ORACLE

Machine Learning with Oracle Graph

Natwest Developer Session

March 2021

Safe harbor statement

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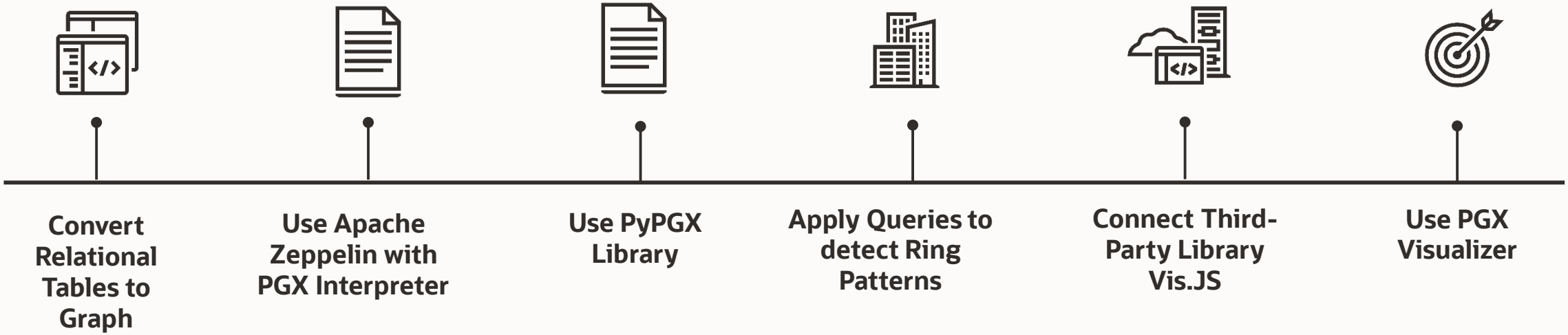
Developer Journey Map



Oracle Environment

Users	Jupyter URL	Zeppelin URL
Workshop001 to workshop020	https://bdabastion.sceceps.com/wsXXX	https://bdabastion.sceceps.com/zp1/
Workshop021 to workshop040	https://bdabastion.sceceps.com/wsXXX	https://bdabastion.sceceps.com/zp2/
Workshop041 to workshop060	https://bdabastion.sceceps.com/wsXXX	https://bdabastion.sceceps.com/zp3/
Workshop061 to workshop080	https://bdabastion.sceceps.com/wsXXX	https://bdabastion.sceceps.com/zp4/
Workshop081 to workshop100	https://bdabastion.sceceps.com/wsXXX	https://bdabastion.sceceps.com/zp5/

pwd: welcome1

Environment to download Documentation / Scripts

GitHub Repository: https://github.com/operard/mlgraph

Documentation for Natwest workshop: https://github.com/operard/mlgraph/tree/main/doc

Documentation of Oracle Graph:

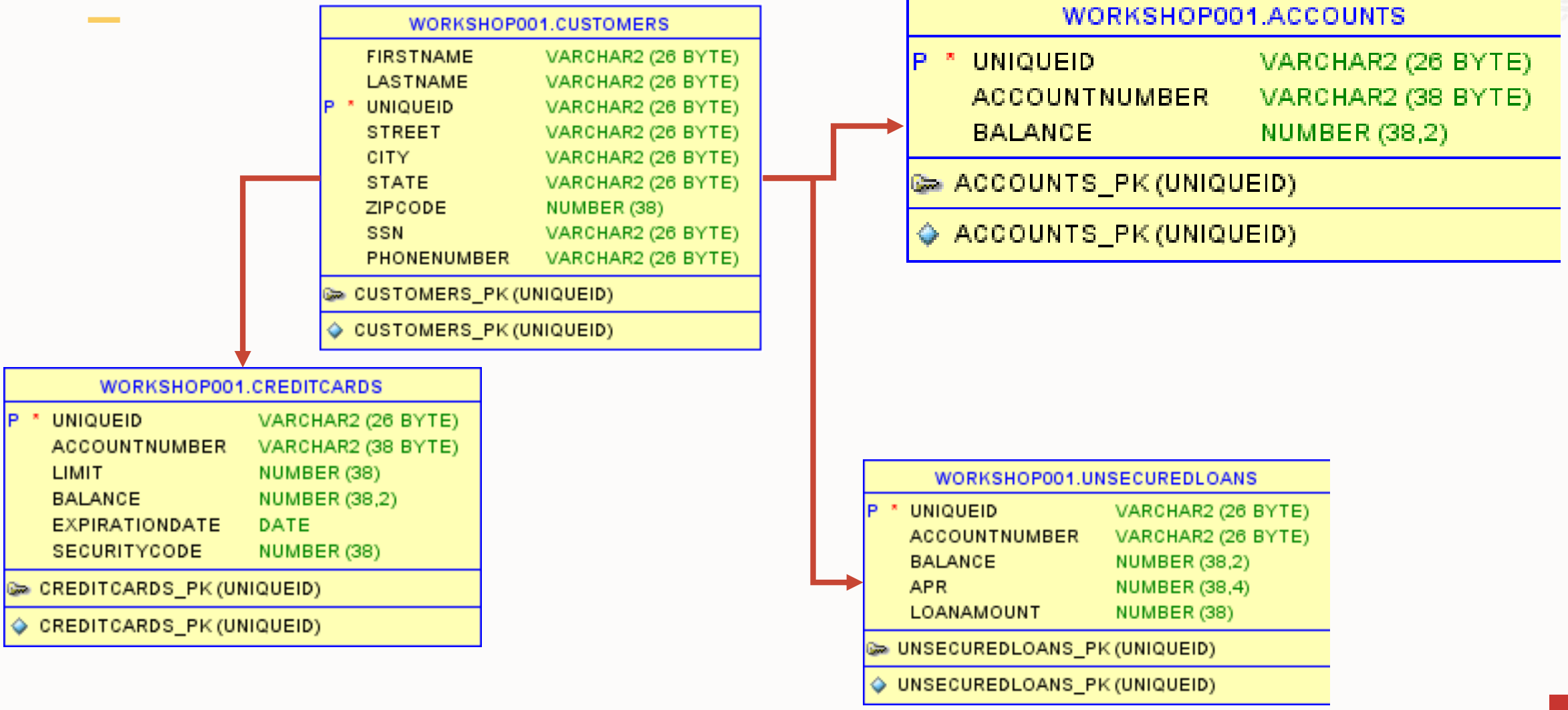
https://docs.oracle.com/cd/E56133_01/latest/prog-guides/index.html

