AskTOM Office Hours: Graph Database and Analytics

- Welcome (back) to our AskTOM Graph Office Hours series!
  We're back with new product updates, use cases, demos and technical tips
  https://asktom.oracle.com/pls/apex/asktom.search?oh=3084
- Sessions will be held about once a month
- **Subscribe** at the page above for updates on upcoming session topics & dates
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- Note: **Spatial** now has a new Office Hours series for location analysis & mapping features in Oracle Database:
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ORACLE

Financial Industry Use Cases for Graph Analytics

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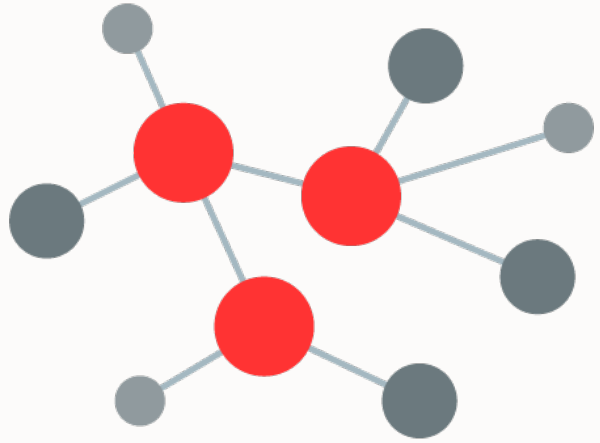
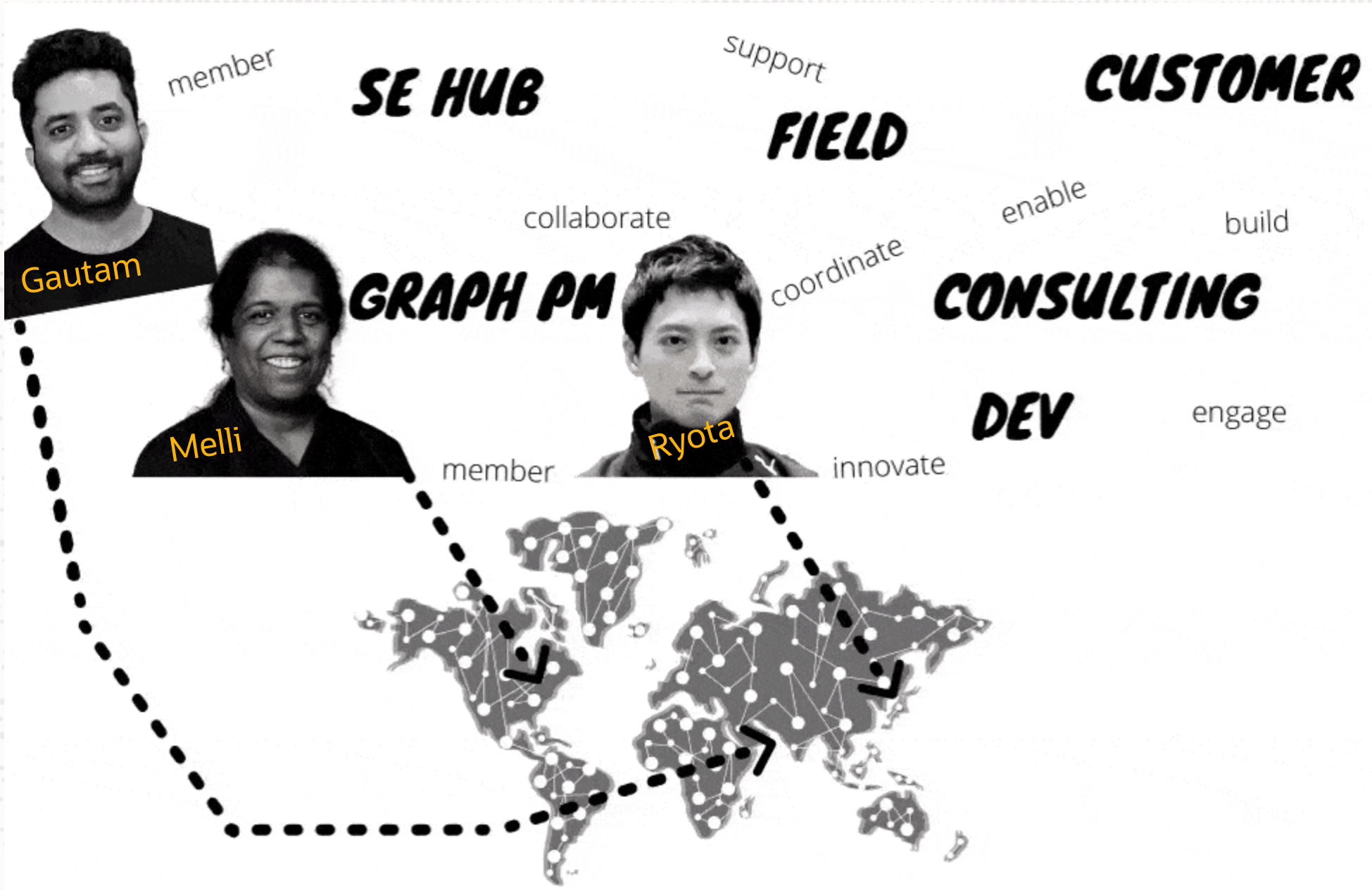
Oracle
May 28, 2020





Safe harbor statement

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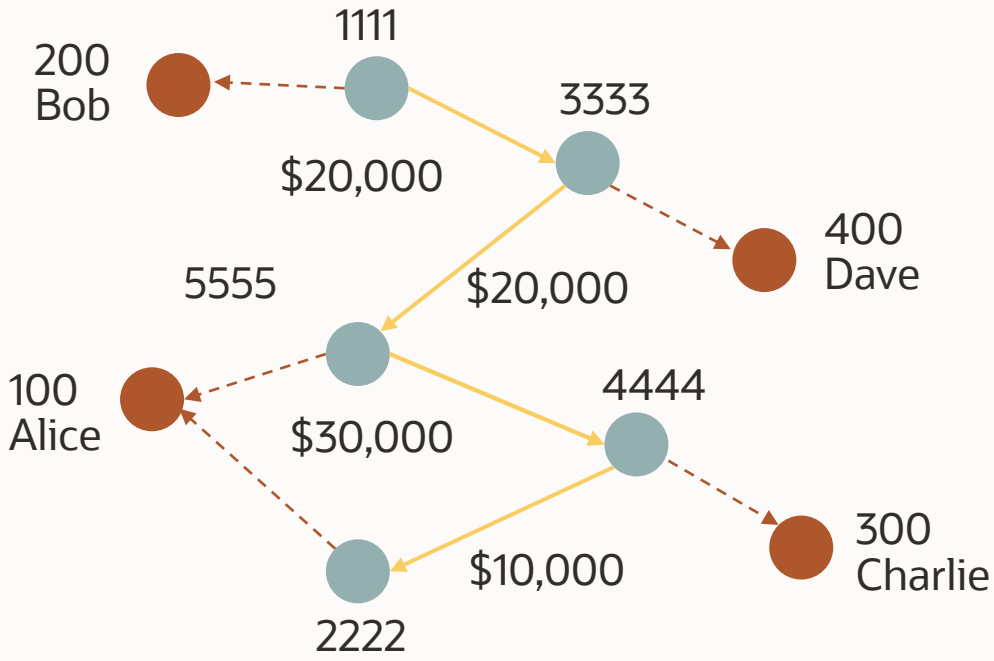
Program Agenda

1	**Graph Applications Overview** Focus on Financial Services	*Ryota*
2	**Customer Use Case** Fraud Detection at a Bank	*Gautam*
3	**Demo App - How to Detect Cycles**	*Ryota*
4	**How to Combine with Machine Learning** Customer Reference: Paysafe	*Ryota*
5	**Customer 360 Analysis Using Graphs** Customer Reference: Banco Galicia	*Melli*

Graph Applications Overview

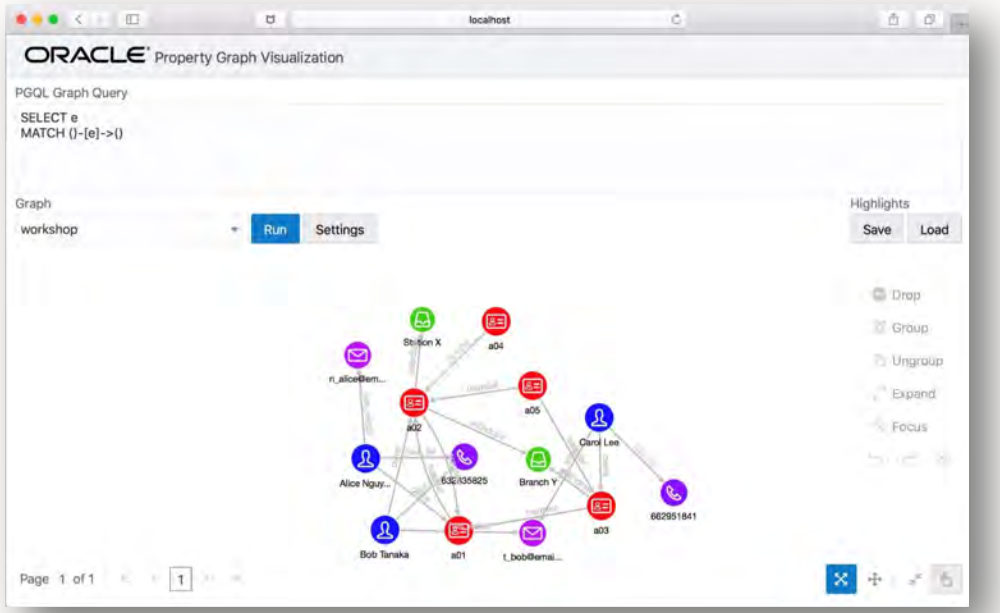
Application 1 - Query to Follow Money

- The graph representation of the transaction data makes queries **intuitive and performant**.
  - E.g. the queries *to find the circular money transfer over multiple intermediate steps*, can be easily written and executed.
- Travarsal queries make users possible to detect **hidden relationships** between accounts and their owners (e.g. paradise papers).
- Complex rules to score **suspicious accounts** (e.g. closeness to known fraud accounts) can be also expressed in graph queries and executed in very short response time.



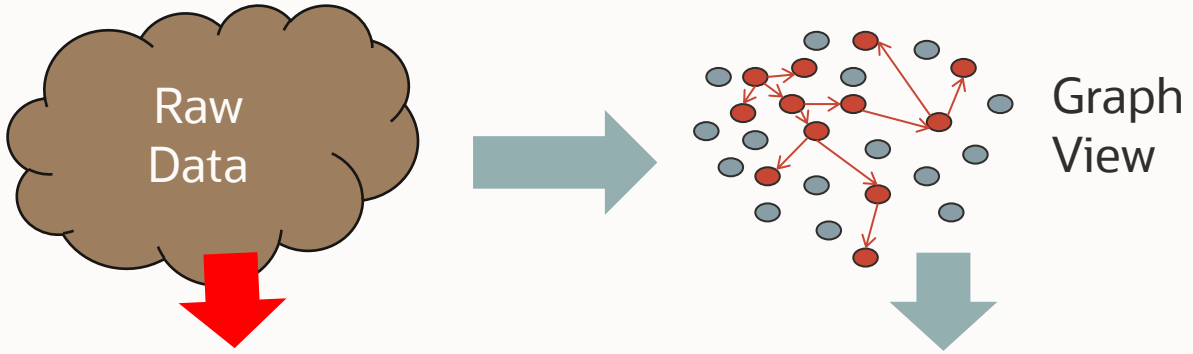
Application 2 - 360 Degrees Visualization

- The graph visualization component can show the original graph data on web browsers. This is **useful for manual inspection** against "suspicious" accounts (which are often detected by rules or machine learning models).
- Users can **"expand"** the graph by clicking particular nodes to see the related information.
- Users can also run **PGQL queries** to find the accounts in certain conditions. This helps users examine the existing rules, as well as try and create new rules.



Application 3 - Enhancing ML Model

- New scores for accounts are calculated based on relationships and **by rules and graph algorithms**
- The scores are used as **input features** to enhance the prediction models

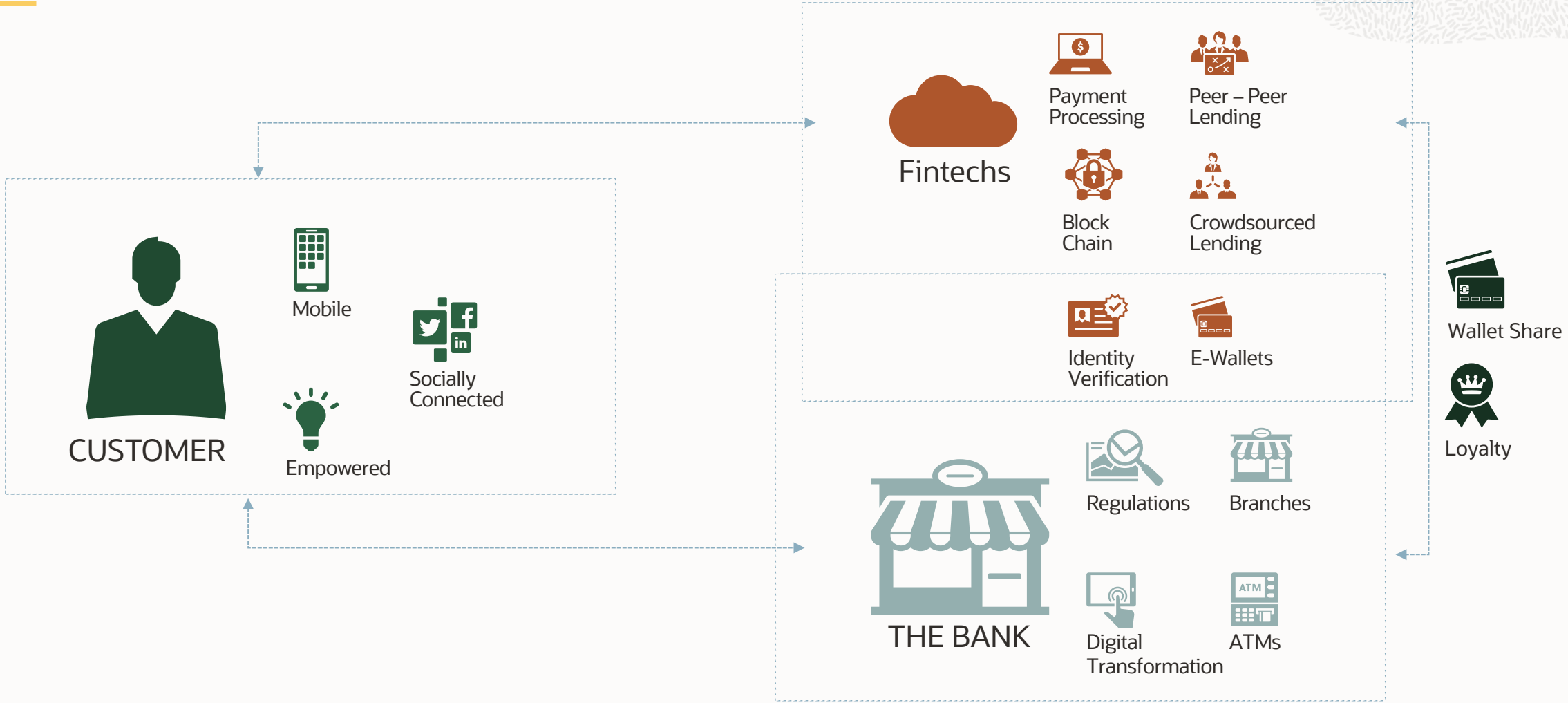


ID	Feature1	Feature 2	Feature 3	Feature 4	Feature 5	Feature 6	Feature 7	Target
1001								Yes
1002								No
1003								No

