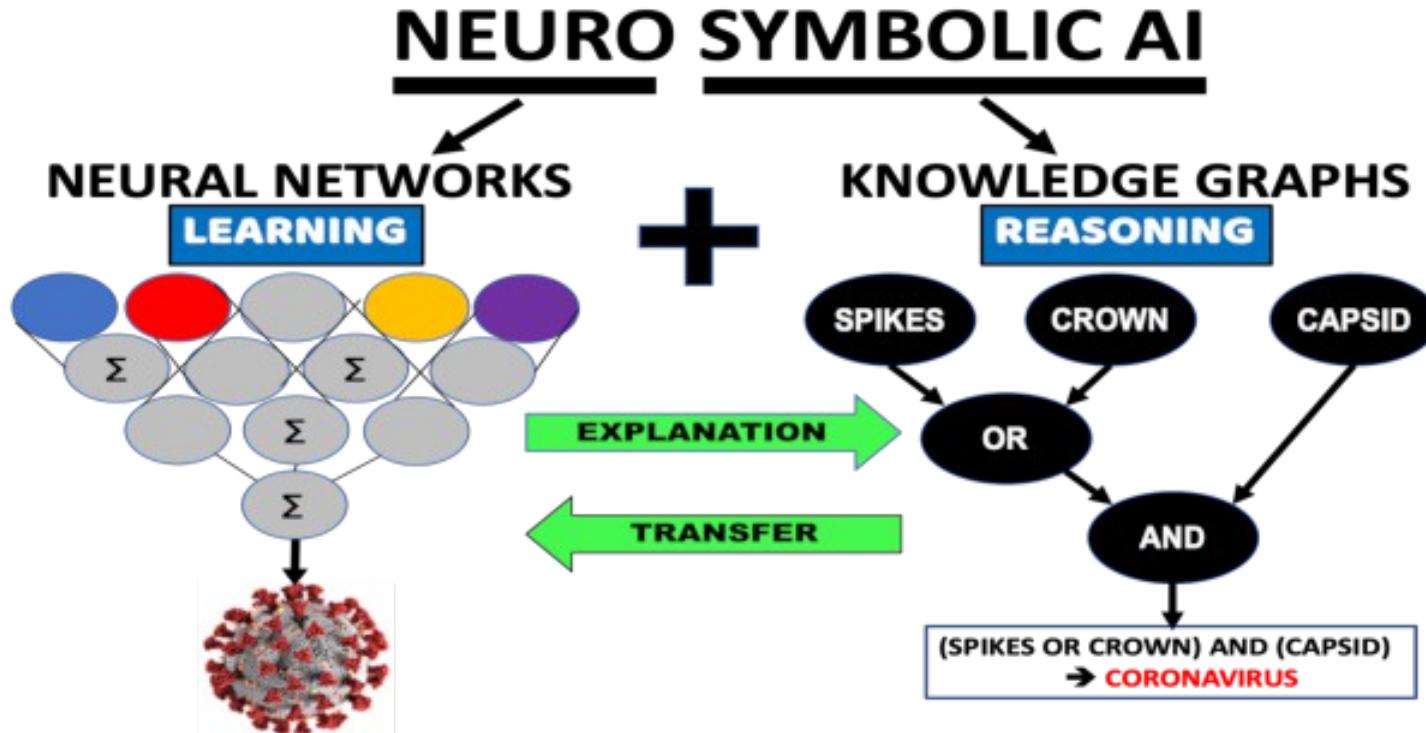


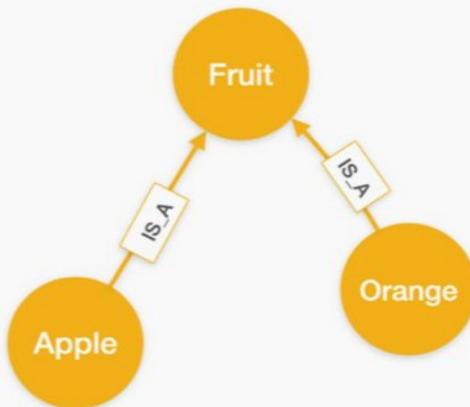
Neuro-Symbolic AI



EXPLICIT (SYMBOLIC)



Representation



IMPLICIT (SUB-SYMBOLIC)



Representation

Apple	[0.2435, 3.7652, 0.00234, 456.66, ...]
Orange	[115.124, 29.7652, 4.2131, 2.431, ...]
Fruit	[0.0035, 17.661, 0.0113, 11.4566, ...]