https://pgql-lang.org/

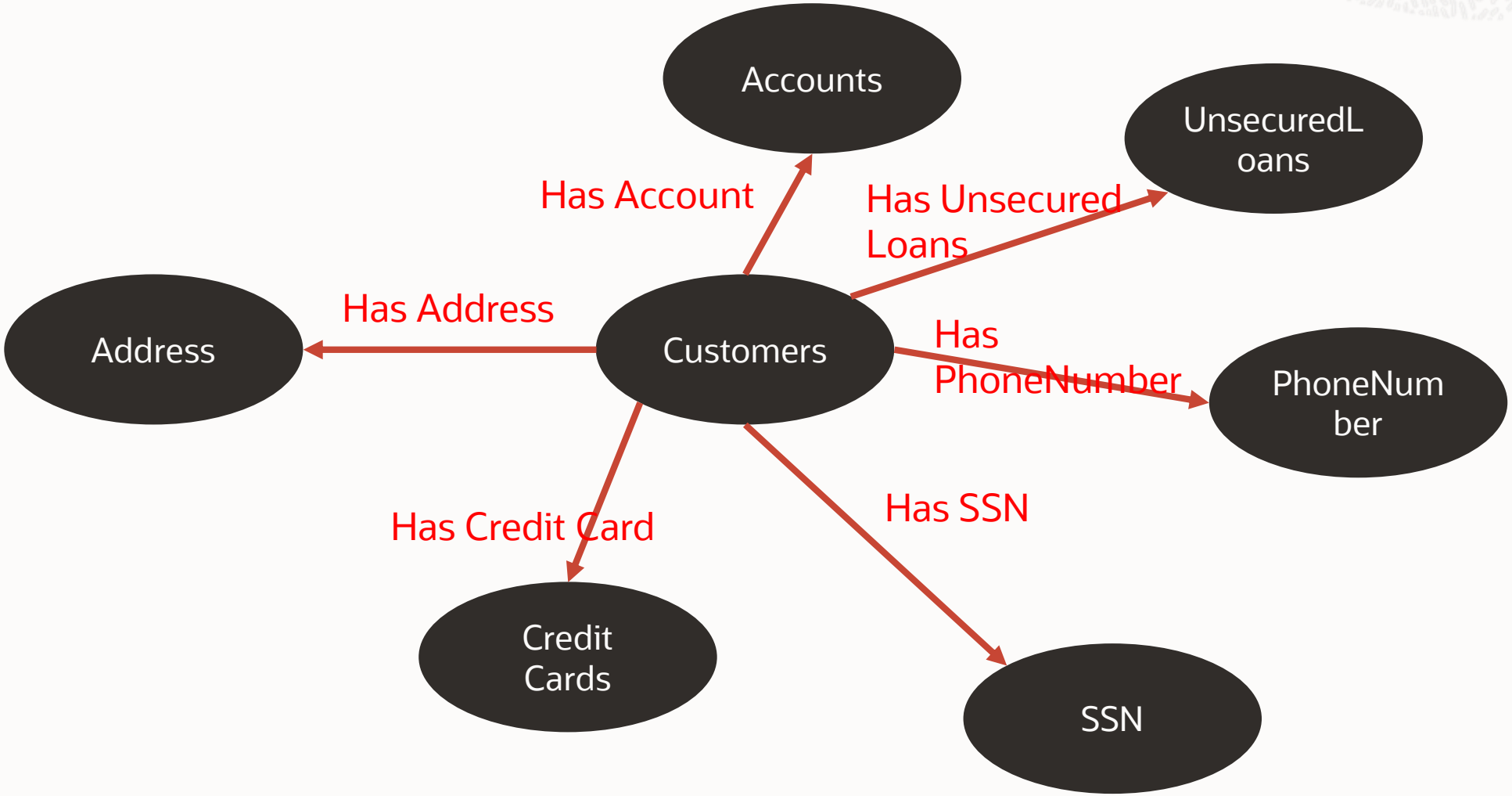
https://github.com/oracle/pgql-lang

STEP1: Convert from Relational Data Model to Property Graph Data Model

Bank Relational Data Model



Transform to Property Graph Data Model



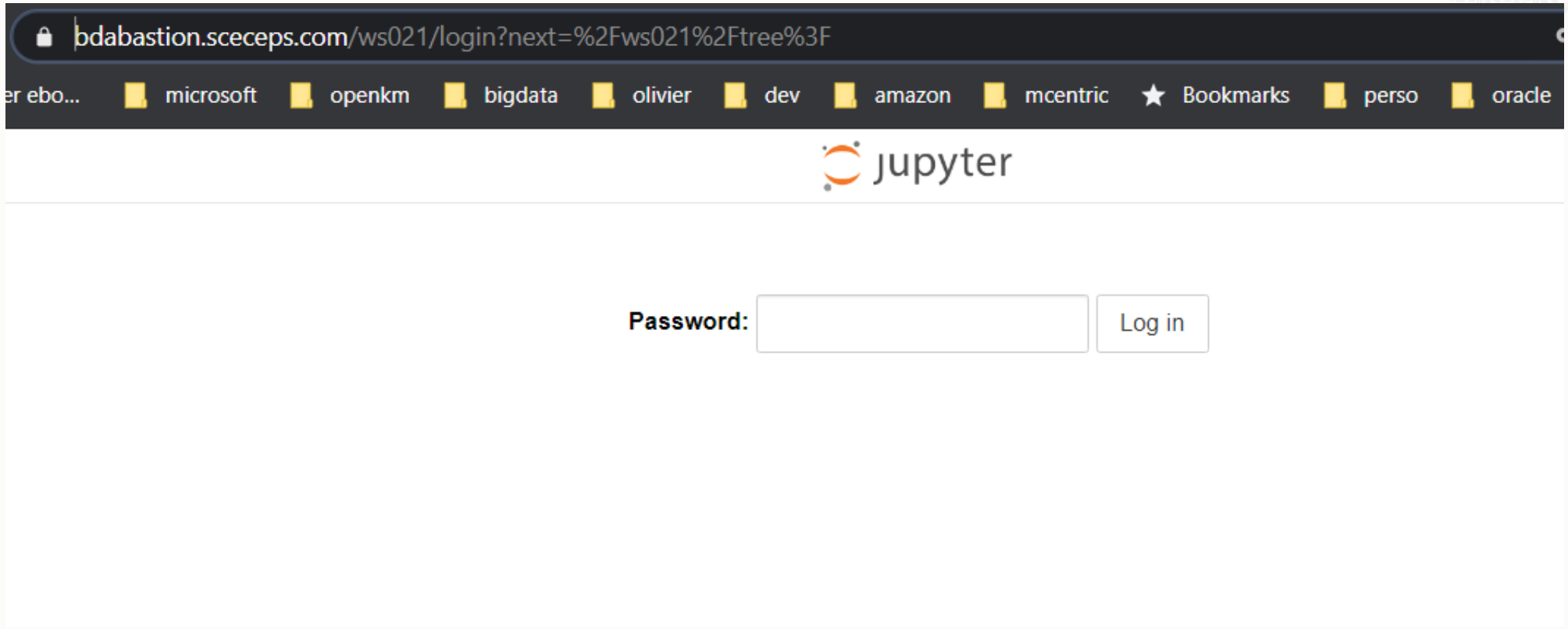
How to Convert with Oracle Graph

```
CREATE PROPERTY GRAPH bank
 VERTEX TABLES (
   ACCOUNTS KEY(UNIQUEID) PROPERTIES ALL COLUMNS,
   CUSTOMERS as CUST KEY(UNIQUEID) PROPERTIES (FIRSTNAME,LASTNAME),
   ADDRESS KEY(STREET,CITY,STATE,ZIPCODE) PROPERTIES (STREET,CITY,STATE,ZIPCODE),
   PHONENUMBERS KEY(PHONENUMBER) PROPERTIES (PHONENUMBER),
   SSN KEY(SSN) PROPERTIES ALL COLUMNS,
   CREDITCARDS KEY(UNIQUEID) PROPERTIES ALL COLUMNS,
   UNSECUREDLOANS KEY(UNIQUEID) PROPERTIES ALL COLUMNS
 )
 EDGE TABLES (
```

How to Convert with Oracle Graph

```
EDGE TABLES (
  ACCOUNTS SOURCE KEY(UNIQUEID) REFERENCES CUST  DESTINATION KEY(UNIQUEID)
REFERENCES ACCOUNTS LABEL HAS_BANKACCOUNT,
  CUST_ADDRESS SOURCE KEY(UNIQUEID) REFERENCES CUST DESTINATION
KEY(STREET,CITY,STATE,ZIPCODE) REFERENCES ADDRESS    LABEL HAS_ADDRESS,
  CUST_PHONENUMBERS SOURCE KEY(UNIQUEID) REFERENCES CUST DESTINATION
KEY(PHONENUMBER) REFERENCES PHONENUMBERS
    LABEL HAS_PHONENUMBER,
  CUST_SSN SOURCE KEY(UNIQUEID) REFERENCES CUST DESTINATION KEY(SSN) REFERENCES SSN
    LABEL HAS_SSN,
  CREDITCARDS SOURCE KEY(UNIQUEID) REFERENCES CUST DESTINATION KEY(UNIQUEID)
REFERENCES CREDITCARDS
    LABEL HAS_CREDITCARDS,
  UNSECUREDLOANS SOURCE KEY(UNIQUEID) REFERENCES CUST DESTINATION KEY(UNIQUEID)
REFERENCES UNSECUREDLOANS
    LABEL HAS_UNSECUREDLOANS
);
```

Connect to Jupyter from your browser



Open Terminal from Jupyter

Select NEW / Terminal

Terminal Access for your user “workshopXXX”

Check Relational Tables in your database

Use the tool SQLCL:

https://www.oracle.com/es/database/technologies/appdev/sqlcl.html

https://docs.oracle.com/en/database/oracle/sql-developer-command-line/19.2/sqcug/working-sqlcl.html#GUID-1343FA2B-BDB4-4645-B4D4-CD7C3E200AC9

Property Graph embedded in SQLCL:

https://docs.oracle.com/en/database/oracle/sql-developer-command-line/20.2/sqcug/using-pgql-plug-sqlcl.html#GUID-E0EFA43F-003F-4C8C-8056-54E9A428B8B7

Check Relational Tables in your database

jupyter

Logout

```
[workshop021@graph02 ~]$ ls
bank.json  jupyter.pid  launchpy.sh  nohup.log  nohup.out
[workshop021@graph02 ~]$ /opt/sqlcl/bin/sql workshop021/welcome1@orclpdb

SQLcl: Release 20.4 Production on Mon Mar 22 05:57:15 2021

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Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.3.0.0.0


SQL> select table_name from user_tables;

       TABLE_NAME
__________________
ACCOUNTS
CREDITCARDS
CUSTOMERS
UNSECUREDLOANS

SQL>
```

Execute the PGQL Command to create the Property Graph Model

```
SQL> pgql auto on

PGQL Auto enabled for graph=[null], execute=[true], translate=[false]
PGQL> CREATE PROPERTY GRAPH bank  VERTEX TABLES (    ACCOUNTS KEY(UNIQUEID) PROPERTIES ALL COLUMNS,    CUSTOMERS as CUST KEY(U
NIQUEID) PROPERTIES (FIRSTNAME,LASTNAME),    ADDRESS KEY(STREET,CITY,STATE,ZIPCODE) PROPERTIES (STREET,CITY,STATE,ZIPCODE),
 PHONENUMBERS KEY(PHONENUMBER) PROPERTIES (PHONENUMBER),    SSN KEY(SSN) PROPERTIES ALL COLUMNS,    CREDITCARDS KEY(UNIQUEID)
PROPERTIES ALL COLUMNS,    UNSECUREDLOANS KEY(UNIQUEID) PROPERTIES ALL COLUMNS  )  EDGE TABLES (   ACCOUNTS     SOURCE KEY(UNI
QUEID) REFERENCES CUST     DESTINATION KEY(UNIQUEID) REFERENCES ACCOUNTS     LABEL HAS_BANKACCOUNT,   CUST_ADDRESS    SOURCE K
EY(UNIQUEID) REFERENCES CUST     DESTINATION KEY(STREET,CITY,STATE,ZIPCODE) REFERENCES ADDRESS     LABEL HAS_ADDRESS,   CUST_P
HONENUMBERS    SOURCE KEY(UNIQUEID) REFERENCES CUST     DESTINATION KEY(PHONENUMBER) REFERENCES PHONENUMBERS     LABEL HAS_PHO
NENUMBER,   CUST_SSN    SOURCE KEY(UNIQUEID) REFERENCES CUST     DESTINATION KEY(SSN) REFERENCES SSN     LABEL HAS_SSN,   CRED
ITCARDS    SOURCE KEY(UNIQUEID) REFERENCES CUST     DESTINATION KEY(UNIQUEID) REFERENCES CREDITCARDS     LABEL HAS_CREDITCARDS
,   UNSECUREDLOANS    SOURCE KEY(UNIQUEID) REFERENCES CUST     DESTINATION KEY(UNIQUEID) REFERENCES UNSECUREDLOANS     LABEL H
AS_UNSECUREDLOANS  );

Graph created

PGQL>
```