Use Case in Practice

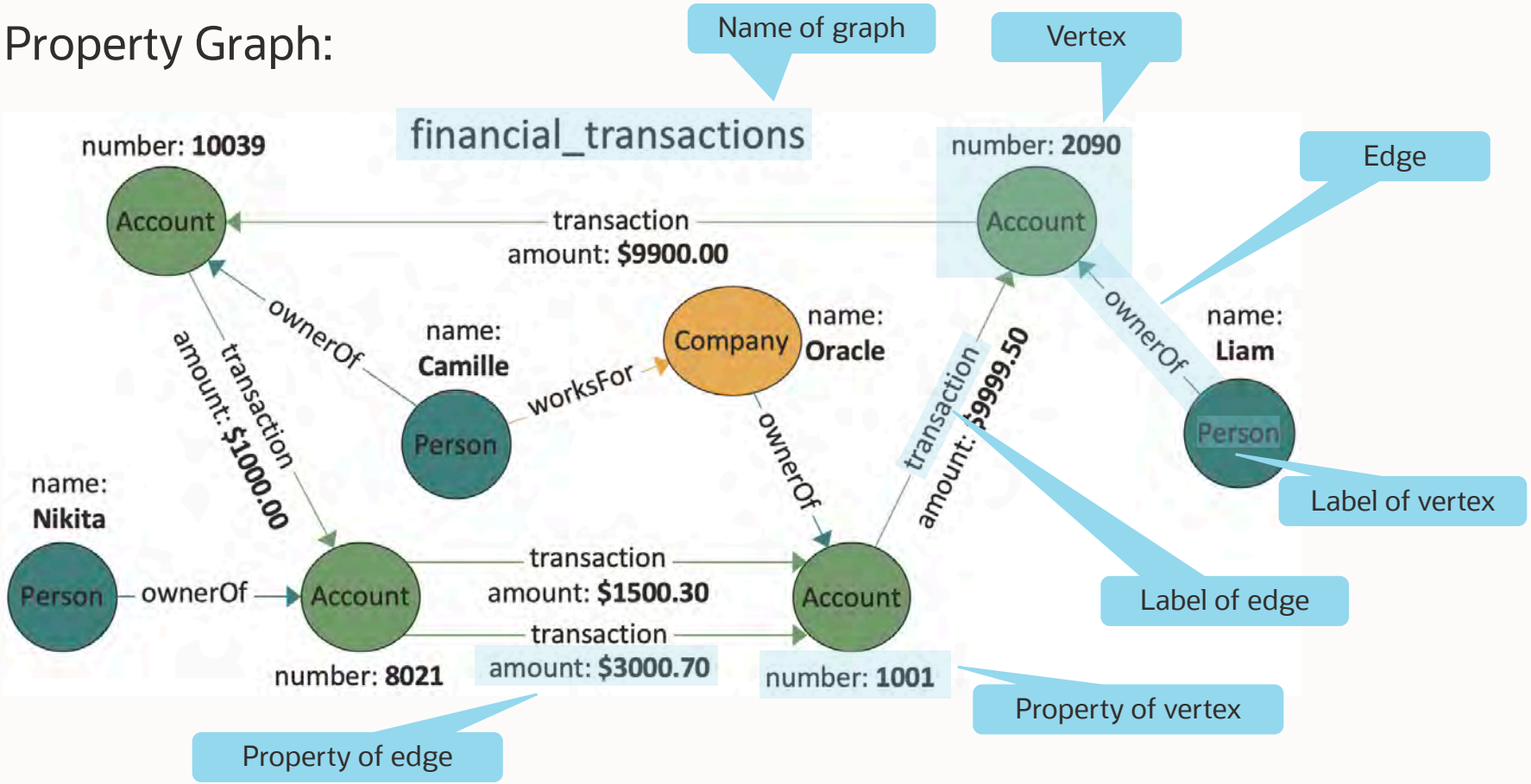
Evolution of Fraud : Examining the Cases

Evolution of Fraud : Connecting the Dots



Evolution of Fraud : Connecting the Dots

Property Graph:



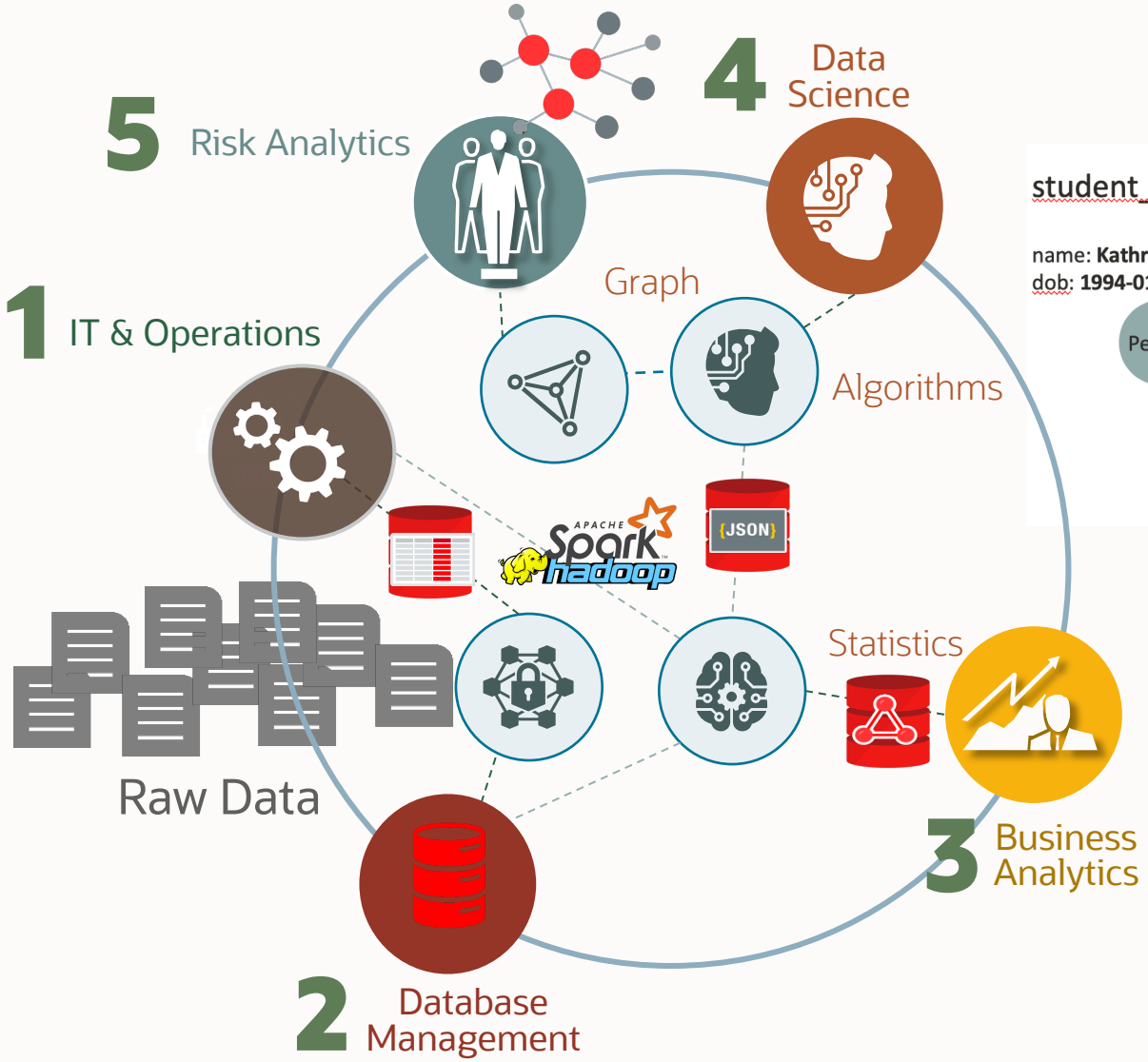
Why Oracle

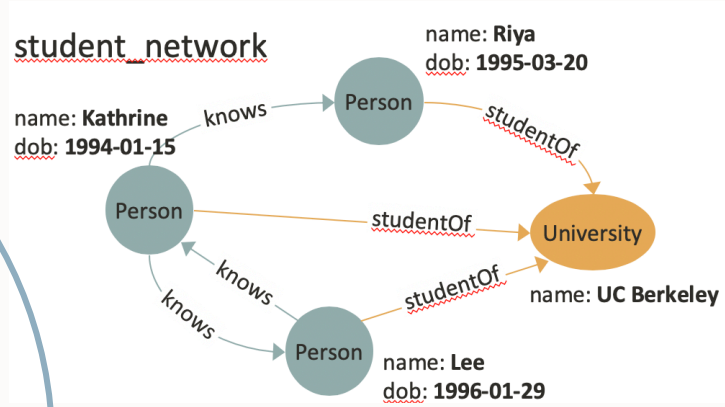
1 Proven scalability and performance

2 Built-in algorithms and visualizations

3 Easy detection of cycles

Connect the Organization





Vertex tables:

Person

id	name	dob
1	Riya	1995-03-20
2	Kathrine	1994-01-15
3	Lee	1996-01-29

University

id	name
1	UC Berkeley

Edge tables:

knows

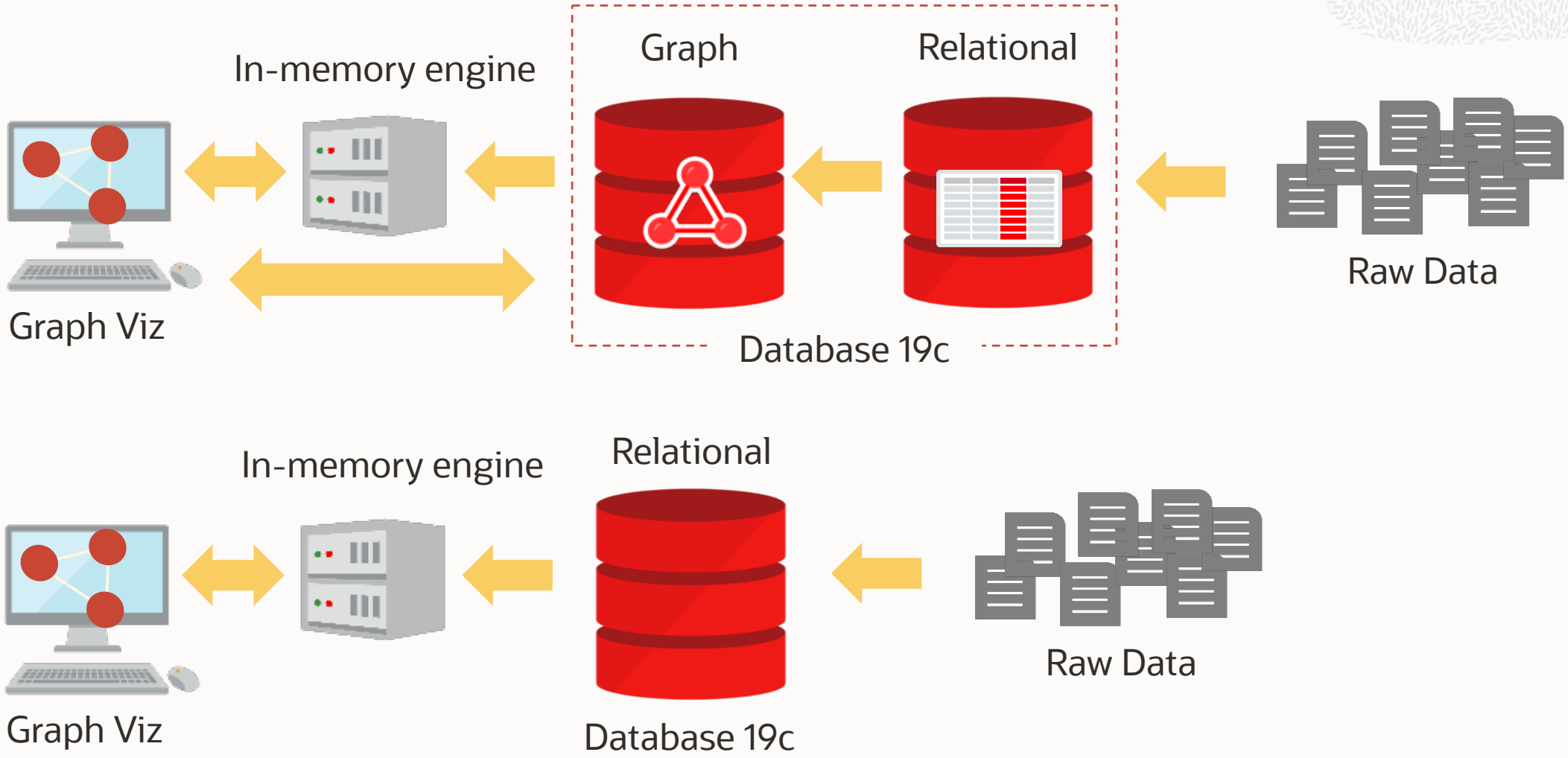
person1_id	person2_id
2	1
2	3
3	2

studentOf

person_id	university_id
1	1
2	1
3	1

Our Approach

Approach 1 vs Approach 2



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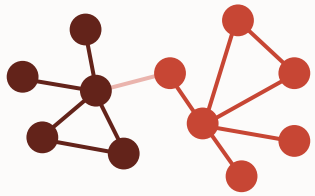
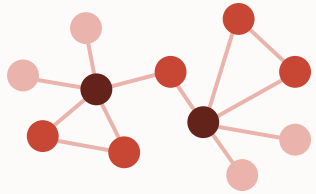
Graph Analytics - 50+ Built-in Algorithms

Detecting Components and Communities



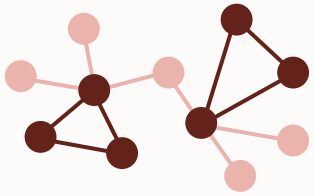
Strongly Connected Components,
Weakly Connected Components,
Label Propagation,
Conductance Minimization,
Infomap

Ranking and Walking



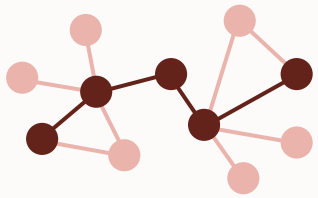
PageRank, Personalized PageRank,
Degree Centrality, Closeness Centrality,
Vertex Betweenness Centrality,
Eigenvector Centrality, HITS, SALSA,
Random Walk with Restart

Evaluating Structures



Adamic-Adar Index, Conductance,
Cycle Detection, Degree Distribution,
Eccentricity, K-Core, LCC, Modularity,
Reachability Topological Ordering,
Triangle Counting

Path-Finding



Shortest Path (Bellman-Ford, Dijkstra,
Bidirectional Dijkstra), Fattest Path,
Compute Distance Index,
Enumerate Simple Paths,
Fast Path Finding, Hop Distance

Link Prediction

WTF (Who to follow)

