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Graph RAG with the Oracle Database



Graph RAG: Bring the Power of Graphs to Generative AI

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Safe harbor statement

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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

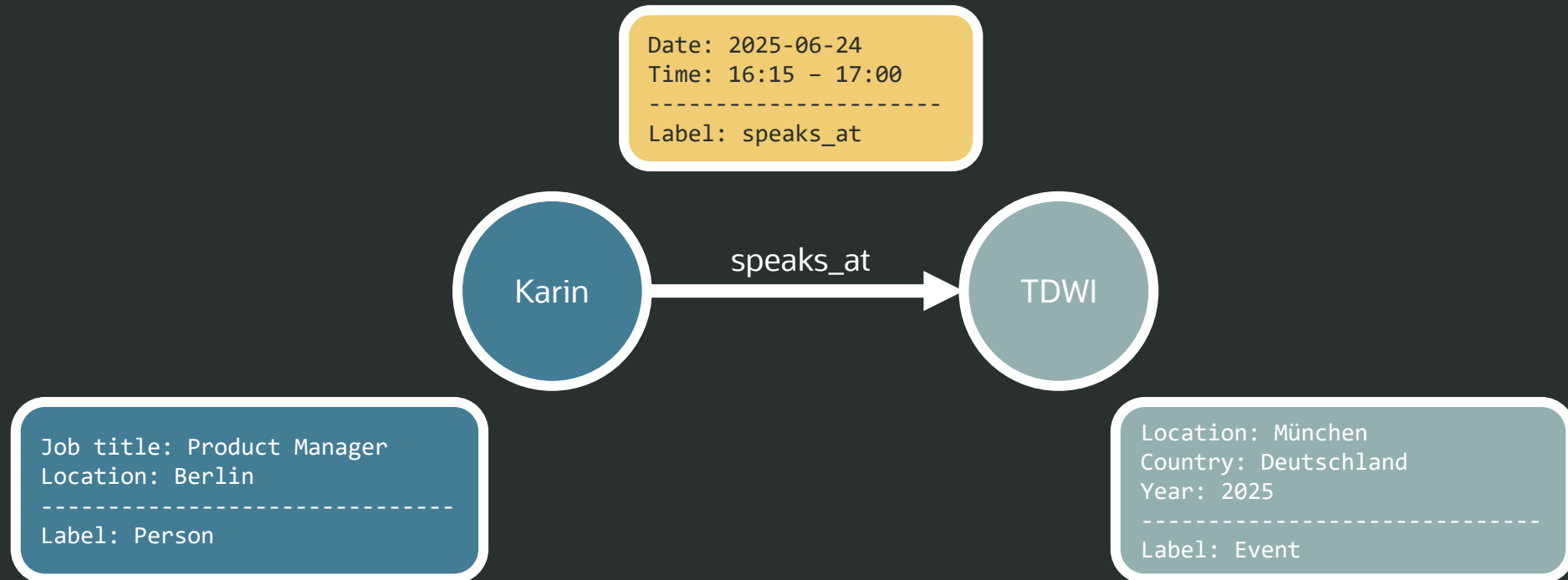
Graph RAG
Example

A Brief Intro to Graphs

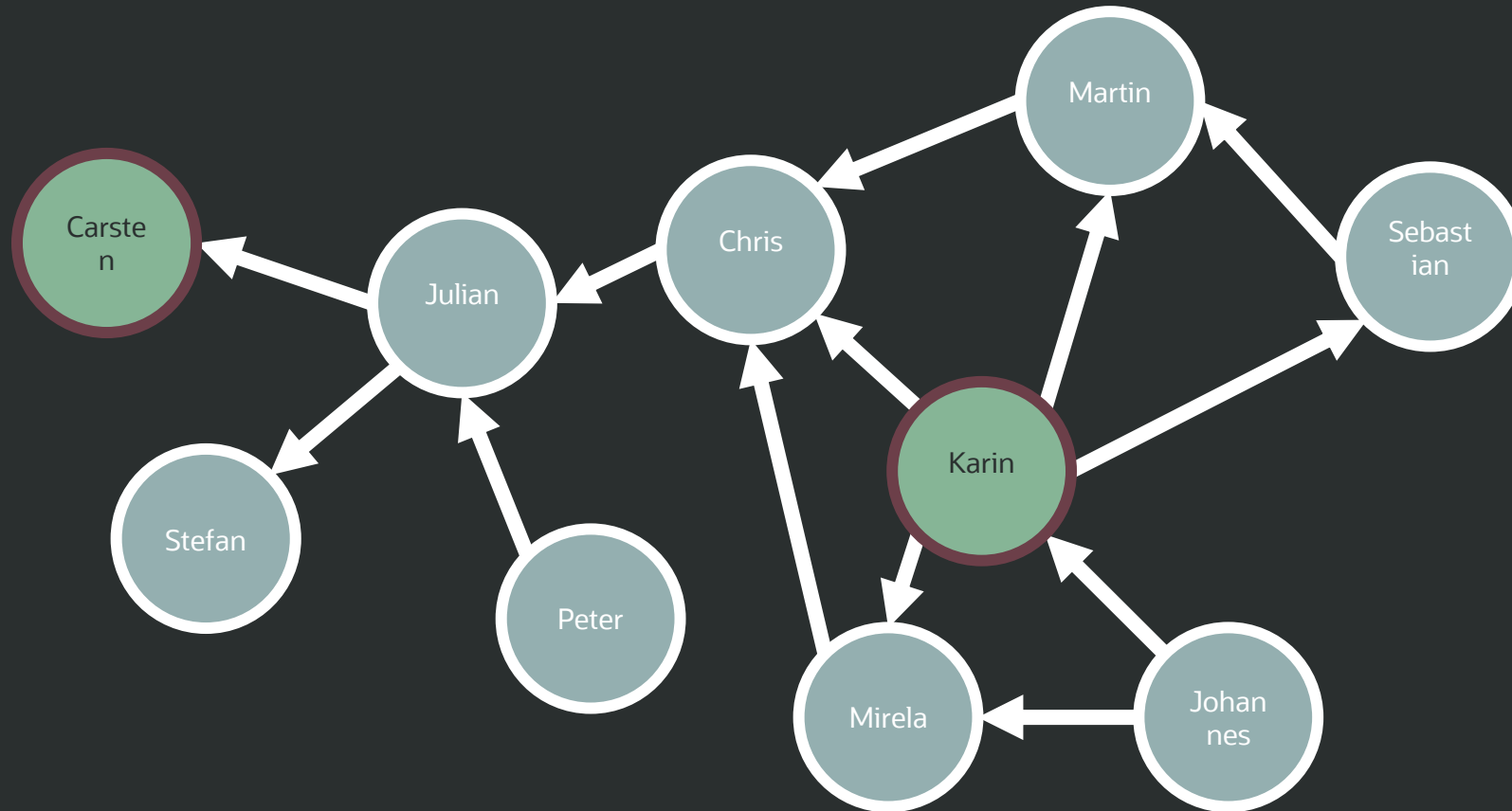


A Graph representing Connections between Entities

Attributed with Properties and Labels

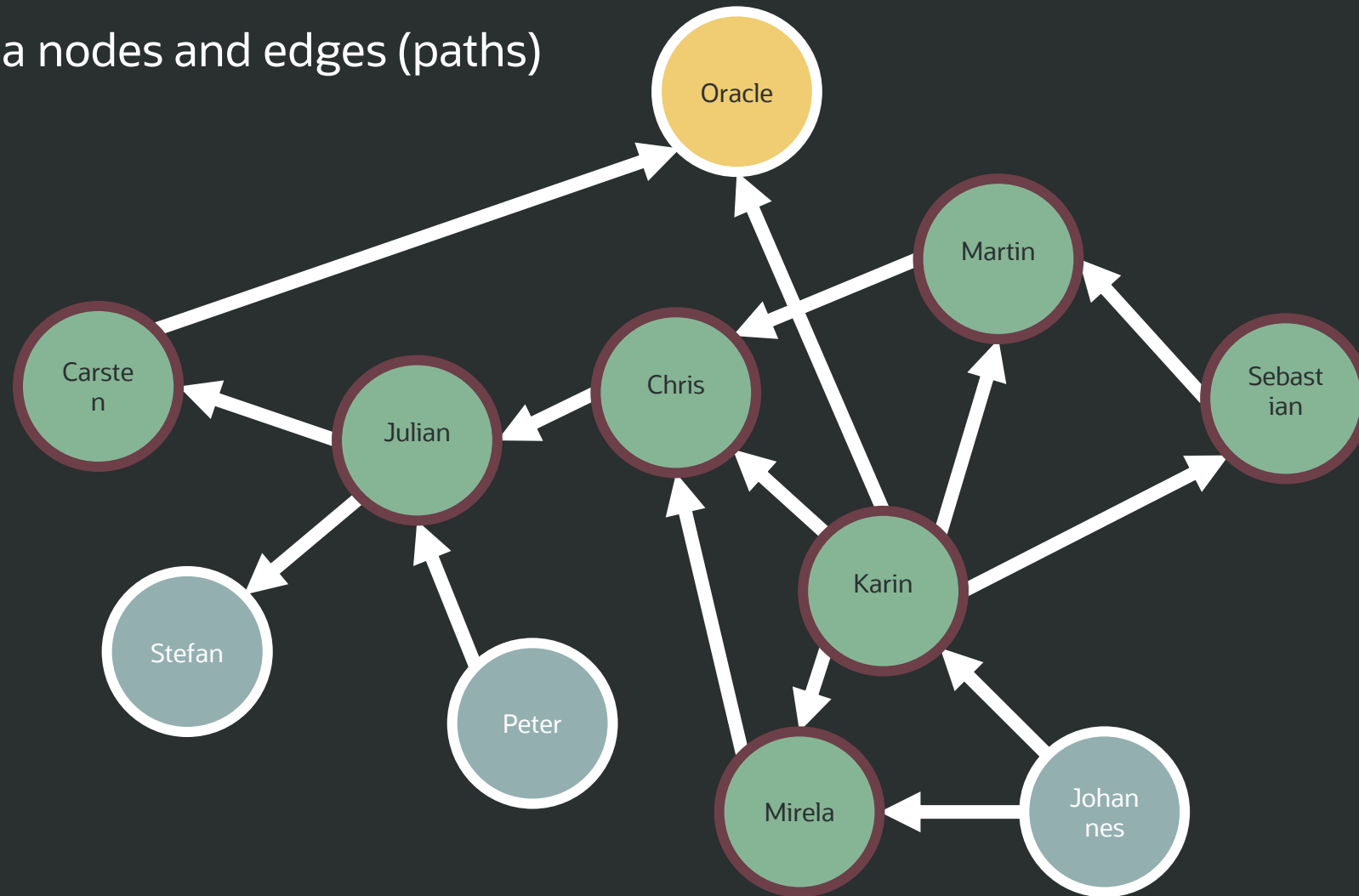


Am I connected to Niall?



Yes, I am!

