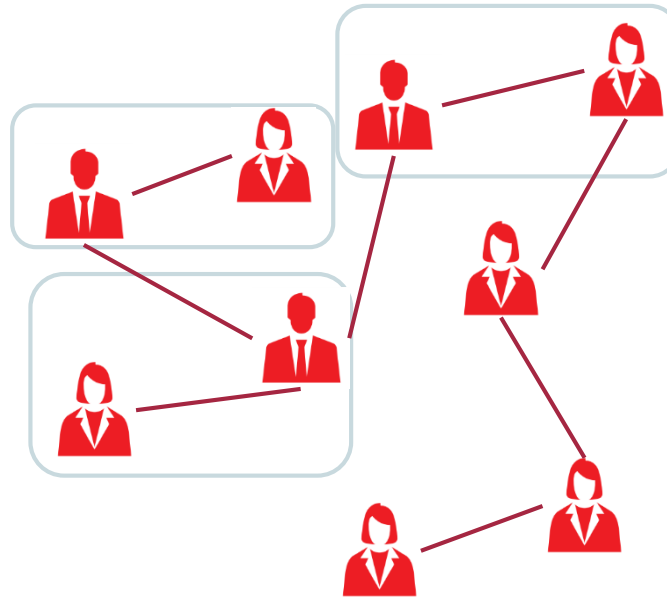
# Use Cases

# Graph Analysis for Business Insight

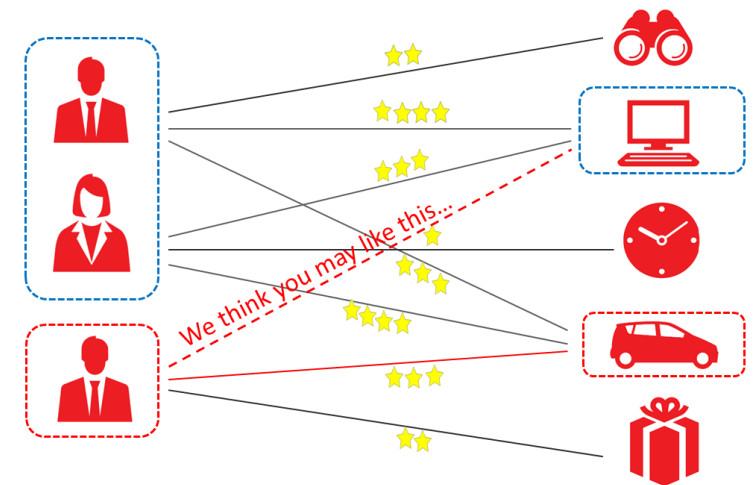
## Identify Influencers



## Discover Graph Patterns in Big Data

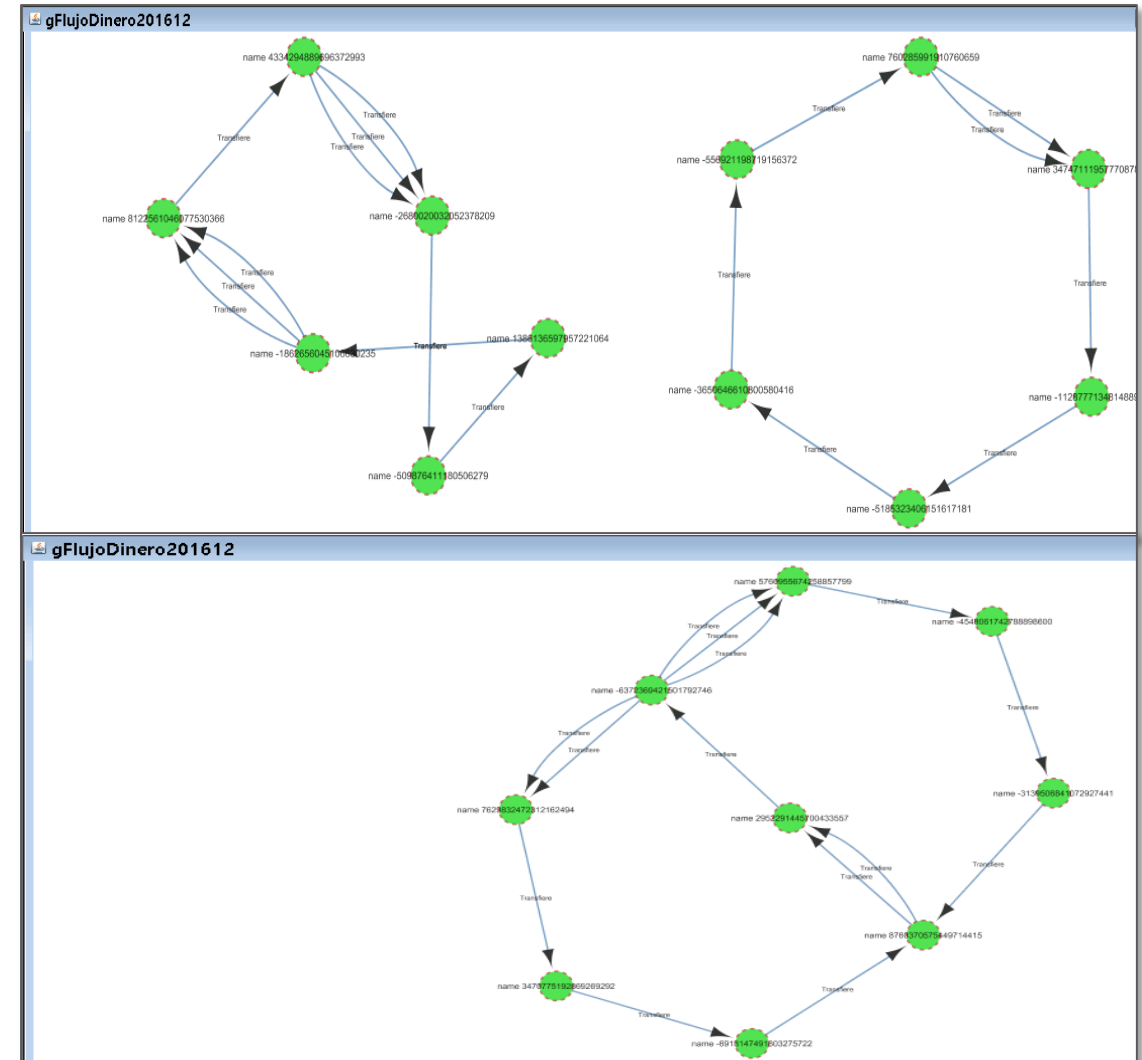


## Generate Recommendations



# Banco de Galicia

- Customer profitability analysis
  - Part of larger Hadoop/Big Data project
- Analysis of banking transactions
  - Focus on corporate customers
- Identification of undesired behavioural patterns, eg.
  - Customers using other banks to make large numbers of transactions
  - Many of which flow back to Banco Galicia
- Increase fees, terminate contracts, or move activities to Banco Galicia
- Implemented by Oracle Consulting