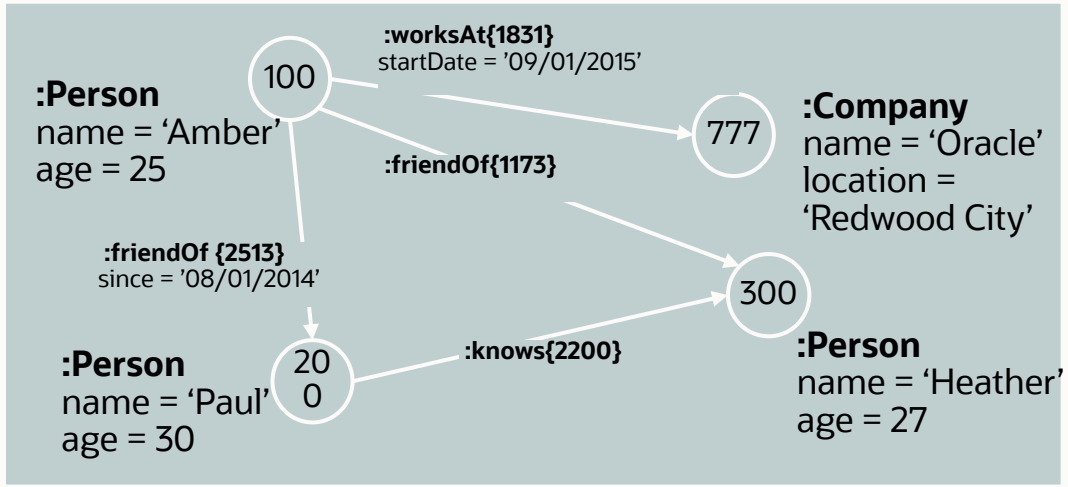
Others

Minimum Spanning-Tree,
Matrix Factorization

Basic Graph Pattern Matching

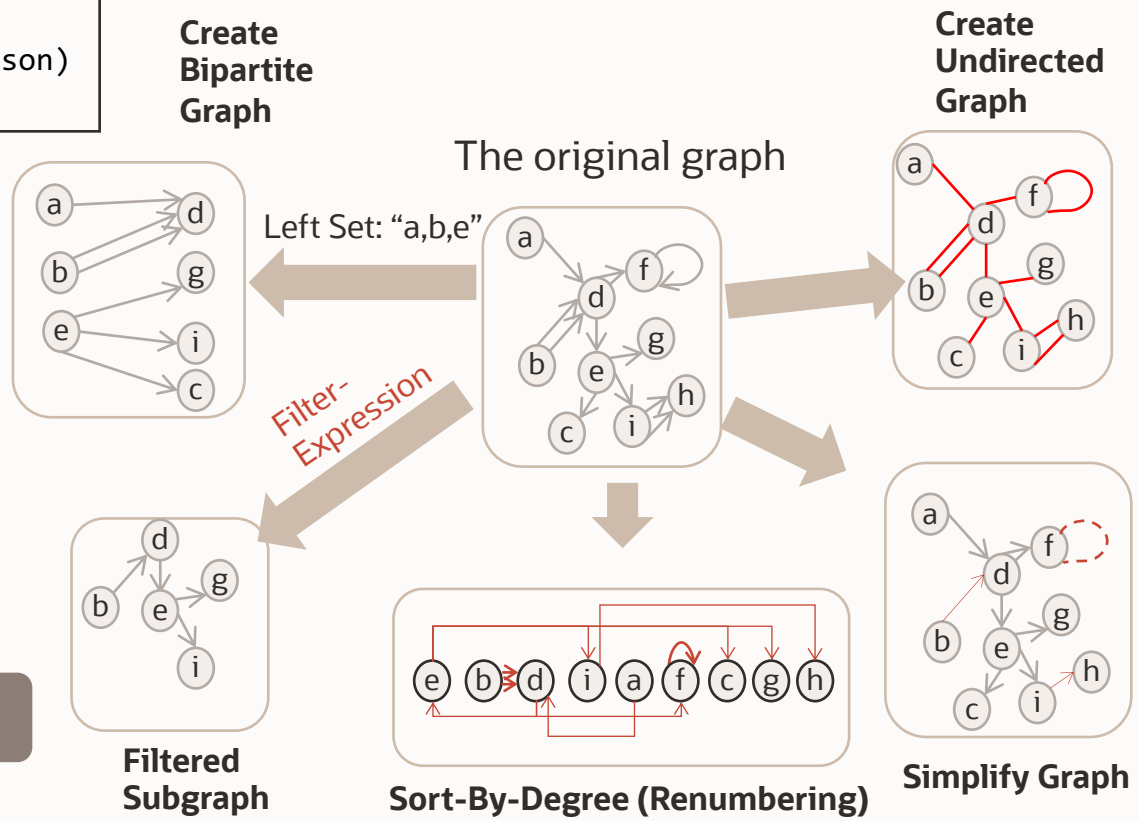
socialNetworkGraph

```
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'.

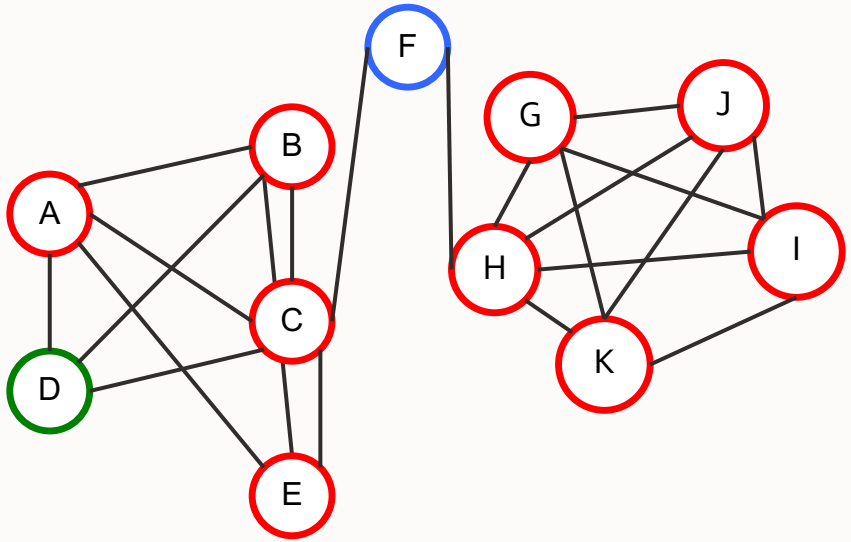
… and parallel graph mutation operations



Example: Determining Betweenness Centrality

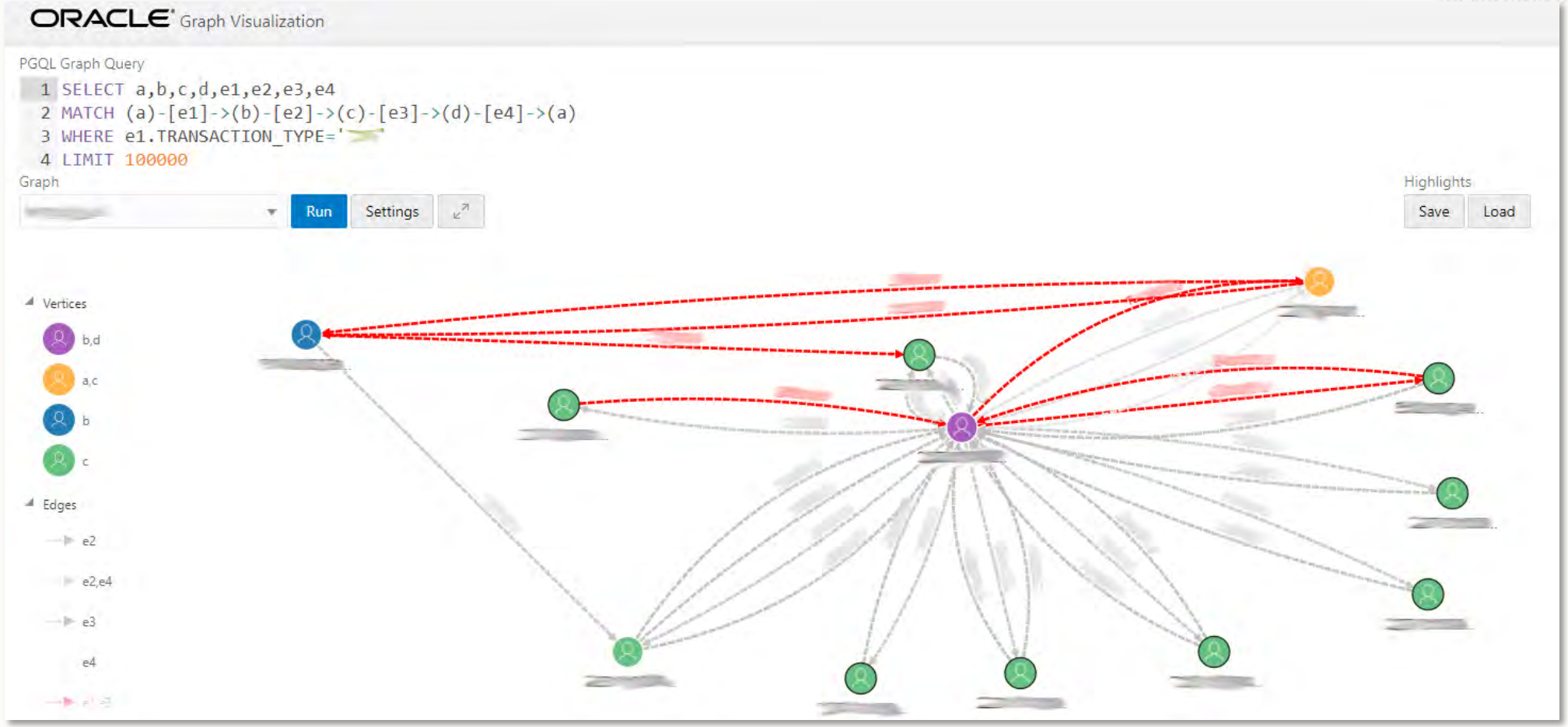
Code snippet

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



Identify influencers

Graph Visualization

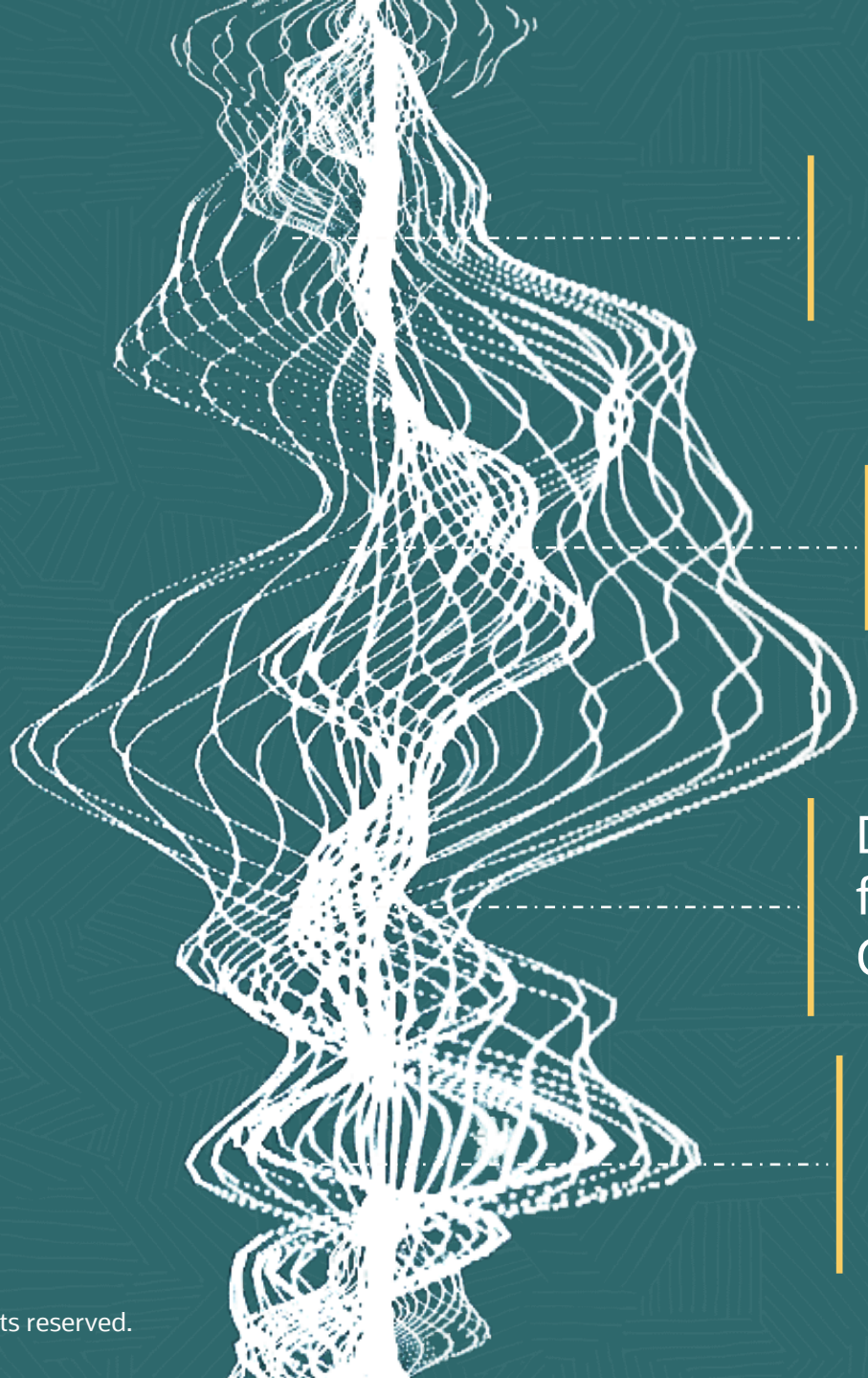


Performance Results

- 73 Million Customers
- 137 Million Transactions
- 0.3 Million Cycles

Reduced	End to End Cycle
	Graph Processing Time
Improved	Scalability
	Performance
	Simplicity

The Oracle Graph Edge



Enable data scientists to create graph models, faster

Comprehensive Platform to Consume all Data quickly

Digital Ecosystem for Complete Graph Cycle

Ensure Business Change

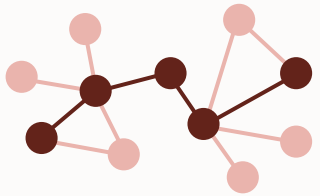
Demo App - How to Detect Cycles

Demo - How to Detect Cycles

How we can find (the shortest) cycle in graphs, starting from one specific node:

Mock data

- 1,000 nodes (bank accounts) + 5,000 edges (money transfers)
- Each node has 5 outgoing edges to randomly selected nodes
- Not consider : transaction date, transaction amount, ...



Scenario

- Select **one specific account** by its ID
- Show how many nodes are connected **in k hops** from this account
- Search for **a cycle** starting from and ending at this account

Demo - How to Detect Cycles

Count the number of the accounts connected **in 6 hops** from account ID=1

```
SELECT DISTINCT COUNT(*)
MATCH (n)-/:transfer{1,6}/->(m)
WHERE ID(n) = 1
```

Search for **the shortest cyclic path** starting from and ending at the account ID=1

- The 1st shortest path has no edge (= 0 hop)
- The 2nd shortest path is the shortest cyclic path