Connected via nodes and edges (paths)



SQL for Property Graphs

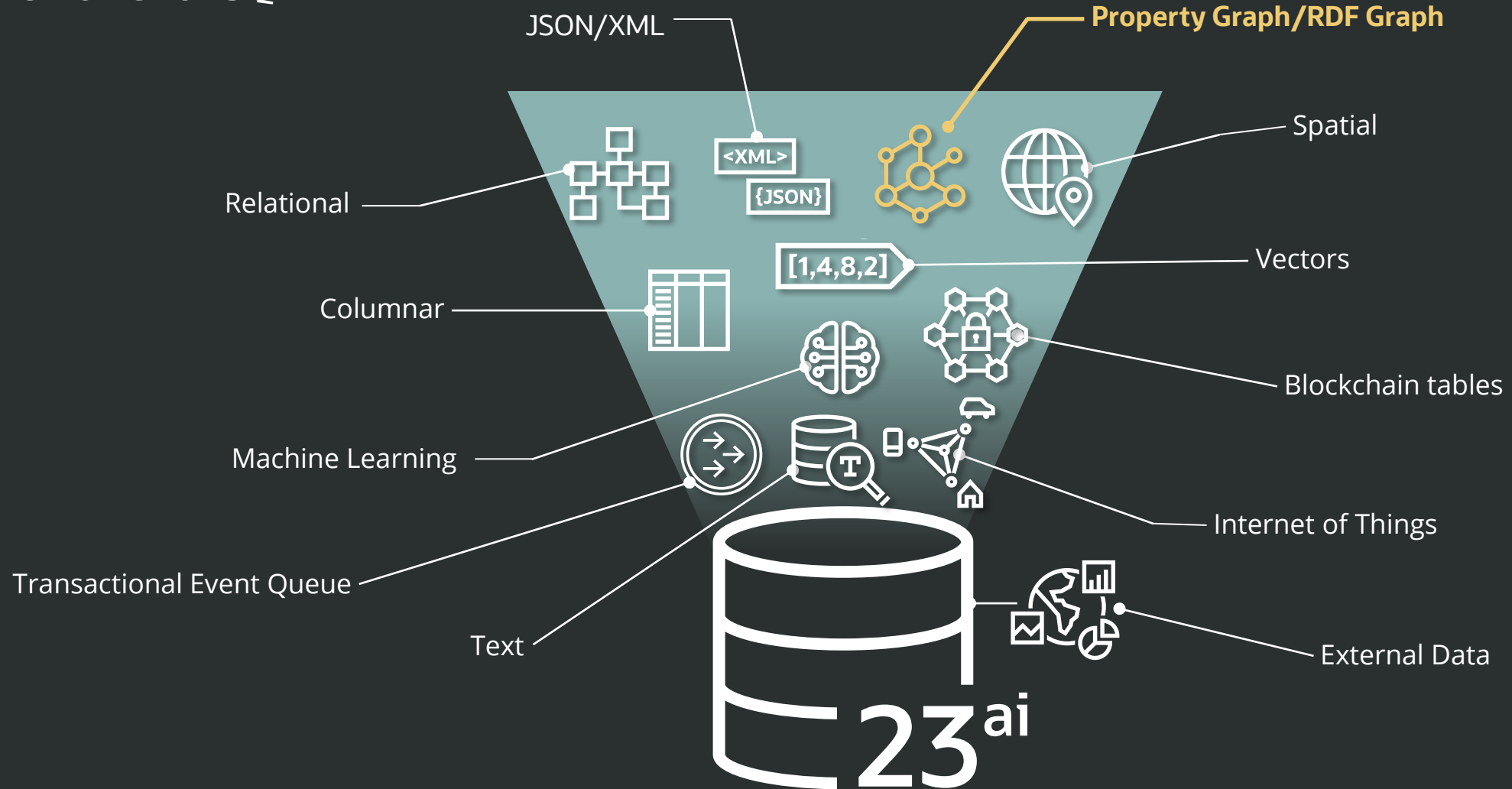
```
CREATE PROPERTY GRAPH IF NOT EXISTS simple_sql_graph
  VERTEX TABLES (
    persons
      KEY ( id ) LABEL person
      PROPERTIES ARE ALL COLUMNS,
    companies
      KEY ( id ) LABEL company
      PROPERTIES ARE ALL COLUMNS,
    events
      KEY ( id ) LABEL event
      PROPERTIES ARE ALL COLUMNS
  )
  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;

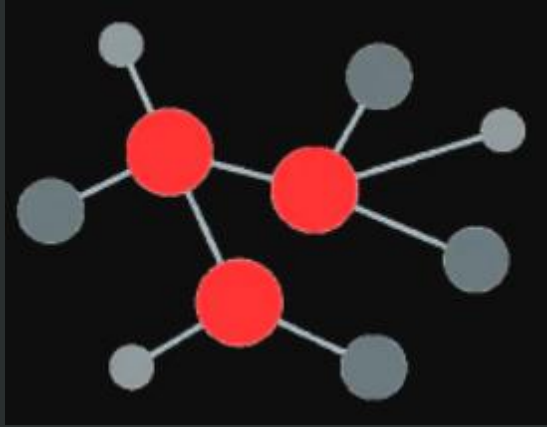
NUM_HOPS PATH
-----
3 Karin -> Chris -> Julian -> Carsten
4 Karin -> Martin -> Chris -> Julian -> Carsten
4 Karin -> Mirela -> Chris -> Julian -> Carsten
5 Karin -> Sebastian -> Martin -> Chris -> Julian -> Carsten
```

How are Graphs connected to the Oracle Database?

