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Graph RAG with the Oracle Database

Graph RAG: Bring the Power of Graphs to Generative AI

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Scripts and data can be found here:
github.com/karinpatenge/events/tree/main/2025/06_TDWI

The next 40 mins at a glance

Graphs
A brief intro

GenAI
Chatting with your DB

RAG
Briefly explained

Graph RAG
A brief intro

Graph RAG
Example

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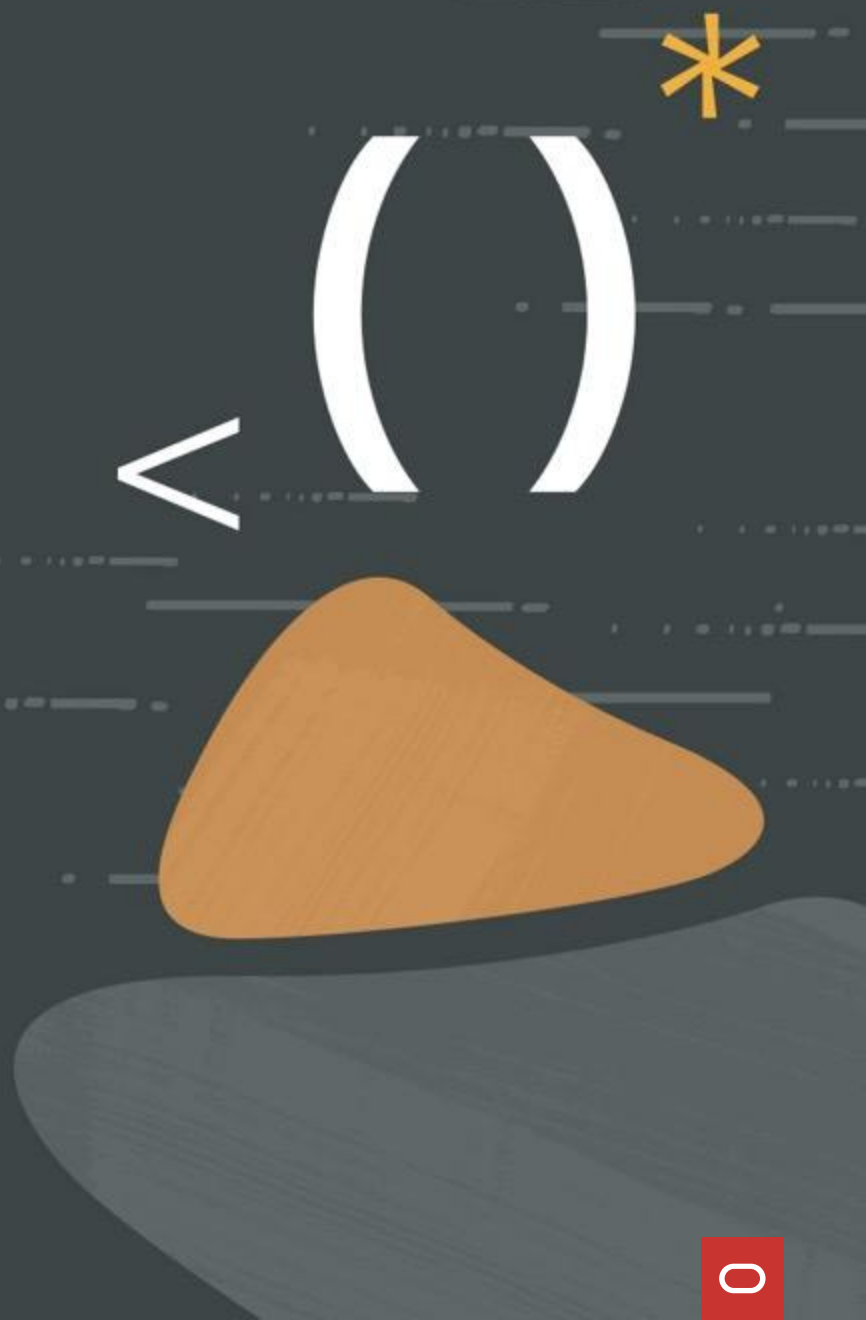
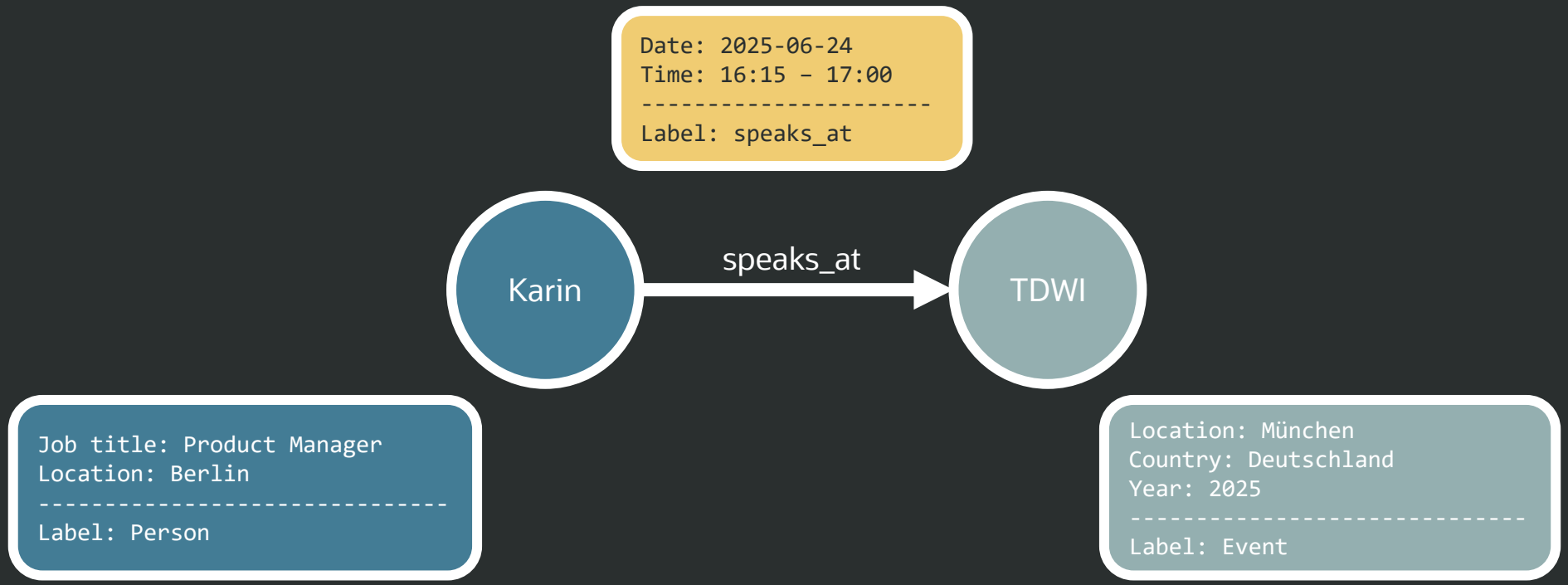
A Brief Intro to Graphs