```
SELECT n, ARRAY_AGG(ID(m)), ARRAY_AGG(ID(e))
MATCH TOP 2 SHORTEST ((n) (-[e:transfer]->(m))* (n))
WHERE ID(n) = 1
```

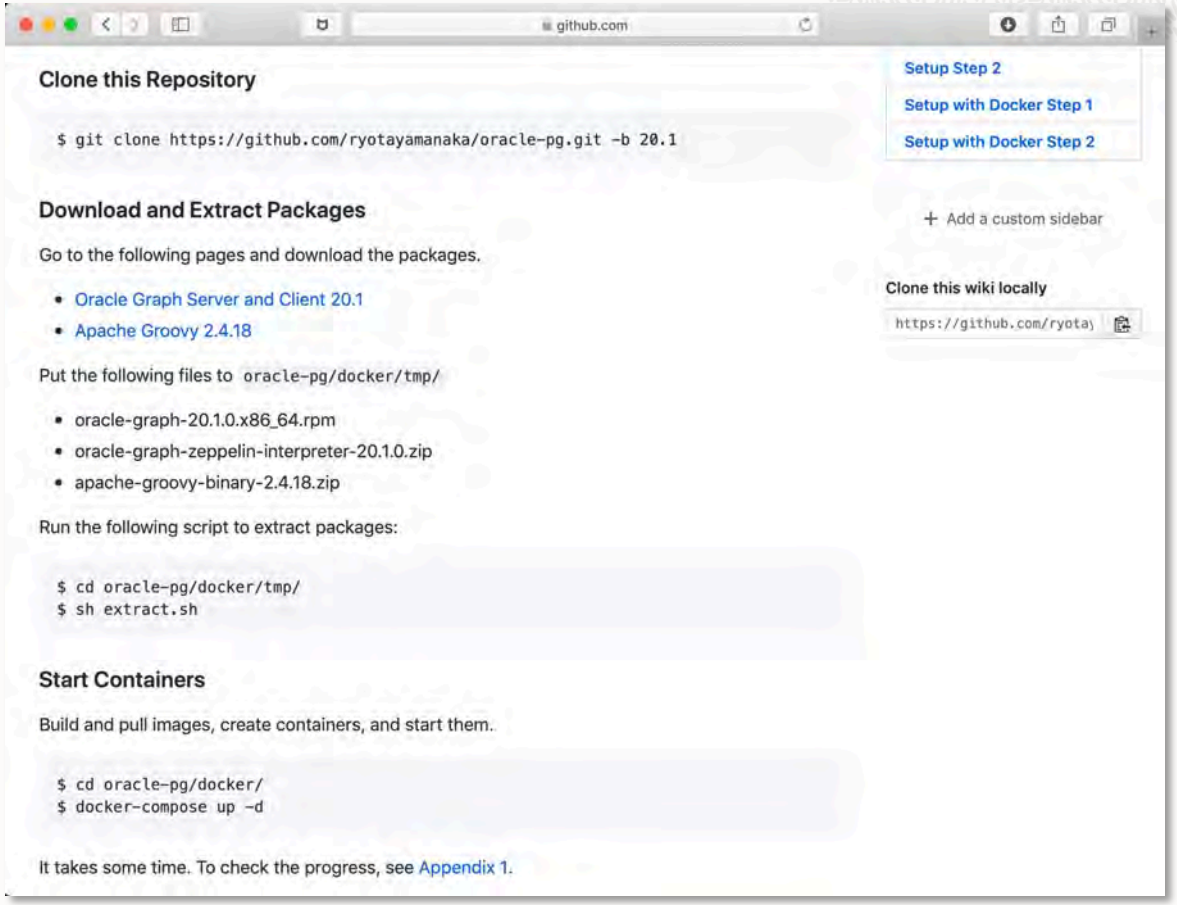
Demo - How to Detect Cycles

This demo content is available here:

https://github.com/ryotayamanaka/oracle-pg/wiki/Setup-with-Docker-Step-1

The Docker containers include

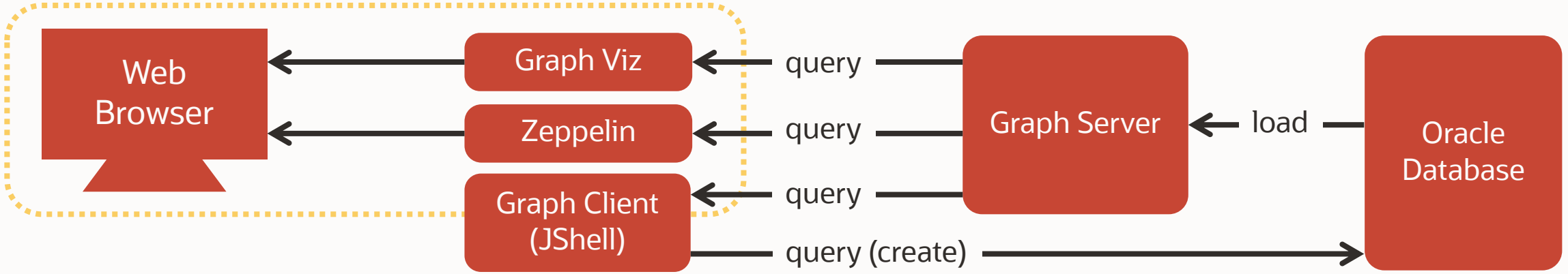
- Mock data (in files)
- Graph Visualization
- Zeppelin notebook



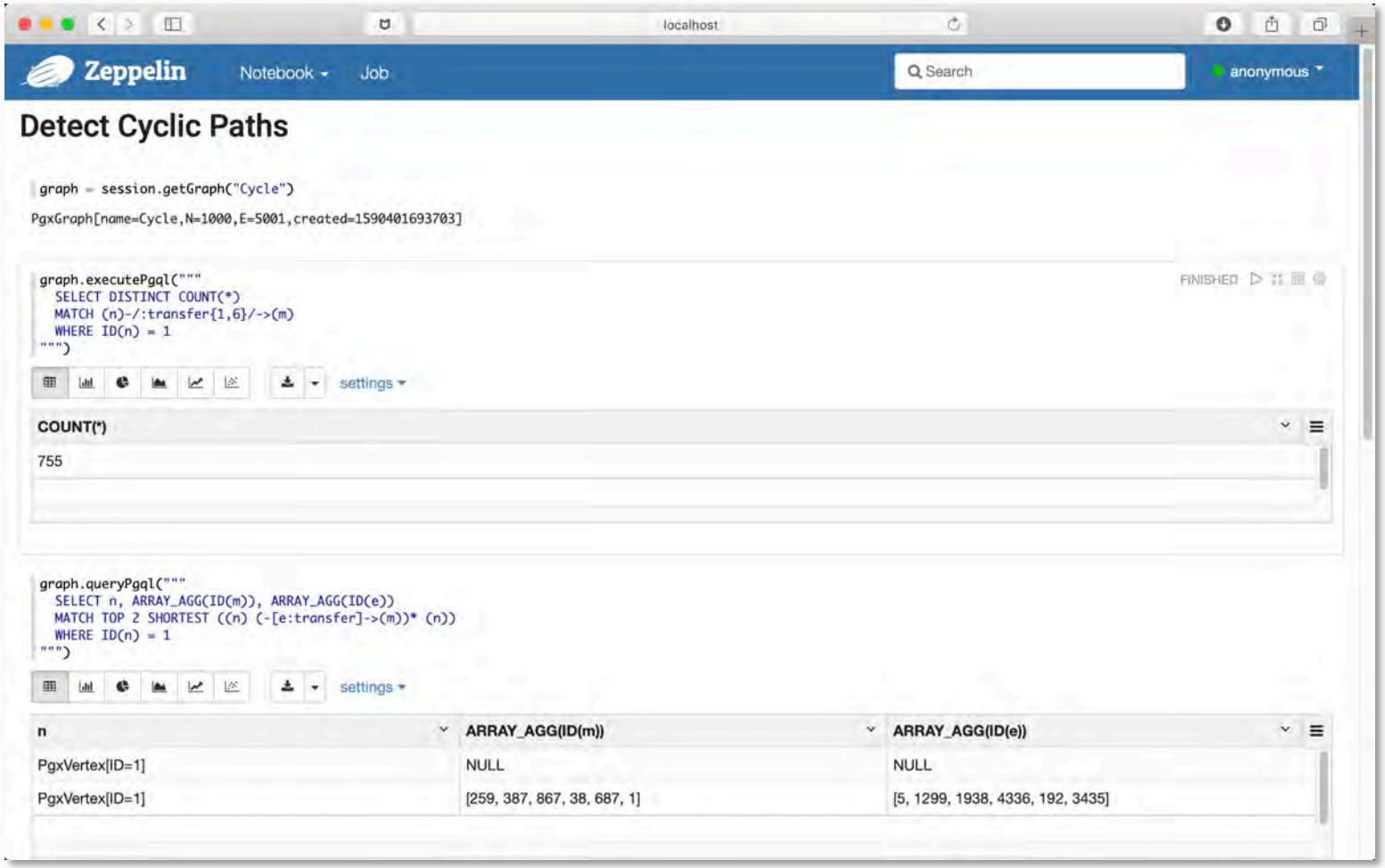
Using Built-in Tools

The cycles will be queried and visualized using the following built-in tools:

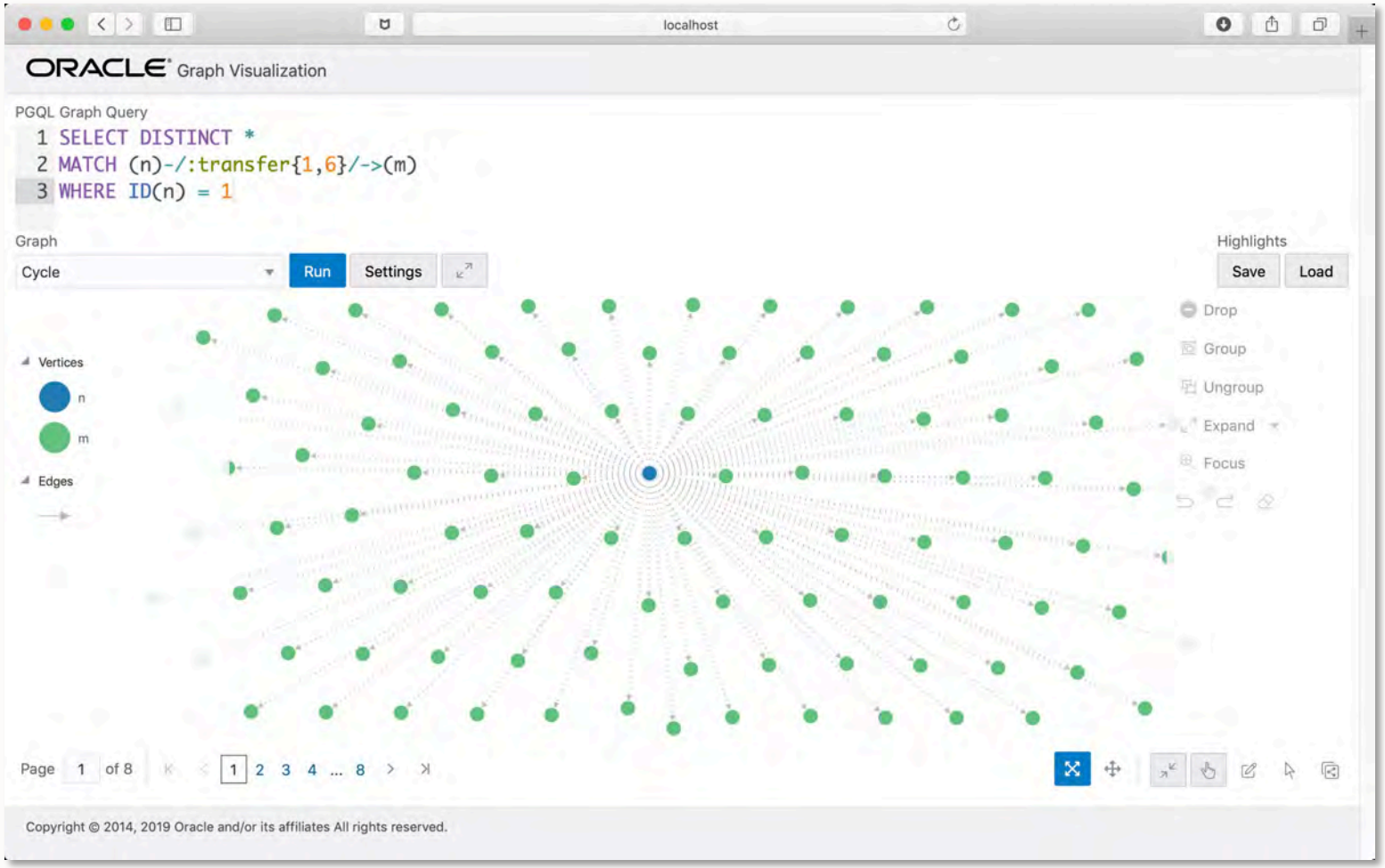
- Zeppelin notebook
- Graph Visualization app



Using Built-in Tools



Using Built-in Tools

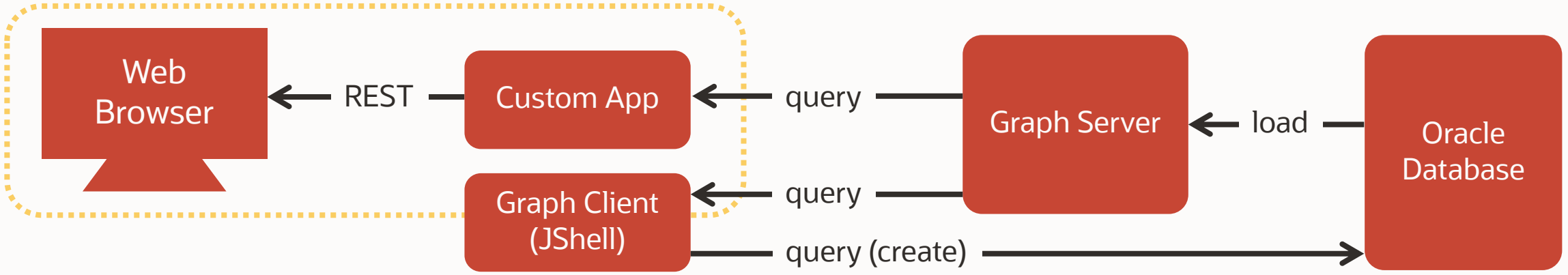


Implementing Custom App

Custom applications can be implemented with **Graph Client Java API**.

In this demo, the components are:

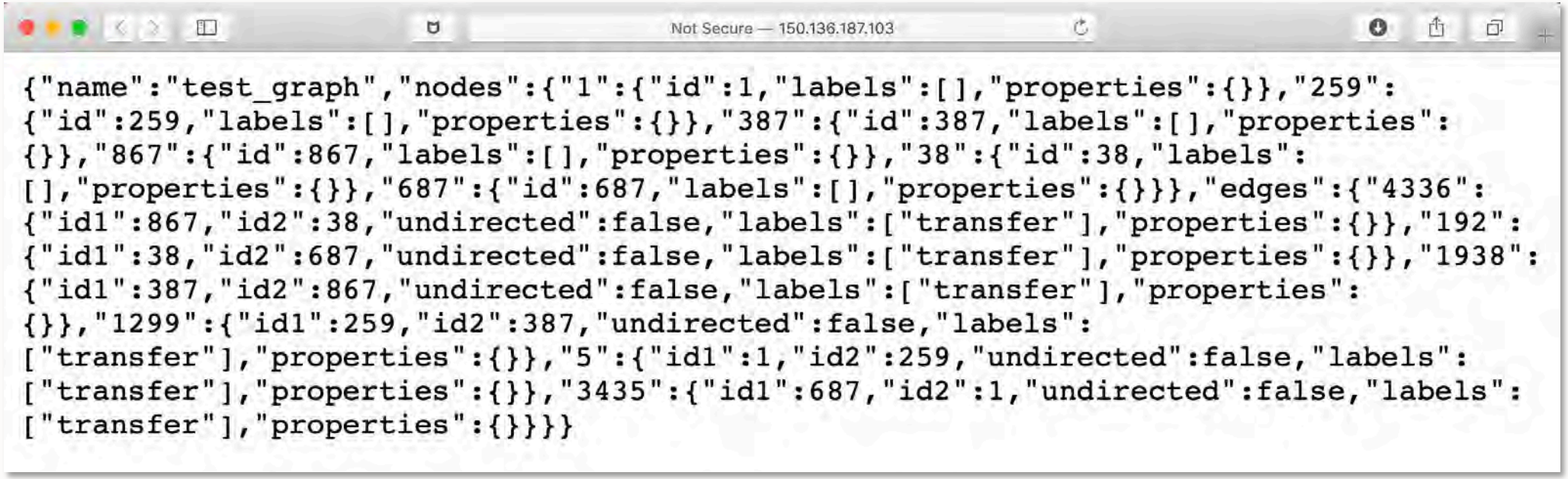
- **REST server** written in Java (using Javalin)
- Custom visualization in JavaScript (using D3.js)



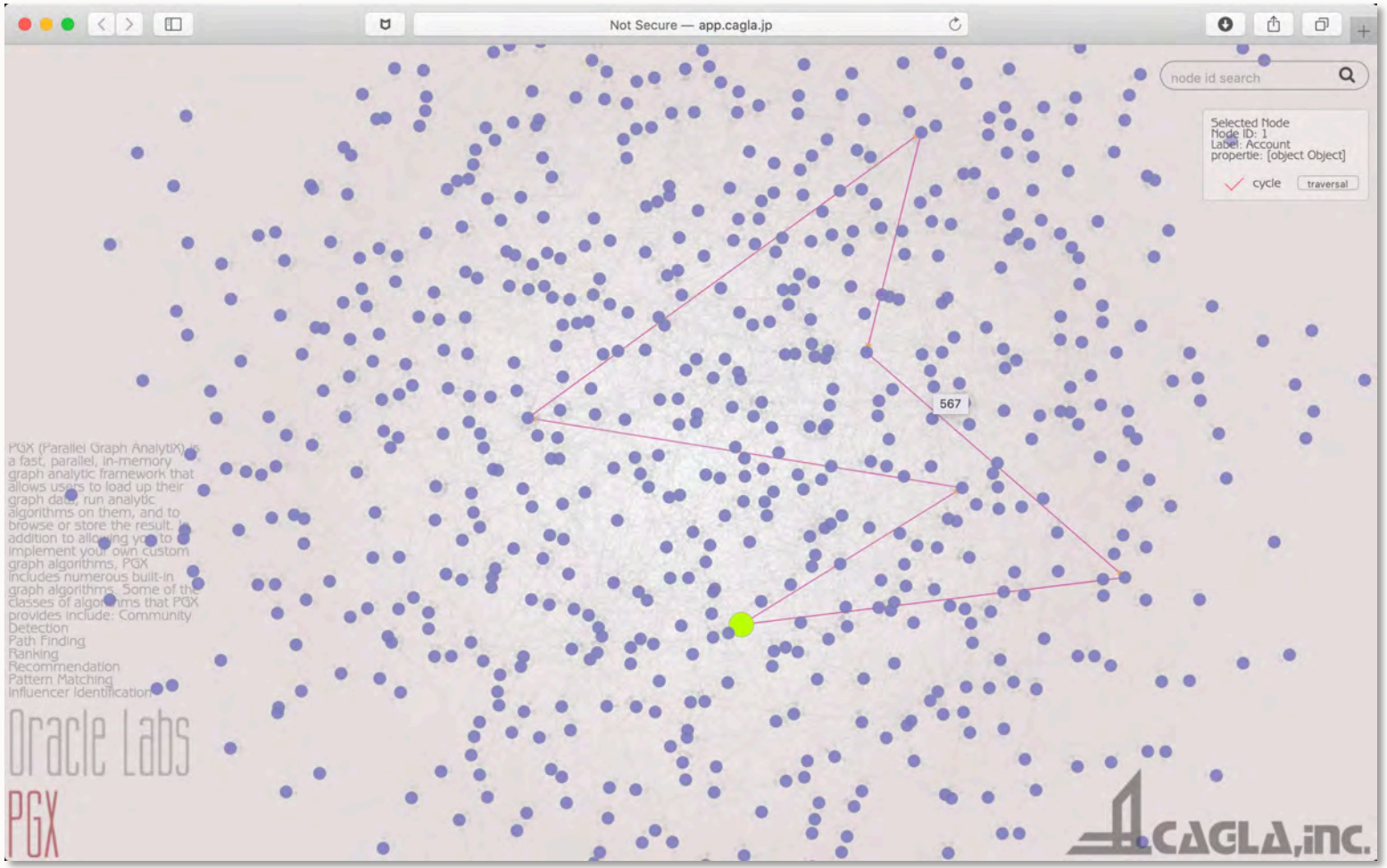
Implementing Custom App

This sample REST API returns subgraph and cycle in JSON format.

- Graph in 6 hops `http://<host:port>/travarsal?node_ids=1&iteration=6`
- Cycle `http://<host:port>/cycle?node_ids=1`



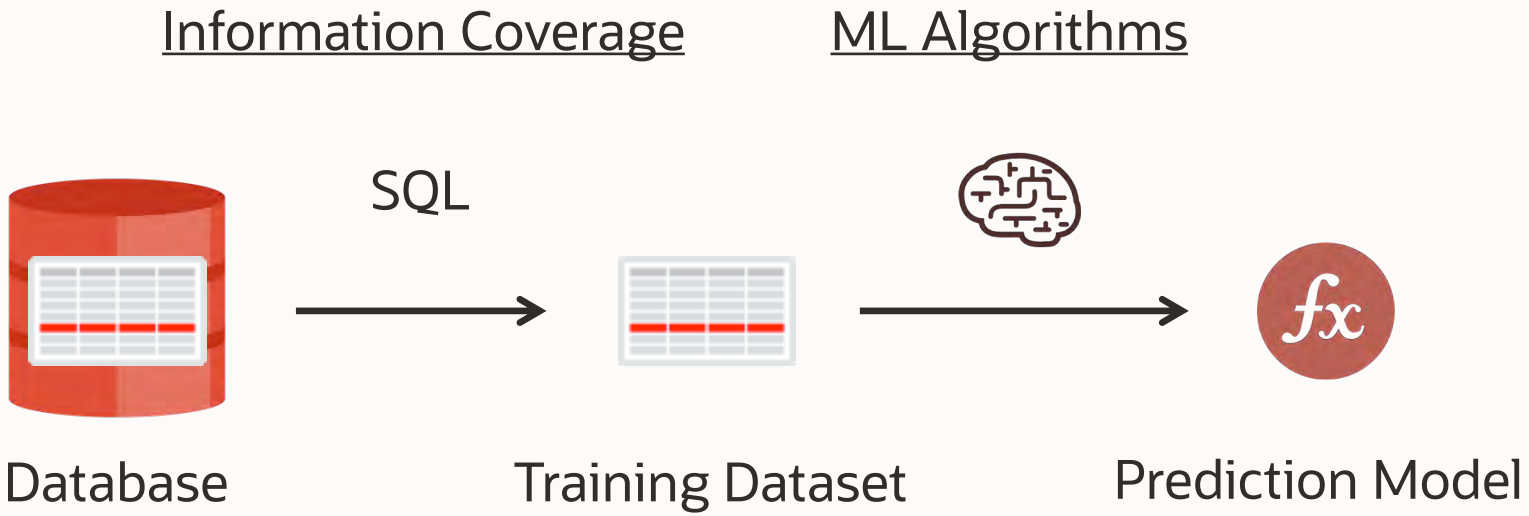
Implementing Custom App



How to Combine with Machine Learning

Machine Learning

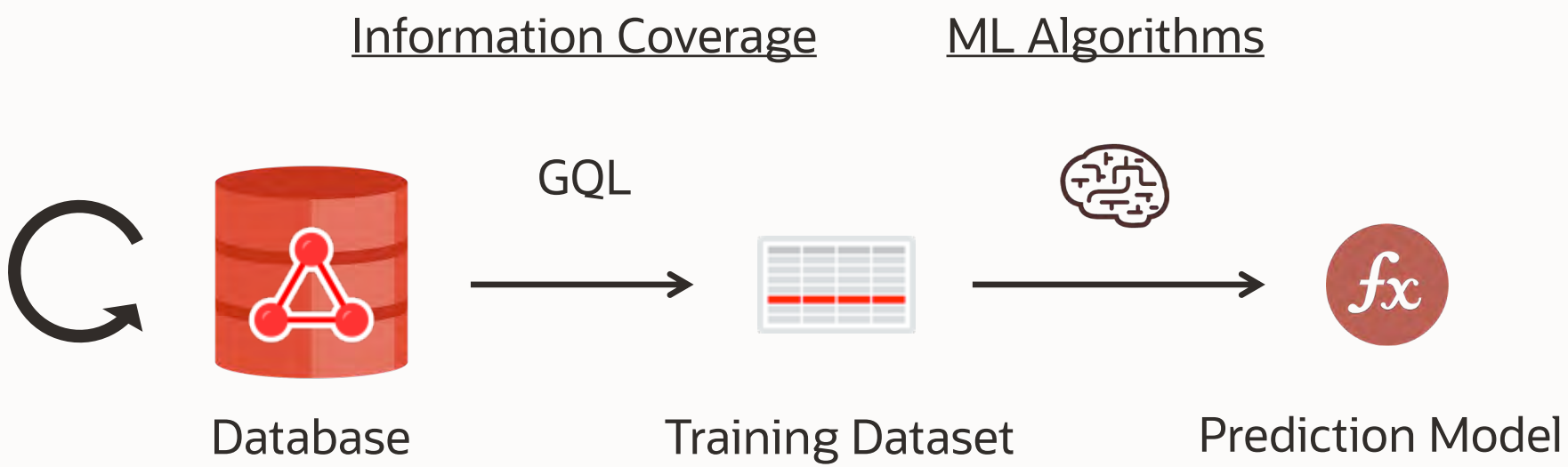
Information coverage of the training dataset is important to make good predictive models



Machine Learning

Graph database potentially provides more information because of its:

- **flexible** model
- **algorithm** capability



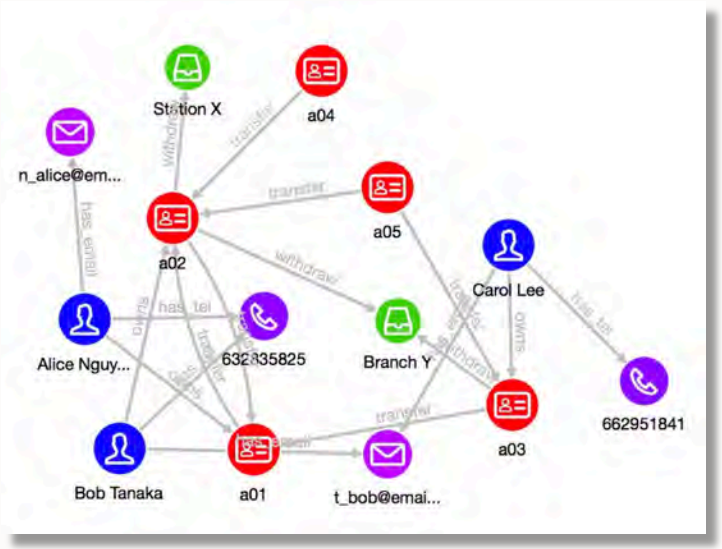
Example - Mule Account Detection

- **Mule accounts** are often stolen accounts and transfers money illegally
- Suspicious accounts are flagged by human curation
  - The system should be able to predict the human decision (= **objective variable**)
- If machine learning can make the predictive model?
  - But the accounts themselves has limited information (= **explanation variables**)
- Is it possible to generate **more features** based on the relationships between accounts (e.g. transaction patterns, family relationships, ...)

Account

name
age
occupation
branch
balance
...

is_fraud

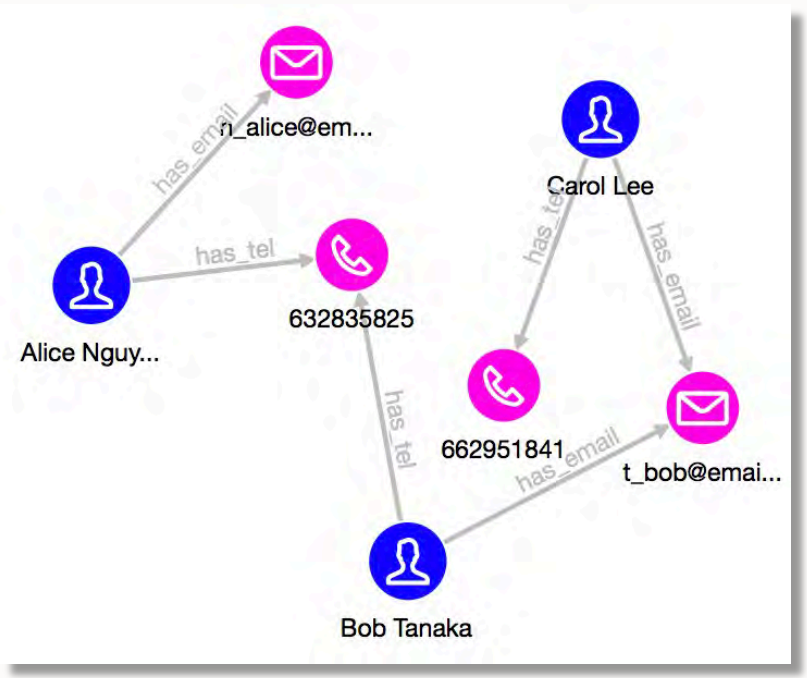


Example - Mule Account Detection

Feature 1

- If the owner of this account is sharing personal information with others