Check Tables created with SQL commands

```
PGQL> pgql auto off

PGQL Auto disabled
SQL> select table_name from user_tables;

       TABLE_NAME
__________________
ACCOUNTS
BANKGE$
BANKGT$
BANKIT$
BANKSS$
BANKVD$
BANKVT$
CREDITCARDS
CUSTOMERS
UNSECUREDLOANS

10 rows selected.
```

Other commands to test PGQL

- Change XXX in the next command for your workshop user:

- You can delete the Graph Data Model using the next commands:

/opt/sqlcl/bin/sql workshopXXX/welcome1@orclpdb

PGQL AUTO ON
DROP PROPERTY GRAPH BANK;

- Execute the BANK Property Graph from command line:

/opt/sqlcl/bin/sql workshopXXX/welcome1@orclpdb @pgbank_create.sql

STEP2: Use Open Source Apache Zeppelin with PGX Interpreter and Groovy.

Oracle Environment

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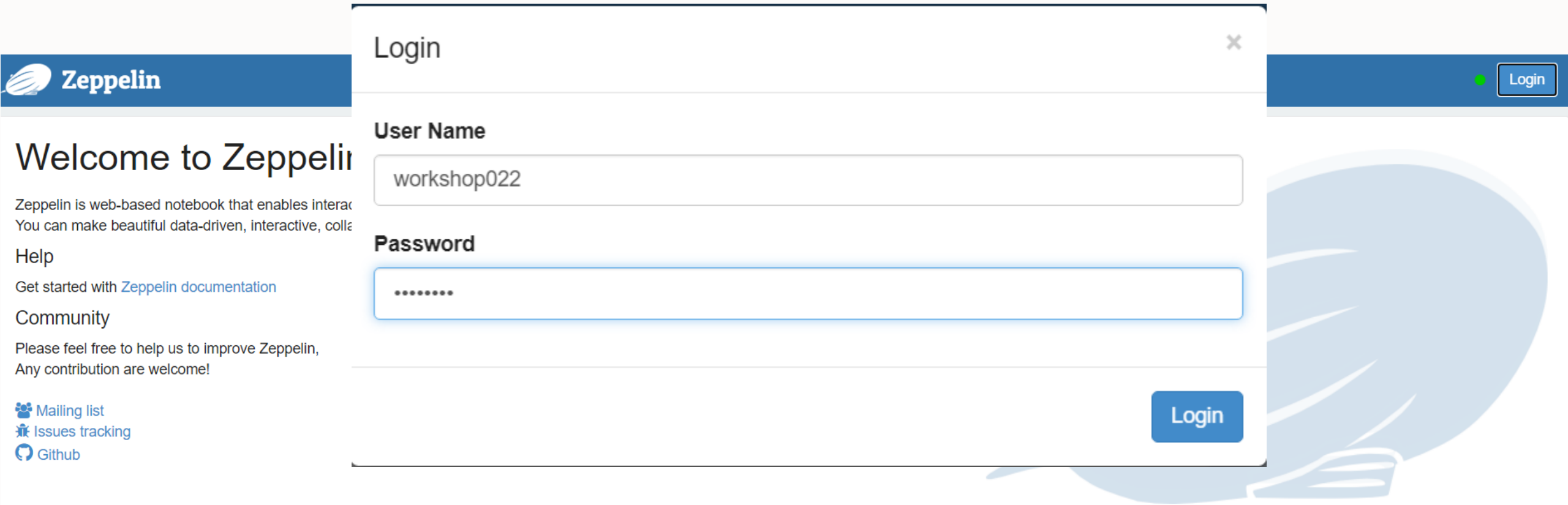
Workshop021 to workshop040	https://bdabastion.sceceps.com/wsXXX	https://bdabastion.sceceps.com/zp2/
Workshop041 to workshop060	https://bdabastion.sceceps.com/wsXXX	https://bdabastion.sceceps.com/zp3/
Workshop061 to workshop080	https://bdabastion.sceceps.com/wsXXX	https://bdabastion.sceceps.com/zp4/
Workshop081 to workshop100	https://bdabastion.sceceps.com/wsXXX	https://bdabastion.sceceps.com/zp5/

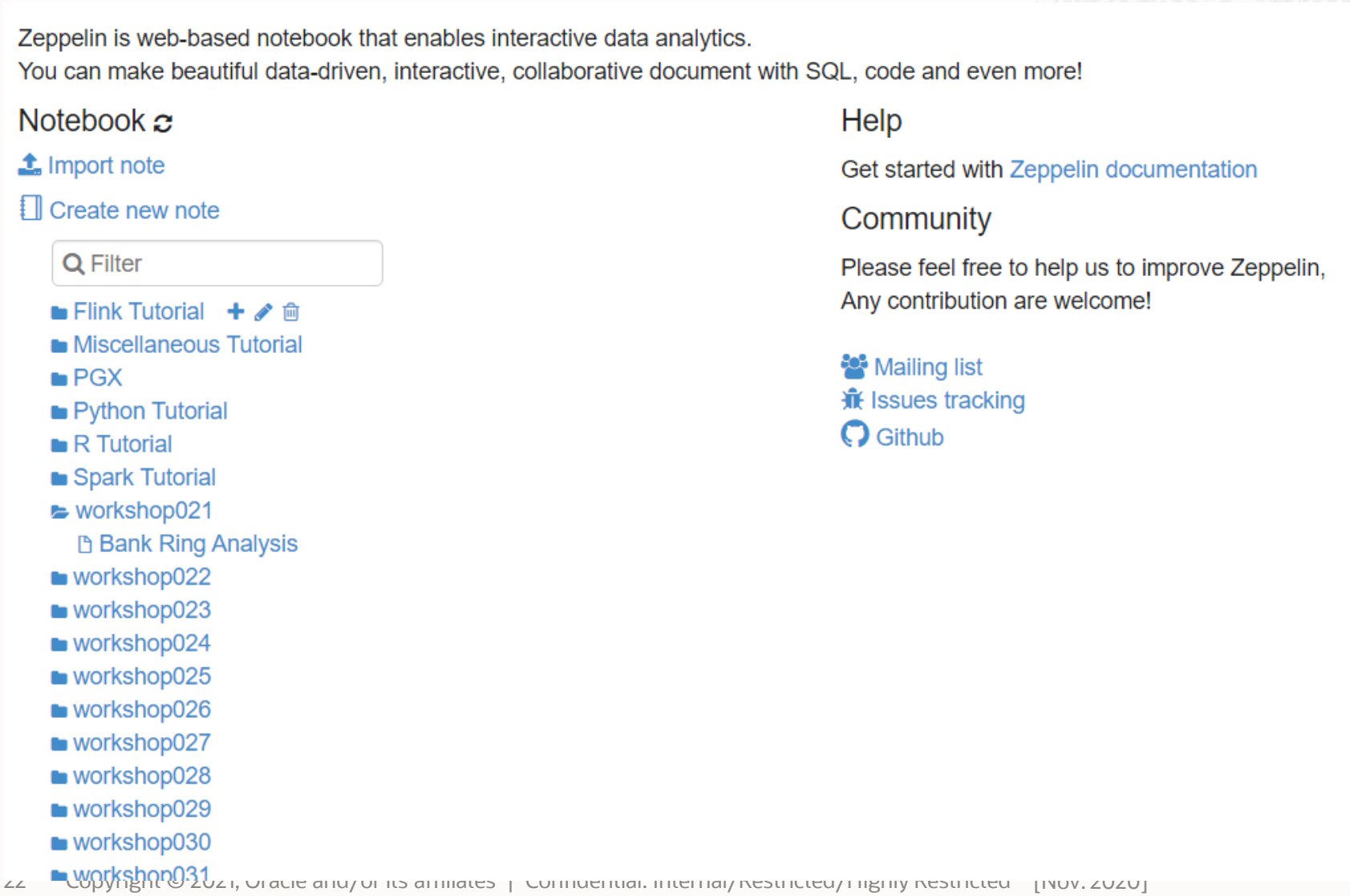
pwd: welcome1

Access to Apache Zeppelin Open Source

Click on “login” button and Use your user “workshopXXX”



Select the notebook in the Folder for your user “workshopXXX”



