

Temporal Data Lineage and Impact Analysis in Oracle Database: Evolution to Oracle Graph Architecture



Part 1: Operational (SQL)
Property Graphs inside the
Oracle AI Database

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Oracle AI Database Product Management
Spatial & Graph Technologies

ORACLE

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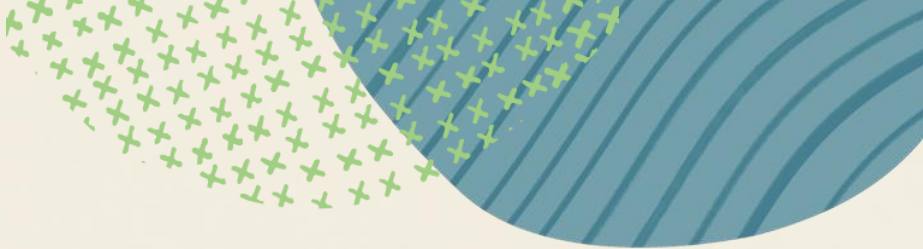
Part 2: Temporal Data Lineage
and Impact Analysis using Visual
Interactive Analysis

Tomislav Zarkovic

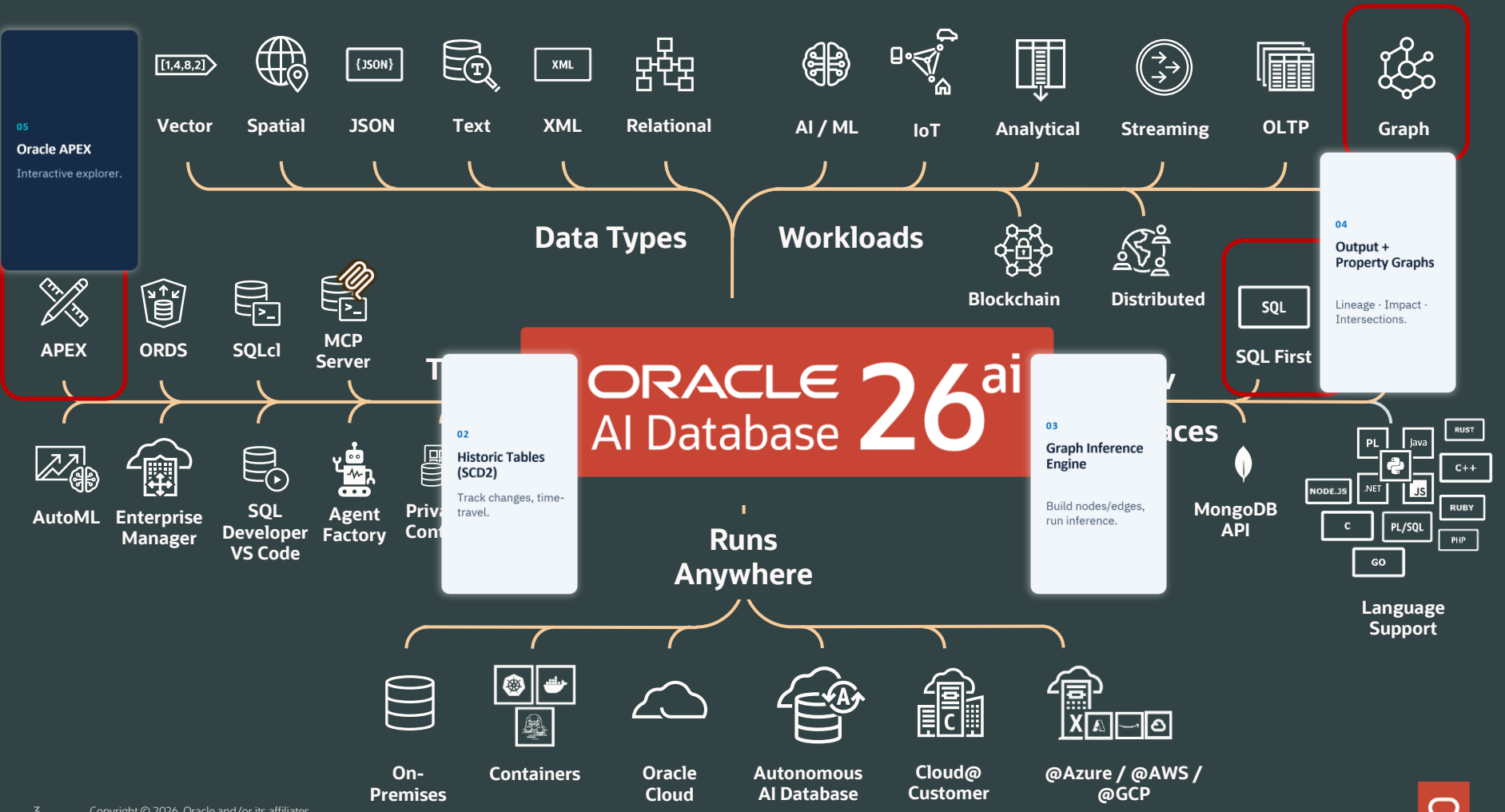
✉ tomislav.zarkovic@koios.hr

Business Intelligence & Data Analytics

koio2.



Part 1: The Oracle AI Database as a Graph Database - Defining and Analyzing Operational (SQL) Property Graphs



shop



Converged Database in Action 🖱️ LiveLabs Workshop

Build Financial Crime and Operations Intelligence on One Governed Oracle Data Platform

The screenshot displays the 'Investigation Query Explorer' interface. On the left, a sidebar contains navigation links: 'Welcome', 'Data Foundation', 'Risk & Operations Dashboard', 'Risk Monitor', 'Financial Crime Network Graph' (highlighted), 'Client Service & SLA Coverage Map', 'Transaction & Case Operations', 'OML Risk, Capacity & Revenue Forecasts', 'Ask Finance Data', and 'Finance Agent Console'. The 'Financial Crime Network Graph' section includes 'PROPERTY GRAPH' and 'SQL/PGQ' tabs. The main panel shows a query titled 'Money Mule Flow' with a description 'Identify high-risk accounts converging on a shared payee or cash'. Below the title, there are input fields for 'MINIMUM AMOUNT' (set to 2500) and a status bar indicating '7 rows returned' and '54 ms'. The SQL query is displayed in a central window, and the results are shown in a table at the bottom right.