A Graph representing Connections between Entities

Attributed with Properties and Labels



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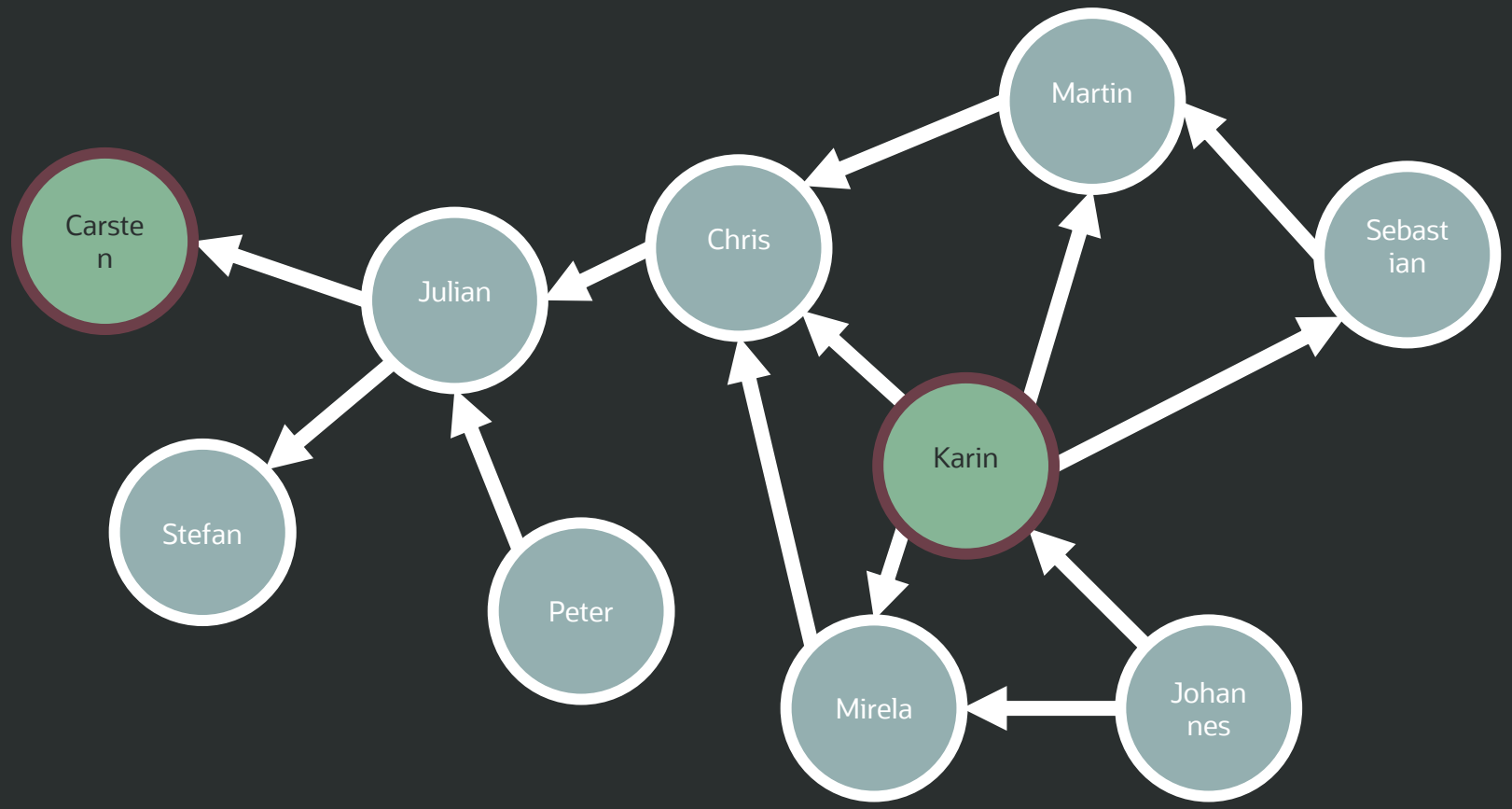
Am I connected to Niall?



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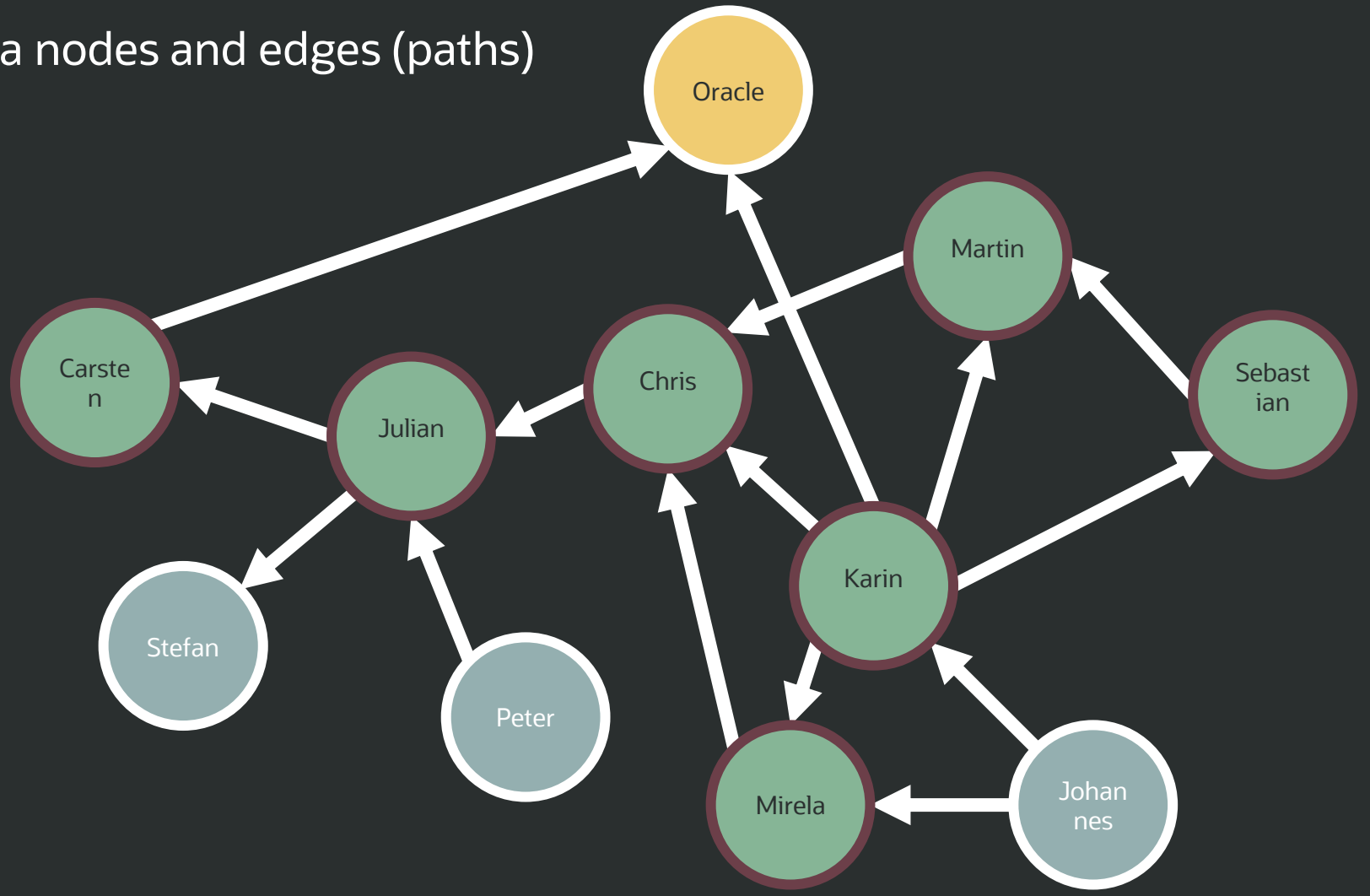
Yes, I am!