Execute each paragraph Step By Step

Bank Ring Analysis

Head

default

Connect to PGX

FINISHED

```
%pgx
import oracle.pgx.api.*
import groovy.json.*

baseUrl = 'https://localhost:7007'
username = 'workshop001'
password = 'welcome1'

conn = new URL("$baseUrl/auth/token").openConnection()
conn.setRequestProperty('Content-Type', 'application/json')
token = conn.with {
  doOutput = true
  requestMethod = 'POST'
  outputStream.withWriter { writer ->
    writer << JsonOutput.toJson([username: username, password: password])
  }
  return new JsonSlurper().parseText(content.text).access_token
}

instance = Pgx.getInstance(baseUrl, token)
```

```
PgxSession[ID=a4877fd4-2462-4d04-a72e-682291db62b1,source=zephr-session]
```

Took 7 sec. Last updated by oracle at March 22 2021, 11:56:22 AM. (outdated)

Database credentials

FINISHED

```
%pgx

jdbcUrl = "jdbc:oracle:thin:@localhost:1521/orclpdb"
user = "workshop001"
pass = "welcome1"
```

Step by Step

Bank Ring Analysis

Head

default

```
%pgx

import oracle.pgx.common.types.*

builder.setUsername(user);
builder.setPassword(pass);
// Read the Graph Name created previously
builder.setName("bank");
builder.addVertexProperty("FIRSTNAME", PropertyType.STRING);
builder.addVertexProperty("LASTNAME", PropertyType.STRING);
builder.addVertexProperty("UNIQUEID", PropertyType.STRING);
builder.addVertexProperty("SSN", PropertyType.STRING);
builder.addVertexProperty("PHONENUMBER", PropertyType.STRING);
builder.addVertexProperty("BALANCE", PropertyType.DOUBLE);
builder.addVertexProperty("APR", PropertyType.DOUBLE);
builder.addVertexProperty("LOANAMOUNT", PropertyType.DOUBLE);
builder.addVertexProperty("STREET", PropertyType.STRING);
builder.addVertexProperty("STATE", PropertyType.STRING);
builder.addVertexProperty("ZIPCODE", PropertyType.STRING);
builder.addVertexProperty("CITY", PropertyType.STRING);
builder.addVertexProperty("ACCOUNTNUMBER", PropertyType.STRING);
builder.addVertexProperty("LIMIT", PropertyType.DOUBLE);
builder.addVertexProperty("SECURITYCODE", PropertyType.STRING);
builder.addVertexProperty("EXPIRATIONDATE", PropertyType.TIMESTAMP);

builder.setLoadVertexLabels(true);
builder.setLoadEdgeLabel(true);
builder.setKeystoreAlias("alias");
```

FINISHED

This name is the table name used in CREATE PROPERTY GRAPH xxxx

```
oracle.pgx.config.PgRdbmsGraphConfigBuilder@3991c5fa
```

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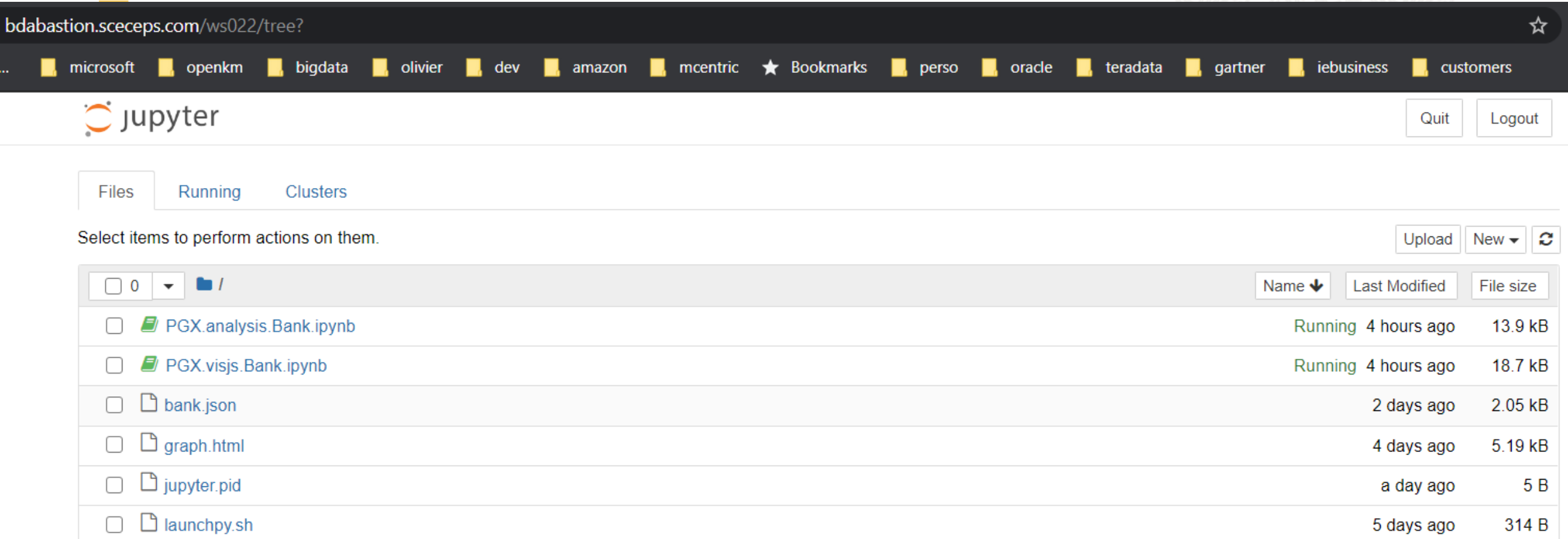
STEP3: Use Python to access to Oracle Graph “PyPGX”.

Connect to https://bdabastion.sceceps.com/wsXXX



Select the notebook “PGX.analysis.bank.ipynb”

jupyter PGX.analysis.Bank Last Checkpoint: 4 hours ago (autosaved)

Logout

File Edit View Insert Cell Kernel Help

Trusted Python 3

Run Markdown

Ring Algorithm using PGX ¶

First Step: Get a session in PGX server.

In [1]:

```
import json
import ssl

ssl._create_default_https_context = ssl._create_unverified_context

def generateToken(base_url, username, password):
    from urllib.request import Request, urlopen
    from urllib.error import HTTPError

    body = json.dumps({ 'username': username, 'password': password }).encode('utf8')
    headers = { 'content-type': 'application/json' }
    request = Request(base_url + '/auth/token', data=body, headers=headers)

    try:
        response = urlopen(request).read().decode('utf-8')
        return json.loads(response).get('access_token')

    except HTTPError as err:

        if err.code == 400:
            print('Authentication failed no username/password given')
        elif err.code == 401:
```

Step by Step in the notebook “PGX.analysis.bank.ipynb”

In [4]:
```
print(session)
```

```
PgxSession(id: 1a5cadf9-2b36-4729-a6d2-4e10f412e6b1, name: pypgx)
```

Load JSON File with Property Graph Definition

In [6]:
```
# read Graph
graph = session.read_graph_with_properties("./bank.json")
```

Bank.json Definition

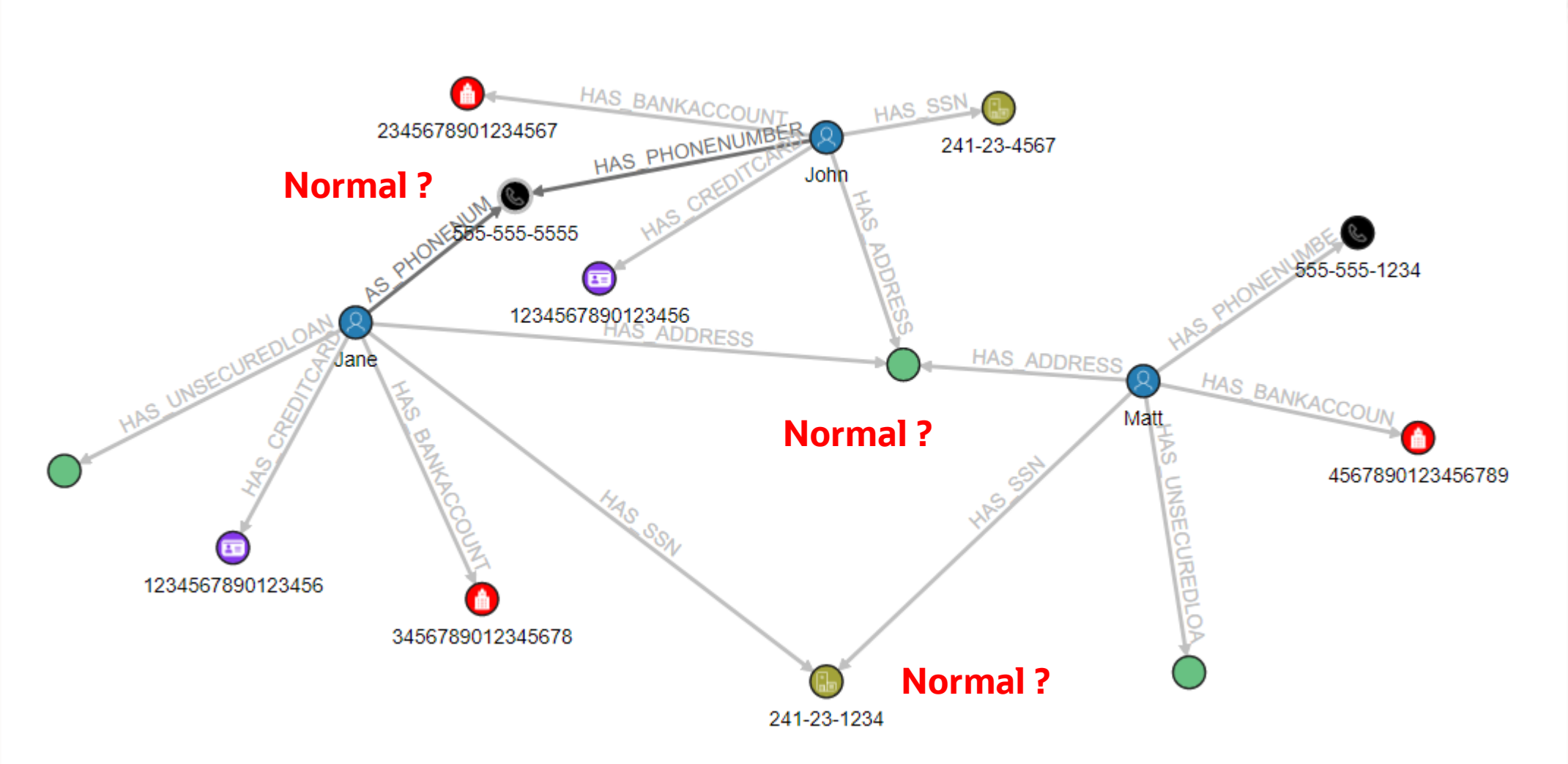

```
{
   "db_engine": "RDBMS",
   "vertex_id_type": "long",
   "error_handling": {},
   "name": "bank",
   "vertex_props": [
      {
         "dimension": 0,
         "name": "FIRSTNAME",
         "type": "string"
      },
      {
         "dimension": 0,
         "name": "LASTNAME",
         "type": "string"
      },
{
   "dimension": 0,
   "name": "UNIQUEID",
   "type": "string"
},
{
   "dimension": 0,
   "name": "SSN",
   "type": "string"
},
{
   "dimension": 0,
   "name": "PHONENUMBER",
   "type": "string"
},
{
   "dimension": 0,
   "name": "BALANCE",
   "type": "double"
},
.....etc.....
   ],
   "loading": {
      "load_vertex_labels": true,
      "load_edge_label": true
   },
   "edge_props": [],
   "attributes": {},
   "format": "pg"
}
```