EXPLICIT (SYMBOLIC)

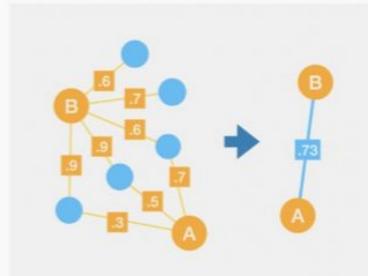
IMPLICIT (SUB-SYMBOLIC)



Similarity calculation

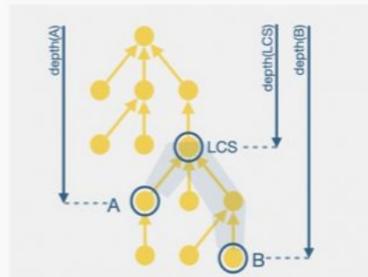
Structural

- ▶ Node similarity
- ▶ Overlap
- ▶ Jaccard



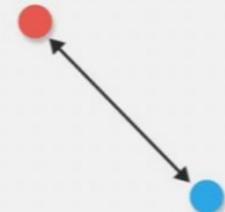
Taxonomy based

- ▶ Path
- ▶ Leacock-Chodorow
- ▶ Wu-Palmer

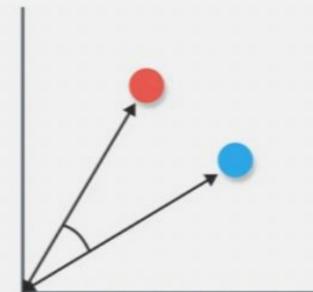


Similarity calculation