Connected via nodes and edges (paths)



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SQL for Property Graphs

```
CREATE PROPERTY GRAPH IF NOT EXISTS simple_sql_graph
  VERTEX TABLES (
    persons
      KEY ( id ) LABEL person
      PROPERTIES ARE ALL COLUMNS,
    companies
      KEY ( id ) LABEL company
      PROPERTIES ARE ALL COLUMNS,
    events
      KEY ( id ) LABEL event
      PROPERTIES ARE ALL COLUMNS
  )
  EDGE TABLES (
    works_for
      KEY (id)
      SOURCE KEY ( src_id ) REFERENCES persons ( id )
      DESTINATION KEY ( dst_id ) REFERENCES companies ( id )
      LABEL works_for PROPERTIES ARE ALL COLUMNS,
    knows
      KEY (id)
      SOURCE KEY ( src_id ) REFERENCES persons ( id )
      DESTINATION KEY ( dst_id ) REFERENCES persons ( id )
      LABEL knows PROPERTIES ARE ALL COLUMNS,
    speaks_at
      KEY (id)
      SOURCE KEY ( src_id ) REFERENCES persons ( id )
      DESTINATION KEY ( dst_id ) REFERENCES events ( id )
      LABEL speaks_at PROPERTIES ARE ALL COLUMNS
  );
```

```
SELECT
  num_hops,
  'Karin -> ' || names_list AS path
FROM GRAPH_TABLE (
  simple_sql_graph
  MATCH (p1 IS Person) (-[e IS knows]-> (x)){1,6} (p2 IS Person)
  WHERE p1.name = 'Karin' AND p2.name = 'Carsten'
  COLUMNS (
    LISTAGG (x.name, ' -> ') AS names_list,
    BINDING_COUNT (e) AS num_hops
  )
)
ORDER BY num_hops;

NUM_HOPS PATH
---------- --------------------------------------------------------------------
         3 Karin -> Chris -> Julian -> Carsten
         4 Karin -> Martin -> Chris -> Julian -> Carsten
         4 Karin -> Mirela -> Chris -> Julian -> Carsten
         5 Karin -> Sebastian -> Martin -> Chris -> Julian -> Carsten
```


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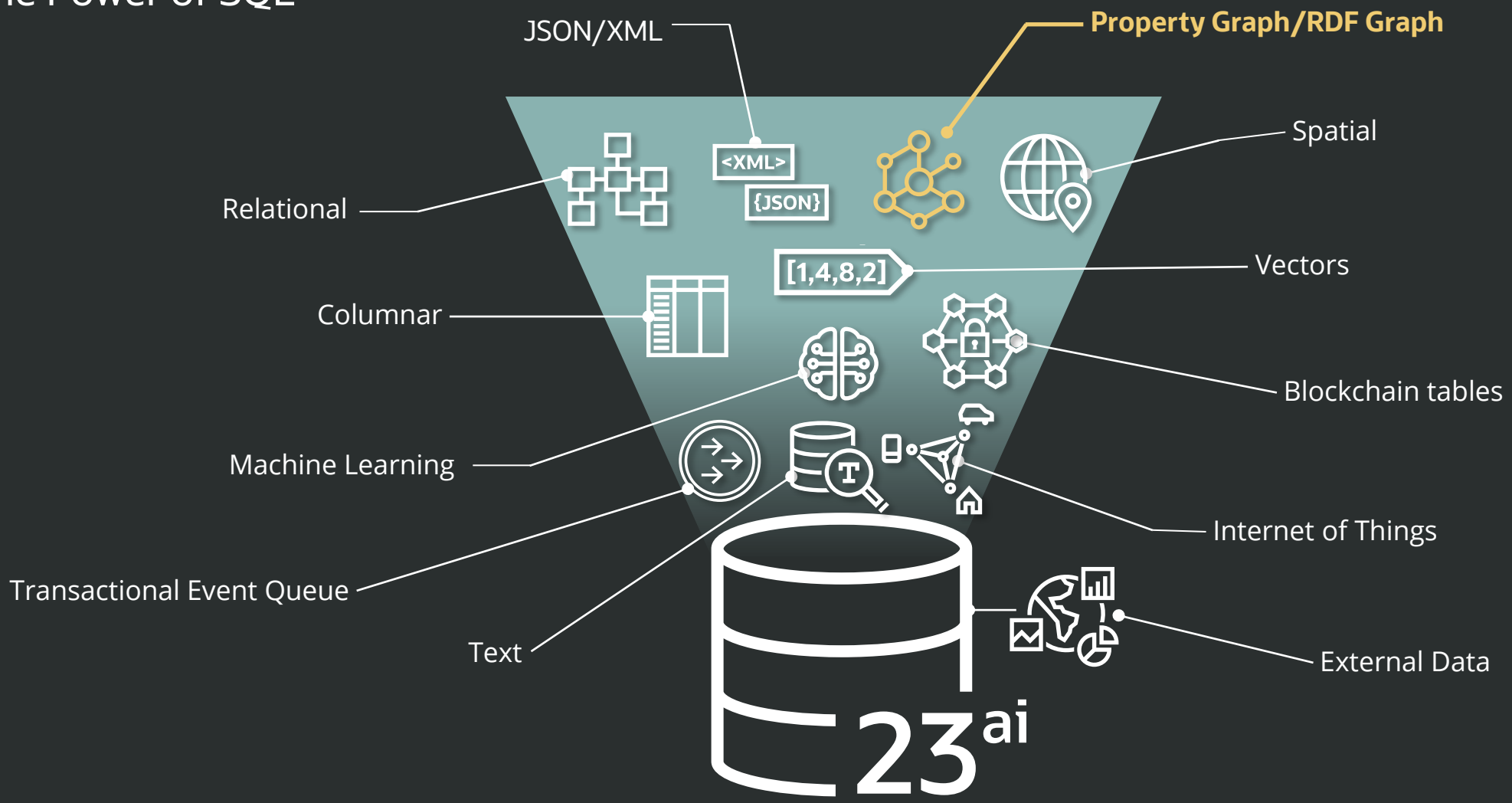
How are Graphs connected to the Oracle Database?