```
SELECT a1, COUNT(s)
MATCH (a1)<-[:owns]-(c1)-(s)-(c2)-[:owns]->(a2)
WHERE a1 != a2 AND c1 != c2
GROUP BY a1
```



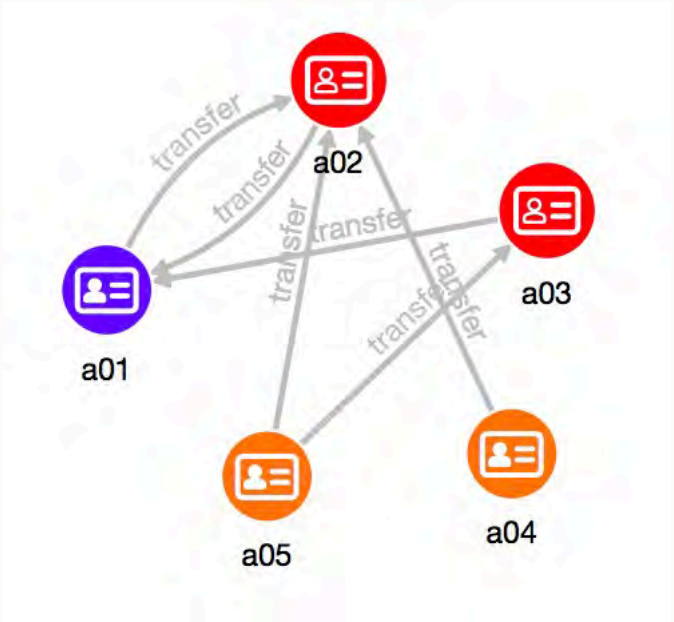
Example - Mule Account Detection

Feature 2

- How many fraud accounts exist in the same money transfer community

```
analyst.communitiesLabelPropagation(G, 100)
```

```
SELECT a.community, COUNT(a)
MATCH (a)
WHERE a.type = 'Account'
  AND a.is_fraud = 'true'
GROUP BY a.community
```



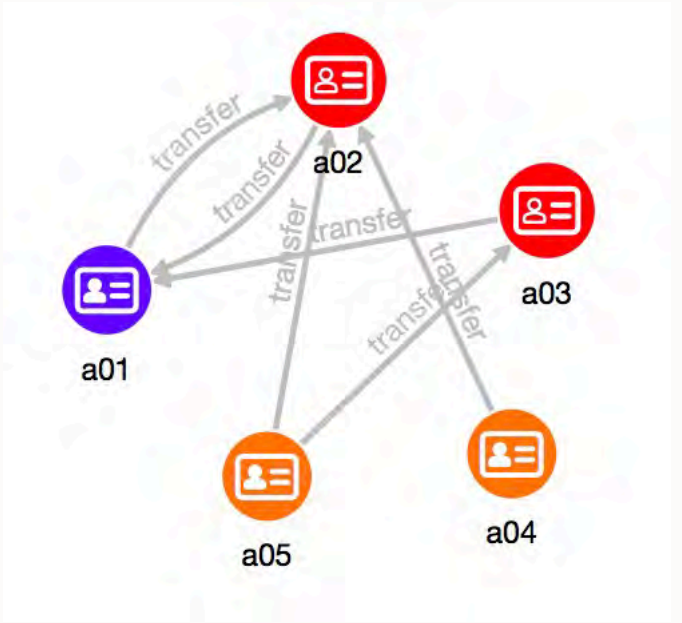
Example - Mule Account Detection

Feature 3

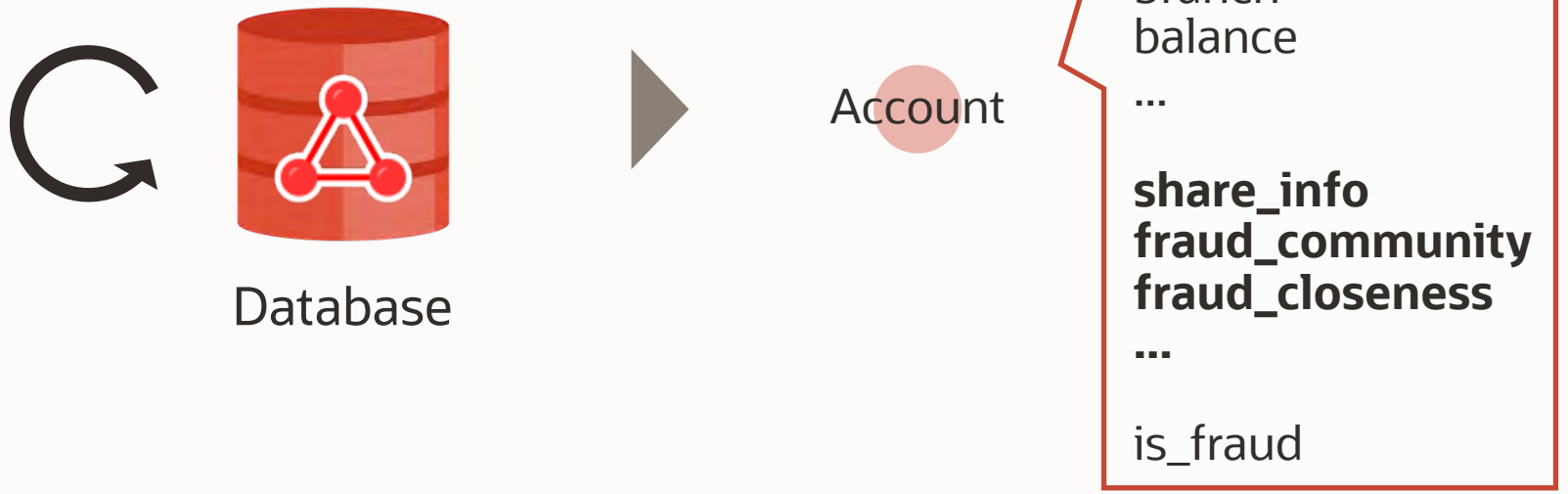
- Closeness to know fraud accounts