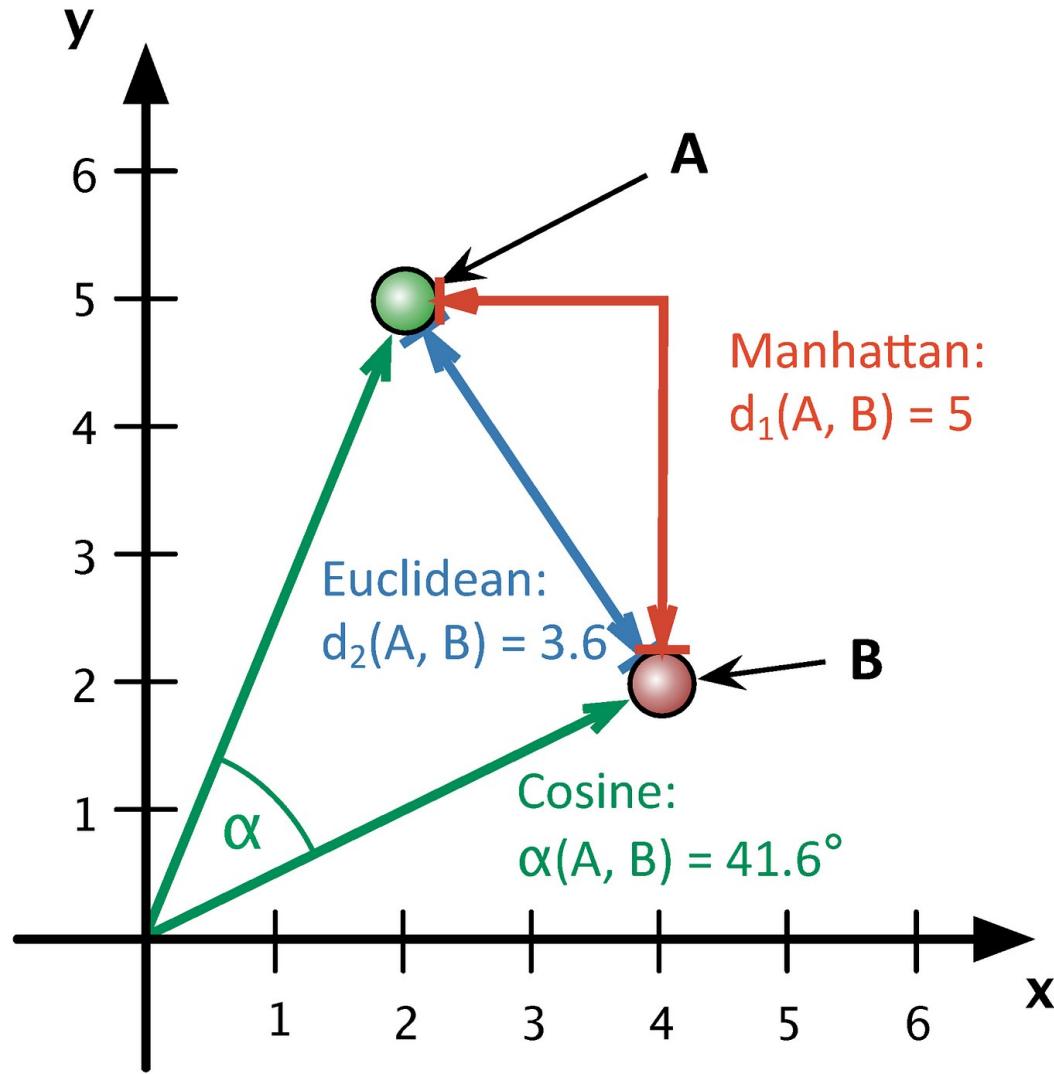
Euclidean



Cosine



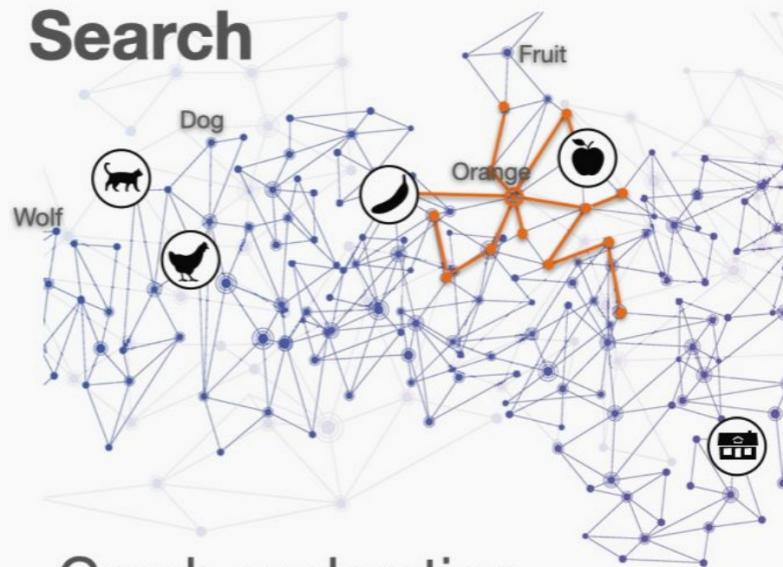
Vector distance based



EXPLICIT (SYMBOLIC)



Search



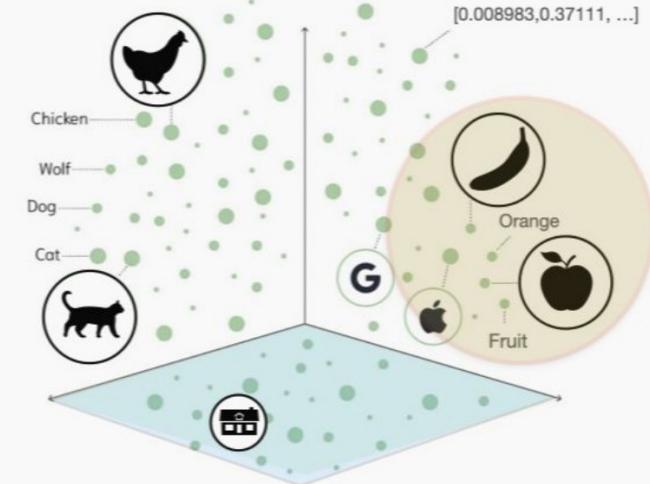
Graph exploration

IMPLICIT (SUB-SYMBOLIC)



Search

Indexing:
► IVF
► HNSW

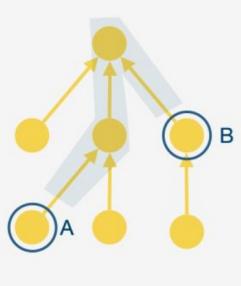


ANN (Approx. Nearest Neighbours)