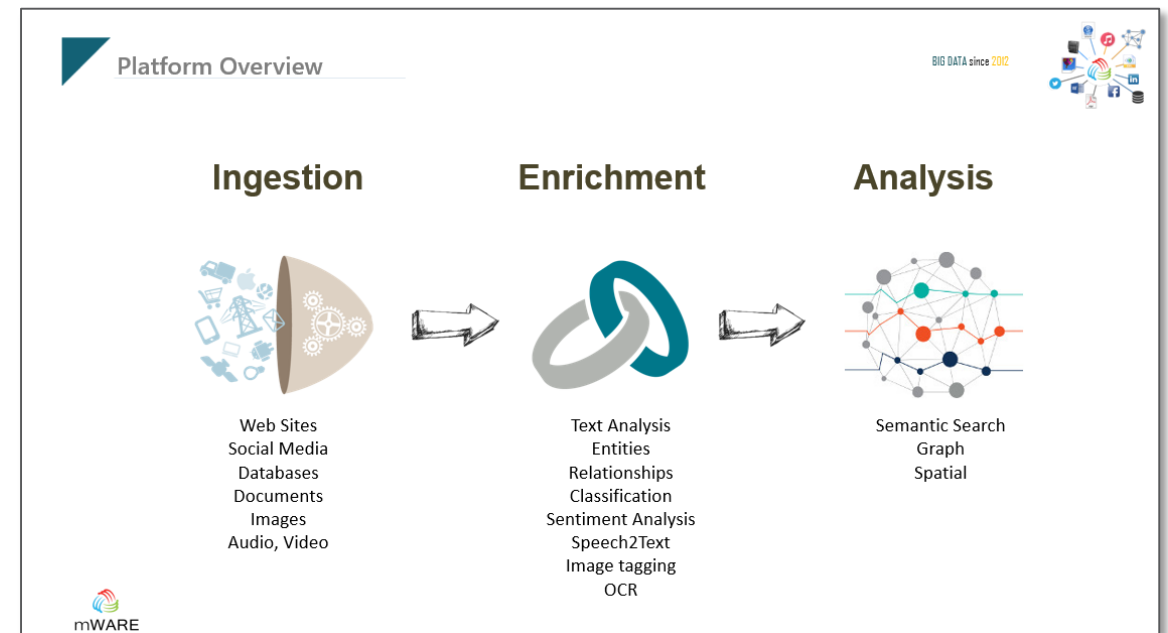


# Romanian Police Force

- Creating Knowledge Graphs from all kinds of content
  - Social media networks, documents, images, audio, video, structured data
  - Using machine learning (text analysis, classification, entity extraction, face recognition, speech2text, ...)
- Enabling relationship analysis and semantic search
- bigCONNECT platform built by mWARE
  - Running on Big Data Appliance, Big Data Cloud Service or commodity Hadoop



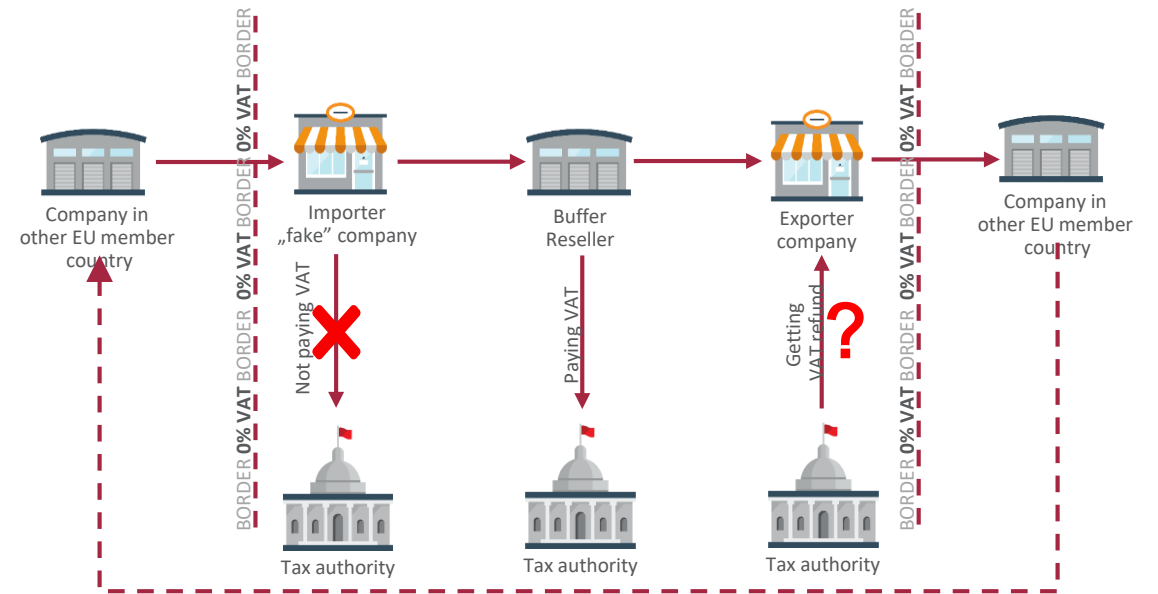
BIG DATA since 2012



# Ministry of Finance, Eastern Europe

- Detecting relationships between people, accounts, companies
  - Similar to Paradise Papers
- Identifying suspicious patterns
  - Circular money transfers
  - Connections (existing path/shortest path) to companies in tax havens
- Ingesting accounting data in SAF-T format
  - Hadoop-based processing (Oozie, Spark, Hive)
  - Terabytes of data, rapidly growing
- Interactive graph analysis in Apex with Cytoscape.js

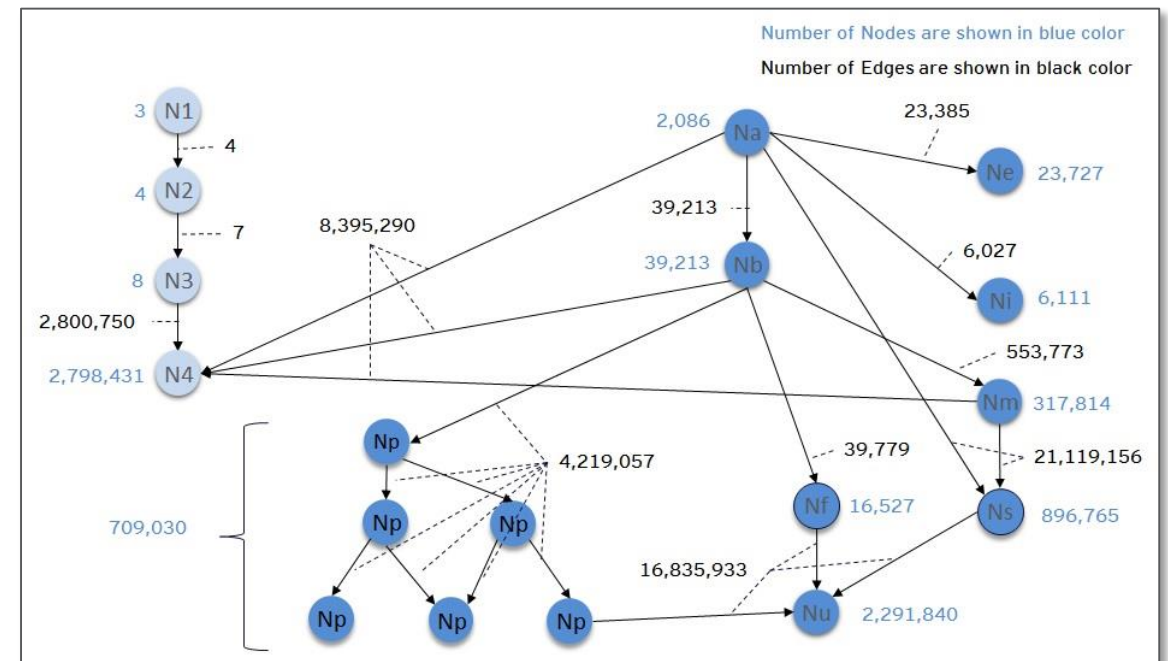
## EU VAT fraud





# Mazda

- Management of Bill-of-materials
  - Automotive manufacturing process
  - Supporting high variance and short innovation cycles
- Data coming from various sources
- Complex PGQL queries to associate parts and subcomponents
  - Performance as key requirement
  - Happy with response times and scalability



## Paysafe

- Providing online payment solutions
  - Real-time payments, e-Wallets
  - 1bn revenue/yr
  - 500000 payments/day
- Strong demand for fraud detection
  - Only feasible with graph data
  - In real-time, upon money movement
  - During account creation
  - In investigation, visualizing payment flows
- Storing payments in database
  - Refreshing graph using delta update