The Power of SQL

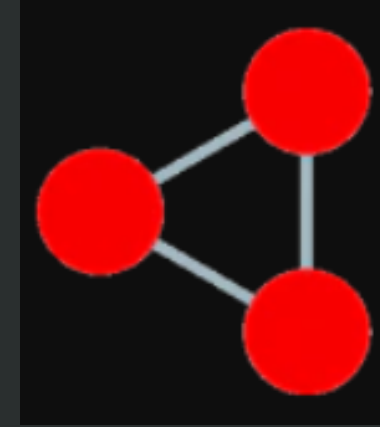


The Oracle Database as Graph Database



(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

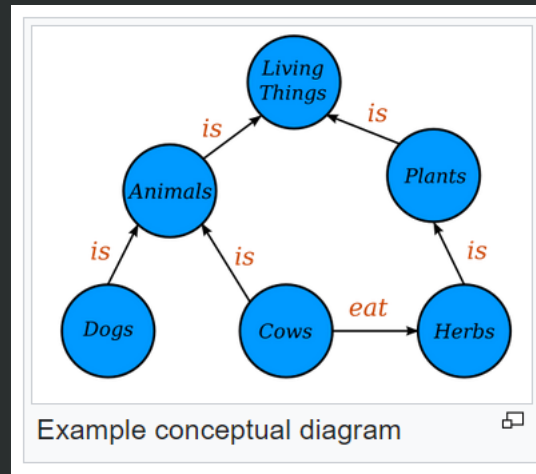


RDF Graphs

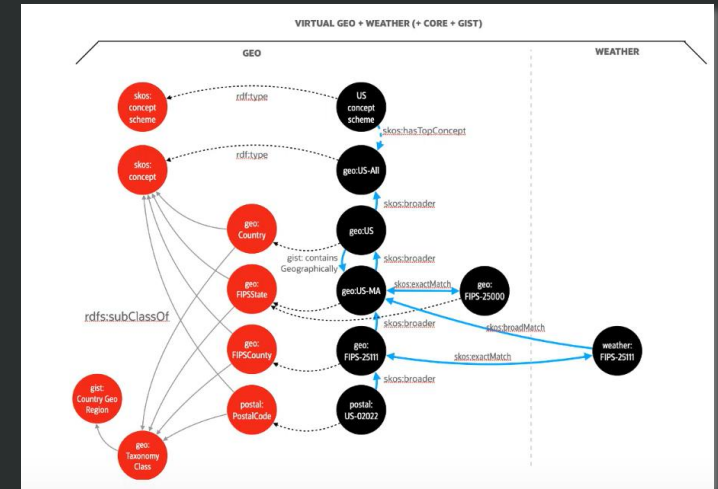
- Specialized, W3C Standards-based graph model
- Since Oracle Database version 10.2
- Keywords: Semantic Webs, RDF, Triples (Quads), Linked (Open) Data, RDFS, OWL, Ontologies, Vocabularies, Inferencing/Reasoning
- Query Language:
 - W3C Standard: SPARQL (www.w3.org/TR/sparql12-query/)
 - Native: SEM_MATCH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

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 !

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!

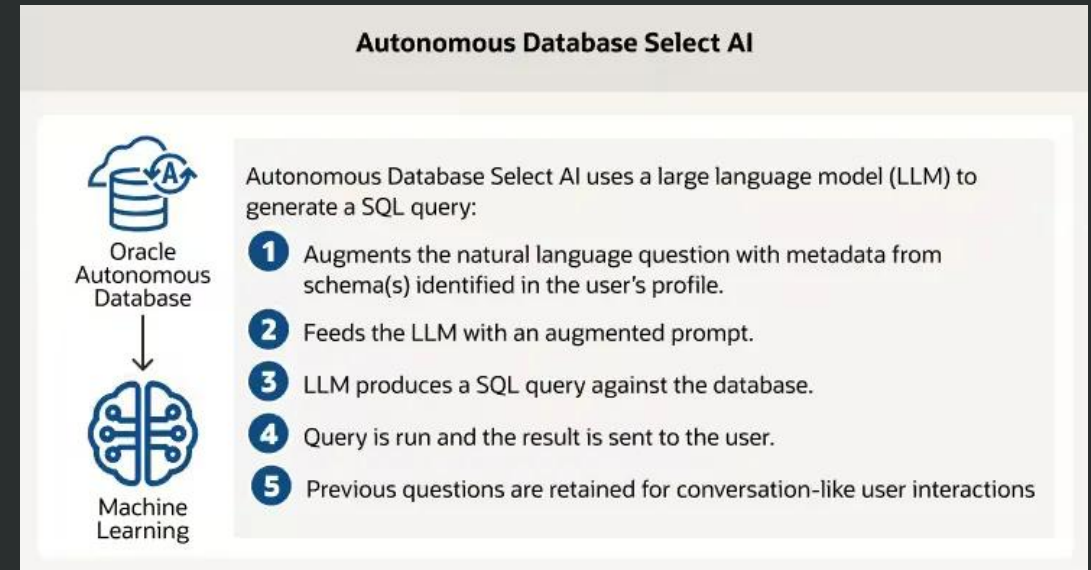
A screenshot of the Oracle SQL Developer Query Builder window. The window has a title bar with standard OS icons and a timer showing '7.671 seconds'. Below the title bar, there are two tabs: 'Worksheet' and 'Query Builder', with 'Query Builder' being the active tab. The main area of the window contains a list of three lines of text, numbered 1 to 3 on the left. Line 1 is 'select ai', line 2 is 'what are our top 10 streamed movies', and line 3 is 'that were released after 2010;'. The text is color-coded: 'select' is blue, 'ai' is black, 'what' is green, 'are' is blue, 'our' is black, 'top' is green, '10' is black, 'streamed' is black, 'movies' is black, 'that' is black, 'were' is black, 'released' is blue, 'after' is black, and '2010;' is black. A mouse cursor is visible over the text in line 3.