Investigation Query Explorer
Run real SQL/PGQ queries against the FRAUD_NETWORK property graph

Oracle
Seer Bank LiveStack
Trace account suspicious

→ **Money Mule Flow**
Identify high-risk accounts converging on a shared payee or cash

MINIMUM AMOUNT
2500

7 rows returned | 54 ms

```
-- SQL/PGQ: Accounts converging on shared mule payees
SELECT source_account, mule_payee, related_account,
       source_amount, related_amount,
       source_risk, related_risk
FROM GRAPH_TABLE ( fraud_network
MATCH (src IS entity)
    -[e1 IS related_to]-> (payee IS entity)
    <-[e2 IS related_to]- (other IS entity)
WHERE src.entity_type = 'account'
    AND other.entity_type = 'account'
    AND src.entity_id < other.entity_id
    AND payee.entity_type = 'payee'
    AND e1.total_amount >= 2500
COLUMNS (
    src.entity_key AS source_account,
    payee.entity_key AS mule_payee,
    other.entity_key AS related_account,
    e1.total_amount AS source_amount,
    e2.total_amount AS related_amount,
    src.risk_score AS source_risk,
    other.risk_score AS related_risk
)
)
ORDER BY source_amount DESC, source_risk DESC
FETCH FIRST 25 ROWS ONLY;
```

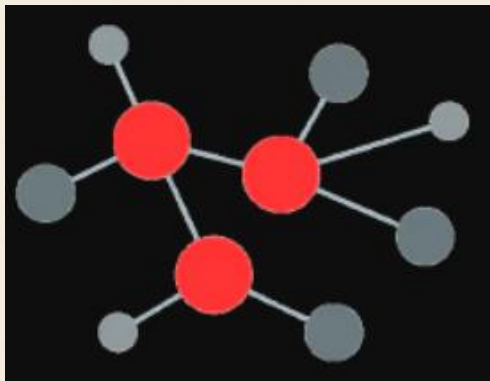
SOURCE_ACCOUNT	MULE_PAYEE	SOURCE_RISK	RELATED_RISK
ACCT-8841	PAYEE-HULE-017	96.500	91
ACCT-8841	PAYEE-HULE-017	96.500	81.500
ACCT-8841	PAYEE-HULE-017	96.500	88
ACCT-9284	PAYEE-HULE-017	94	86
ACCT-1190	PAYEE-HULE-017	91	88
ACCT-1190	PAYEE-HULE-017	91	81.500