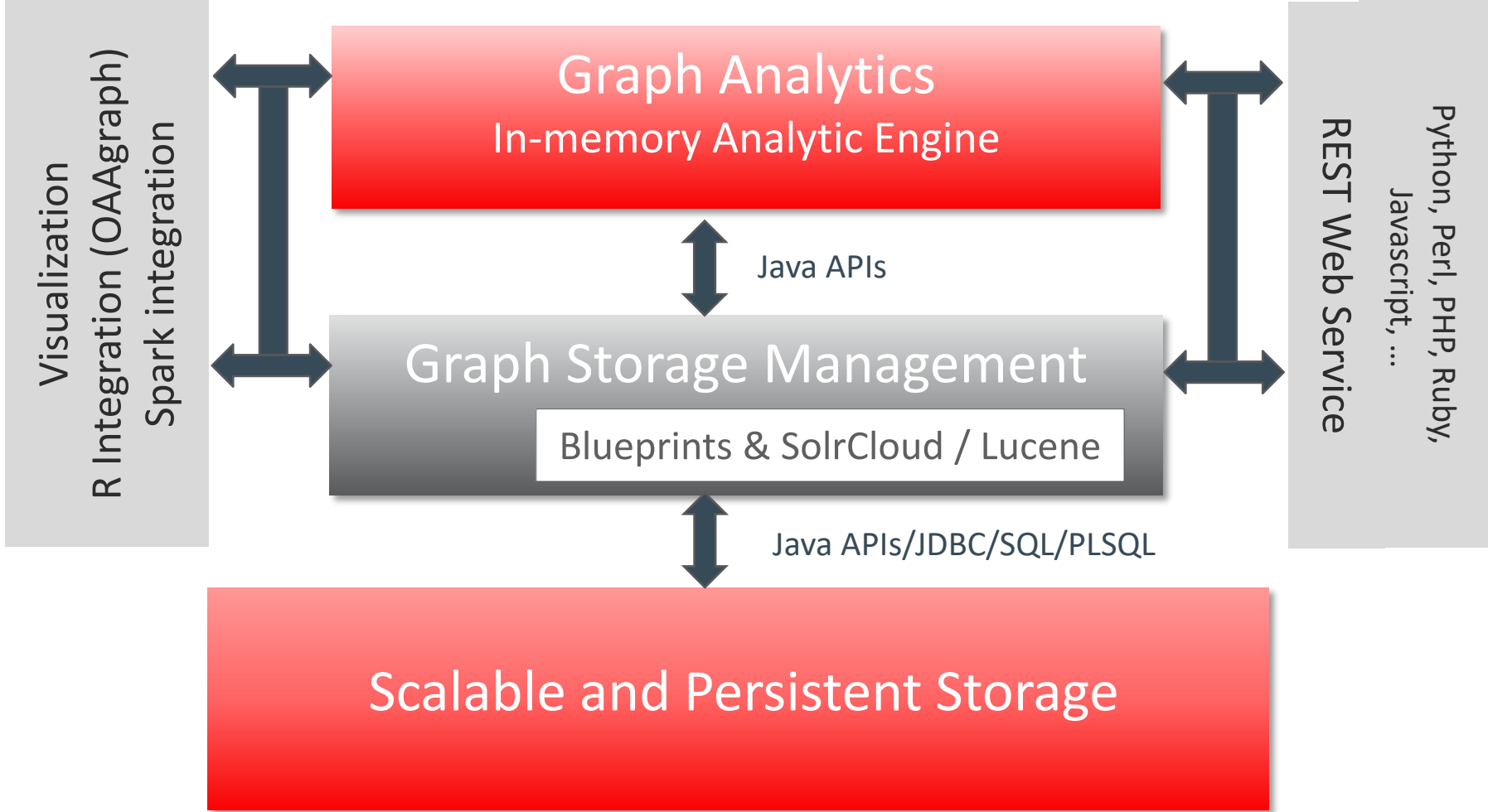
# Graph use case sessions at AnD Summit '19

- Wednesday
  - Using Graph Analysis for Fraud Detection in Fintech at Paysafe – S. Dalekova/Y. Ivanov, Paysafe – 1:00pm
  - Building Consistent Crime Investigation Practices Using Big Data and Graph Technologies – D. Belchior/F. Ferreira, Rio Public Prosecutor's Office – 2:20pm
  - Room 103



# Feature Overview

# Oracle Graph Analytics Architecture



# Interacting with the Graph

On-premise product geared towards data scientists and developers

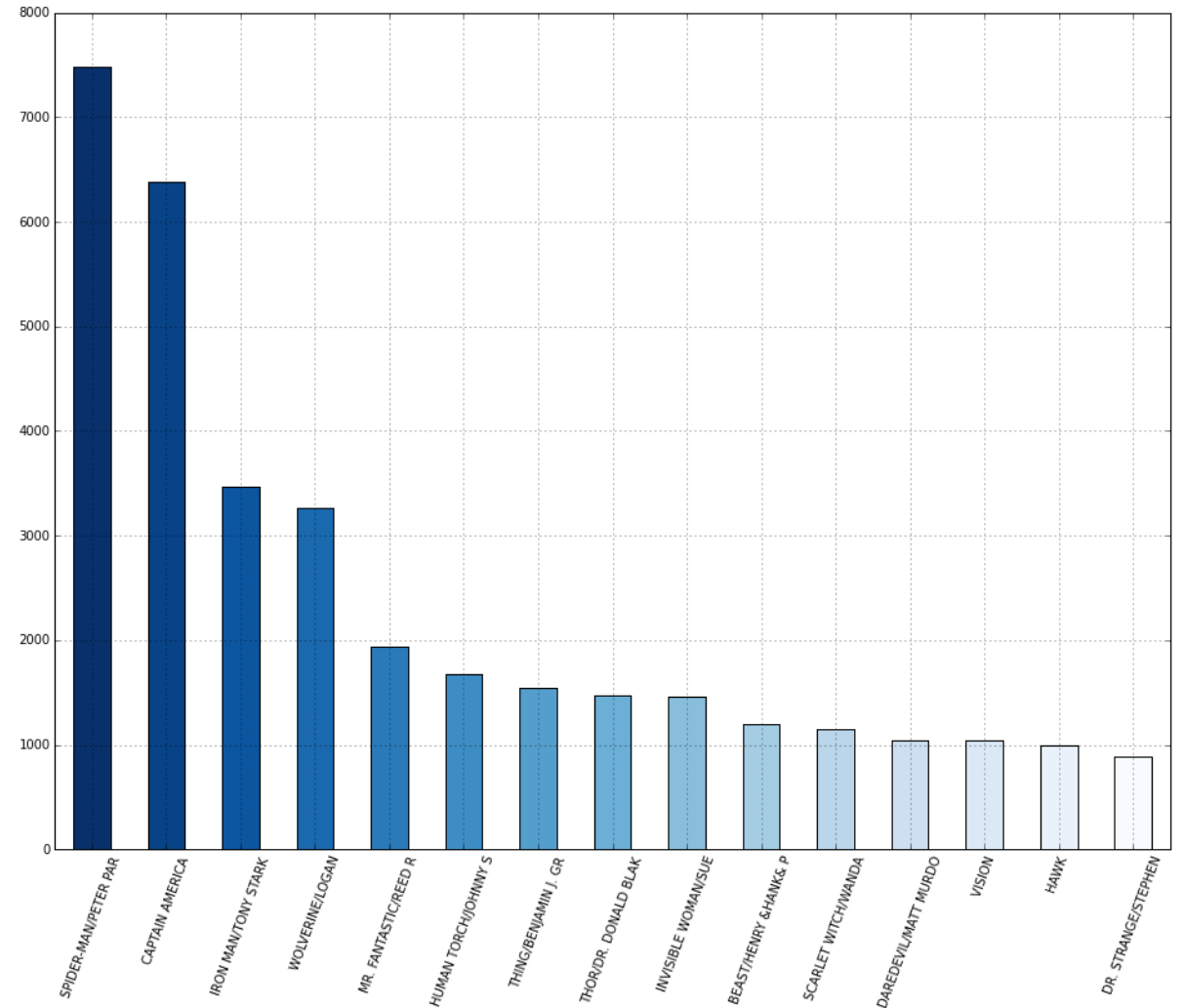
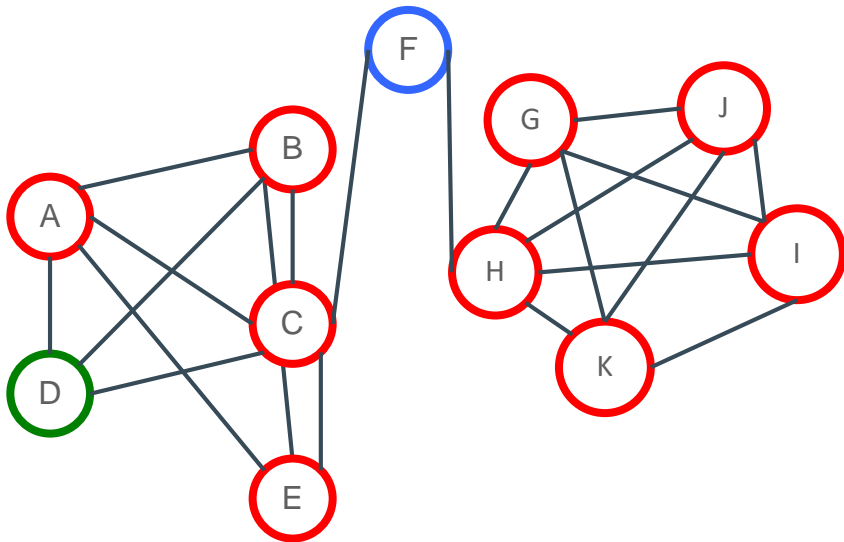
- Access through APIs
  - Implementation of Apache Tinkerpop Blueprints APIs
  - Based on Java, REST plus SolR Cloud/Lucene support for text search
- Scripting
  - JShell, Python, Javascript, ...
  - Apache Zeppelin integration
- Graphical UIs
  - **Property Graph Visualization component (forthcoming)**, Cytoscape, plug-in available
  - Commercial Tools such as TomSawyer Perspectives