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

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

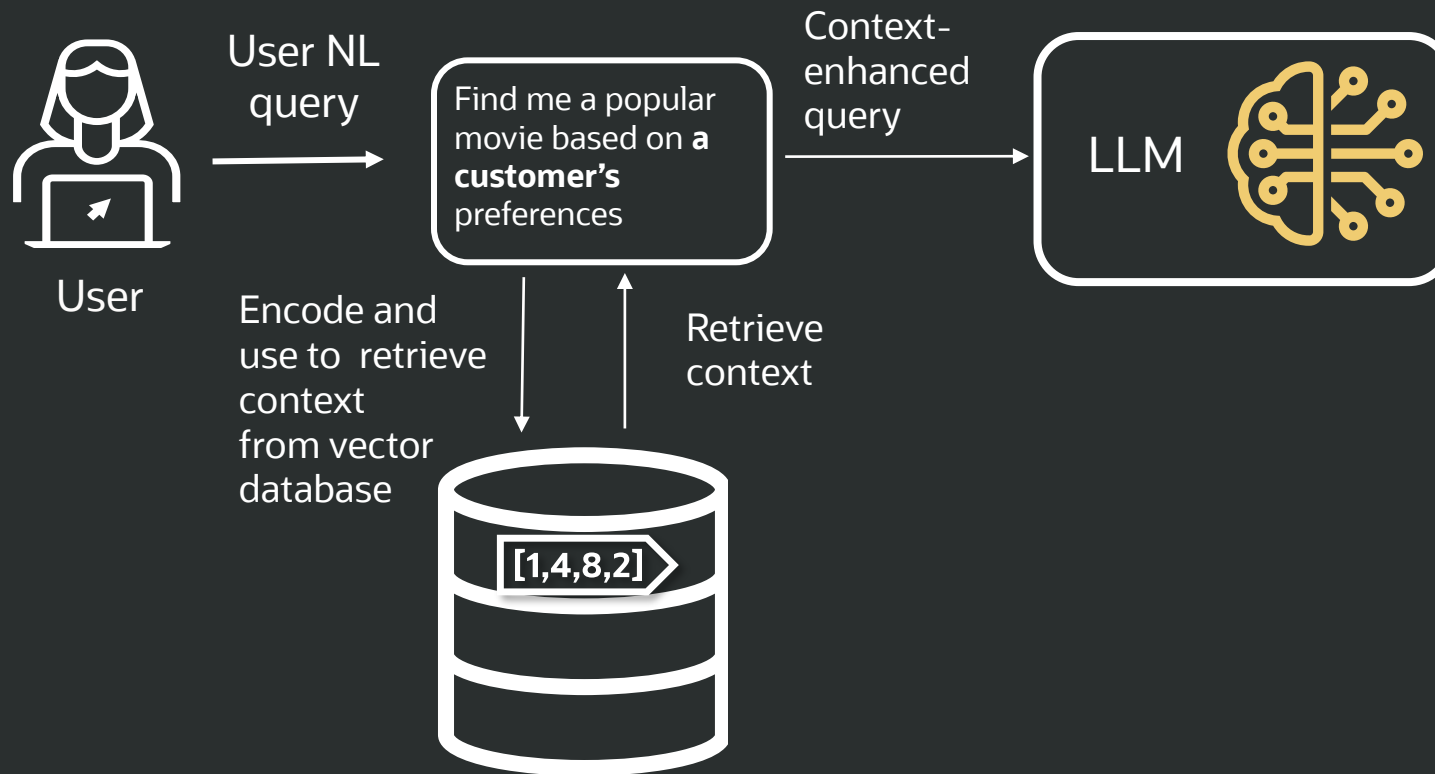


Retrieval Augmented Generation (aka RAG)