Fundamentals

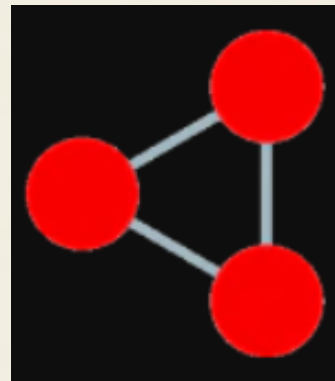


Graph Support in the Oracle Database



(Labeled) Property Graphs

- Since Oracle Database version 11.2
- Generic graph model
- Keywords: Graph Pattern-Matching, Graph Algorithms, Graph Machine Learning, PGQL, SQL/PGQ

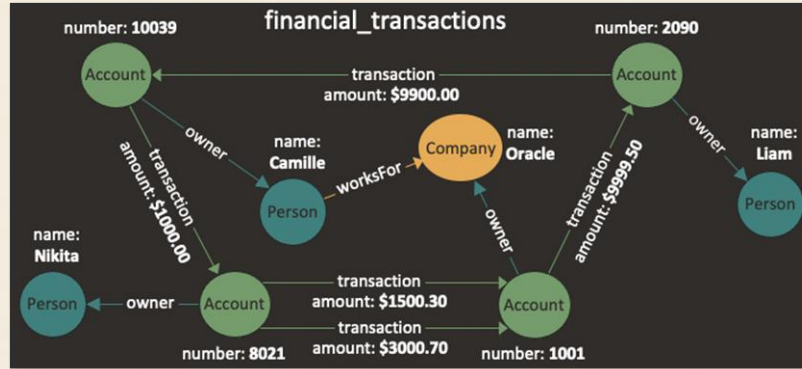


RDF Knowledge Graphs

- Since Oracle Database version 10.2
- Specialized, standards-based graph model
- Keywords: Semantic technologies, Linked Data, SPARQL, RDF, RDF-S, OWL, Ontologies, Inferencing

No additional license costs
All editions of the Oracle DB
All Oracle DB Cloud Services

The Property Graph Data Model



Source: pgql-lang.org

A representation of the real world, focusing on relationships using

- **Vertices** (nodes)
representing a *Thing*
- **Edges**
representing connections between vertices
- **Properties**
expressed as key-value pairs attached to vertices and/or edges
- **Labels**
representing the type of a vertex or edge

Create and Analyze Property Graphs using SQL



Prerequisite: Oracle Database 23ai or higher

- **Operational (SQL) Property Graphs** using **SQL/PGQ**
- SQL/PGQ is an extension to SQL:2023 (ISO/IEC 9075-16)

Step 1: Create a graph

CREATE PROPERTY GRAPH to build graphs as **metadata objects** over the original data

- Work with data where it lives ➡ No data copy or move

Step 2: Analyze the graph

MATCH clause inside the **GRAPH_TABLE** function to run **Pattern-Matching Queries**

Latest addition: DBMS_OGA to run **Graph Algorithms**
(PageRank and variants, Bellman-Ford, Weakly Connected Components)

Schema flexibility through JSON

- JSON document as a property
- JSON element as a property

Combines all converged DB features using SQL

See also:

www.oracle.com/a/ocom/docs/database/operational_property_graph_with_23c.pdf
blogs.oracle.com/database/post/property-graphs-in-oracle-database-26ai-the-sql-pgq-standard



Tools



Tools to work with SQL Property Graphs in 26ai



All your existing SQL tools work with graphs

- SQL Developer (**Latest: 26.2**), SQLcl
- VSCode
 - SQL Developer Extension
 - SQL Developer Graph Visualization Extension
- Graph Visualization JavaScript Library
- APEX (Plug-in, Sample Graph Viz app)
- Advanced queries, graph algorithms