# Example: Betweenness Centrality in Big Data Graph

## Code

```
analyst.vertexBetweennessCentrality(pg)  
  .getTopKValues(15)
```



# Pattern matching in Property Graphs using PGQL

- Finding a given pattern in graph
  - Fraud detection
  - Anomaly detection
  - Subgraph extraction
  - ...
- 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

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



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

## PGQL · Property Graph Query Language

An SQL-like query language for graphs

Try It

### Graphs + SQL

PGQL is a graph pattern matching query language for the [property graph data model](#), inspired by [Cypher](#), [SQL](#), and [G-CORE](#). PGQL combines Cypher-like [ASCII art syntax](#) with familiar constructs from SQL, such as `SELECT`, `FROM` and `WHERE`. PGQL also provides powerful constructs for matching regular path expressions (e.g. `PATH`).

An example PGQL query is as follows:

```
SELECT p2.name AS friend_of_friend
FROM facebook_graph
MATCH (p1:Person) -/:friend_of{2}/-> (p2:Person) /* ..match two-hop friends.. */
WHERE p1.name = 'Mark' /* ..of Mark. */
```

See [PGQL 1.1 Specification](#) for a detailed specification of the language.



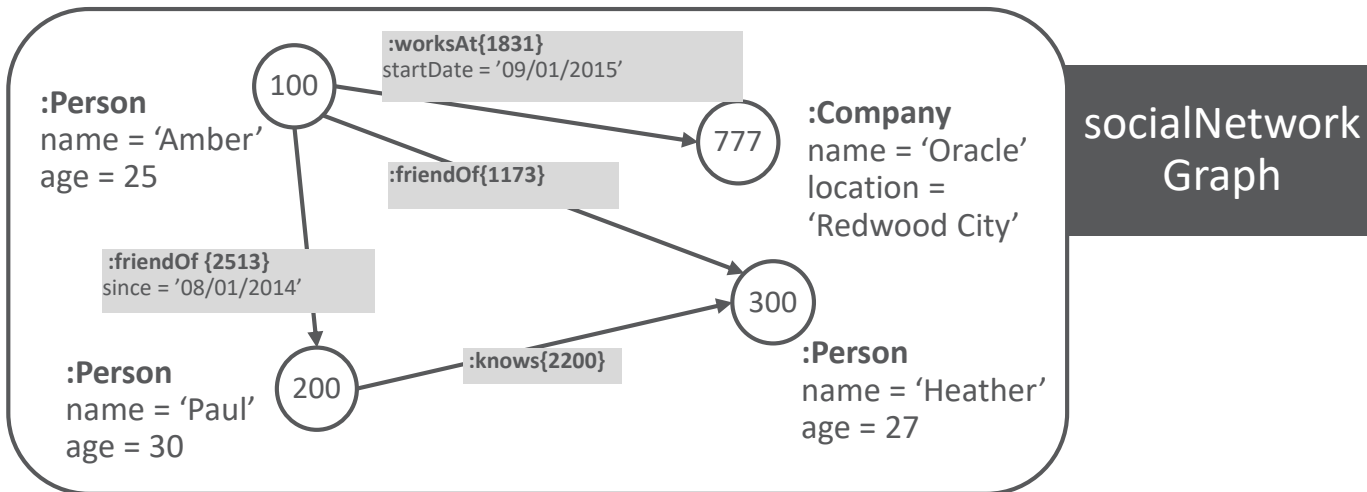
## More on PGQL...

- PGQL: A Query Language for Property Graphs – O. van Rest, Oracle –  
Wednesday, 3:25pm

# Basic graph pattern matching

- Find all instances of a given pattern/template in the data graph

```
SELECT v3.name, v3.age
FROM socialNetworkGraph
MATCH (v1:Person) -[:friendOf]-> (v2:Person) -[:knows]-> (v3:Person)
WHERE v1.name = 'Amber'
```

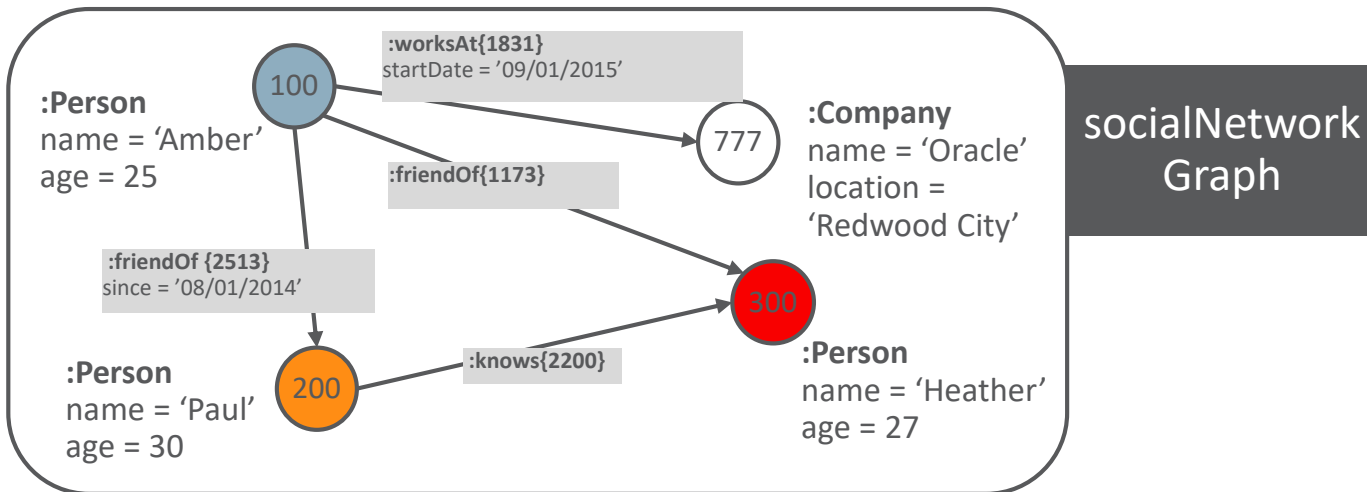


Query: Find all people who are known by friends of 'Amber'.