The Power of SQL



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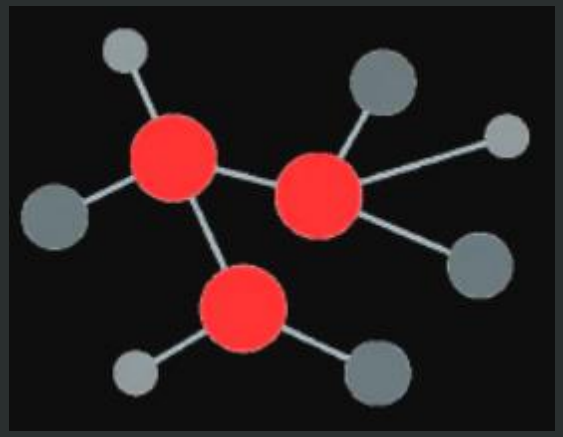
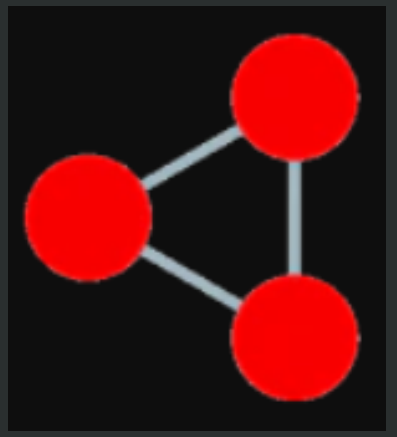
The Oracle Database as Graph Database



(Labeled) Property Graphs

- Generic graph model
- Since Oracle Database version 11.2
- Keywords: Graph Pattern-Matching, Graph Algorithms, Graph Machine Learning
- Query Languages:
  - Native: PGQL (pgql-lang.org)
  - ISO Standard: SQL/PGQ implemented in 23ai



RDF Graphs

- Specialized, W3C Standards-based graph model
- Since Oracle Database version 10.2
- Keywords: Semantic Webs, RDF, Triples (Quads), Linked (Open) Data, RDFS, OWL, Ontologies, Vocabularies, Inferencing/Reasoning
- Query Language:
  - W3C Standard: SPARQL (www.w3.org/TR/sparql12-query/)
  - Native: SEM_MATCH embedding SPARQL

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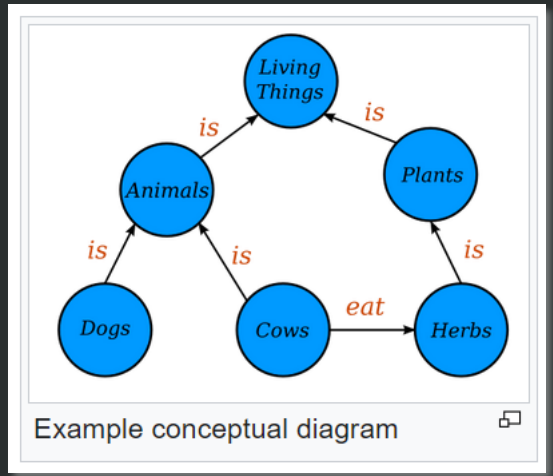
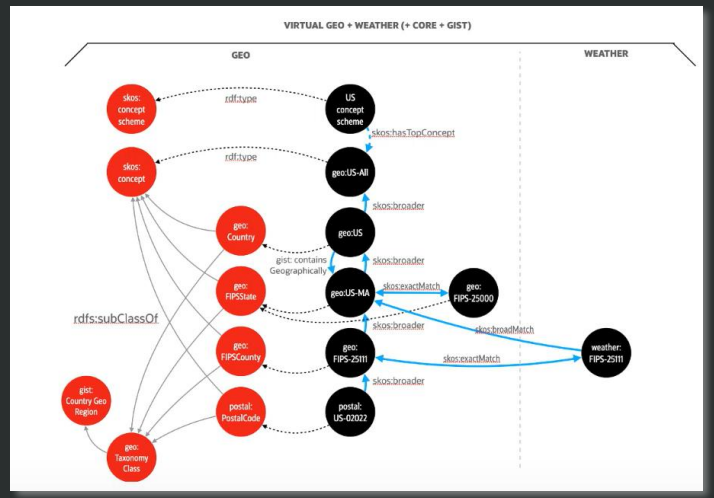
Knowledge Graphs

*"In knowledge representation and reasoning, a **knowledge graph** is a knowledge base that uses a graph-structured data model or topology to represent and operate on data. Knowledge graphs are often used to store interlinked descriptions of entities – objects, events, situations or abstract concepts – while also encoding the free-form semantics or relationships underlying these entities."*



Source (text and image on the right side):
en.wikipedia.org/wiki/Knowledge_graph



www.youtube.com/watch?v=RlyHAuvx93M

Both Graph Models are in use for Knowledge Graphs !

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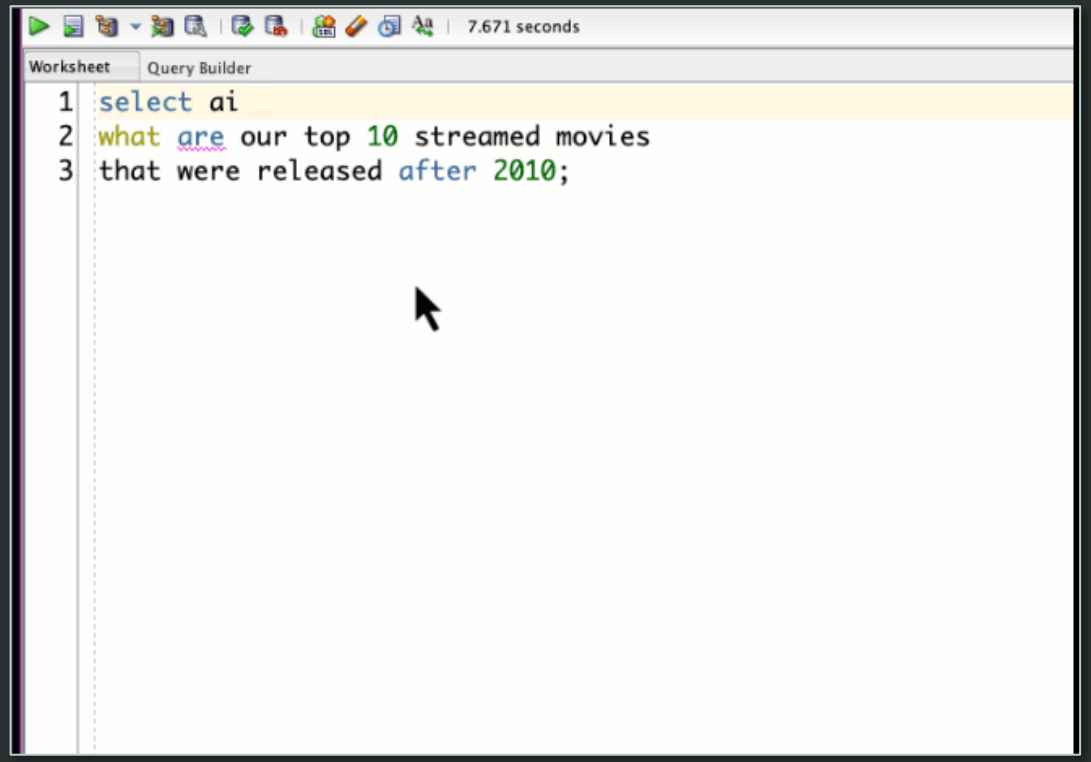
Generative AI

Chatting with your Oracle Database 23ai

SQL Generation with SELECT AI inside the Oracle Database

- Use natural language to query data with the help of LLMs
- Increase application developer productivity
- Enable non-technical users to query information from their database
- Invoke from SQL command line and PL/SQL function
- Inherit security and authentication of the database



Try it out!