Graph Server and Clients

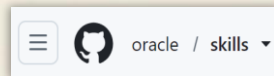
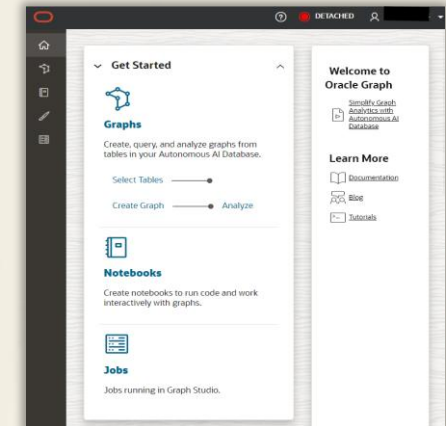
(Latest: 26.3)

providing additional capabilities

- APIs and CLIs
- Graph Algorithms
- Graph Machine Learning
- Graph Visualization Web App (*User-managed Graph Studio*)
- Graph Visualization JavaScript Library
- Integration with Jupyter Notebook/Lab

Graph Studio

- Autonomous AI Database integrated tool  *Graph Studio*
 - Automated and AI-supported graph modeling
 - Built-in notebook support, including visualization tools



[github.com/oracle/skills > db > appdev > sql-property-graph.md](https://github.com/oracle/skills/tree/main/db/appdev/sql-property-graph.md)



Graph-Enabled Low-Code App Dev

Property Graphs natively supported in
Oracle Application Express (APEX)



Sample Graph Visualization App and Plugin

This screenshot shows the GitHub repository for the 'Sample Graph Visualizations' app. The breadcrumb path 'apex / sample-apps / sample-graph-visualizations /' is highlighted with a red box. The file list on the left includes 'README.md', 'THIRD_PARTY_LICENSES.txt', and 'sample-graph-visualizations_26ai.sql'. The commit history table shows three commits: 'Update README.md' (3 weeks ago), 'graph viz update (#105)' (11 months ago), and 'Update app alias' (3 weeks ago). The README content is visible at the bottom, with the title 'Sample Graph Visualizations' highlighted by a red box.

Name	Last commit message	Last commit date
..		
README.md	Update README.md	3 weeks ago
THIRD_PARTY_LICENSES.txt	graph viz update (#105)	11 months ago
sample-graph-visualizations_26ai.sql	Update app alias	3 weeks ago

Sample Graph Visualizations

This application demonstrates the use of the Graph Visualization plug-in. This plug-in supports visualization of property graph queries in the database as an interactive network graph. More information about the region plug-in and its usage can be found [here](#).

github.com/oracle/apex/tree/26.1/sample-apps/sample-graph-visualizations

This screenshot shows the GitHub repository for the 'Graph Visualization Plug-In'. The breadcrumb path 'apex / plugins / region / graph-visualization /' is highlighted with a red box. The file list on the left includes 'plugins', 'dynamic-action', 'region/graph-visualization', 'required-for-26ai', 'rest-source', and 'sample-apps'. The commit history table shows three commits: 'Update required 26ai' (3 months ago), 'Update graph-visualization general plugin files' (3 months ago), and 'graph viz update (#105)' (11 months ago). The README content is visible at the bottom, with the title 'Graph Visualization Plug-In' highlighted by a red box.

Name	Last commit message	Last commit date
..		
required-for-26ai	Update required 26ai	3 months ago
README.md	Update graph-visualization general plugin files	3 months ago
THIRD_PARTY_LICENSES.txt	graph viz update (#105)	11 months ago
region_type_plugin_graphviz.sql	Update graph-visualization general plugin files	3 months ago