Standard vs Vector semantics

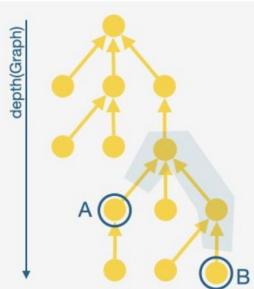
Path Similarity

$$sim(a, b) = \frac{1}{1 + dist(a, b)}$$



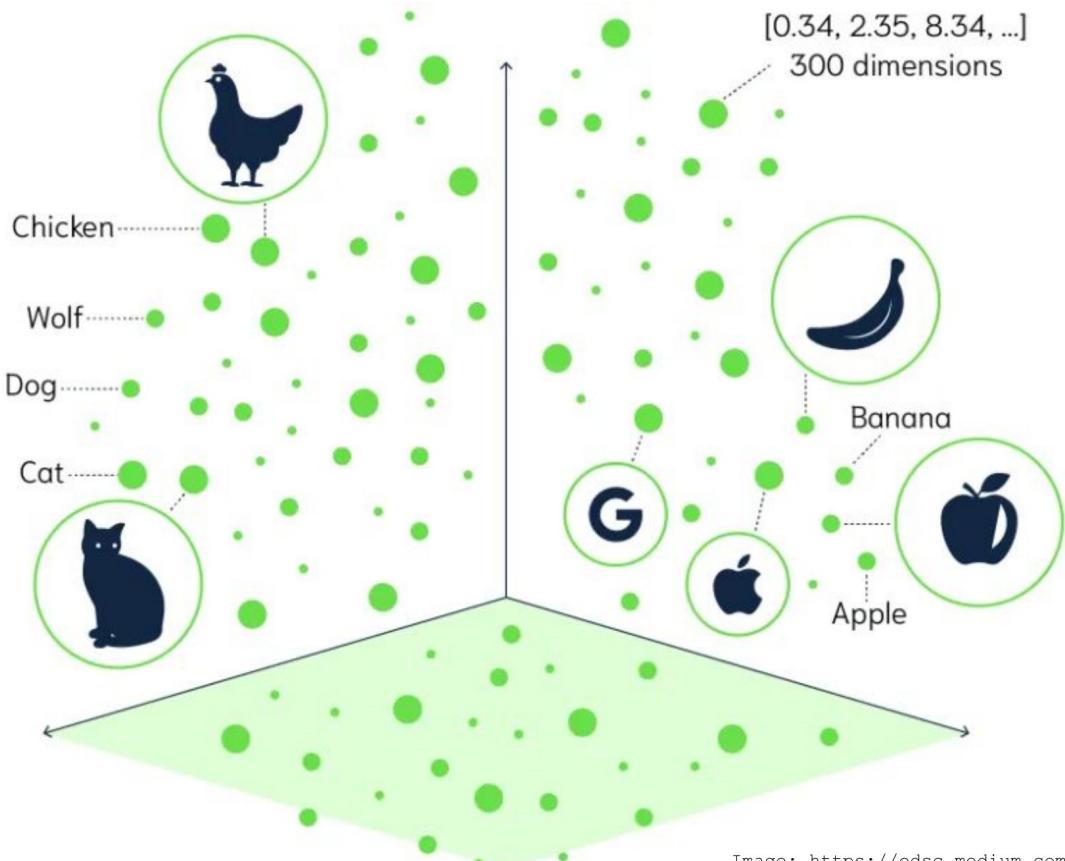
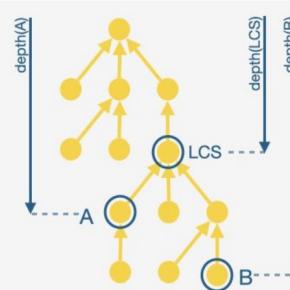
Leacock-Chodorow

$$sim(a, b) = -\log \frac{dist(a, b)}{2 \times Depth(T)}$$

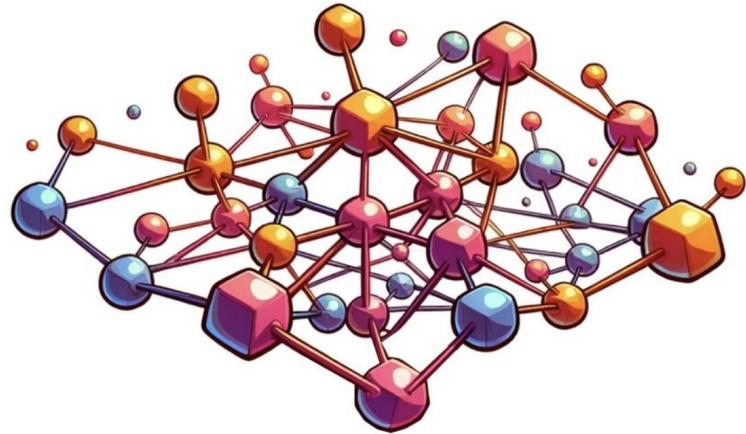


Wu-Palmer

$$sim(a, b) = \frac{2 \times depth(LCS(a, b))}{depth(a) + depth(b)}$$

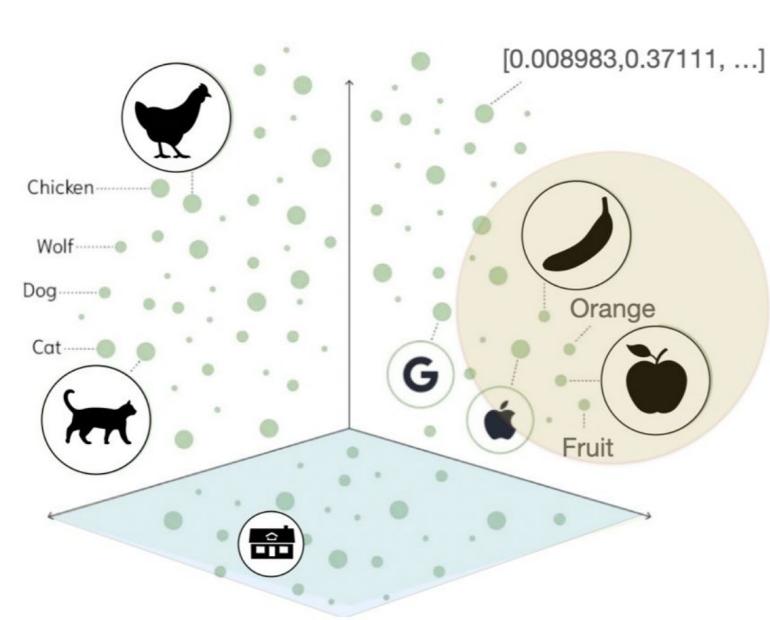


Advanced RAG patterns combine vector & graph...