Compare with Apache Zeppelin Definition

```
%pgx
import oracle.pgx.common.types.*
builder.setUsername(user);
builder.setPassword(pass);
// Read the Graph Name created previously
builder.setName("bank");
builder.addVertexProperty("FIRSTNAME", PropertyType.STRING);
builder.addVertexProperty("LASTNAME", PropertyType.STRING);
builder.addVertexProperty("UNIQUEID", PropertyType.STRING);
builder.addVertexProperty("SSN", PropertyType.STRING);
builder.addVertexProperty("PHONENUMBER", PropertyType.STRING);
builder.addVertexProperty("BALANCE", PropertyType.DOUBLE);
builder.addVertexProperty("APR", PropertyType.DOUBLE);

…..etc…..
```

STEP4: Apply Queries to detect Ring Patterns in the Graph Data Model.

Checking the Data with Graph Visualizer



Analysis in the different Vertex in order to check Ring Data Fraud (PyPGX)

Entity Link Analysis

Performing entity link analysis on the above Graph data model is demonstrated below. We use brackets in the below table is to isolate individual elements of a collection.

Find account who share more than one piece of legitimate contact

In [ ]:

```
pgxResultSetNode = graph.query_pgql("""
  select label(contact), listagg(acct.FIRSTNAME,','), count(*) as size
from match (acct)-[]->(contact)
where exists (
  SELECT count(*) as ringsize, contact
  from MATCH (account:CUST)-[]->(contact)
  group by contact
  having ringsize > 1
  order by ringsize desc
)
group by label(contact)
""")

for i in pgxResultSetNode:
    print (i)
```

Check the Financial Risk for posible Fraud Ring (PyPGX)

Determine the financial risk of a possible fraud ring

In [ ]:

```
pgxResultSetNode = graph.query_pgql("""
select label(contact), listagg(acct.FIRSTNAME,','),
        count(*) as size, round(sum(CASE
                                     WHEN label(r)='HAS_CREDITCARDS' THEN unsecuredAccount.LIMIT
                                     WHEN label(r)='HAS_UNSECUREDLOANS' THEN unsecuredAccount.BALANCE
                                     ELSE 0
                                    END)) as FINANCIALRISK
from match (acct)-[]->(contact),
     match (acct)-[r:HAS_CREDITCARDS|HAS_UNSECUREDLOANS]->(unsecuredAccount)
where exists (
  SELECT count(*) as ringsize, contact
  from MATCH (account:CUST)-[]->(contact)
  group by contact
  having ringsize > 1
  order by ringsize desc
)
group by label(contact)
""")

for i in pgxResultSetNode:
    print (i)
```

Analysis in the different Vertex in order to check Ring Data Fraud (Zeppelin)

This is another way to find the same list using a pattern.

FINISHED

Took 0 sec. Last updated by oracle at March 22 2021, 11:57:10 AM.

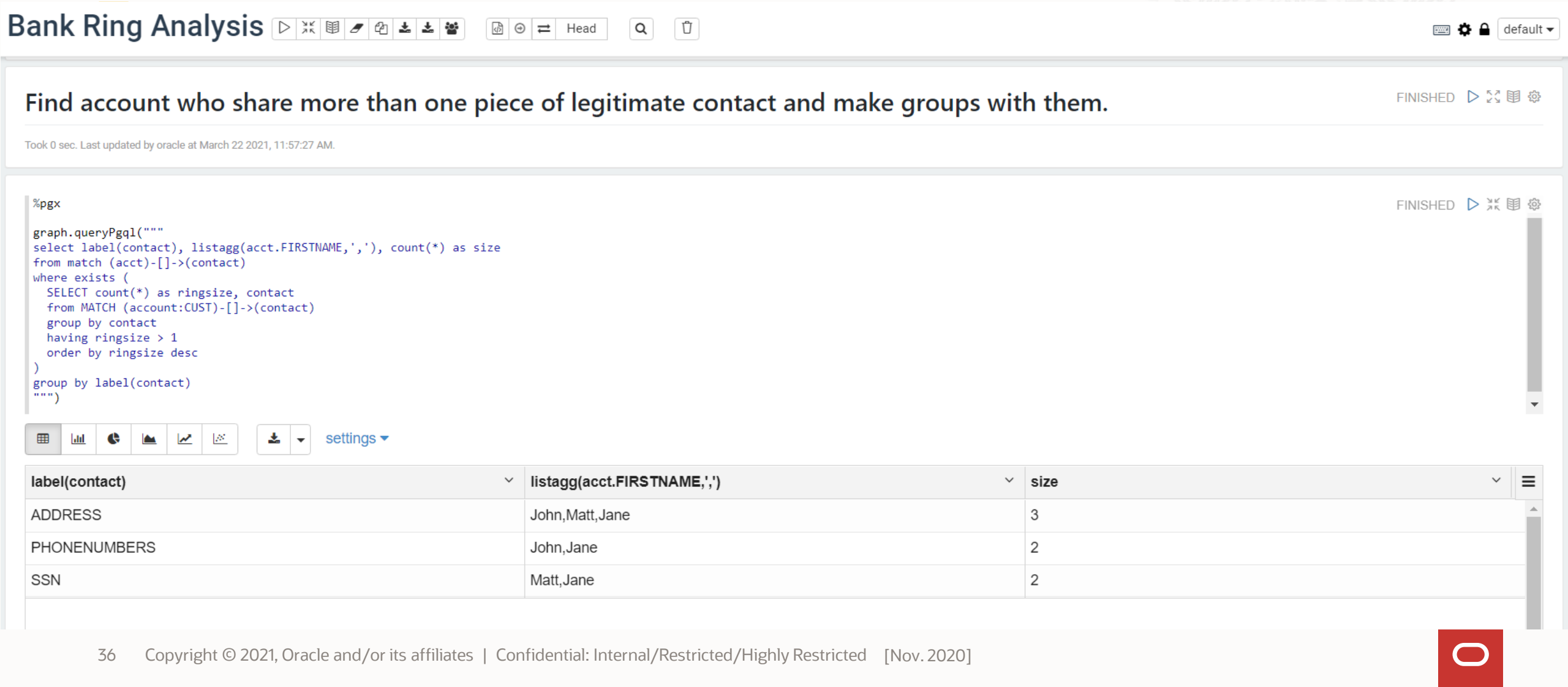
FINISHED

```
%pgx

graph.queryPgql("""
select label(contact), count(*) as ringsize
match (accta:CUST)-[e1]->(contact)<-[e2]-(acctb:CUST)
where accta != acctb
group by contact
having count(*) >1
""")
```