# Basic graph pattern matching

- Find all instances of a given pattern/template in the data graph

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SELECT v3.name, v3.age
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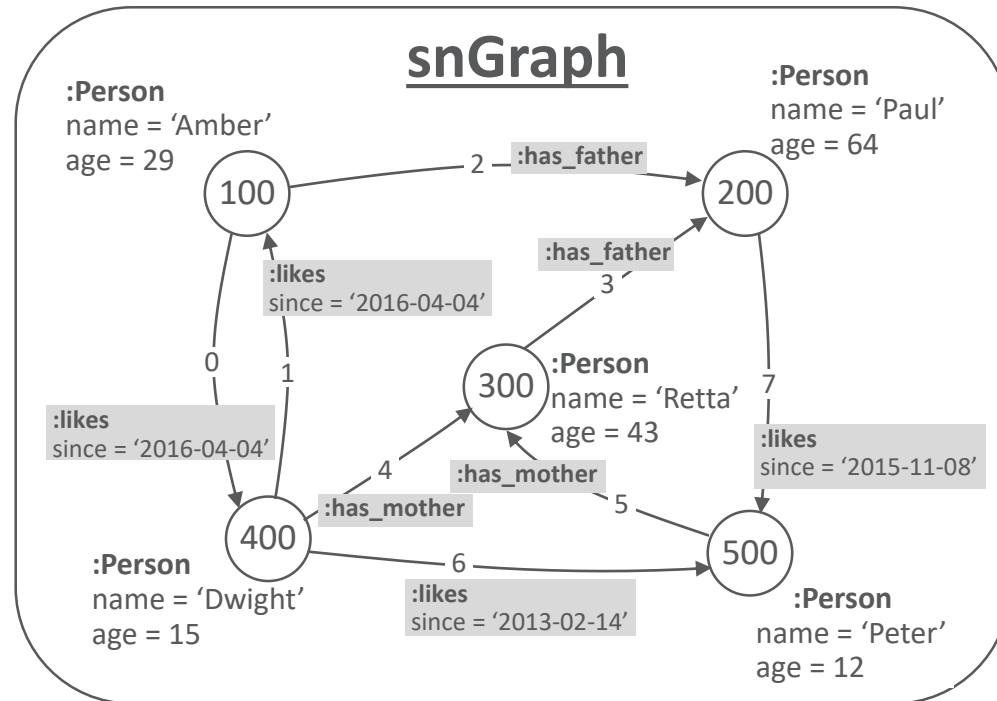
Query: Find all people who are known by friends of 'Amber'.

# Regular path expressions

- Matching a pattern repeatedly

- Define a **PATH** expression at the top of a query
- Instantiate the expression in the **MATCH** clause
- Match **repeatedly**, e.g. zero or more times (\*) or one or more times (+)

```
PATH has_parent AS (child) -[:has_father|has_mother]-> (parent)
SELECT x.name, y.name, ancestor.name
FROM snGraph
MATCH (x:Person) -/has_parent+/-> (ancestor)
, (y) -/has_parent+/-> (ancestor)
WHERE x.name = 'Peter' AND x <> y
```



# Regular path expressions

- Matching a pattern repeatedly

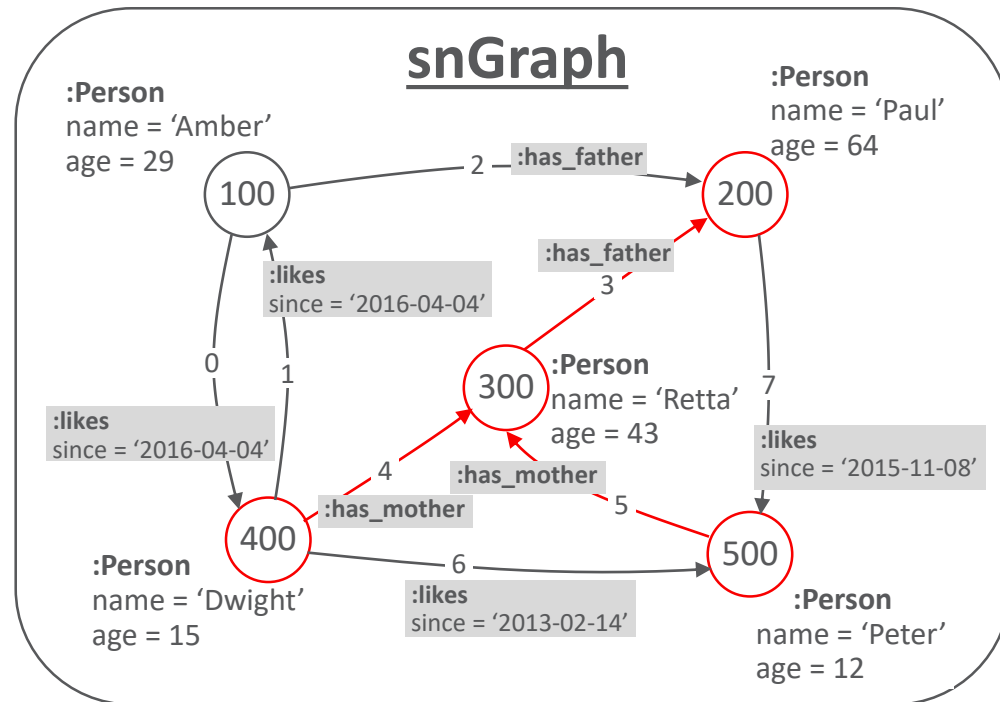
- Define a **PATH** expression at the top of a query
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```

PATH has_parent AS (child) -[:has_father|has_mother]-> (parent)
SELECT x.name, y.name, ancestor.name
FROM snGraph
MATCH (x:Person) -/has_parent+/-> (ancestor)
, (y) -/has_parent+/-> (ancestor)
WHERE x.name = 'Peter' AND x <> y
    
```

Result set

x.name	y.name	ancestor.name
Peter	Retta	Paul
Peter	Dwight	Paul
Peter	Dwight	Retta





# Notebook integration

- Multi-purpose notebook for data analysis and visualization
  - Browser-based script and query execution
- For documentation and interactive analysis
  - Typically used by Data Scientist
- Interpreters for graph analysis and graph pattern matching
  - PGX, PGQL, Markdown
- Graph visualization
- Integrated with Graph Cloud Service

**Zeppelin** Notebook - Interpreter Search in your notebooks Connected

## Reachability

Our Green-Marl program will populate it. Then we will run some code to query this property and return the graph nodes with a high value for it.

```
// create a new property named 'count'
count = graph.createVertexProperty(PropertyType.INTEGER, "count");

==> Vertex Property named 'count' of type integer belonging to graph flight
```

Now we are ready to run our Green-Marl program against the graph: Run this paragraph (Shift+Enter)

ORACLE Oracle Labs Data Studio Copy of OOW/OOW

Download Files Build Graph