Oracle LiveLabs: Chat with Your Data in Autonomous Database Using Select AI

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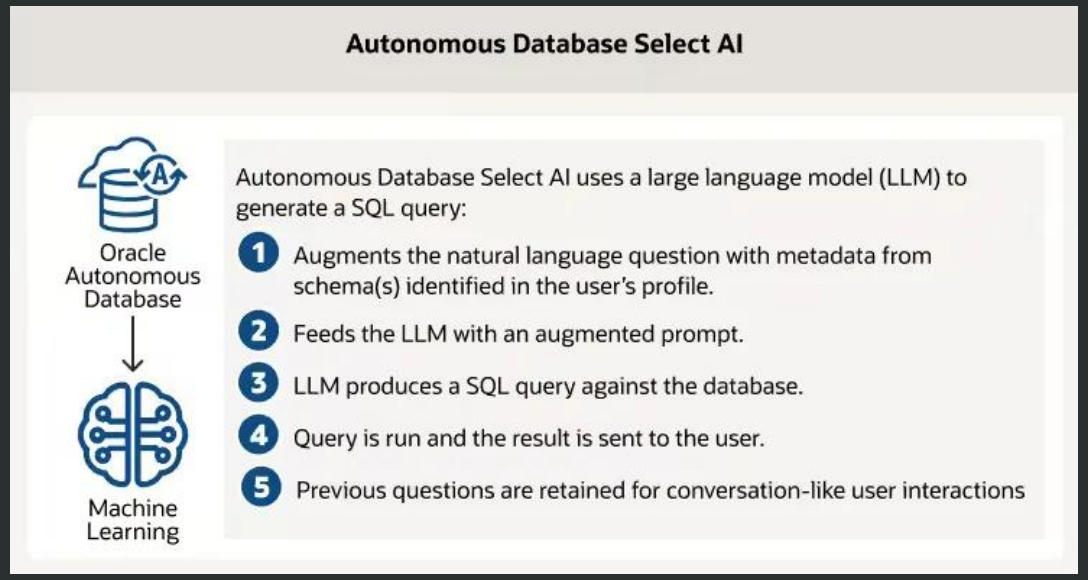
Use Natural Language to Query Data (NL2SQL)

Get Responses using Generative AI

SELECT AI Actions	
runsql	Return the SQL result set
showsql	Return the generated SQL
explainsql	Explain the generated SQL
showprompt	Display the generated prompt
narrate	Return a conversational result
chat	General AI chat – passthrough to the LLM



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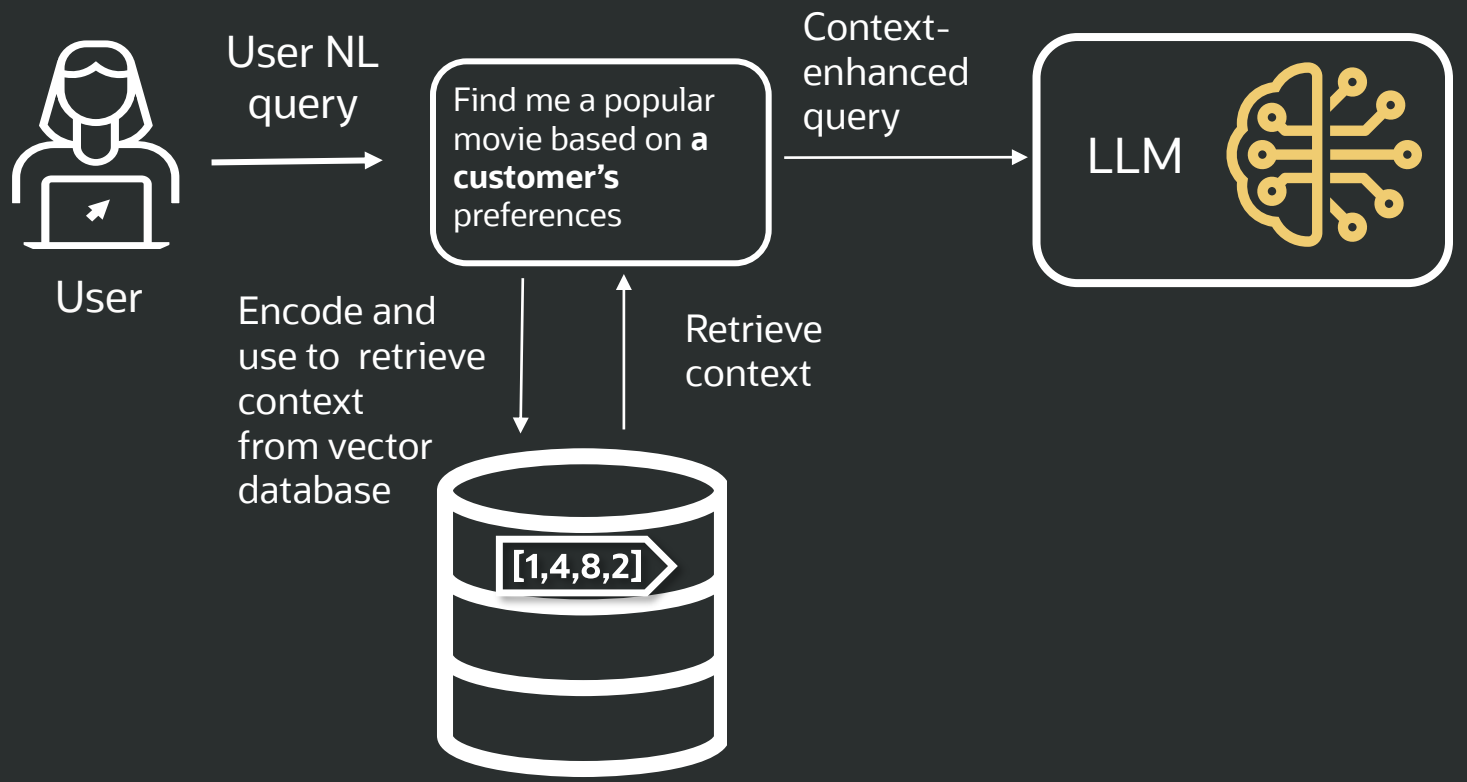
Retrieval Augmented Generation (aka RAG)

A brief overview

Enhance Queries with Data in the Oracle Database



- Use latest and private data from a database to provide context to LLM
- Typically use vector search to find matching data in a database to provide as context to an LLM
  - Create embeddings for data and store as vectors in a vector database
  - Vectorize user's natural language query and match with stored vectors
  - Augment user query with top matches from the database