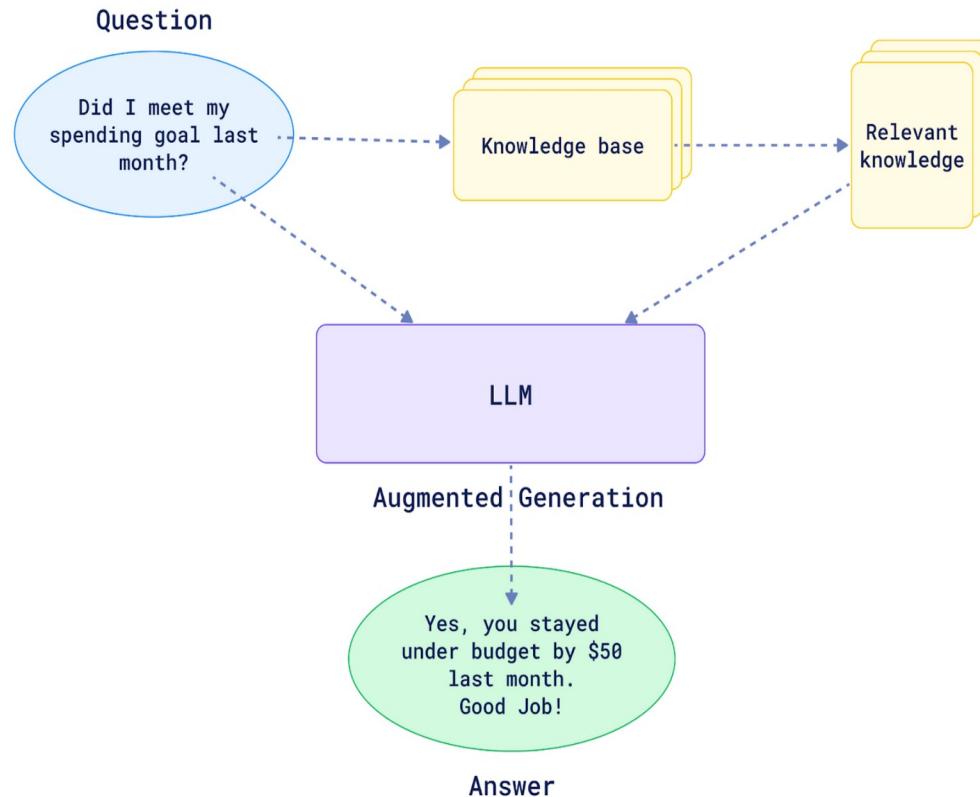
GRAPH

\$



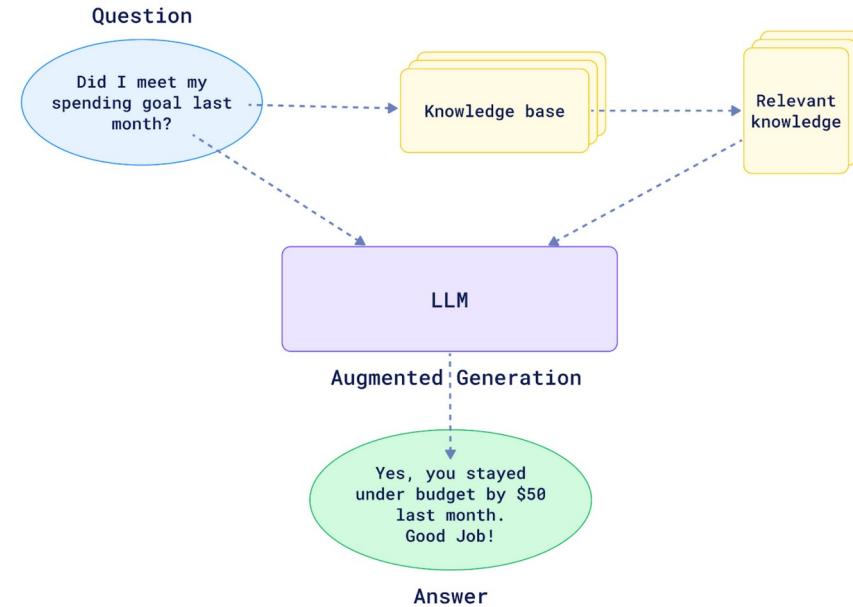
VECTOR

Retrieval Augmented Generation



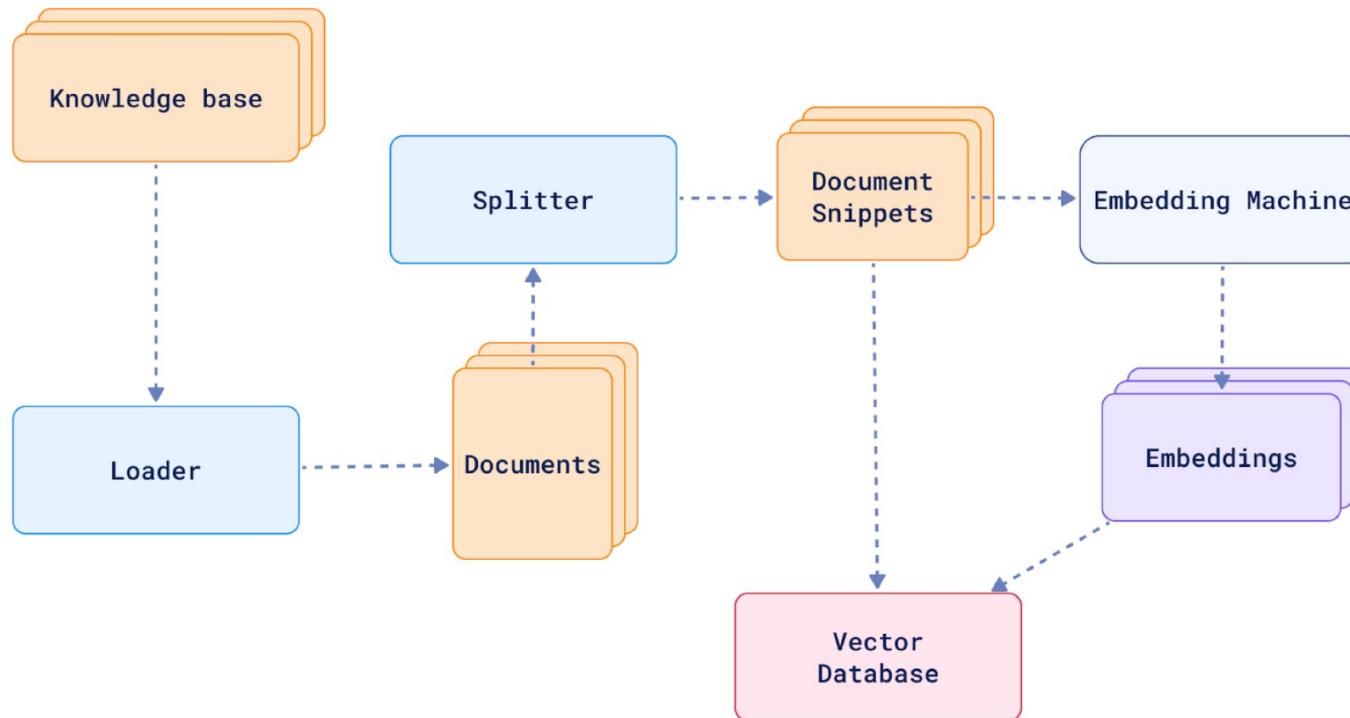
Retrieval Augmented Generation

- Hybrid Approach: RAG combines retrieval-based and generation-based capabilities in NLP.
- Retrieval Component: Retrieves knowledge base.
- Generation Component: Synthesizes coherent responses.
- Applications: Used for question answering systems, summarization, etc.
- Advantages: Overcomes limitations of retrieval-based models.
- Performance: Demonstrates state-of-the-art results on various NLP tasks.