```
!pgx
graphName = "OOW_graph4"
oowGraph = session.getGraph(graphName)
if (oowGraph == null) {
  session.readGraphWithProperties('/var/shared/btc.json', graphName)
}
```

Graph Stats 253 ms @ 11:26:5

Vertices	Edges
364735	751089

!pgql SELECT COUNT(\*) AS Vertices FROM OOW\_graph4 MATCH (v)

!pgql SELECT COUNT(\*) AS Edges FROM OOW\_graph4 MATCH () -[e]-> ()

Transactions per Bitcoin Address

Pagerank Top 6

ID	value
166682	0.0018036832049004724
287831	0.0015917534143622494
247741	0.0014478296328467209
150550	0.0014050903831874285
181060	0.0013945728538161453
45172	0.0013637063958313869

# Demo

Browser tabs: Datasources

Address bar: Not secure | slc14rui:32000/graphstudio/?root=ds-datasources



ORACLE Graph Cloud

Search | ogcs-dev-user

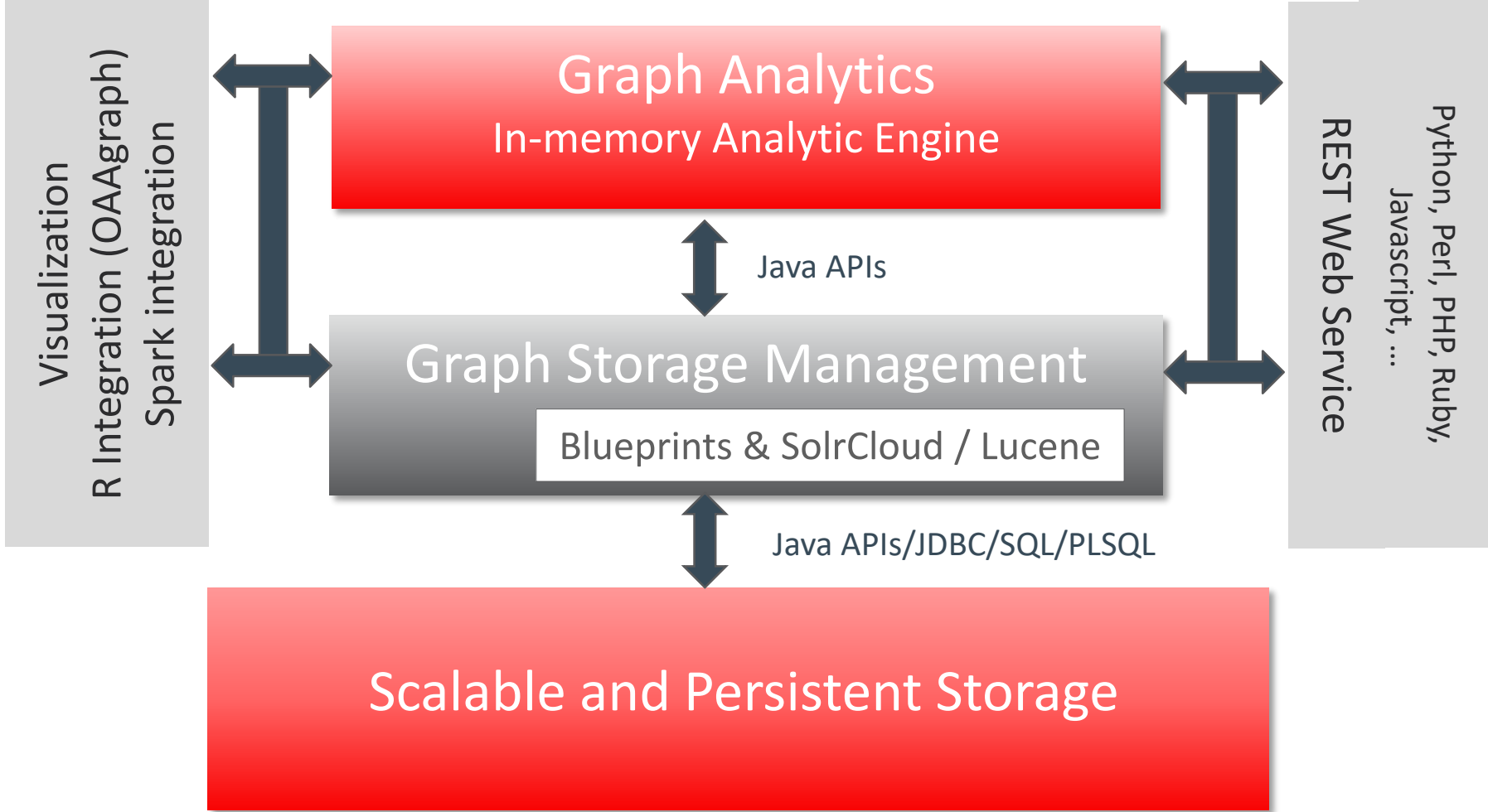
## Data Sources

Create

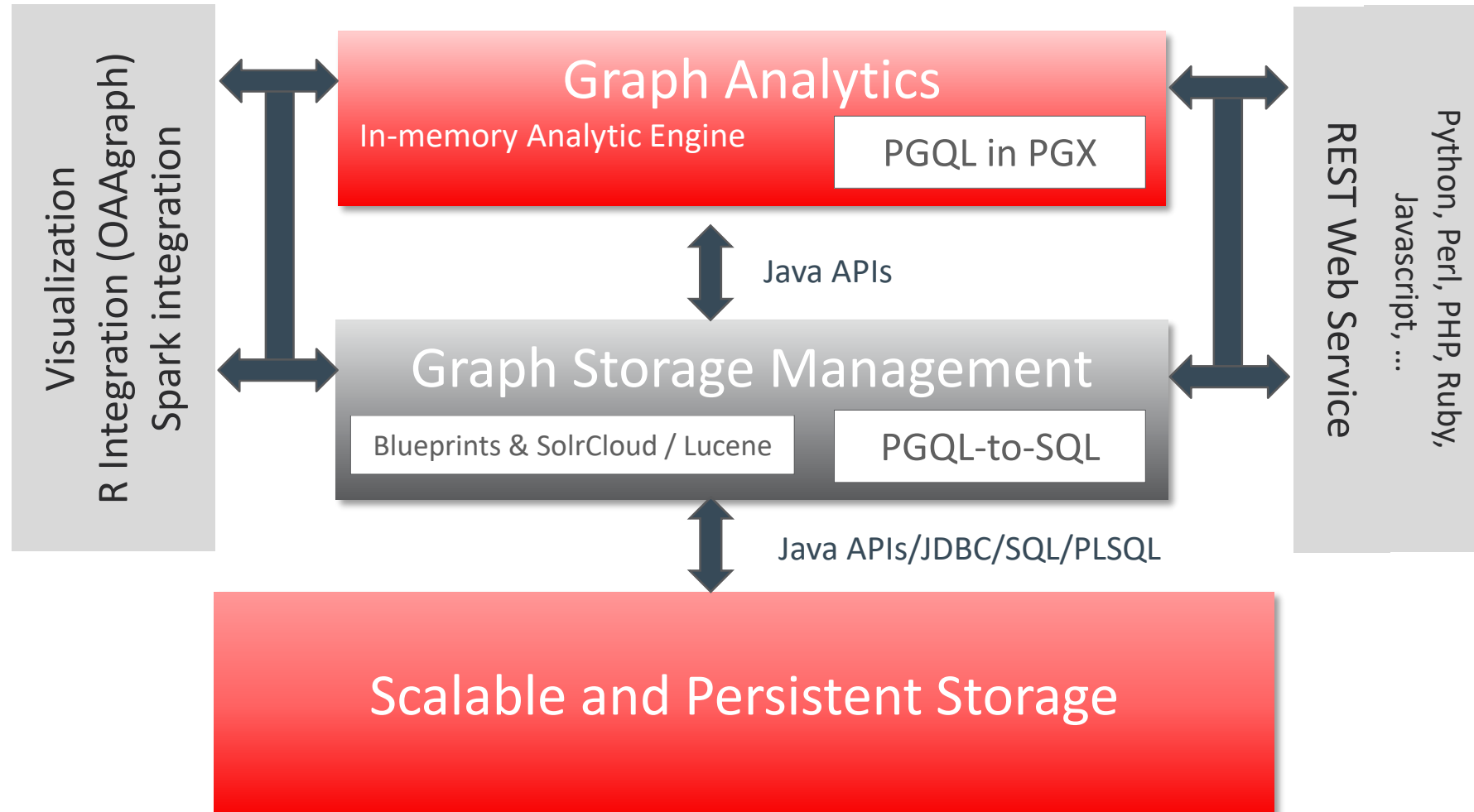
Search | Sort by: [dropdown]

Type	Name	Description	Owner	Status	Last Applied
	Financial Demo Dataset	Financial Demo Dataset	ogcs-dev-user	Tue, 16 Oct 2018 20:18:04 GMT	[menu]
	slcai607	Sales Demo Dataset	ogcs-dev-user	Fri, 12 Oct 2018 21:30:25 GMT	[menu]

# Oracle Graph Analytics Architecture



# Support for Graph Pattern Matching



# Path Query (Parallel Recursive With)

## PGQL:

```
PATH knows_path := () -[:knows]-> ()
SELECT s1.fname, s2.fname
WHERE (s1) -/[:knows_path*]/-> (o) <-/[:knows_path*]/-(s2)
ORDER BY s1,s2
```

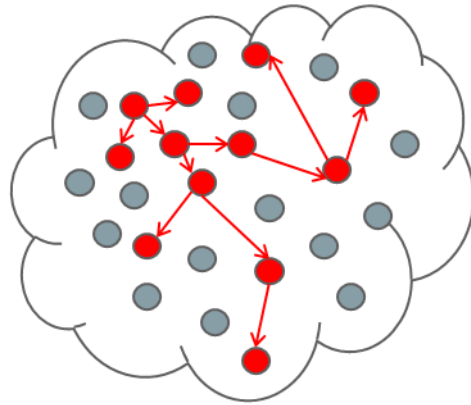
Find the **pairs of people** who are connected to a common person through the **“knows”** relation

## SQL:

```
SELECT T2.T AS "s1.fname$T",T2.V AS "s1.fname$V",T2.VN AS "s1.fname$VN",T2.VT AS "s1.fname$VT",
       T3.T AS "s2.fname$T",T3.V AS "s2.fname$V",T3.VN AS "s2.fname$VN",T3.VT AS "s2.fname$VT"
FROM (/*Path[*/SELECT DISTINCT SVID, DVID FROM ( SELECT VID AS SVID, VID AS DVID FROM "GRAPH1VT$" UNION ALL SELECT SVID,DVID
FROM (WITH RW (ROOT, SVID, DVID, LVL) AS ( SELECT ROOT, SVID, DVID, LVL FROM (SELECT SVID ROOT, SVID, DVID, 1 LVL
FROM (SELECT T0.SVID AS SVID, T0.DVID AS DVID FROM "GRAPH1GT$" T0 WHERE (T0.EL = n'knows'))
) UNION ALL SELECT DISTINCT RW.ROOT, R.SVID, R.DVID, RW.LVL+1 FROM (SELECT T1.SVID AS SVID,
T1.DVID AS DVID FROM "GRAPH1GT$" T1 WHERE (T1.EL = n'knows')) R, RW WHERE RW.DVID = R.SVID )
CYCLE SVID SET cycle_col TO 1 DEFAULT 0 SELECT ROOT SVID, DVID FROM RW ))/*]Path*/) T6,
/*Path[*/SELECT DISTINCT SVID, DVID FROM ( SELECT VID AS SVID, VID AS DVID FROM "GRAPH1VT$" UNION ALL SELECT SVID,DVID
FROM (WITH RW (ROOT, SVID, DVID, LVL) AS ( SELECT ROOT, SVID, DVID, LVL FROM (SELECT SVID ROOT, SVID, DVID, 1 LVL
FROM (SELECT T4.SVID AS SVID, T4.DVID AS DVID FROM "GRAPH1GT$" T4 WHERE (T4.EL = n'knows'))
) UNION ALL SELECT DISTINCT RW.ROOT, R.SVID, R.DVID, RW.LVL+1 FROM (SELECT T5.SVID AS SVID,
T5.DVID AS DVID FROM "GRAPH1GT$" T5 WHERE (T5.EL = n'knows')) R, RW WHERE RW.DVID = R.SVID )
CYCLE SVID SET cycle_col TO 1 DEFAULT 0 SELECT ROOT SVID, DVID FROM RW ))/*]Path*/) T7,
"GRAPH1VT$" T2, "GRAPH1VT$" T3
WHERE T2.K=n'fname' AND T3.K=n'fname' AND T6.SVID=T2.VID AND T6.DVID=T7.DVID AND T7.SVID=T3.VID
ORDER BY T6.SVID ASC NULLS LAST, T7.SVID ASC NULLS LAST
```

# Combining Graph Analytics and Machine Learning

## Graph Analytics

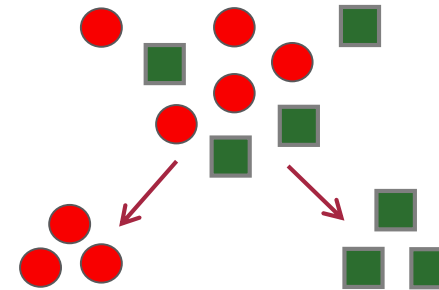


- Compute graph metric(s)
- Explore graph or compute new metrics using ML result

Add to structured data

Add to graph

## Machine Learning



- Build predictive model using graph metric
- Build model(s) and score or classify data

# Machine learning session

- When Graphs Meet Machine Learning – S. Hong/R. Patra, Oracle – Thursday, 10:55am



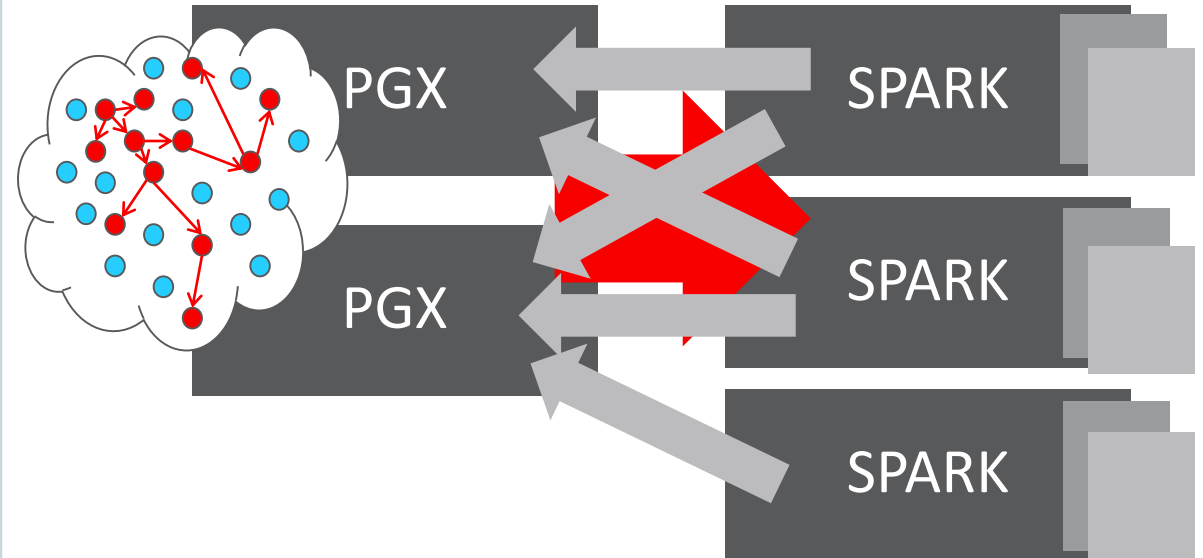


# OAGraph integration with R

- OAGraph integrates in-memory engine into ORE and ORAAH
- Adds powerful graph analytics and querying capabilities to existing analytical portfolio of ORE and ORAAH
- Built in algorithms of PGX available as R functions
- PGQL pattern matching
- Concept of “cursor” allows browsing of in-memory analytical results using R data structures (R data frame), allows further client-side processing in R
- Exporting data back to Database / Spark allows persistence of results and further processing using existing ORE and ORAAH analytical functions

# Graph Analytics on SPARK vs. GraphX

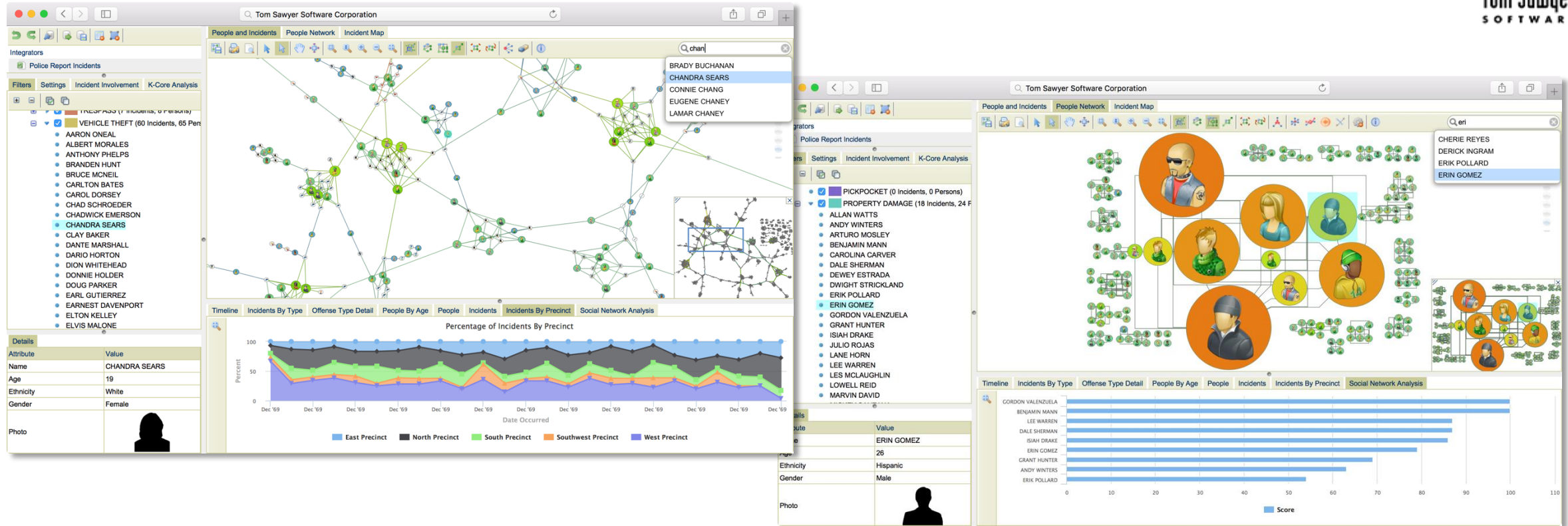
- Use SPARK for conventional tabular data processing (RDD, Dataframe, -set)
- Define graph view of the data
  - View it as node table and edge table
- Load into PGX
- Execute graph algorithms in PGX
  - Orders of magnitude faster than GraphX
  - More scaleable
- Push analysis results back into SPARK as additional tables
- Continue SPARK analysis



SPARK data structure and communication mechanism not optimized for graph analysis workloads



# Graph Visualization – Commercial Tools



**Left Screenshot: Search for 'chan'**

- BRADY BUCHANAN
- CHANDRA SEARS
- CONNIE CHANG
- EUGENE CHANEY
- LAMAR CHANEY

**Percentage of Incidents By Precinct**

Precinct	East Precinct	North Precinct	South Precinct	Southwest Precinct	West Precinct
Dec '99	~10%	~10%	~10%	~10%	~50%
Dec '00	~10%	~10%	~10%	~10%	~50%
Dec '01	~10%	~10%	~10%	~10%	~50%
Dec '02	~10%	~10%	~10%	~10%	~50%
Dec '03	~10%	~10%	~10%	~10%	~50%
Dec '04	~10%	~10%	~10%	~10%	~50%
Dec '05	~10%	~10%	~10%	~10%	~50%
Dec '06	~10%	~10%	~10%	~10%	~50%
Dec '07	~10%	~10%	~10%	~10%	~50%
Dec '08	~10%	~10%	~10%	~10%	~50%
Dec '09	~10%	~10%	~10%	~10%	~50%
Dec '10	~10%	~10%	~10%	~10%	~50%
Dec '11	~10%	~10%	~10%	~10%	~50%
Dec '12	~10%	~10%	~10%	~10%	~50%
Dec '13	~10%	~10%	~10%	~10%	~50%
Dec '14	~10%	~10%	~10%	~10%	~50%
Dec '15	~10%	~10%	~10%	~10%	~50%
Dec '16	~10%	~10%	~10%	~10%	~50%
Dec '17	~10%	~10%	~10%	~10%	~50%