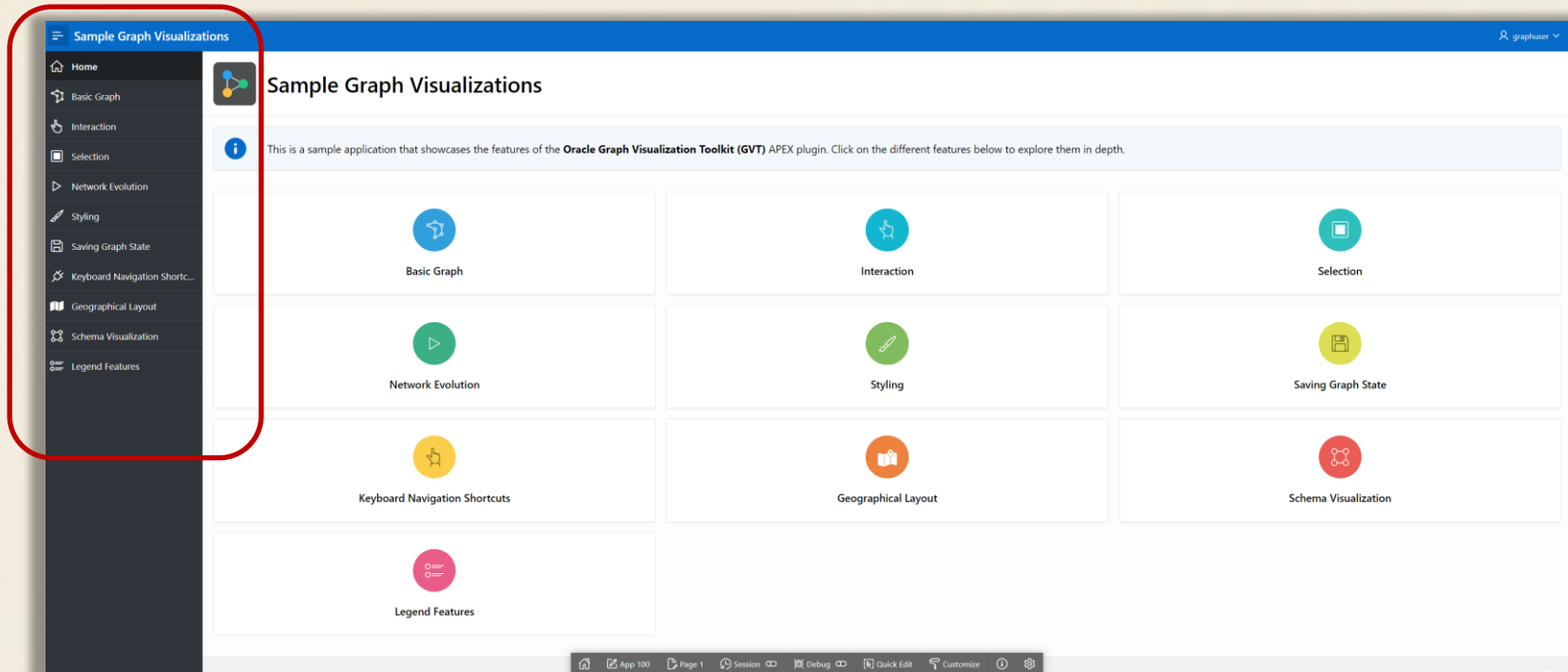
Graph Visualization Plug-In

This plug-in supports visualization of property graph queries in the database as an interactive network graph. The queries can be expressed in SQL (specifically the new SQL/PGQ standard) for

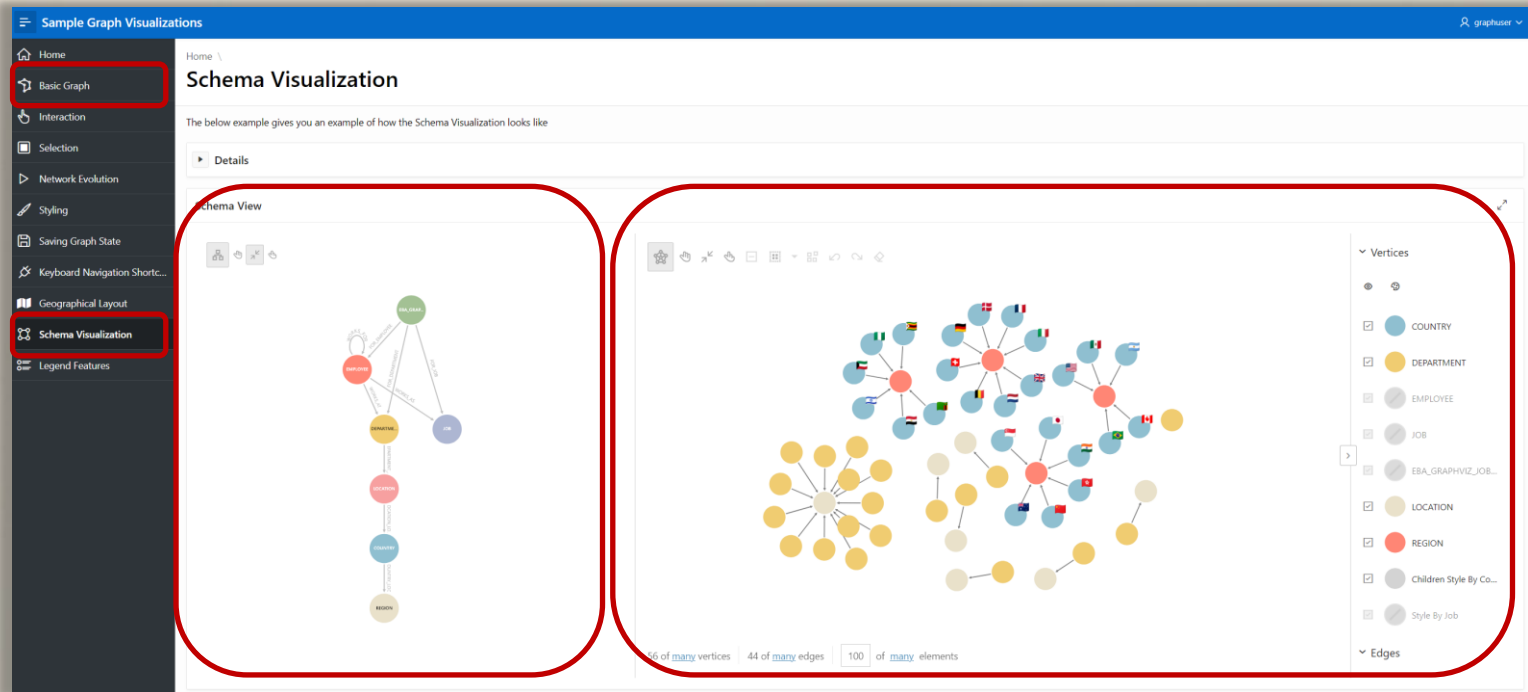
github.com/oracle/apex/tree/26.1/plugins/region/graph-visualization