```
analyst.personalizedPagerank(G, fraud_accounts)
```

```
SELECT a.account_no, a.pagerank, a.is_fraud
MATCH (a) WHERE a.type = 'Account'
ORDER BY a.pagerank DESC
```



Example - Mule Account Detection



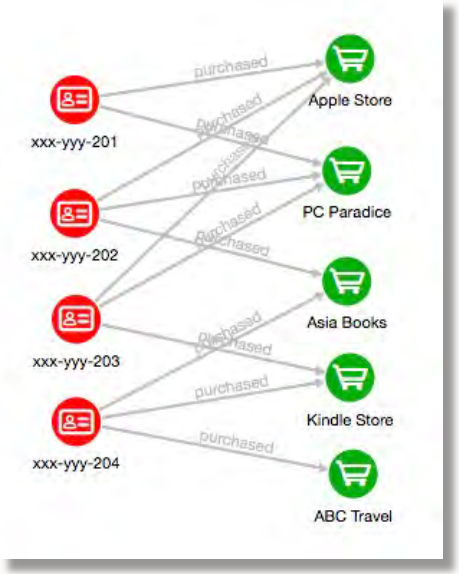
Example - Mule Account Detection

ID	age	occupation	balance	share_info	fraud_com	fraud_clo	is_fraud	prediction
1001							Yes	Yes 85%
1002							No	**Yes 78%**
1003							No	No 62%

More Algorithms

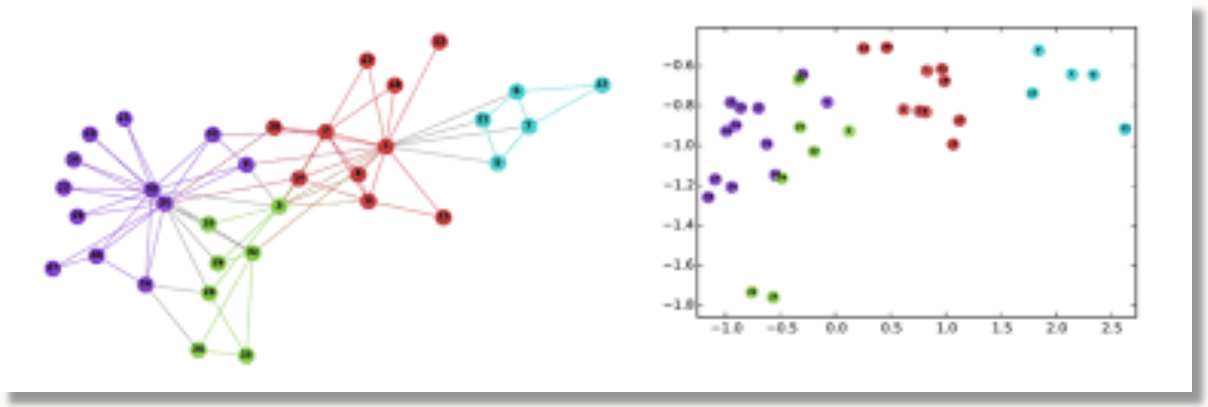
RandomWalk

- Closeness to other nodes



DeepWalk

- Collect sequences by RandomWalk
- Use the sequences as input of Skip-gram
- Obtain the tensor for each node

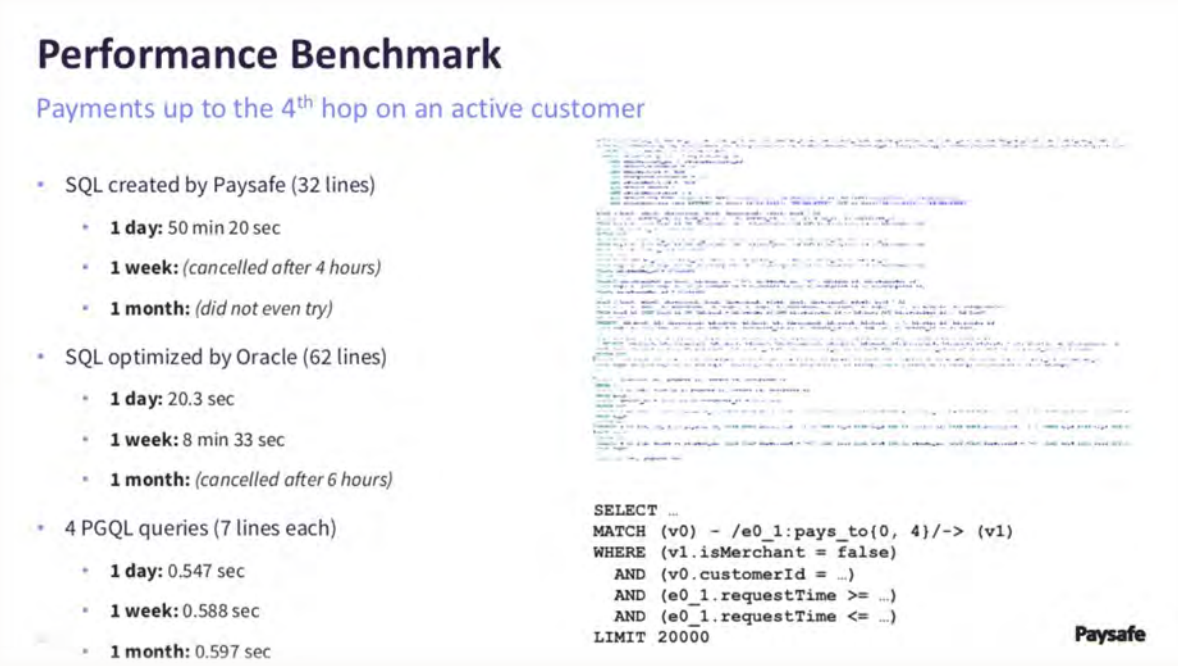


Customer Reference - Paysafe

- Providing **online payment** solutions
  - Real-time payments, e-Wallets
  - 1B revenue/year, 500K payments/day
- Strong demand for **fraud detection**
  - Combination with rule-based approach and machine learning
  - In real-time, upon money movement
- More information
  - AnD Summit : 2020 slides, 2019 slides
  - YouTube : video

Customer Reference - Paysafe (Query)

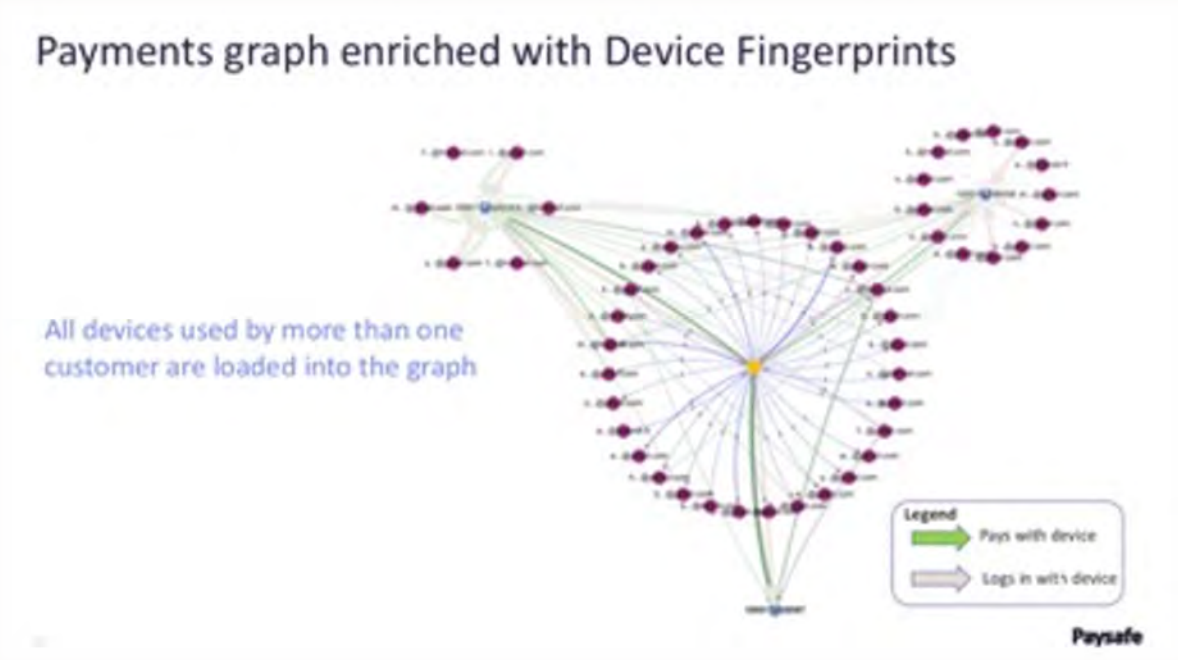
- The queries to follow transactions **multiple hops** need to join the tables multiple times.
- The existing complex SQL queries were rewritten into PGQL queries.
- Queries become **much simpler**
  - e.g. 32 lines --> 7 lines
- Queries become **much faster**
  - e.g. 50 min --> 0.5 sec
  - Possible to run the queries that didn't complete in reasonable time by SQL.



Analytics and Data (AnD) Summit 2020 Presentation

Customer Reference - Paysafe (Visualization)

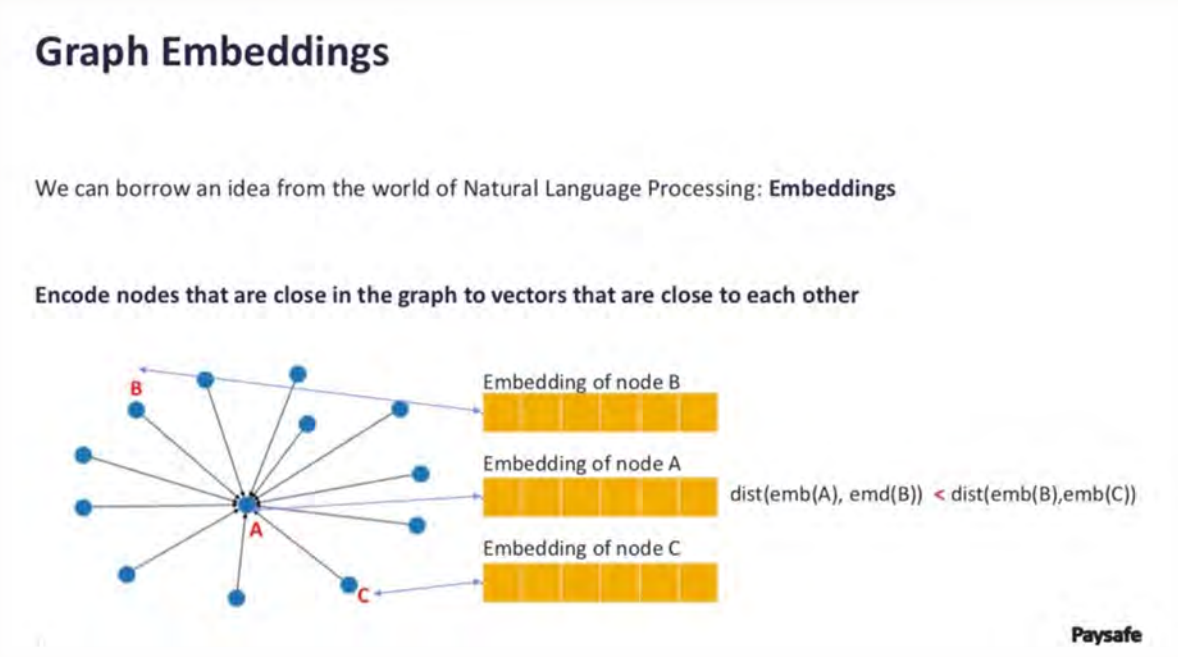
- Visualization of money flows is essential to manually check the activities of suspicious accounts, as well as to understand the **common fraud patterns**.
- Using this custom visualization application, interesting networks such as possible **money laundering flows** (typically consists of 3 steps : placement, layering, integration) were detected.
- Using device fingerprints, the multiple accounts **using the same device**, and their money flows are also visualized.



Analytics and Data (AnD) Summit 2020 Presentation

Customer Reference - Paysafe (Machine Learning)

- Introduction of graph visualization and graph analytics helps the investigations of fraud specialists, and **saves a lot of time and effort**.
- For further automation, the fraud patterns should be also detected without human intervention. For this goal, **machine learning** will be combining with graphs.