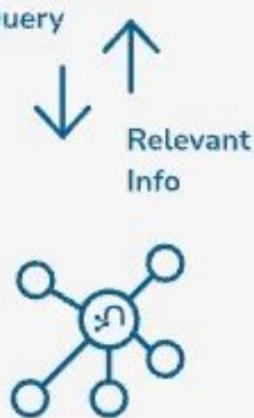


Retrieval Augmented Generation

Indexing

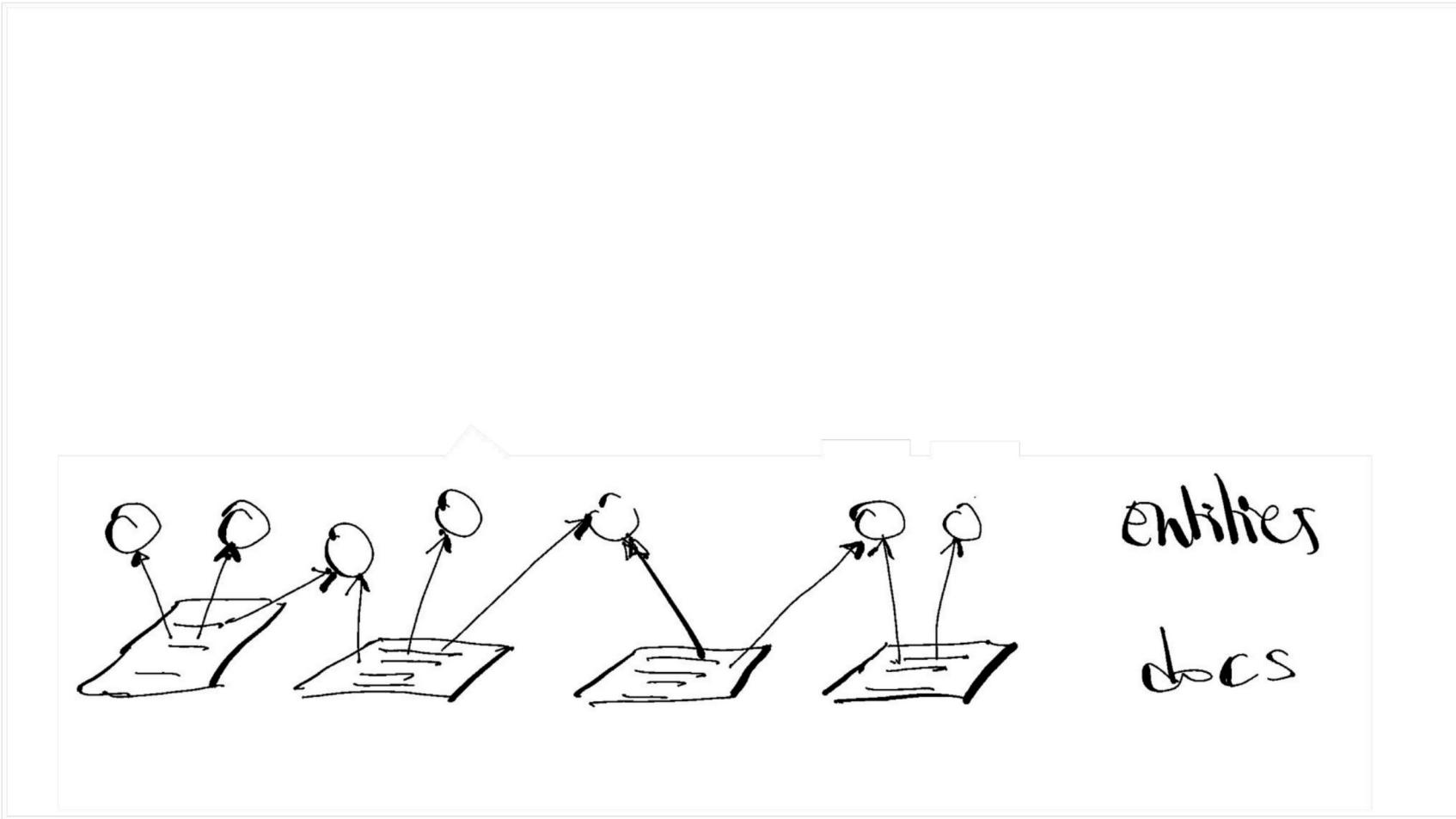


Query Knowledge Graph with LLM Application

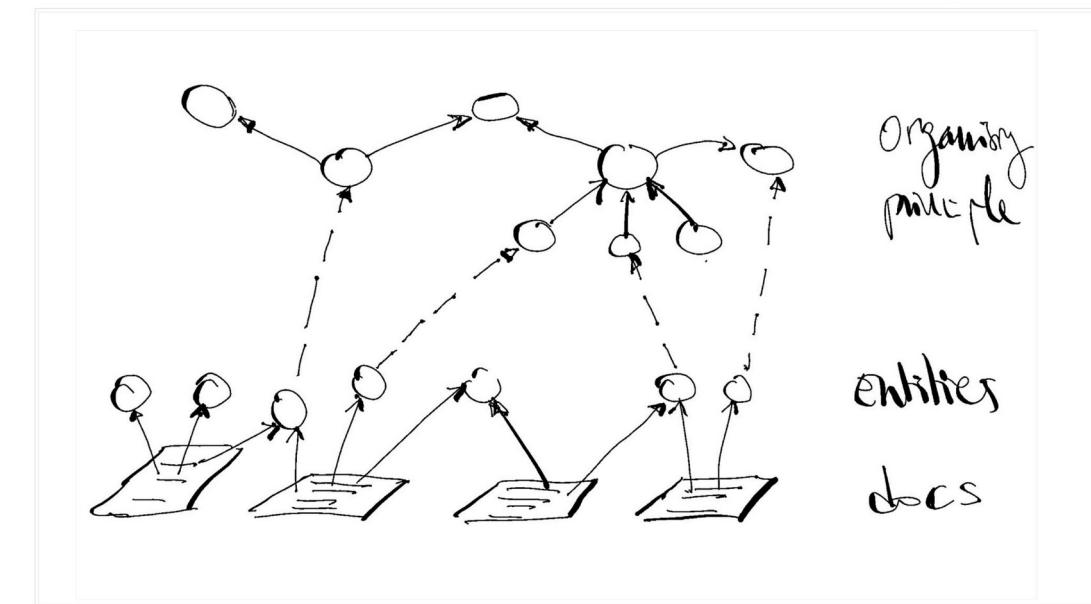