Sample Graph Viz app – Home



Sample Graph Viz app – Schema Visualization



KOIO2. via Property Graphs

The LINEAGE Graph
under the Hood



Create the LINEAGE Graph

```
CREATE PROPERTY GRAPH via_lineage_graph
VERTEX TABLES (
  mv_via_nodes_columns AS column_node
    KEY (node_id)
    LABEL column_node
    PROPERTIES (schema_name, table_name, column_name, full_name)
)
EDGE TABLES (
  mv_via_intersections AS data_flow
    KEY (edge_id)
    SOURCE KEY (node_id_src) REFERENCES column_node (node_id)
    DESTINATION KEY (node_id) REFERENCES column_node (node_id)
    LABEL data_flow
    PROPERTIES (
      source_schema, source_table, source_column,
      target_schema, target_table, target_column,
      valid_from, valid_to
    )
)
OPTIONS (TRUSTED MODE, DISALLOW MIXED PROPERTY TYPES)
```

Query the LINEAGE Graph

```
SELECT DISTINCT
  n.schema_name||'.'||n.table_name||'.'||n.column_name AS id,
  n.schema_name, n.table_name, n.column_name
FROM
  GRAPH_TABLE (via_lineage_graph          -- columns upstream of the table
    MATCH
      (n IS column_node)
      -[e IS data_flow WHERE e.valid_from <= DATE '2026-08-24' AND (e.valid_to IS NULL OR e.valid_to > DATE '2026-08-24')]
      ->{1,2}(tgt IS column_node WHERE tgt.schema_name='HISTORY_NFL' AND tgt.table_name='HISTORY_ALL_POSITIONS_BY_WEEK')
    COLUMNS (n.schema_name, n.table_name, n.column_name))
UNION
SELECT DISTINCT
  n.schema_name || '.' || n.table_name || '.' || n.column_name,
  n.schema_name, n.table_name, n.column_name
FROM
  GRAPH_TABLE (via_lineage_graph          -- columns downstream of the table
    MATCH
      (src IS column_node WHERE src.schema_name='HISTORY_NFL' AND src.table_name='HISTORY_ALL_POSITIONS_BY_WEEK')
      -[e IS data_flow WHERE e.valid_from <= DATE '2026-08-24' AND (e.valid_to IS NULL OR e.valid_to > DATE '2026-08-24')]
      ->{1,2}(n IS column_node)
    COLUMNS (n.schema_name, n.table_name, n.column_name))
UNION
SELECT                                -- the table's own columns
  schema_name||'.'||table_name||'.'||column_name,
  schema_name, table_name, column_name
FROM mv_via_nodes_columns
WHERE schema_name='HISTORY_NFL' AND table_name='HISTORY_ALL_POSITIONS_BY_WEEK';
```