- Graph embedding techniques such as DeepWalk was experimented, and this feature **improved the accuracy** of the machine learning model significantly.



[Analytics and Data (AnD) Summit 2020 Presentation]

Customer 360 Analysis Using Graphs

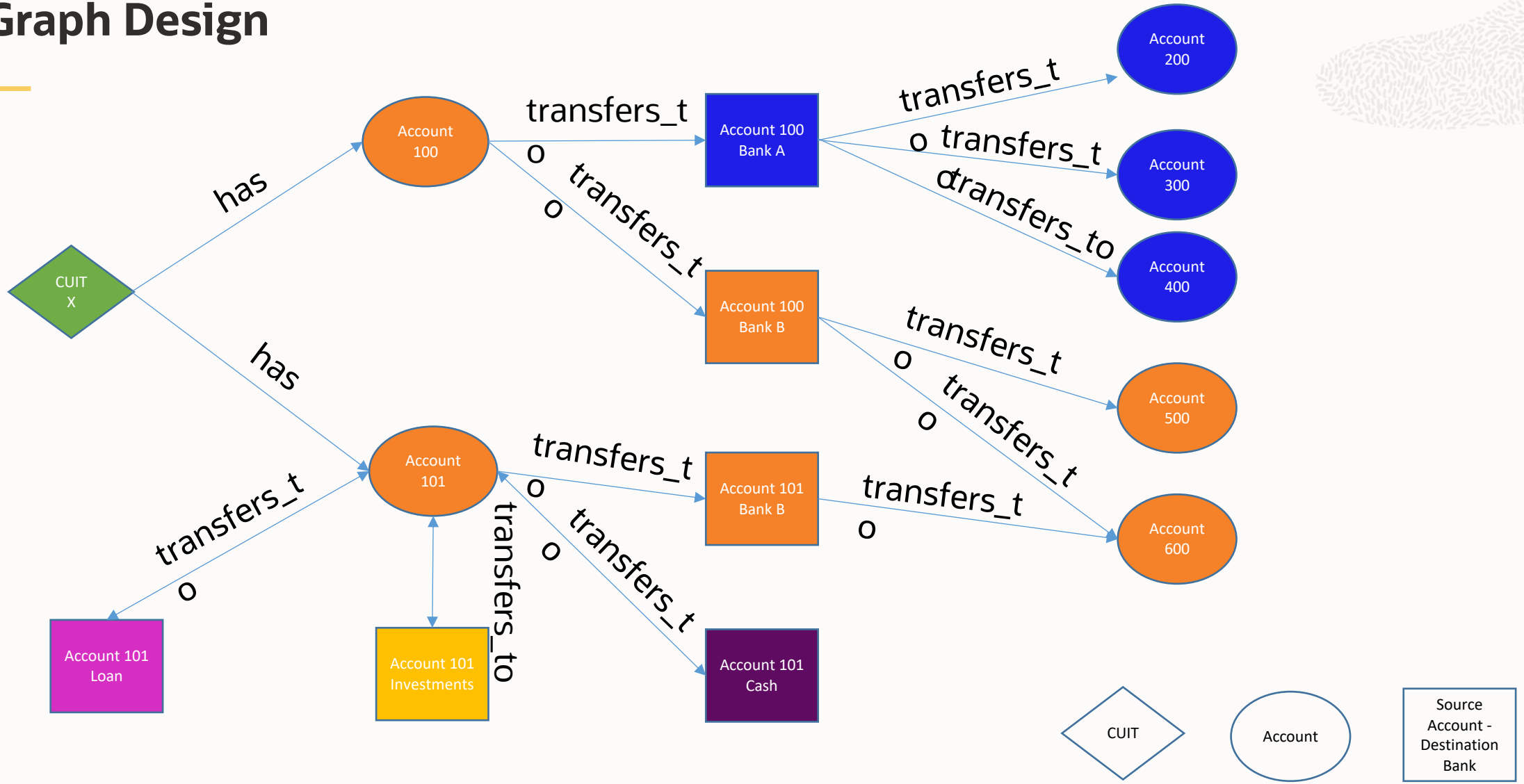
Money Transfer Use Case

Actionable Targets

- **Cash Deposits:** Identify Galicia's accounts with many cash deposits that then transfer their money to self accounts in another Banks

- **Value Chain:** Identify Galicia's big accounts who pay their providers through other banks

Graph Design



Money Transfer Use Case - Discoveries

Money Transfer Use Case - Discoveries

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segmento_empresa = PYME MES
sucursal = SANTA FE
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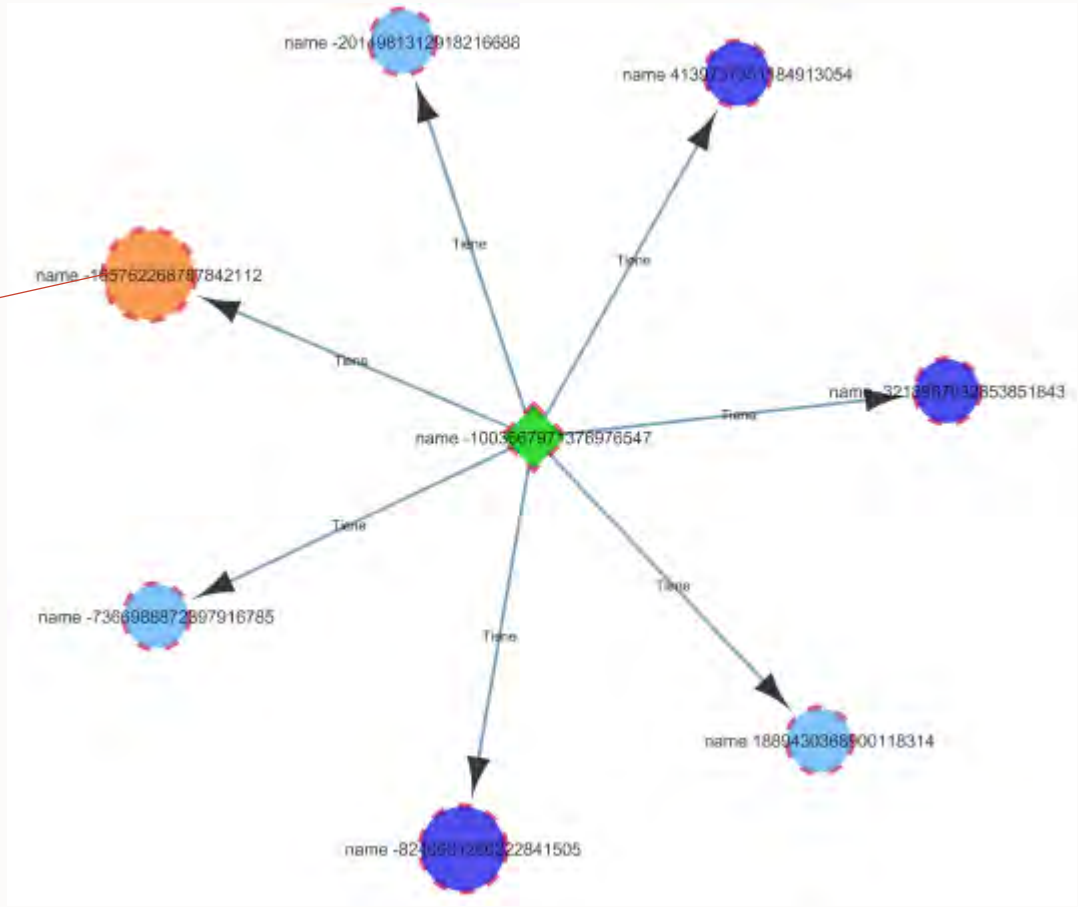
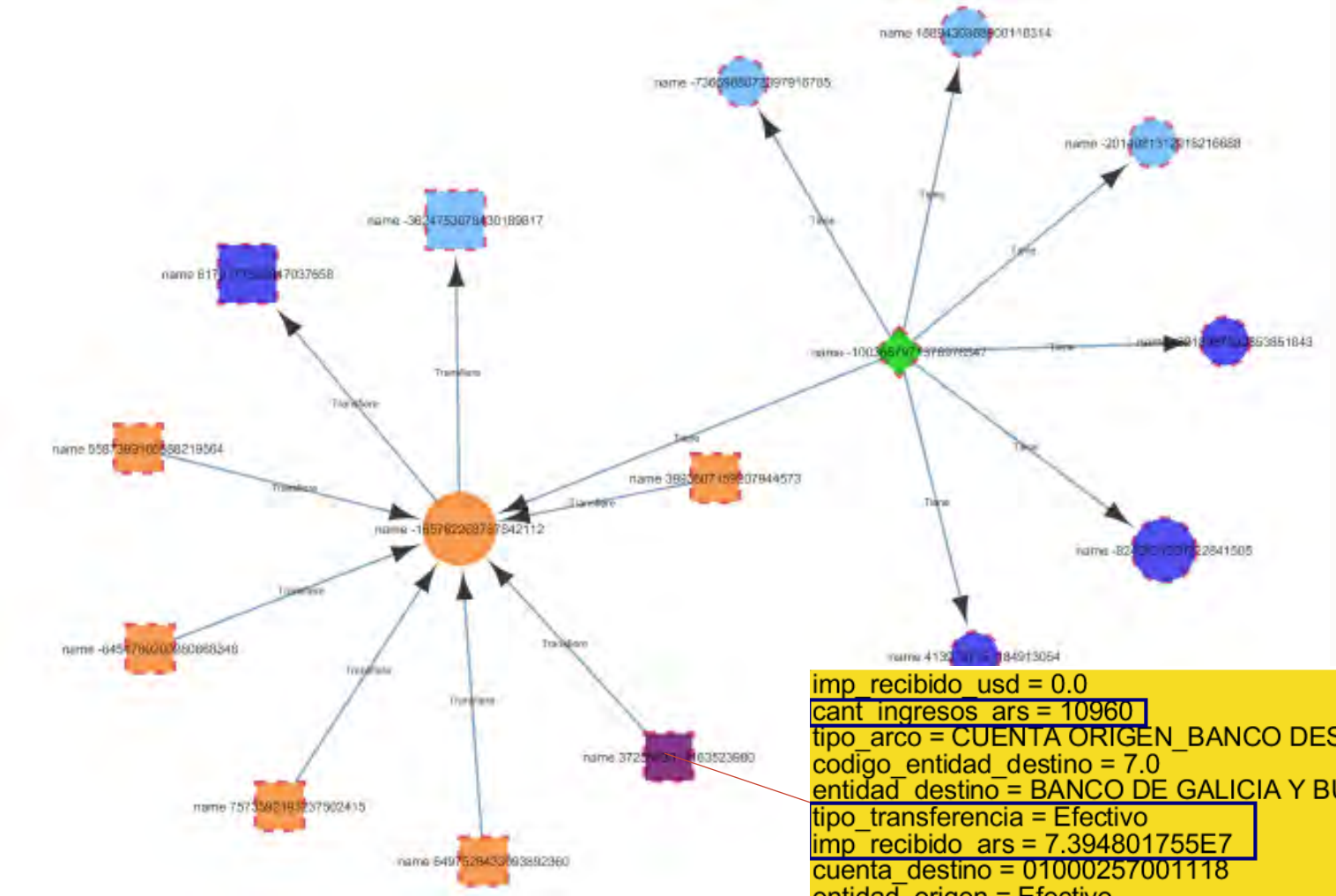
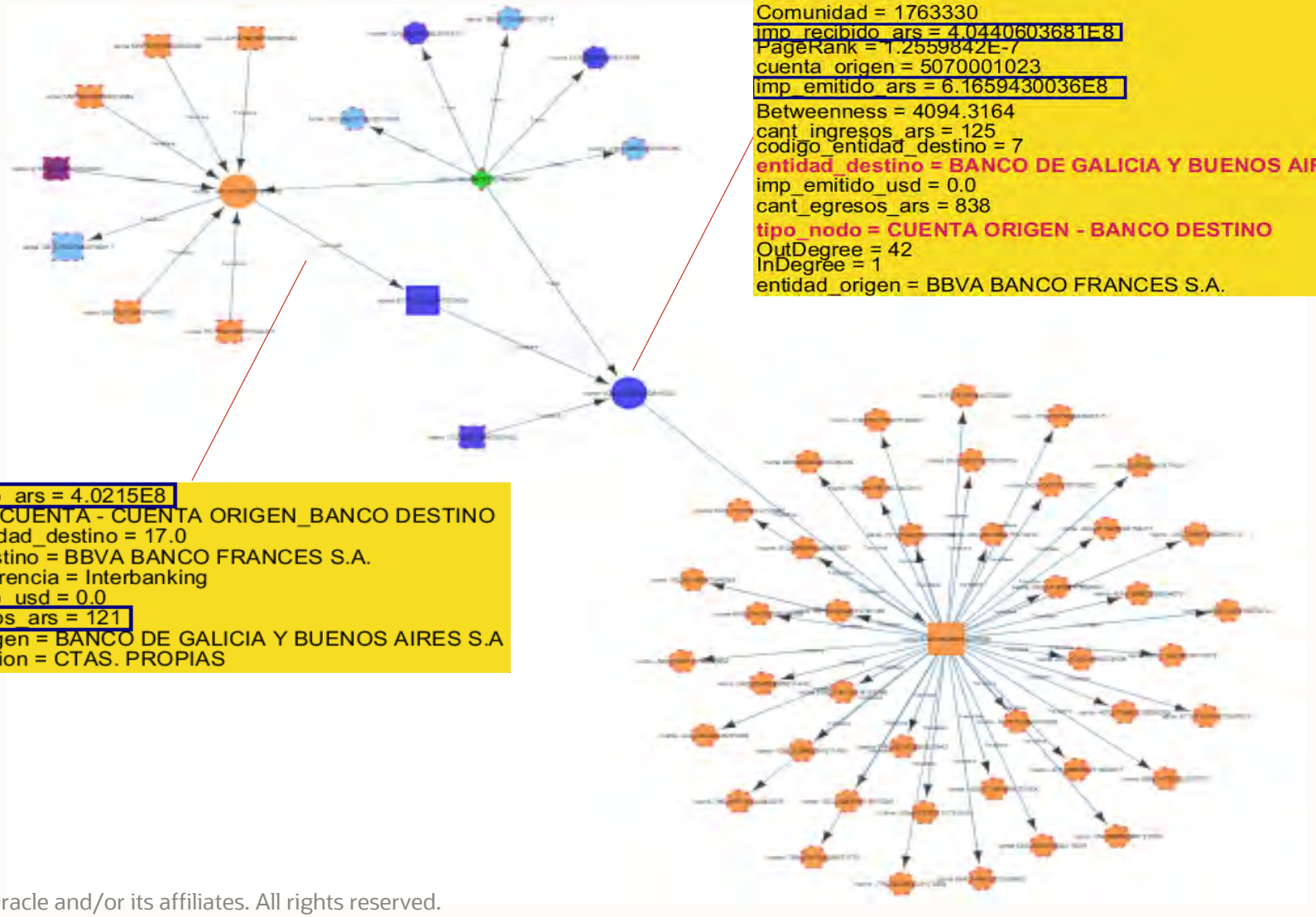


Money Transfer Use Case - Discoveries



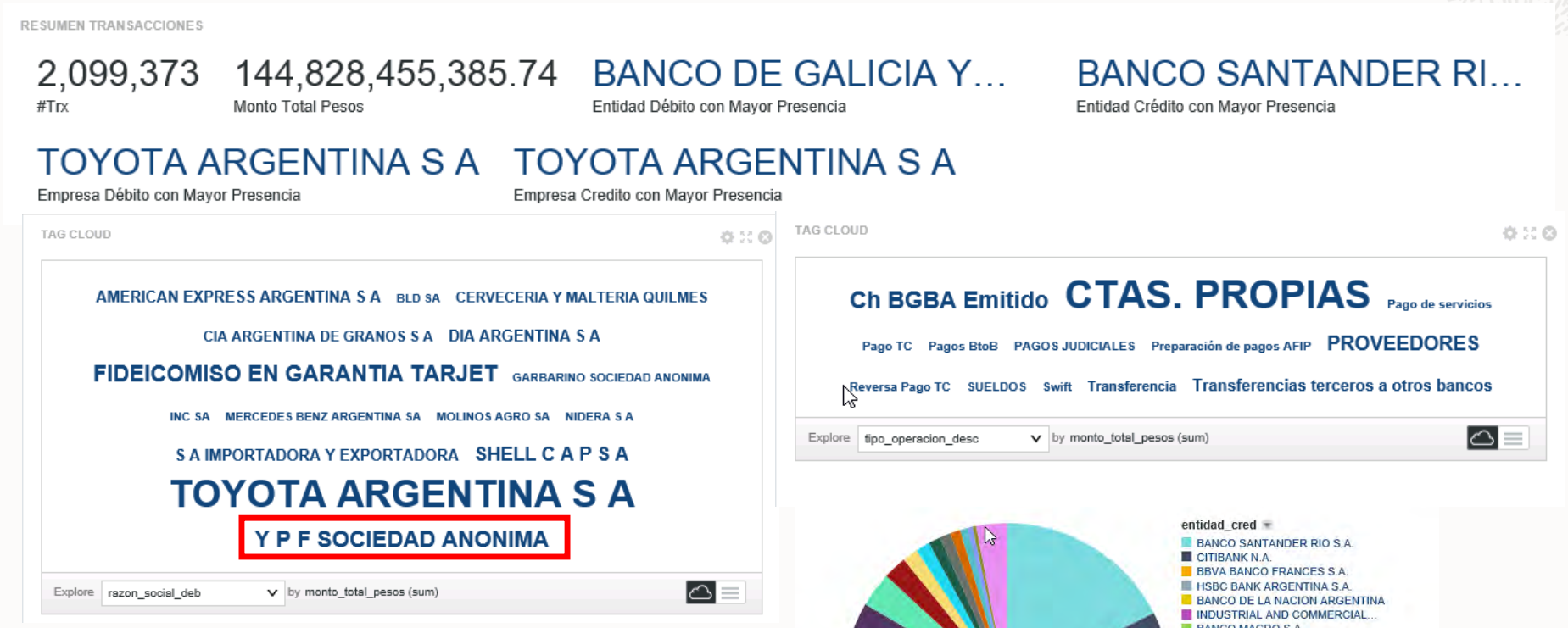
Money Transfer Use Case - Discoveries



Money Transfer Use Case - Discoveries

- **Discoveries**
  - On its Galicia Bank account **CUSTOMER** receives 73MM ars in cash from more than 10M deposits
  - From its Galicia Bank account **CUSTOMER** transfers more tan 400MM ars to a self account on Banco Frances.
  - Banco Frances account transfers more tan 600MM ars to different providers with accounts on Galicia Bank
- **Actionable**: Payment to providers should be done through Banco Galicia and not Banco Frances so that the money stays within Galicia's circuit. Otherwise a higher fee could be charged given this huge amount of deposits

Money Transfer Use Case - Discoveries



Credit Entity: **NO Banco Galicia**

Money Transfer Use Case - Discoveries

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sucursal = METRO I
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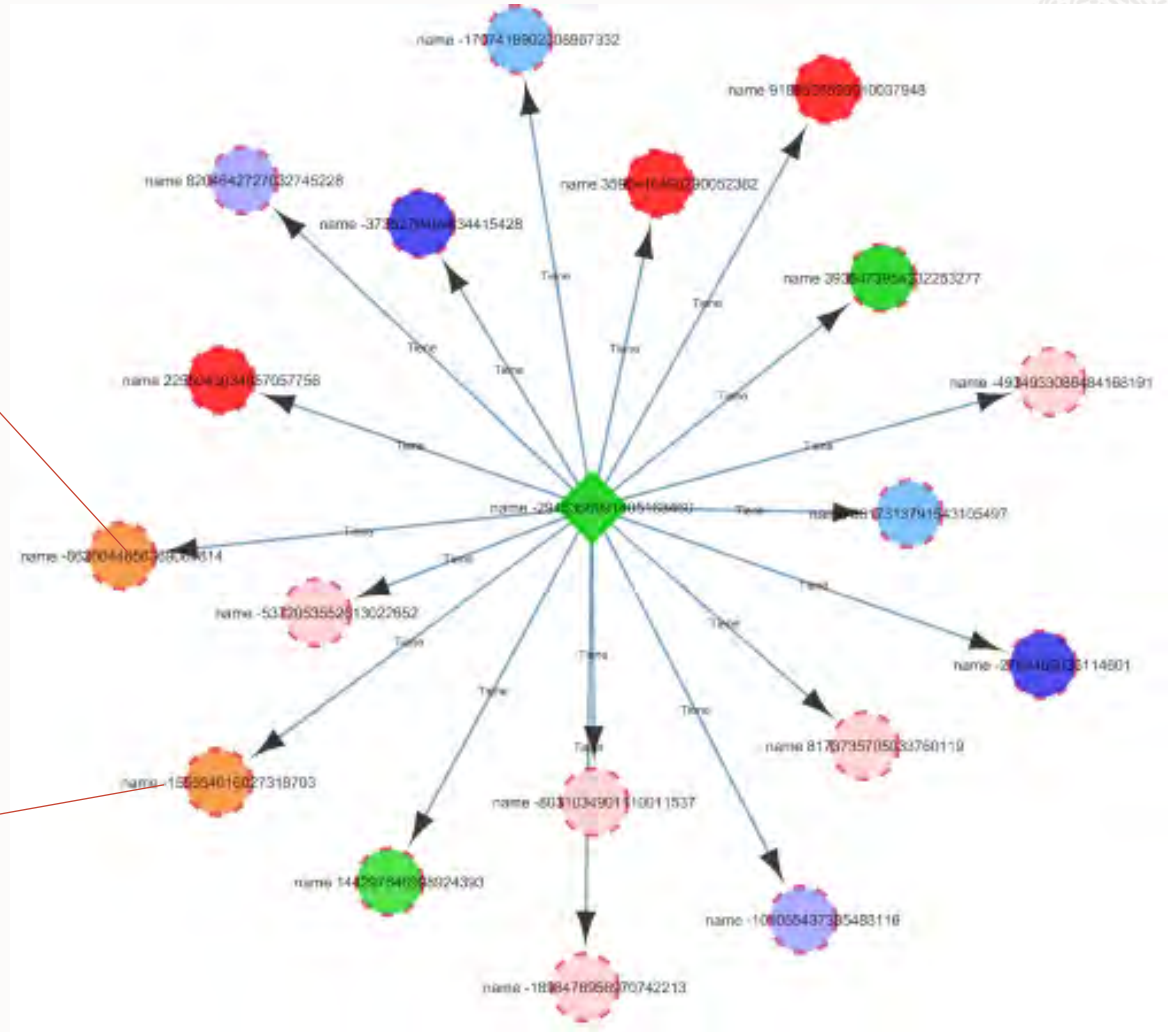
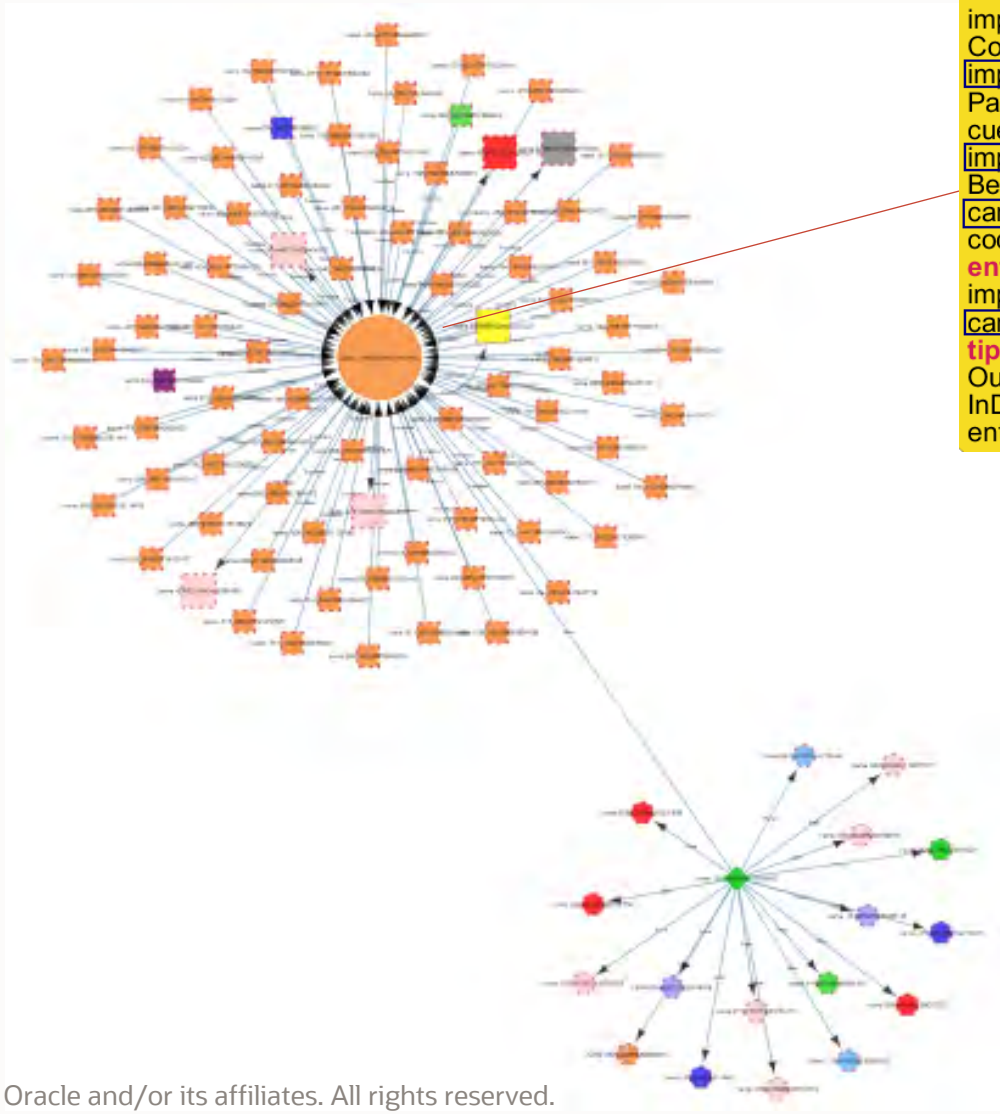


Money Transfer Use Case - Discoveries



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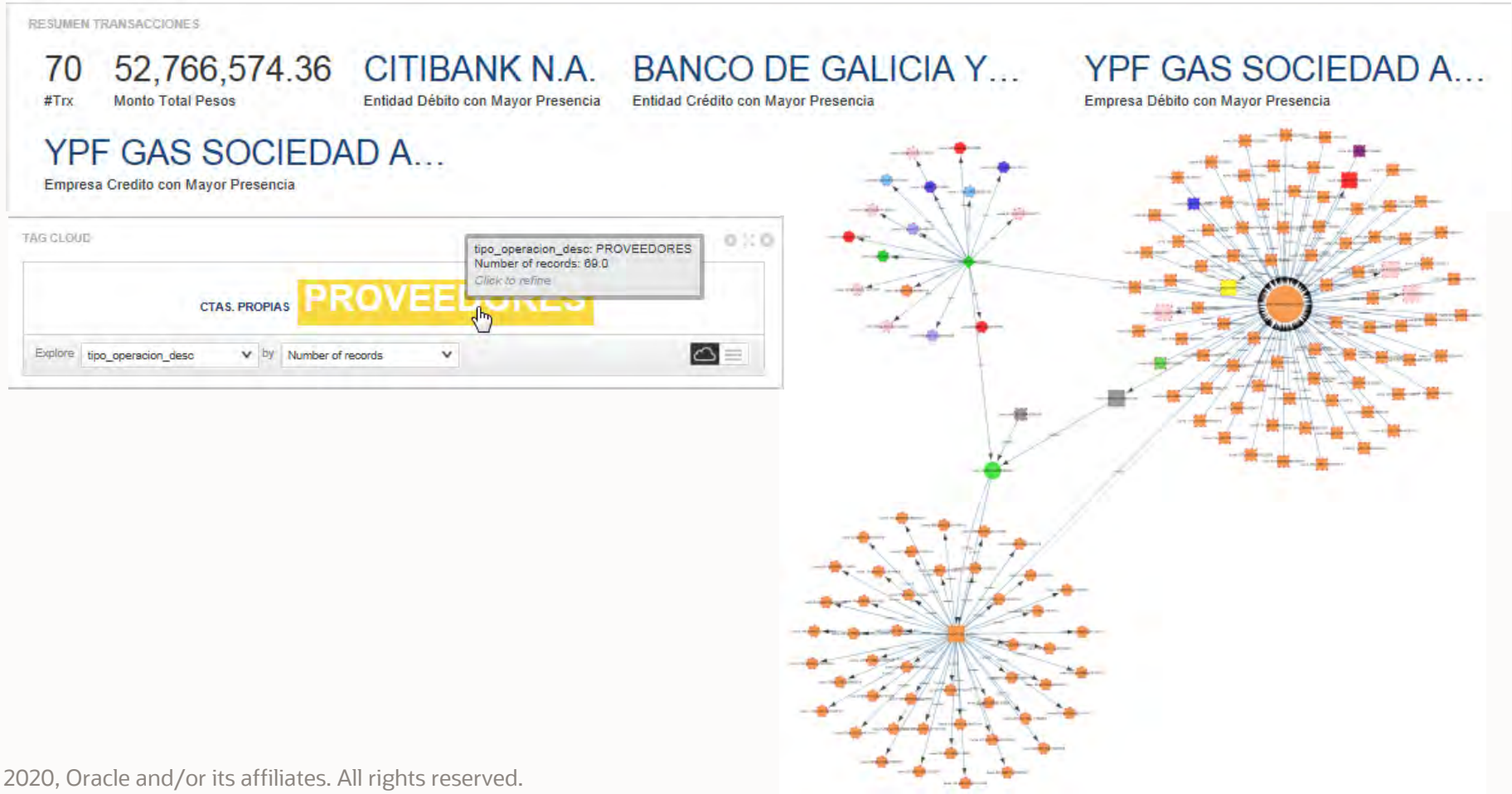
OutDegree = 1
InDegree = 1
entidad_origen = BANCO DE GALICIA Y BUENOS AIRES S.A

Money Transfer Use Case - Discoveries

Debit Entity: **Citibank**



Money Transfer Use Case - Discoveries

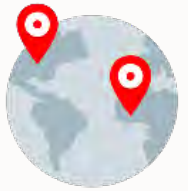
- **Discoveries**
  - 50% of operations between self accounts
  - Providers payment mainly through Citi Bank
  - CUSTOMER uses Galicia's Investment Funds to then withdraw money + interests and pay Providers