Try it out: livelabs.oracle.com/pls/apex/r/dbpm/livelabs/view-workshop?wid=4114

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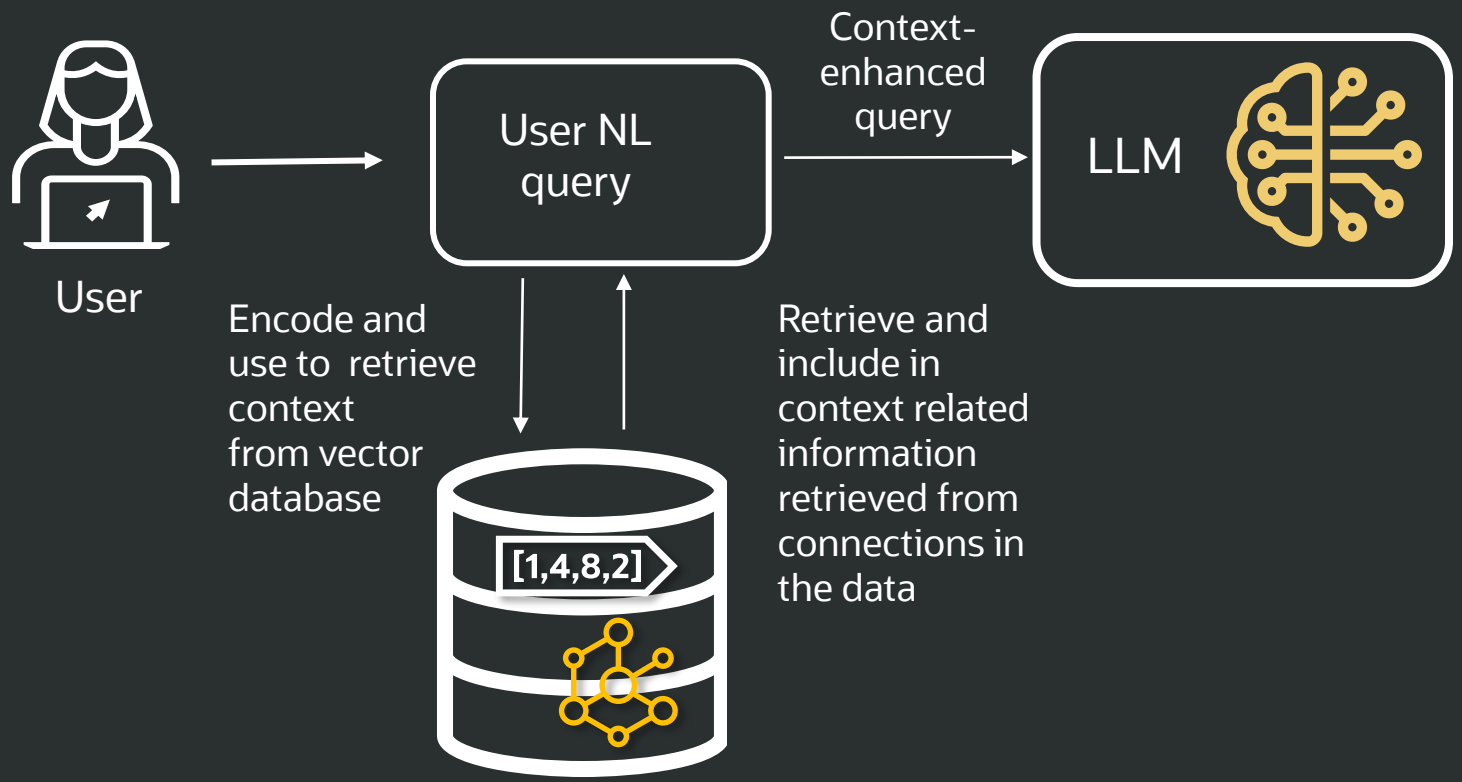
Graph RAG

Going a step further

Enhance Queries with Connections in Data

Vectors & Graphs are even better together



Graph RAG

Benefits of RAG

\+

Connections in Data

blogs.oracle.com/database/post/graph-rag-bring-the-power-of-graphs-to-generative-ai

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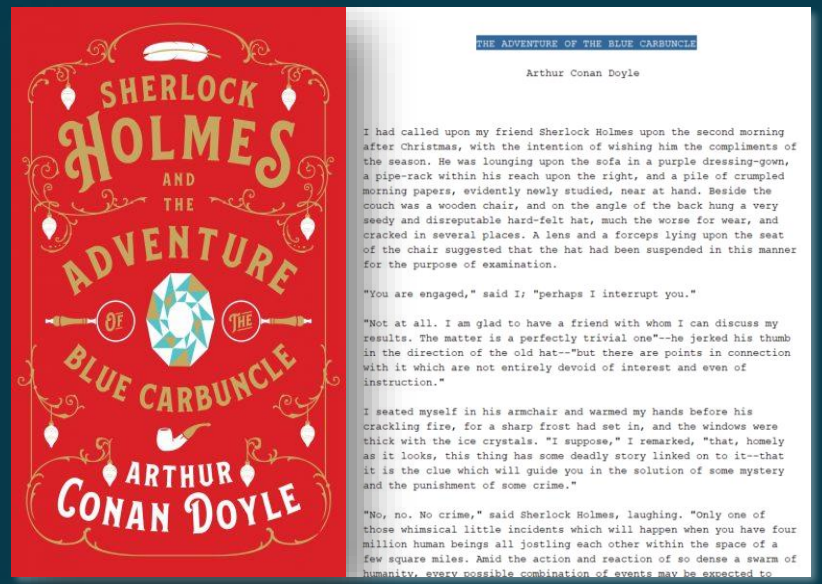


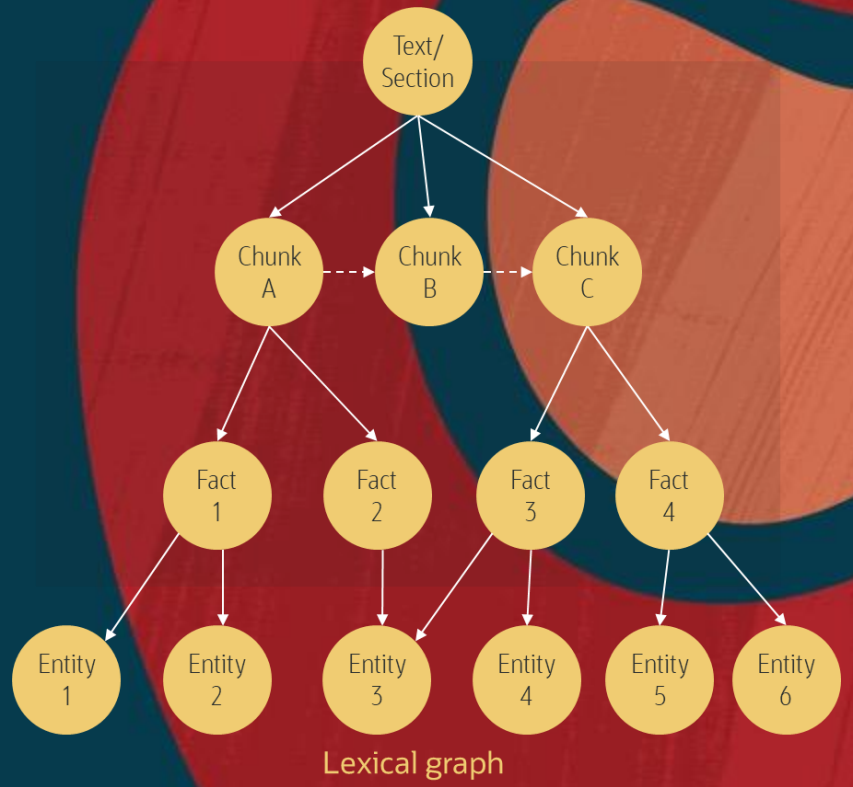
Demo

Build a **Lexical Graph** from text and use it to enrich the context used by the LLM for even better responses

Model used: Tiny BERT (Bidirectional Encoder Representations from Transformers)

Source:
apexapps.oracle.com/pls/apex/r/dbpm/livelabs/view-workshop?wid=4174

Kudos to Eduard Cuba



The Adventure of the Blue Carbuncle

I had called upon my friend Sherlock Holmes upon the second morning after Christmas, with the intention of wishing him the compliments of the season. He was lounging upon the sofa in a purple dressing-gown, a pipe-rack within his reach upon the right, and a pile of crumpled morning papers, evidently newly studied, near at hand. Beside the couch was a wooden chair, and on the angle of the back hung a very seedy and disreputable hard-felt hat, much the worse for wear, and cracked in several places. A lens and a forceps lying upon the seat of the chair suggested that the hat had been suspended in this manner for the purpose of examination.