settings

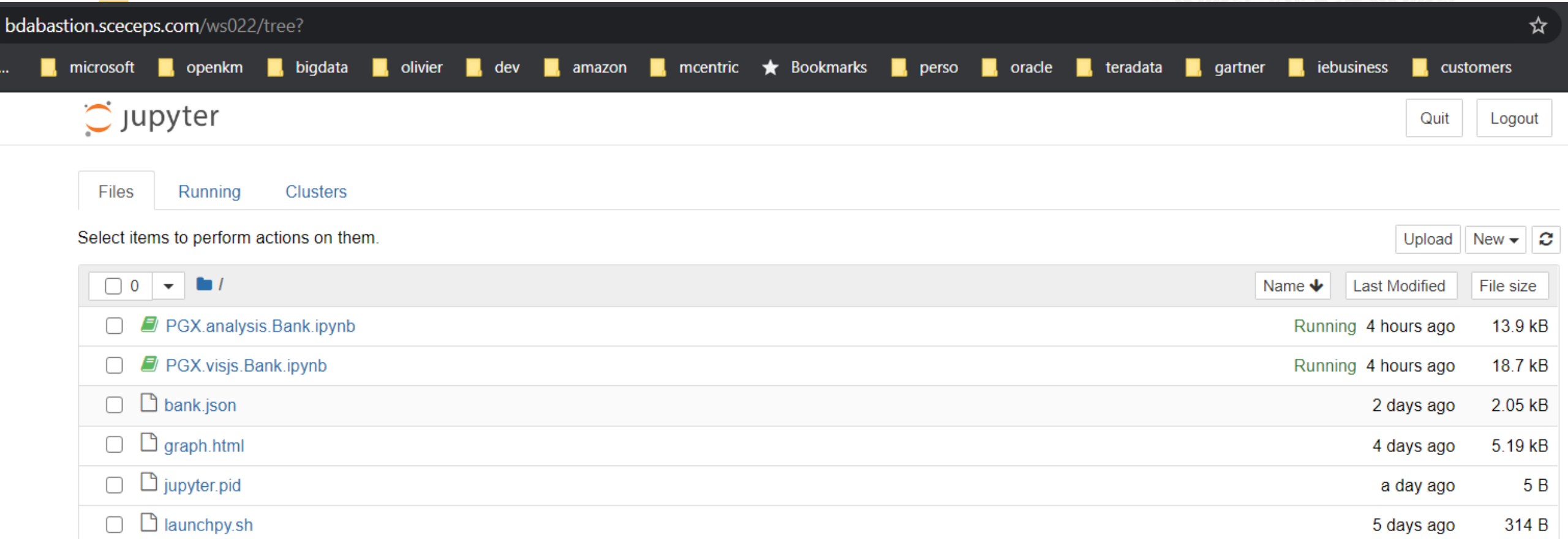
label(contact)	ringsize
PHONENUMBERS	2
SSN	2
ADDRESS	6

Check the Financial Risk for posible Fraud Ring (Zeppelin)



STEP5: Connect Third-Party Library Vis.JS from Python.

Connect to https://bdabastion.sceceps.com/wsXXX



Select the notebook “PGX.visjs.bank.ipynb”

Query to prepare Data for Vis.JS, Network and NetworkX (Python)

In [ ]:

```
# get result
# node data
pgxResultSetNode = graph.query_pgql("""
  SELECT id(x), label(x), x.FIRST_NAME, x.CITY
  MATCH (x)-[]-()
""")

#['size', 'value', 'title', 'x', 'y', 'label', 'color']

node_id = []
node_title =[]
node_value = []
node_label = []

for i in pgxResultSetNode:
    size = i[0]
    if size not in node_id:
        node_id.append(size)
        node_label.append(i[1])
        if i[2] != '':
           node_title.append(i[2])
           print('Node: size: ' + str(i[0]) + ' label: ' + i[1] + ' FIRST_NAME: ' + i[2])
        elif i[3] != '':
           node_title.append(i[3])
           print('Node: size: ' + str(i[0]) + ' label: ' + i[1] + ' CITY: ' + i[3])
        else:
           node_title.append('n/a')
           print('Node: size: ' + str(i[0]) + ' label: ' + i[1] + ' title: n/a')
```

Use Vis.JS Library (PYVIS Library in Python)

Open Source Vis.JS Visualization using Network Python Library

In [ ]:

```
from pyvis.network import Network

g = Network(notebook=True, height = '800px', width = '100%' , directed = True)
g.options = {
            "nodes": {
              "scaling": {
                "min": 16,
                "max": 32,
              },
            },
            "edges": {
              "color": "GRAY",
              "smooth": "false",
            },
            "physics": {
              "barnesHut": { "gravitationalConstant": -30000 },
              "stabilization": { "iterations": 2500 },
            }
}

g.add_nodes(node_id,label=node_label,title=node_title)
g.add_edges(edge_list)
#g.show_buttons()
g.show('graph.html')
```