Getting started

Try it out yourself



LiveLabs Workshop

Explore Operational Property Graphs in Oracle AI Database

The screenshot shows the LiveLabs workshop interface. On the left is a table of contents with the following items:

- + Introduction
- + Getting Started
- + Lab 1: Provision an ADB Instance
- + Lab 2: Create a Graph User
- + Lab 3: Setup Property Graph
- Lab 4: Operational Property Graphs Example with SQL/PGQ in 26ai
 - Introduction
 - Task 1: Import the notebook
 - Task 2: Query bank_graph
 - Learn More
 - Acknowledgements
- + Bonus Lab: Integration with APEX
- + Need Help?

The main area displays a SQL query in a code editor:

```
SELECT *
FROM graph_table (BANK_GRAPH
MATCH (src) - []->(4) (src)
WHERE src.name = 'RUSSELL RIVERA'
ONE ROW PER STEP ( v1, e1, v2 )
COLUMNS (src.id AS acct_id, vertex_id(src) as src_id, vertex_id(v1) as v1_id, edge_id(e1) as e1_id, vertex_id(v2) as v2_id )
)
```

Below the query is a graph visualization showing a central green node connected to several blue nodes, which are further interconnected.

The Run on Your Environment button provides step-by-step instructions so you can run this workshop using your own resources!

Run on Your Environment

The Run on LiveLabs button will dynamically create resources in an Oracle-owned tenancy for you to use for free!

[Oracle account help](#) | [Oracle account signup](#)

Run on LiveLabs Sandbox

The Preview Sandbox Instructions button will open a link with the sandbox instructions for you to preview before creating a reservation.

Preview Sandbox Instructions



Summary



- 
- ➡ Graphs offer a different view of your data, regardless of your business and use case
 - ➡ With Oracle 26ai, use your existing tools and APIs to work with graphs
 - ➡ Oracle AI Database is the Graph database for the enterprise
 - ➡ Developing your Graph-powered applications made simple

More information



Useful Resources (1/2)

General information

- www.oracle.com/database/graph/
- Graph Size Estimator
www.oracle.com/webfolder/assets/graph-size-estimator/index.html
- PGQL Spec 2.1 pgql-lang.org/spec/2.1/

Documentation Release 26.3

- Oracle Property Graph Developer's Guide
docs.oracle.com/en/database/oracle/property-graph/26.3/index.html
- Property Graph Visualization Developer's Guide and Reference
docs.oracle.com/en/database/oracle/property-graph/26.3/pgvtr/graph-visualization-library-reference.html
- Python API
docs.oracle.com/en/database/oracle/property-graph/26.3/pypgx/pypgx/api.html
- Java API
docs.oracle.com/en/database/oracle/property-graph/26.3/spgjav/index.html
- Graph Server REST API
docs.oracle.com/en/database/oracle/property-graph/26.3/spgdg/graph-server-rest-api-version-2.html

GitHub

- Machine Learning Workshop with Oracle Property Graph
github.com/operard/mlgraph
- github.com/oracle-samples/oracle-graph

Oracle Cloud MarketPlace

- Graph Server and Client – Image
cloud.oracle.com/marketplace/application/74883066

YouTube

- youtube.com/@oraclespatialandoraclegraph
- Analytics and Data Techcasts: youtube.com/@analyticsanddatatechcasts90