Dec '18	~10%	~10%	~10%	~10%	~50%
Dec '19	~10%	~10%	~10%	~10%	~50%
Dec '20	~10%	~10%	~10%	~10%	~50%

**Right Screenshot: Search for 'eri'**

- CHERIE REYES
- DERICK INGRAM
- ERIK POLLARD
- ERIN GOMEZ

**Score Chart**

Person	Score
GORDON VALENZUELA	~100
BENJAMIN MANN	~95
LEE WARREN	~90
DALE SHERMAN	~85
ISIAH DRAKE	~80
ERIN GOMEZ	~75
GRANT HUNTER	~70
ANDY WINTERS	~65
ERIK POLLARD	~60

**See Tom Sawyer vis demo:** Partner lightning round – Tuesday 12:00pm (Auditorium), Finding Malicious Network Packets Using Anomaly Detection with Graph Analytics – Thursday, 12:00pm

# 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

# Graph Cloud Service

## Fully managed graph cloud service

- “One-click” deployment: no installation, zero configuration
  - Automated failure detection and recovery
- Automated graph modeler
  - Easily convert your relational data into property graphs
- Pre-built algorithms, flows and interactive queries
  - Java
  - PGQL
  - Rest APIs
- Rich User Interface
  - Low code / zero code features
  - Notebook support and powerful data visualization features



**Session:** Graph Cloud Preview: How to Analyze Data Warehouse Data as a Graph – K. Schmid/J. Sharma, Oracle – Tuesday 11:15am

# Summary

## Graph capabilities in Oracle Database and Big Data Spatial and Graph



- Graph databases are powerful tools, complementing relational databases
  - Especially strong for analysis of graph topology and multi-hop relationships
- Graph analytics offer new insight
  - Especially relationships, dependencies and behavioural patterns
- Oracle Property Graph technology offers
  - Comprehensive analytics through various APIs, integration with relational database
  - Scalable, parallel in-memory processing
  - Secure and scalable graph storage using Oracle Database or Big Data Platform
- Available both on-premise or in the Cloud



# Graph sessions at AnD Summit '19

All sessions in room 103  
unless otherwise noted

- Tuesday

- Graph Cloud Preview: How to Analyze Data Warehouse Data as a Graph – K. Schimd/J. Sharma, Oracle–11:15am
- Hands On Lab: Introduction to Property Graphs in Oracle Databases – K. Hare, JCC Consulting – 3:35pm **room 202**

- Wednesday

- Using Graph Analysis for Fraud Detection in Fintech at Paysafe – S. Dalekova/Y. Ivanov, Paysafe – 1:00pm
- Building Consistent Crime Investigation Practices Using Big Data and Graph Technologies – D. Belchior/F. Ferreira, Rio Public Prosecutor's Office – 2:20pm
- PGQL: A Query Language for Property Graphs – O. van Rest, Oracle – 3:25pm
- Translating Natural Language to Graph Queries for Financial Crime Investigation – M. Brantner, Oracle – 4:30pm



# Graph sessions at AnD Summit '19 (cont.)

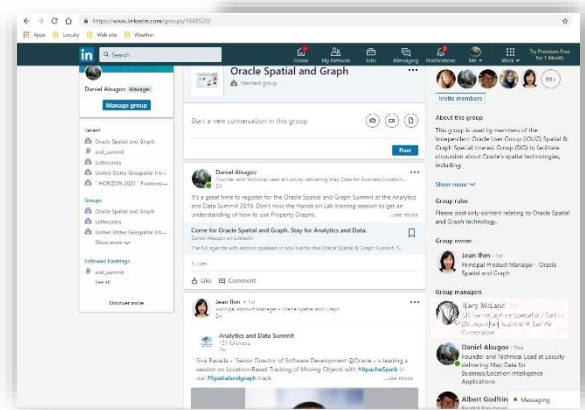
All sessions in room 103  
unless otherwise noted

- Thursday

- Build Knowledge Graphs with Oracle RDF to Extract More Value from Your Data – S. Das/M. Perry/M. Annamalai, Oracle – 8:45am
- Semantic Middleware - the Cornerstone of Your Next IT – S. Gabler, Semantic Web Company – 9:50am
- Oracle Spatial and Graph RDF Semantic Model for BIM Classification & Scheduling – T. McLane, Bechtel – 10:15am
- When Graphs Meet Machine Learning – S. Hong/R. Patra, Oracle – 10:55am
- Finding Malicious Network Packets Using Anomaly Detection with Graph Analytics – S. Hong, Oracle – 12:00pm
- I know what you mean: leveraging graph for linking entities into knowledge base – S. Hong, Oracle – 3:40pm **room 202**

# The Spatial & Graph SIG User Community

We are a vibrant community of customers and partners that connects and exchanges knowledge online, and at conferences and events.



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# Engage with the Spatial and Graph SIG

Promotes interaction and communication to drive the market for spatial and graph technology and data

Members connect and exchange knowledge via online communities and at conferences and events

- Talk with us at the Summit! Look for badges with yellow ribbons

Birds of a Feather Lunch Wednesday 12-1pm Auditorium	Receptions Tues & Wed evenings
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