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

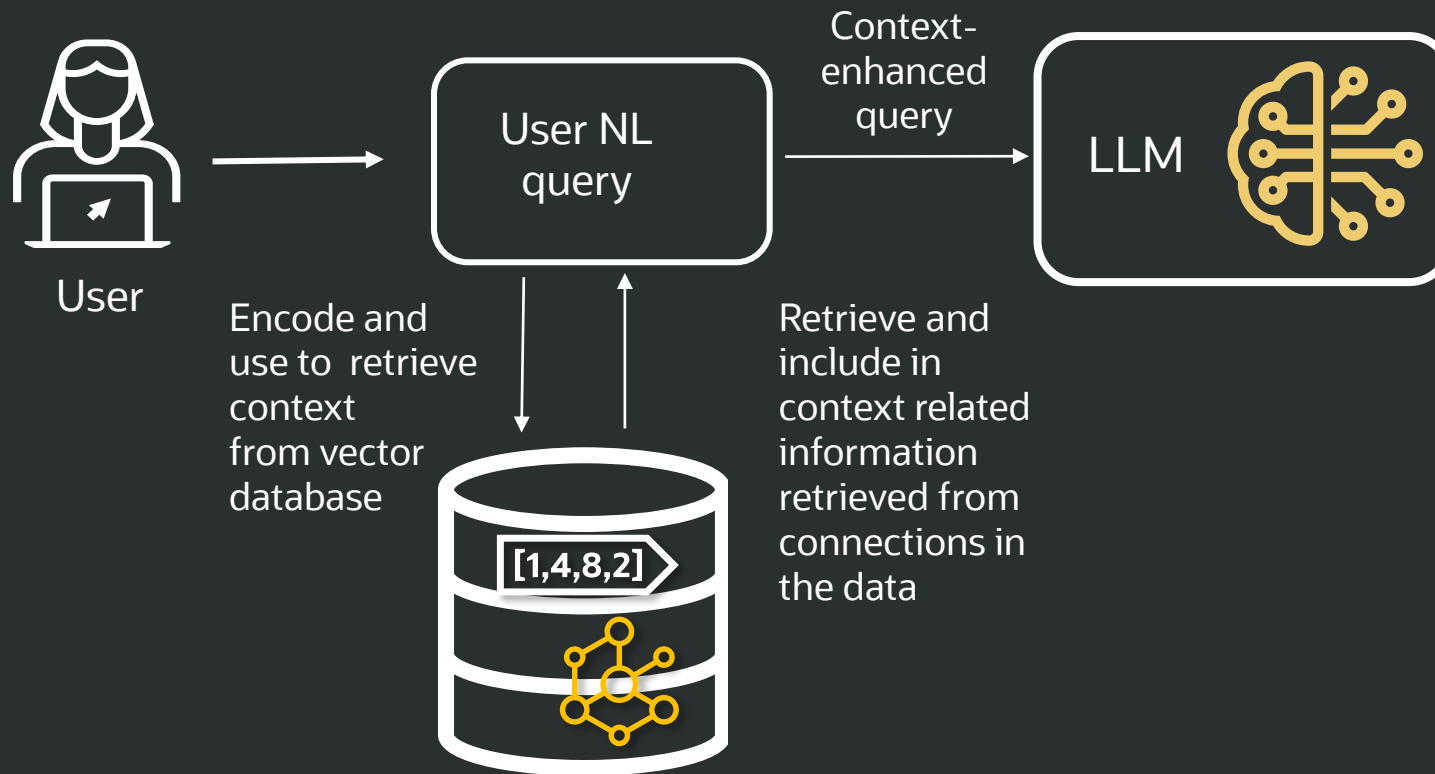
Graph RAG

Going a step further



Enhance Queries with Connections in Data

Vectors & Graphs are even better together

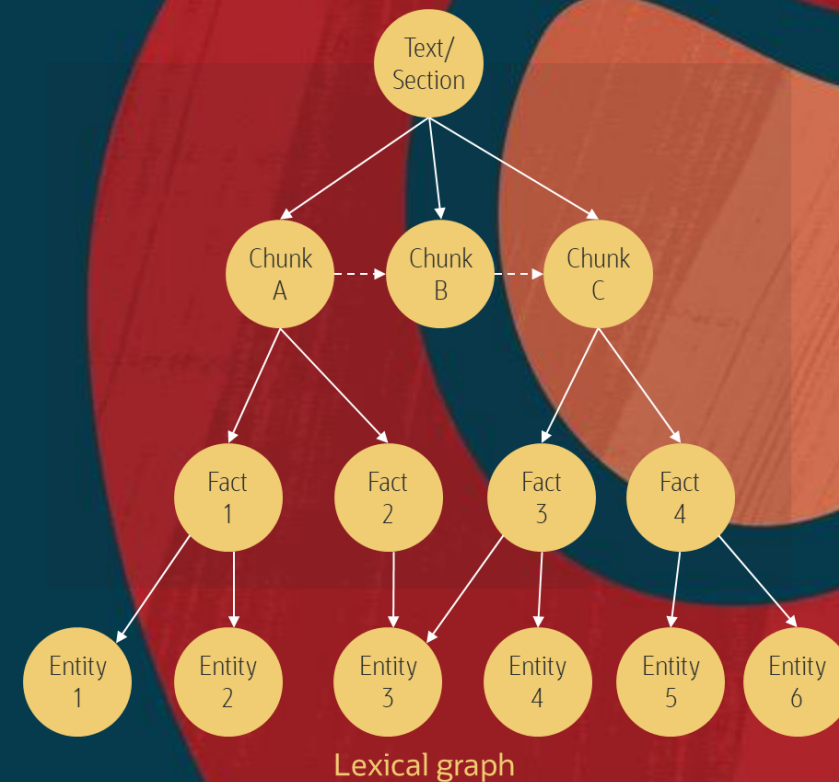
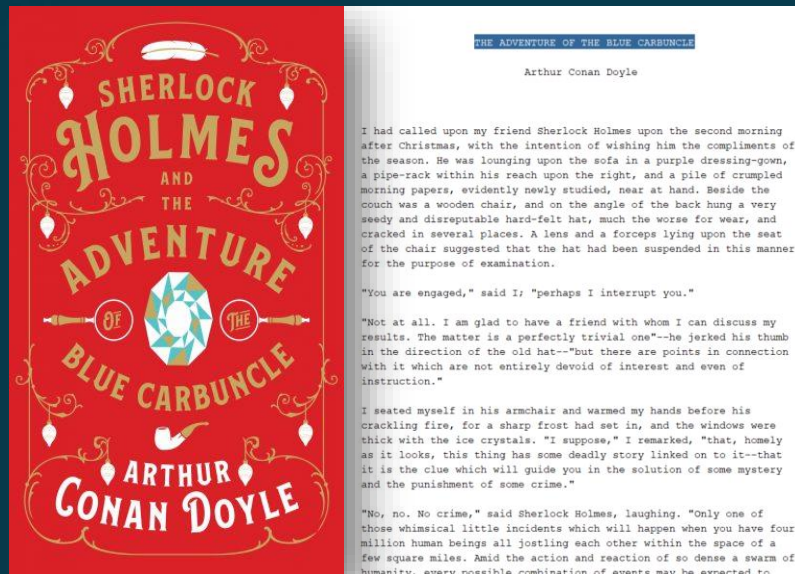