"You are engaged," said I; "perhaps I interrupt you."

"Not at all. I am glad to have a friend with whom I can discuss my results. The matter is a perfectly trivial one" -- he jerked his thumb in the direction of the old hat --"but there are points in connection with it which are not entirely devoid of interest and even of instruction."

I seated myself in his armchair and warmed my hands before his crackling fire, for a sharp frost had set in, and the windows were thick with the ice crystals. "I suppose," I remarked, "that, homely as it looks, this thing has some deadly story linked on to it -- that it is the clew which will guide you in the solution of some mystery and the punishment of some crime."

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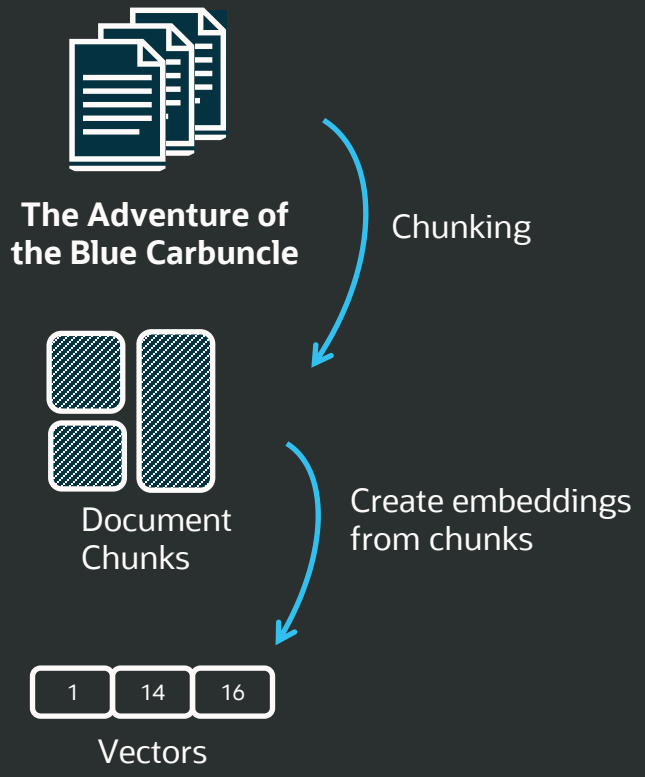
Query Text Chunks using Vector Search



lady's jewel-case. The evidence against him was so strong that the case has been referred to the Assizes.

John Horner, 26, plumber, was brought up upon the charge of having upon the 22d inst., abstracted from the jewel-case of the Countess of Morcar the valuable gem known as the blue carbuncle.

Question: **Who stole the Jewel?**

Answer: **The jewel was stolen by** John Horner, a **plumber, who was accused of ...**

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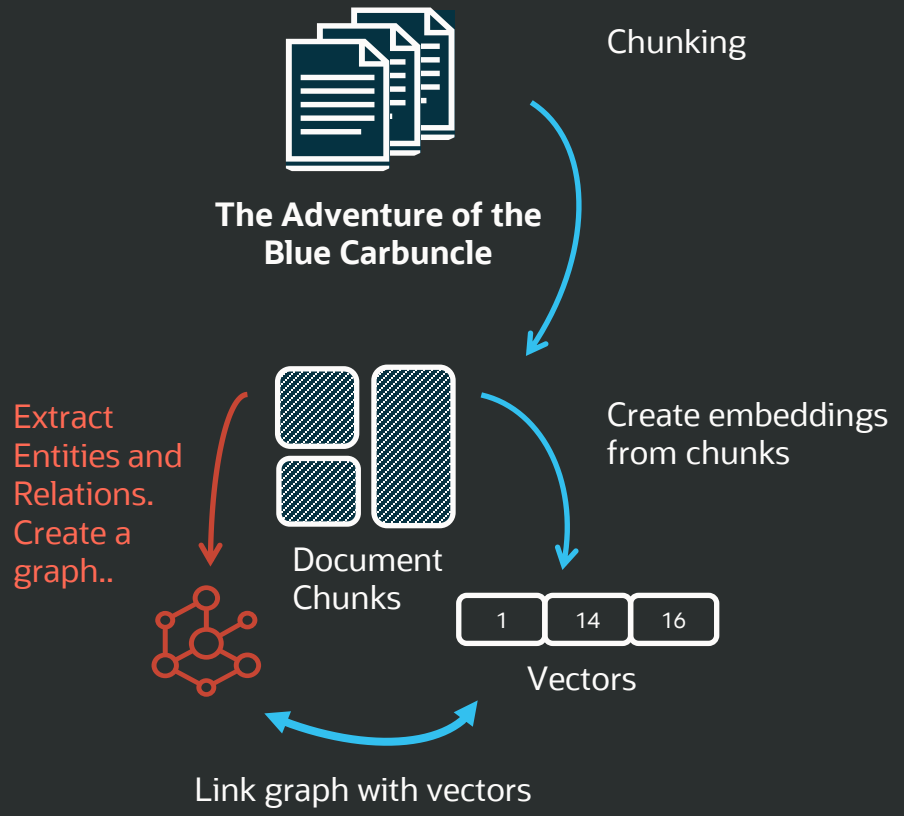
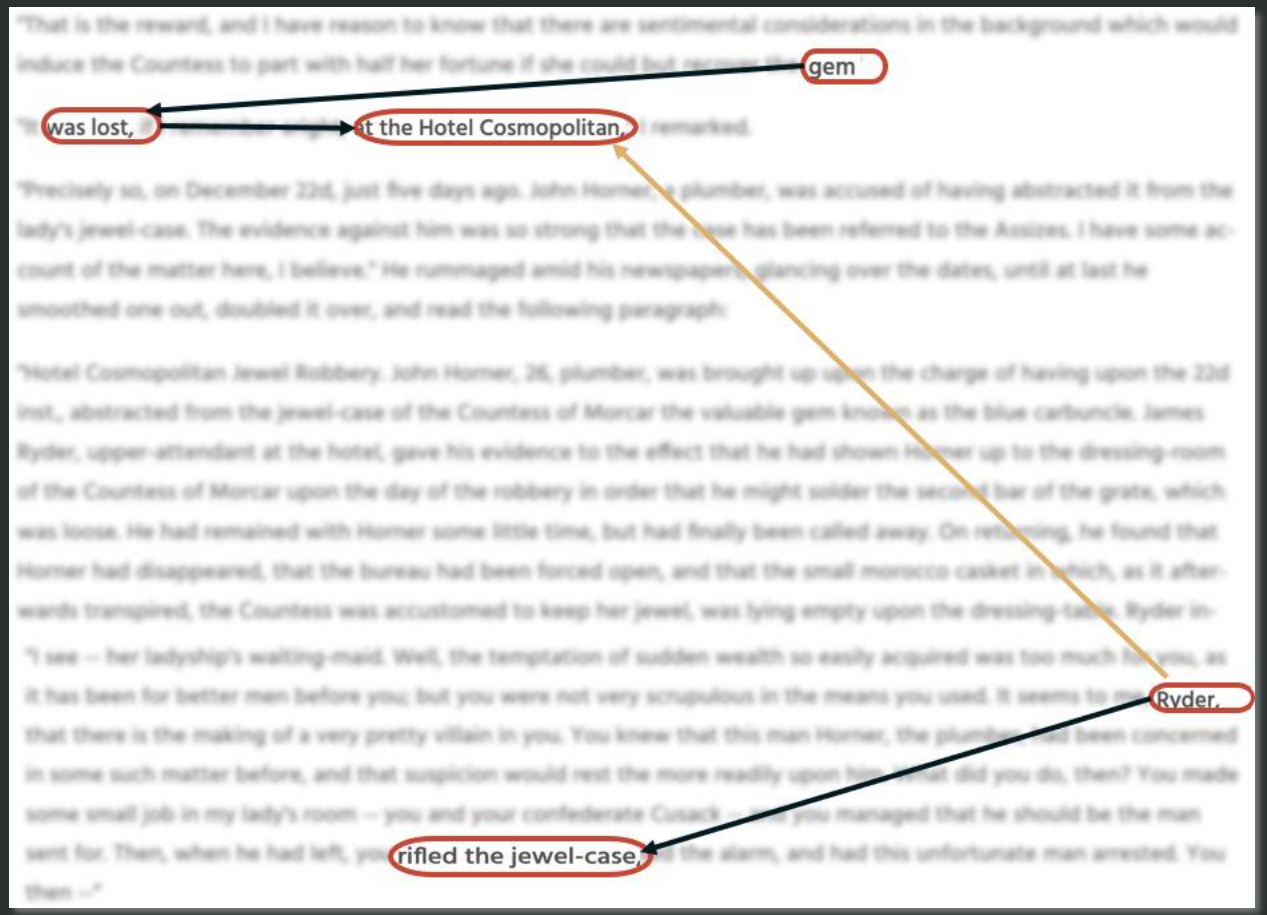
Extract a Graph and Link with Text Chunks