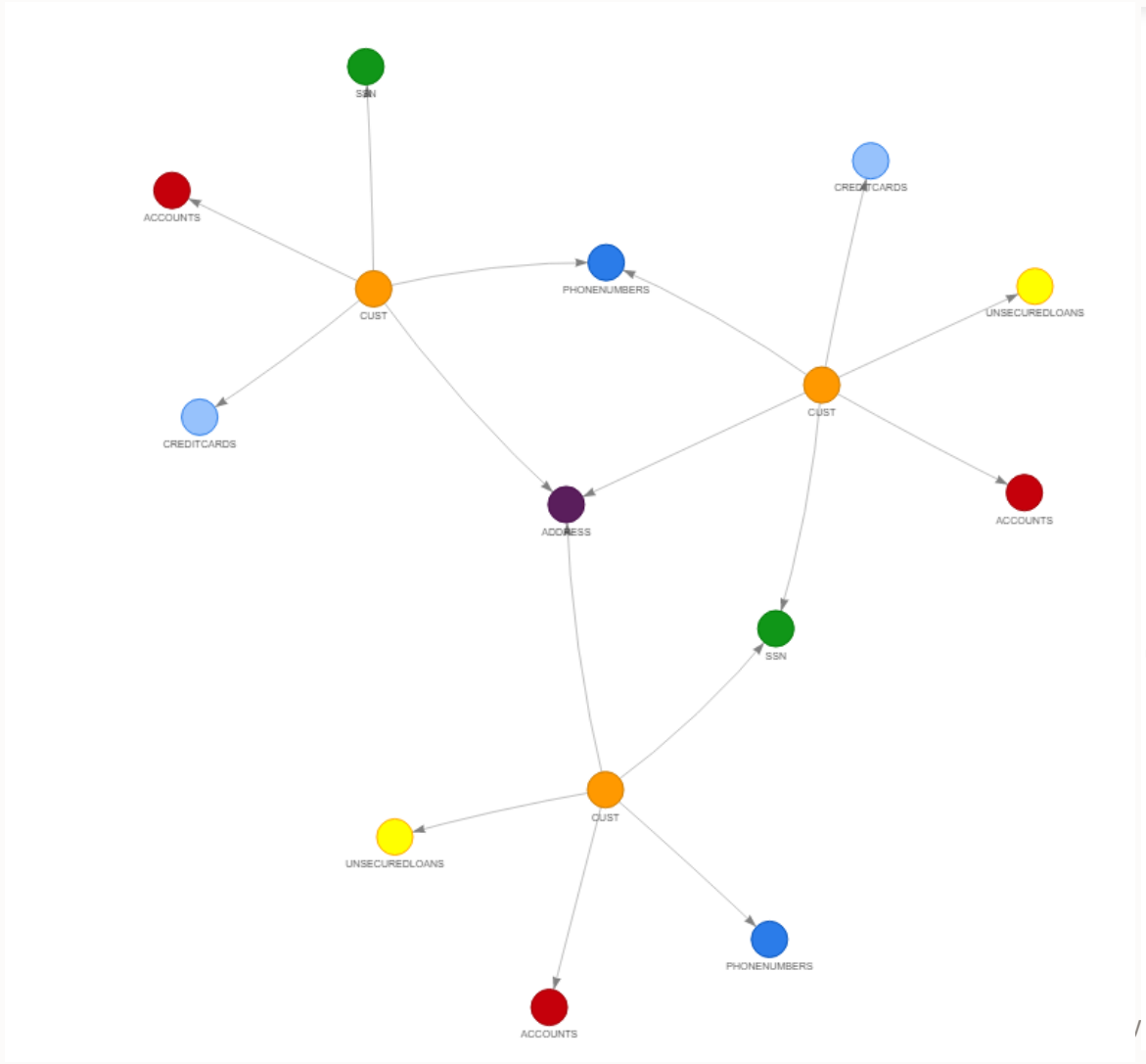
Use NetworkX with Vis.JS

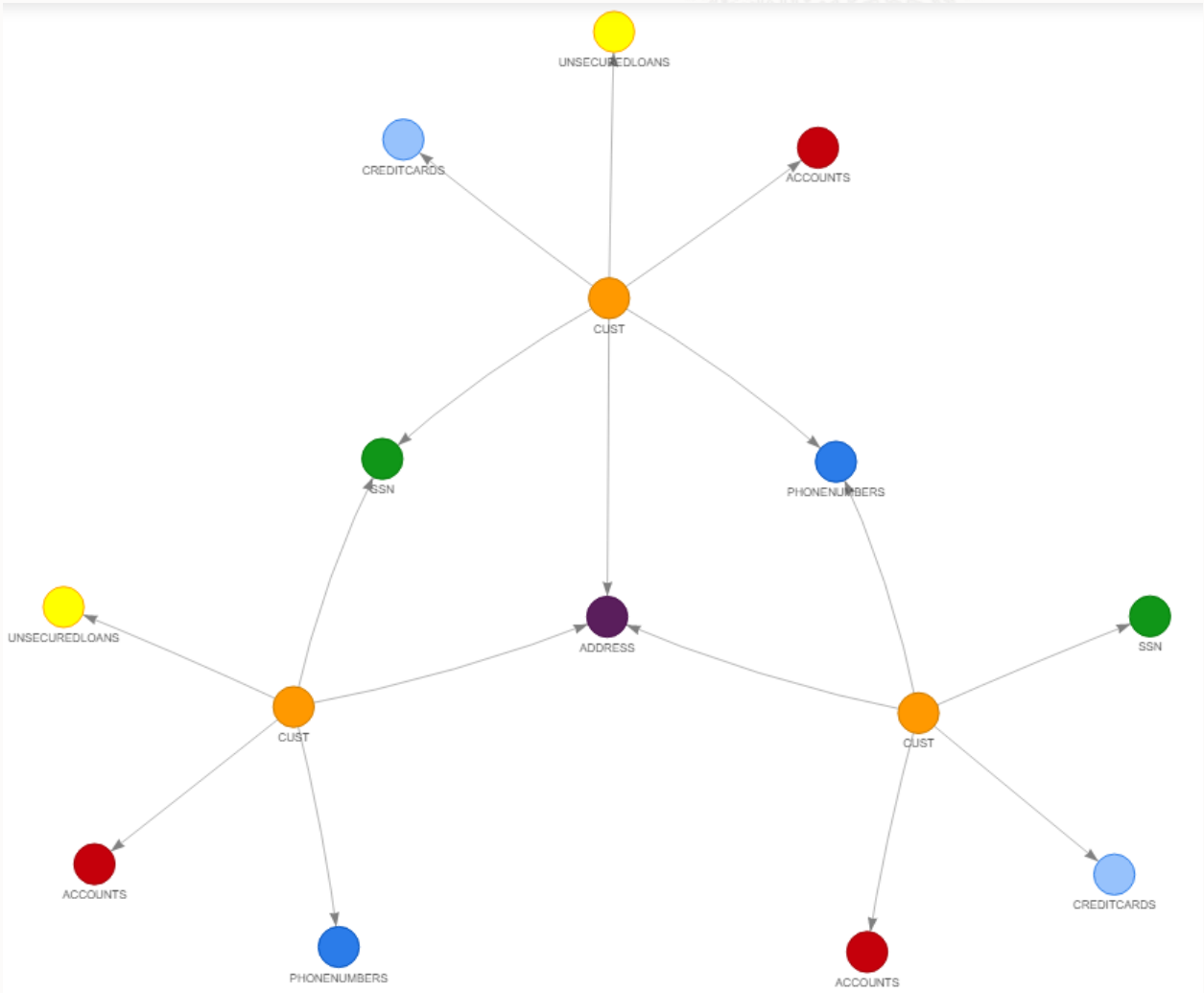
Another Vis.JS Visualization using NetworkX Python Library

In [ ]:

```
from pyvis.network import Network
import networkx as nx

nx_graph = nx.Graph()

pgxResultSetNode = graph.query_pgql("""
  SELECT id(x), label(x), x.FIRSTNAME, x.CITY
  MATCH (x)-[]-()
""")

for i in pgxResultSetNode:
    if i[2]:
      nx_graph.add_node(i[0], size=20, title=i[2], group=i[1])
    else:
      nx_graph.add_node(i[0], size=20, title=i[3], group=i[1])

# edge data
pgxResultSetEdge = graph.query_pgql("""
  SELECT id(x), id(y), label(e)
  MATCH (x)-[e]->(y)
""")

edge_list = []
for i in pgxResultSetEdge:
    nx_graph.add_edge(i[0], i[1], weight=5)

nt = Network(notebook=True, height = '800px', width = '100%')
# populates the nodes and edges data structures
nt.from_nx(nx_graph)
nt.show('nx.html')
```

Use NetworkX with Vis.JS





STEP6: Use PGX Visualizer.

Access to PGX Visualizer

https://bdabastion.sceceps.com/ui

User: bankuser

Pwd: welcome1

ORACLE

Graph Visualization

username

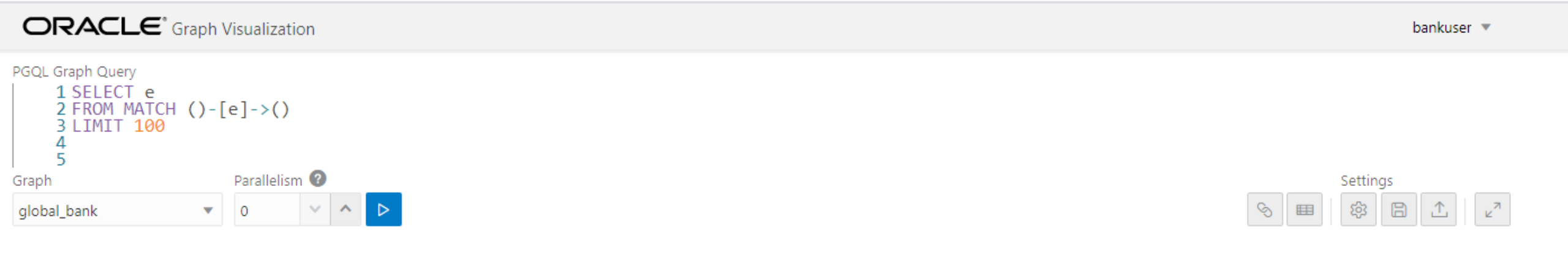
password

PGX Session ID (optional)