Graph RAG

Benefits of RAG
+
Connections in Data

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

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

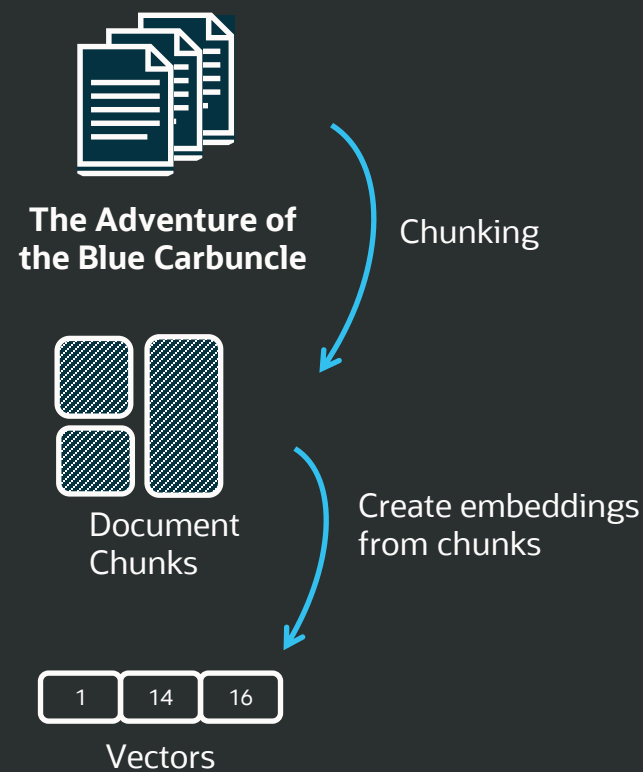
I had called upon my friend Sherlock Holmes upon the second morning after Christmas, with the intention of wishing him the compliments of the season. He was lounging upon the sofa in a purple dressing-gown, a pipe-rack within his reach upon the right, and a pile of crumpled morning papers, evidently 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."

Query Text Chunks using Vector Search



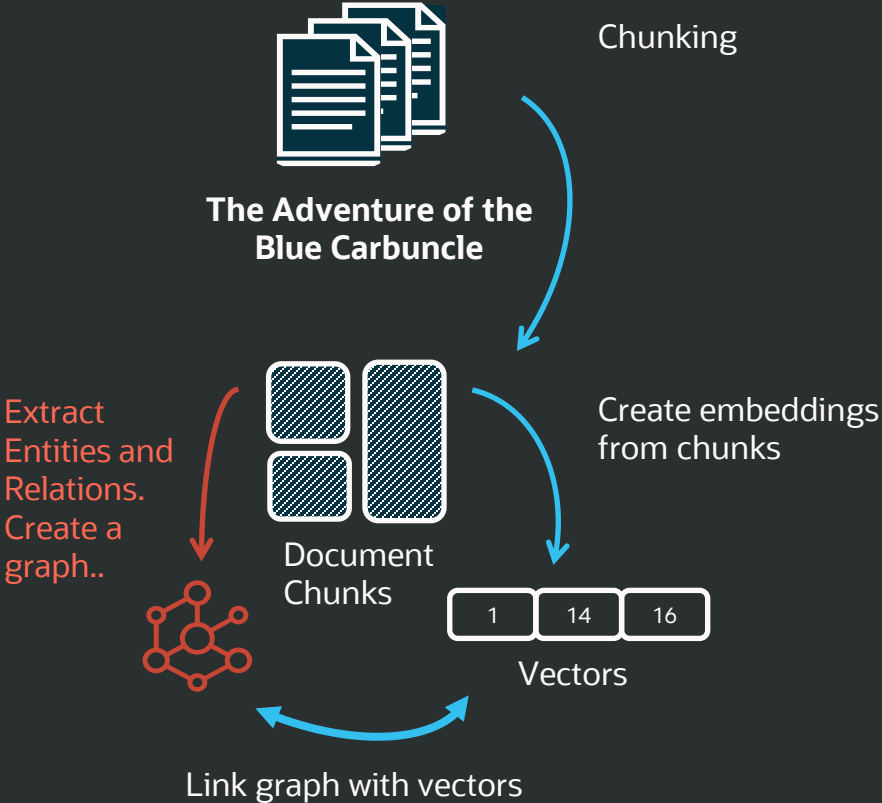
...lady's jewel-case. The evidence against him was so strong that the case has been referred to the Assizes. ...

...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**



Extract a Graph and Link with Text Chunks



"That is the reward, and I have reason to know that there are sentimental considerations in the background which would induce the Countess to part with half her fortune if she could but recover the **gem**."

"It **was lost**, ... **at the Hotel Cosmopolitan**," remarked.