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Graphs Connect Entities Across Text Chunks

Graph RAG

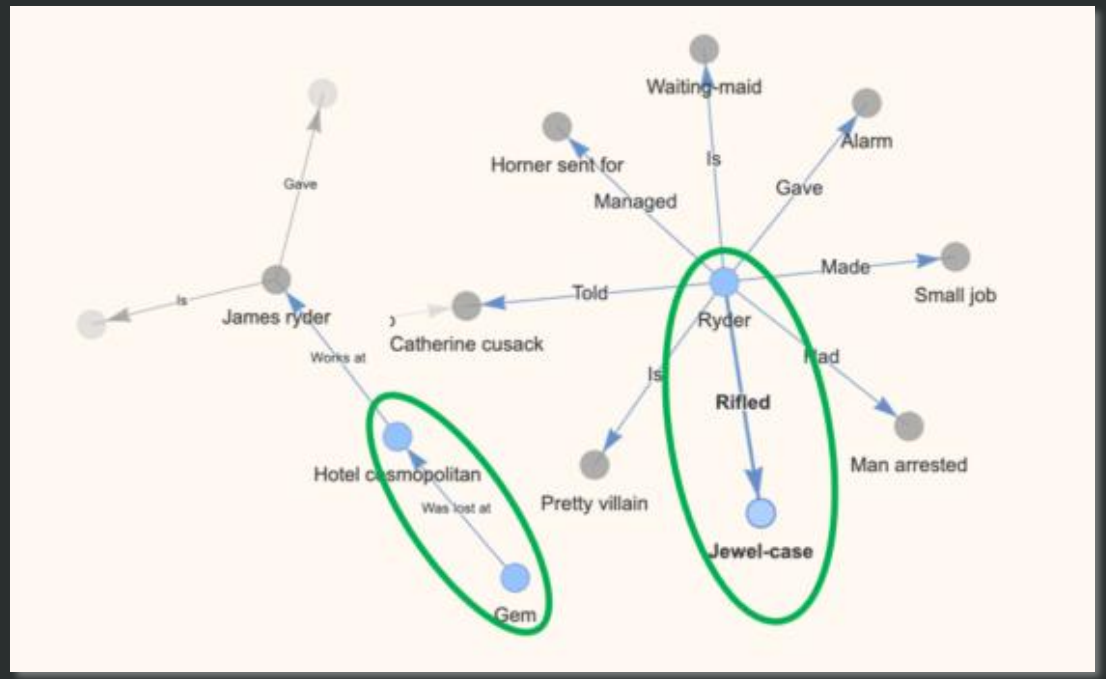
1. Find entities related to “Who Stole the Jewel”?
2. Retrieve text chunks associated with those entities

   The jewel robbery → LOCATION_OF → Hotel Cosmopolitan

   Ryder → EMPLOYED_BY → Hotel Cosmopolitan

   Ryder → RIFLED → The jewel case

Answer: James Ryder, the hotel attendant, is implicated in the theft of the jewel.



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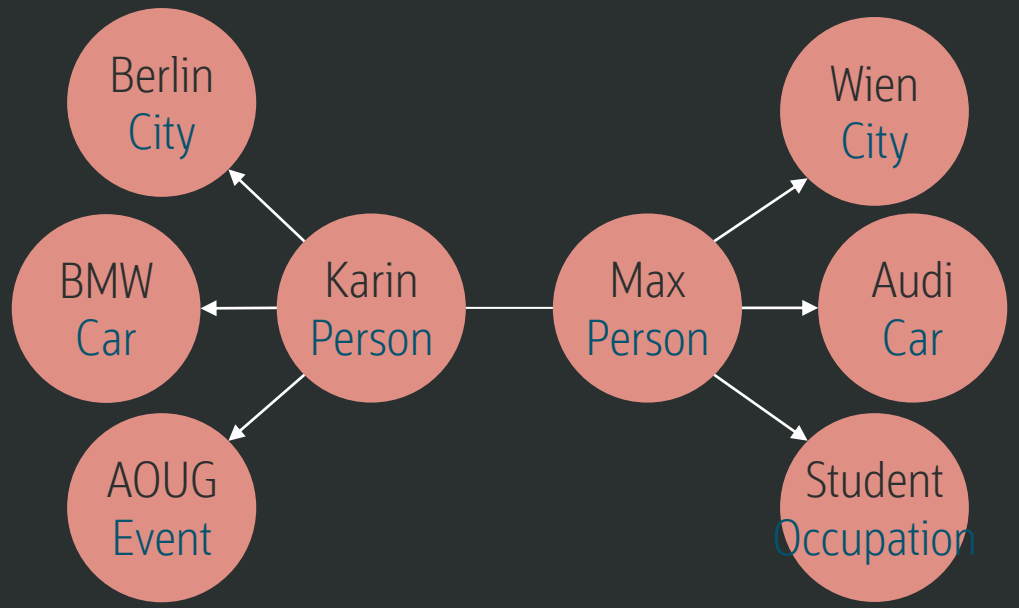
Benefits of Graph RAG

- Graphs contain explicit representations of connections in data
- They take the semantics into account
- Searching data is based on graph traversal



Compared to vectors:

- Opaque data structure
- Different distance metrics
- Search based on proximity

Karin: `[0.273, 0.165, 0.268, 0.183,…]`

Max: `[0.734, 0.707, 0.413, 0.229,…]`

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Summary

Graph RAG typically produces more accurate, explainable results than baseline RAG

Using Oracle 23ai and Oracle Graph simplifies development of Graph RAG workflows

Graph RAG as a technique offers huge potential and is evolving rapidly

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Vielen Dank !

Karin Patenge

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