Blogs

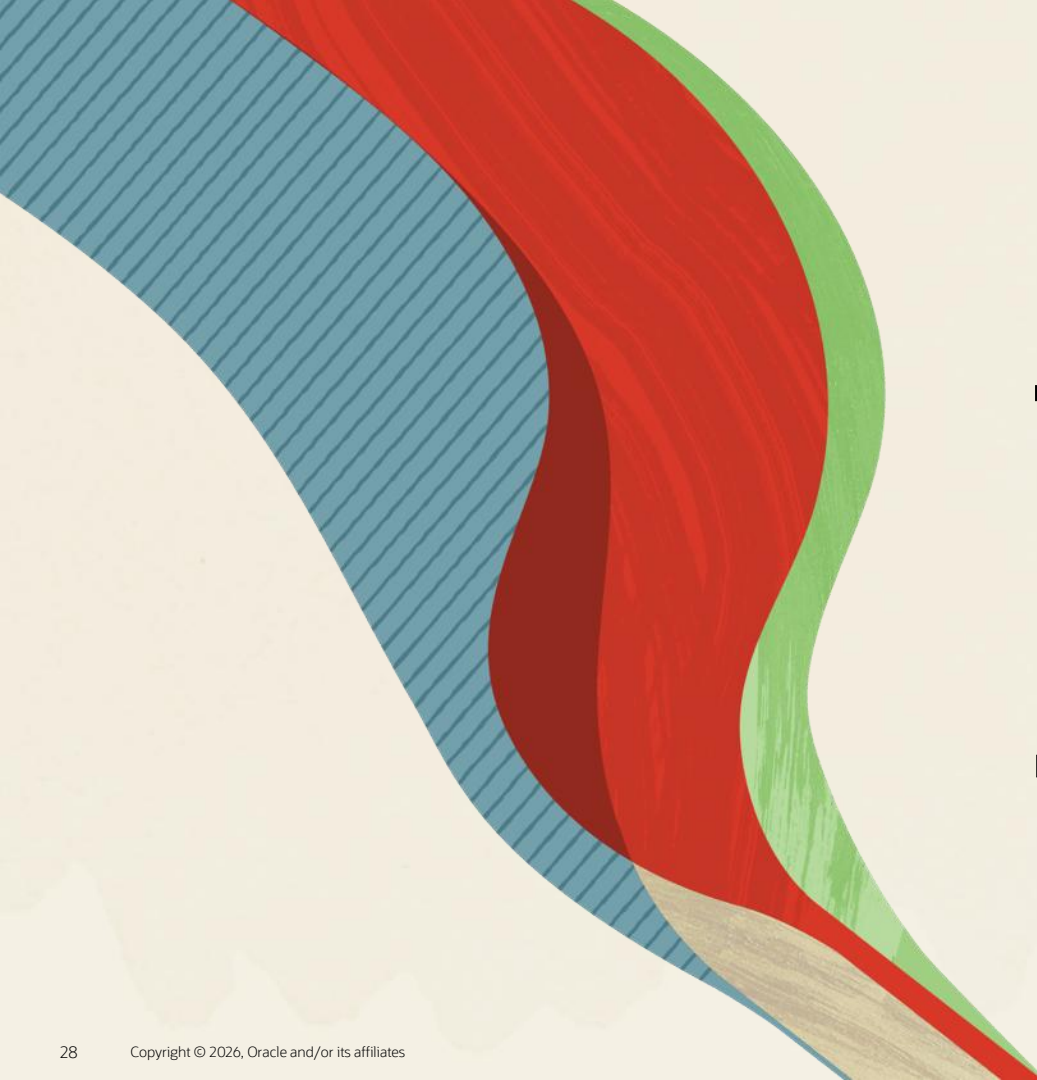
- Oracle Database Insider – Graph: blogs.oracle.com/database/category/db-graph
- Medium: medium.com/tag/oracle-graph
- Database & Cloud Technology: blogs.oracle.com/coretec/

LinkedIn

- Oracle Spatial and Oracle Graph group: www.linkedin.com/groups/1848520/

Useful Resources (2/2)

- Oracle SQL Developer for VSCode
marketplace.visualstudio.com/items?itemName=Oracle.sql-developer
- Oracle SQL Developer Graph Visualization for VSCode
marketplace.visualstudio.com/items?itemName=Oracle.sql-developer-graph-visualization
- Graph Server and Clients downloads
oracle.com/database/technologies/spatialandgraph/property-graph-features/graph-server-and-client/graph-server-and-client-downloads.html
- Oracle Graph Quickstart Container image
container-registry.oracle.com/ords/ocr/ba/database/graph-quickstart
- APEX
 - Sample Graph App
github.com/oracle/apex/tree/26.1/sample-apps/sample-graph-visualizations
 - Graph Visualization Plugin
github.com/oracle/apex/tree/26.1/plugins/region/graph-visualization
- Get Started with APEX Graph Visualization Plug-in
docs.oracle.com/en/cloud/paas/autonomous-database/csgu/get-started-apex-graph-visualization-plug.html
- Oracle Graph samples on GitHub
github.com/oracle-samples/oracle-graph
- Linkurious Ogma integration with Oracle SQL Property Graphs (including a Node.js sample app)
linkurious.github.io/ogma-oracle-parser/getting-started.html



Thank you

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