"Precisely so, on December 22d, just five days ago. John Horner, a plumber, was accused of having abstracted it from the lady's jewel-case. The evidence against him was so strong that the case has been referred to the Assizes. I have some account of the matter here, I believe." He rummaged amid his newspapers, glancing over the dates, until at last he smoothed one out, doubled it over, and read the following paragraph:

"Hotel Cosmopolitan Jewel Robbery. 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. James Ryder, upper-attendant at the hotel, gave his evidence to the effect that he had shown Horner up to the dressing-room of the Countess of Morcar upon the day of the robbery in order that he might solder the second bar of the grate, which was loose. He had remained with Horner some little time, but had finally been called away. On returning, he found that Horner had disappeared, that the bureau had been forced open, and that the small morocco casket in which, as it afterwards transpired, the Countess was accustomed to keep her jewel, was lying empty upon the dressing-table. Ryder in-
"I see -- her ladyship's waiting-maid. Well, the temptation of sudden wealth so easily acquired was too much for you, as it has been for better men before you; but you were not very scrupulous in the means you used. It seems to me that there is the making of a very pretty villain in you. You knew that this man Horner, the plumber, had been concerned in some such matter before, and that suspicion would rest the more readily upon him. What did you do, then? You made some small job in my lady's room -- you and your confederate Cusack -- and you managed that he should be the man sent for. Then, when he had left, you **rifled the jewel-case**, ... the alarm, and had this unfortunate man arrested. You then --"

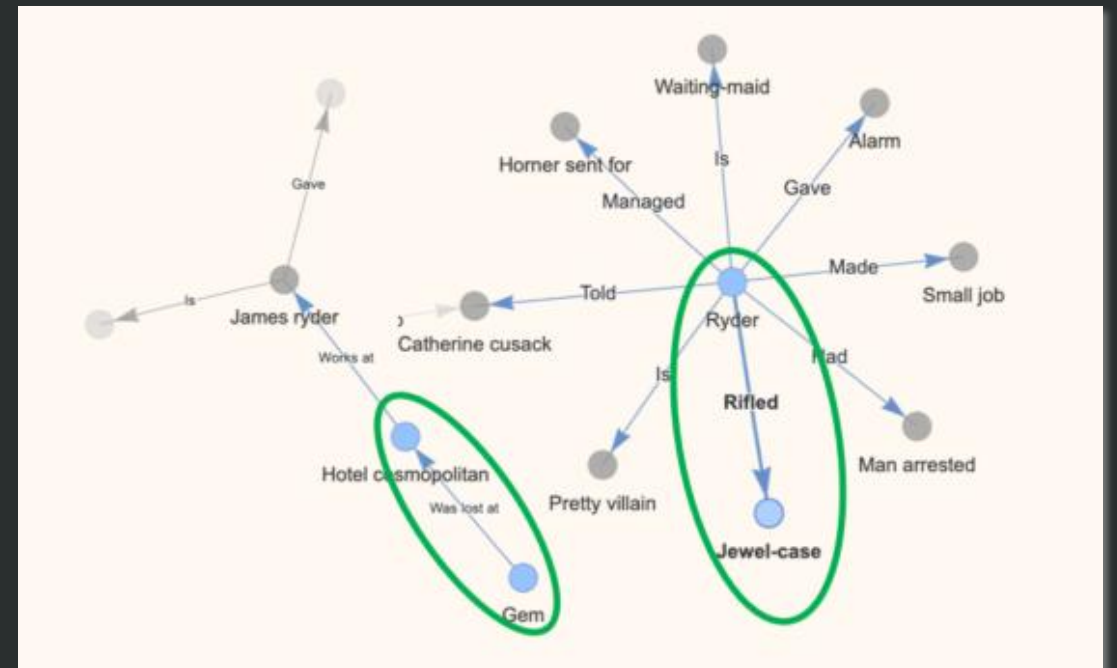


Graphs Connect Entities Across Text Chunks

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.

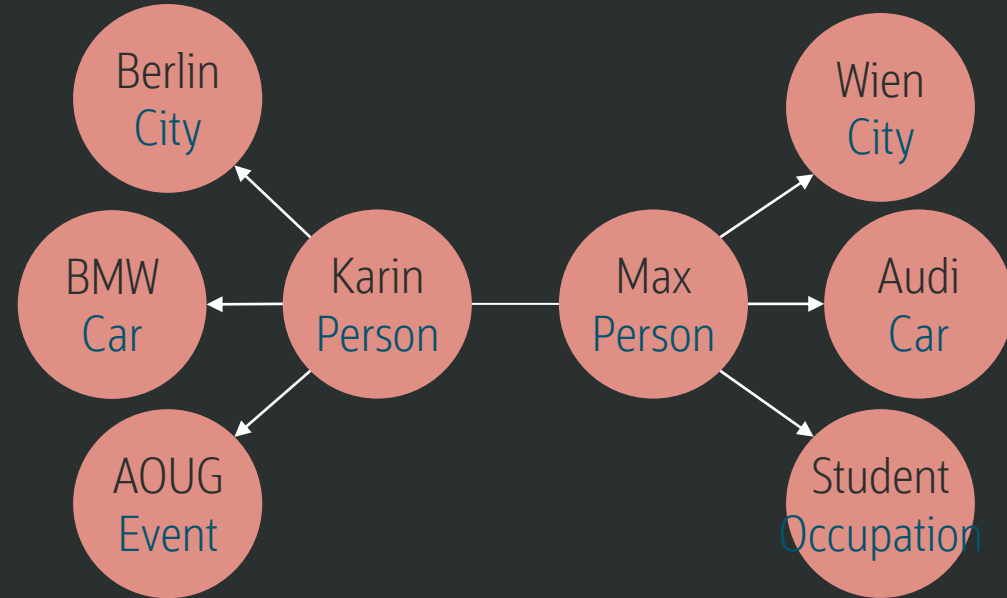


Benefits of Graph RAG

- 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,...]



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

Vielen Dank !

Karin Patenge

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