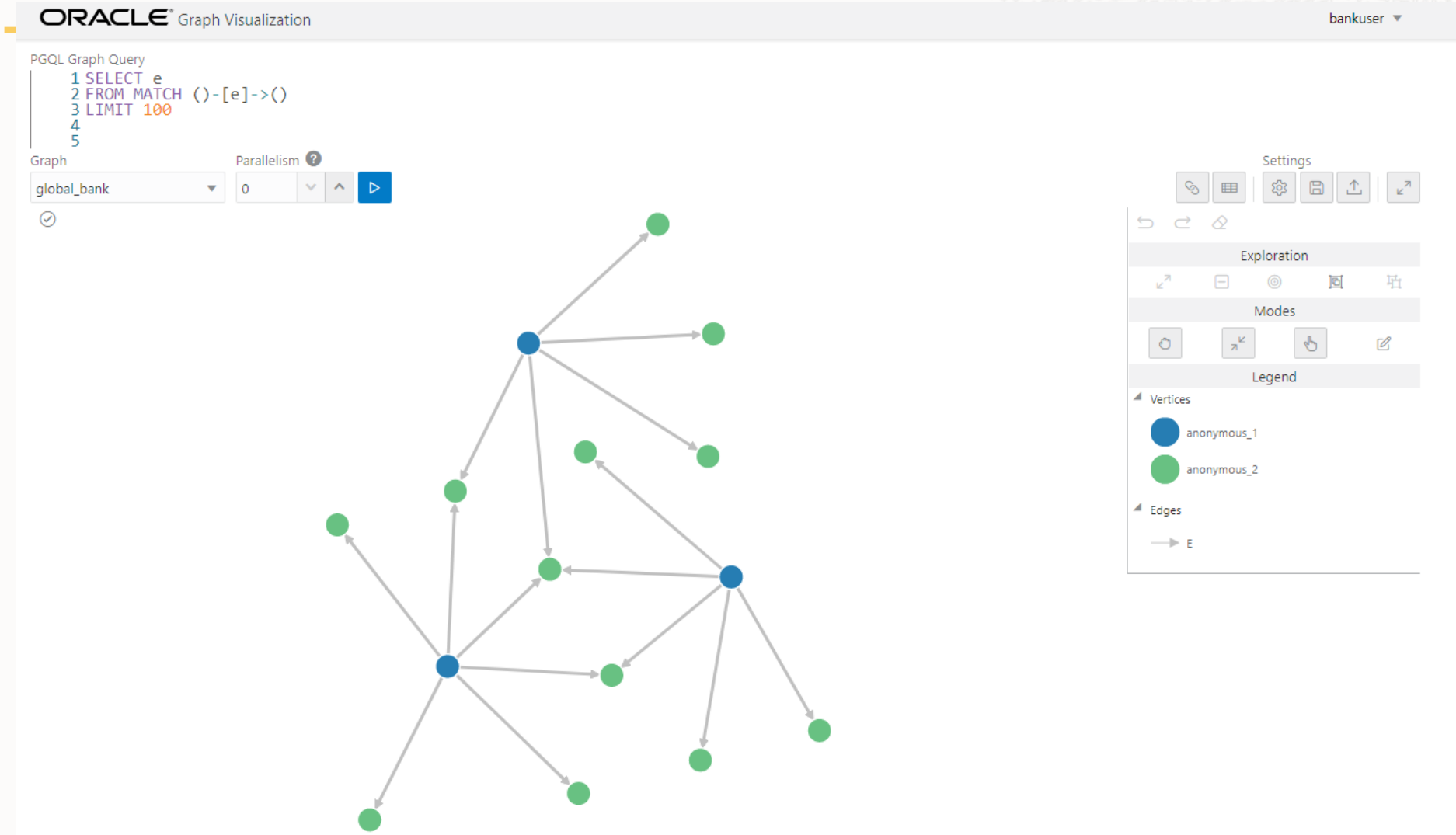
SUBMIT

PGX Visualizer

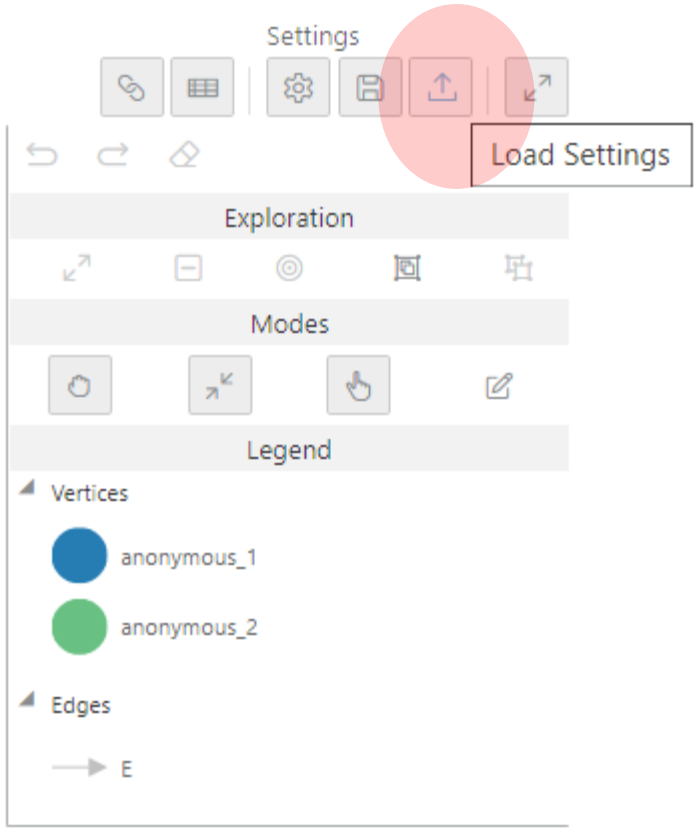
Choose the graph “global_bank”. Execute the query.



PGX Visualizer Result



Upload the JSON Configuration “bank_settings_20210315.json”



Download the JSON Configuration file:

https://github.com/operard/mlgraph/blob/main/graphviz/bank_settings_20210315.json.

Upload the JSON configuration “bank_settings_20210315.json”.

ORACLE Graph Visualization

bankuser

PGQL Graph Query

```
1 SELECT e
2 FROM MATCH ()-[e]->()
3 LIMIT 100
4
5
```

Graph: global_bank

Parallelism: 0

Settings

Exploration

Modes

Legend

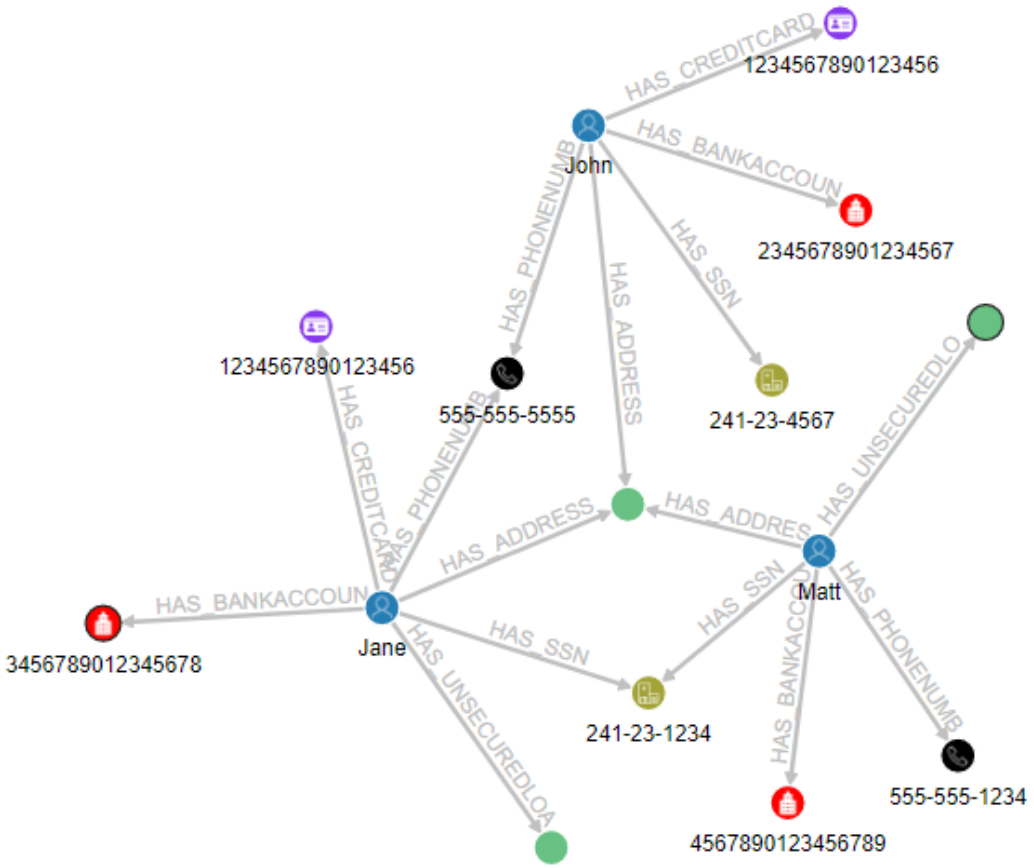
Vertices

anonymous_1

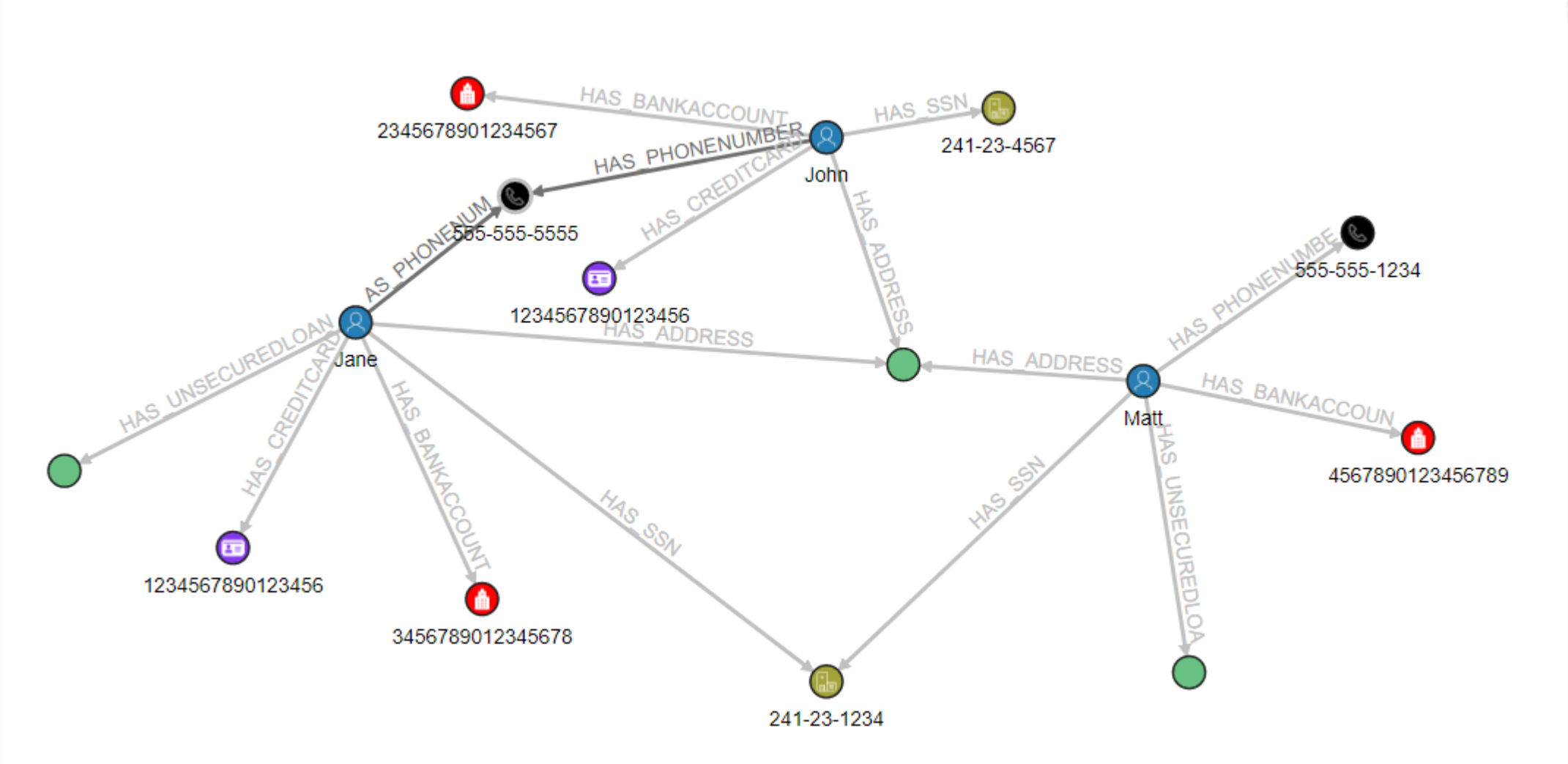
anonymous_2

Edges

E



Bank Property Graph UI



Thank You

DevRel Team

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