  - CUSTOMER's chain of providers is outside Galicia's circuit
- **Actionable**: Payment to providers should be done through Galicia accounts instead of Citi's

Useful Links

AskTOM Office Hours: Graph Database and Analytics

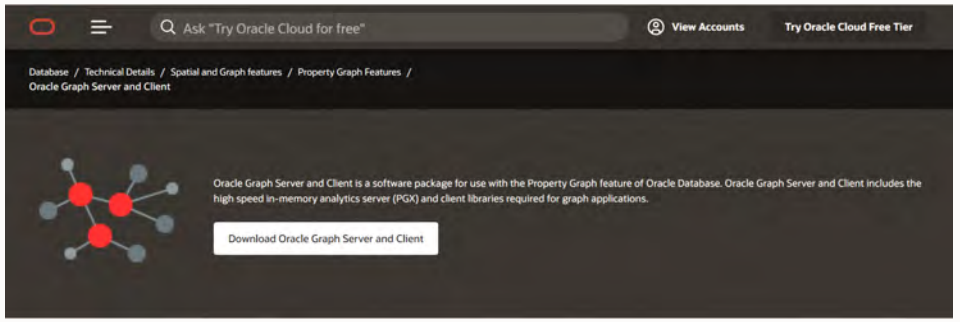
ASK TOM

- Welcome (back) to our AskTOM Graph Office Hours series!
  We're back with new product updates, use cases, demos and technical tips
  https://asktom.oracle.com/pls/apex/asktom.search?oh=3084
- Sessions will be held about once a month
- **Subscribe** at the page above for updates on upcoming session topics & dates
  And submit feedback, questions, topic requests, and view past session recordings
- Note: **Spatial** now has a new Office Hours series for location analysis & mapping features in Oracle Database:
  https://asktom.oracle.com/pls/apex/asktom.search?oh=7761



Helpful Links

Search for ‘Oracle Graph Server and Client’ to download from oracle.com



- Graphs at Oracle
  https://www.oracle.com/goto/graph
- Oracle Property Graph
  http://www.oracle.com/goto/propertygraph
- Blog: Examples, Tips and Tricks
  http://bit.ly/OracleGraphBlog
- AskTOM Series: https://asktom.oracle.com/pls/apex/asktom.search?office=3084
- Social Media
  - Twitter: @OracleBigData, @SpatialHannes, @Jeanlhm, @ryotaymnk
  - LinkedIn: Oracle Spatial and Graph Group
  - YouTube: youtube.com/c/OracleSpatialandGraph

The Spatial & Graph User Community

- A part of Analytics and Data Oracle User Community (formally BIWA)
- Vibrant community of tech enthusiasts including customers, partners, students
- We share knowledge online, and at conferences and events
- Global – Americas, Europe, Africa, Asia

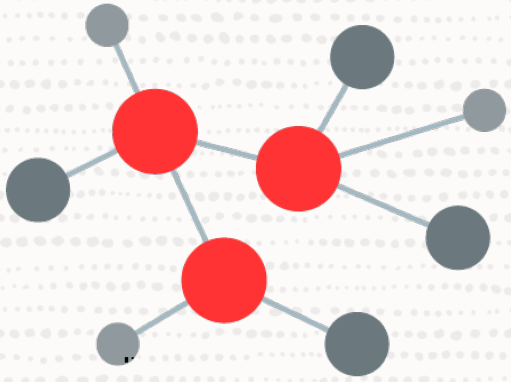
LinkedIn Oracle Spatial and Graph group
linkedin.com/groups/1848520/

@oraspatialsig

oraclespatialsig@gmail.com

AskTOM Office Hours: Graph Database and Analytics

- Today's session will be repeated for EMEA/Americas on May 28 (17:00 Central Europe | 11:00 New York | 08:00 San Francisco)
- Next session - save the date:
  - **Topic:** Building Recommendation Systems with Graphs
  - **Date:** Likely June 25th -- *Check back at landing page for details*
- Recording of today's session will be available at the landing page
- **Subscribe** for updates on upcoming session topics & dates
- Submit feedback, questions, topic requests, and view past session recordings https://asktom.oracle.com/pls/apex/asktom.search?oh=3084



Thanks for attending! See you next time.

https://asktom.oracle.com/pls/apex/asktom.search?oh=3084