Neo4j's Knowledge Graph

Semantic Search / (Graph-based) Semantic Similarity



Semantic Search / (Graph-based) Semantic Similarity

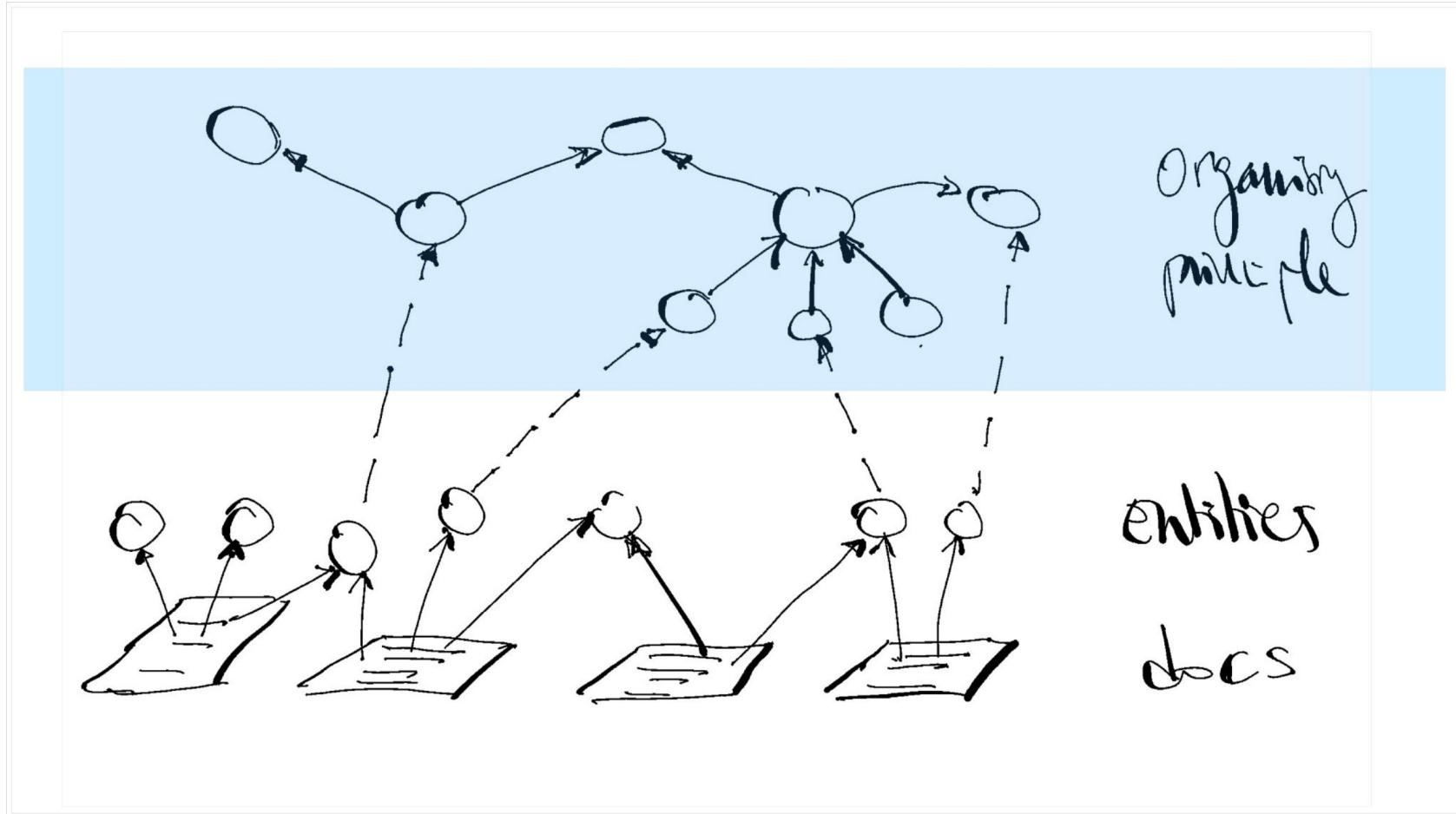


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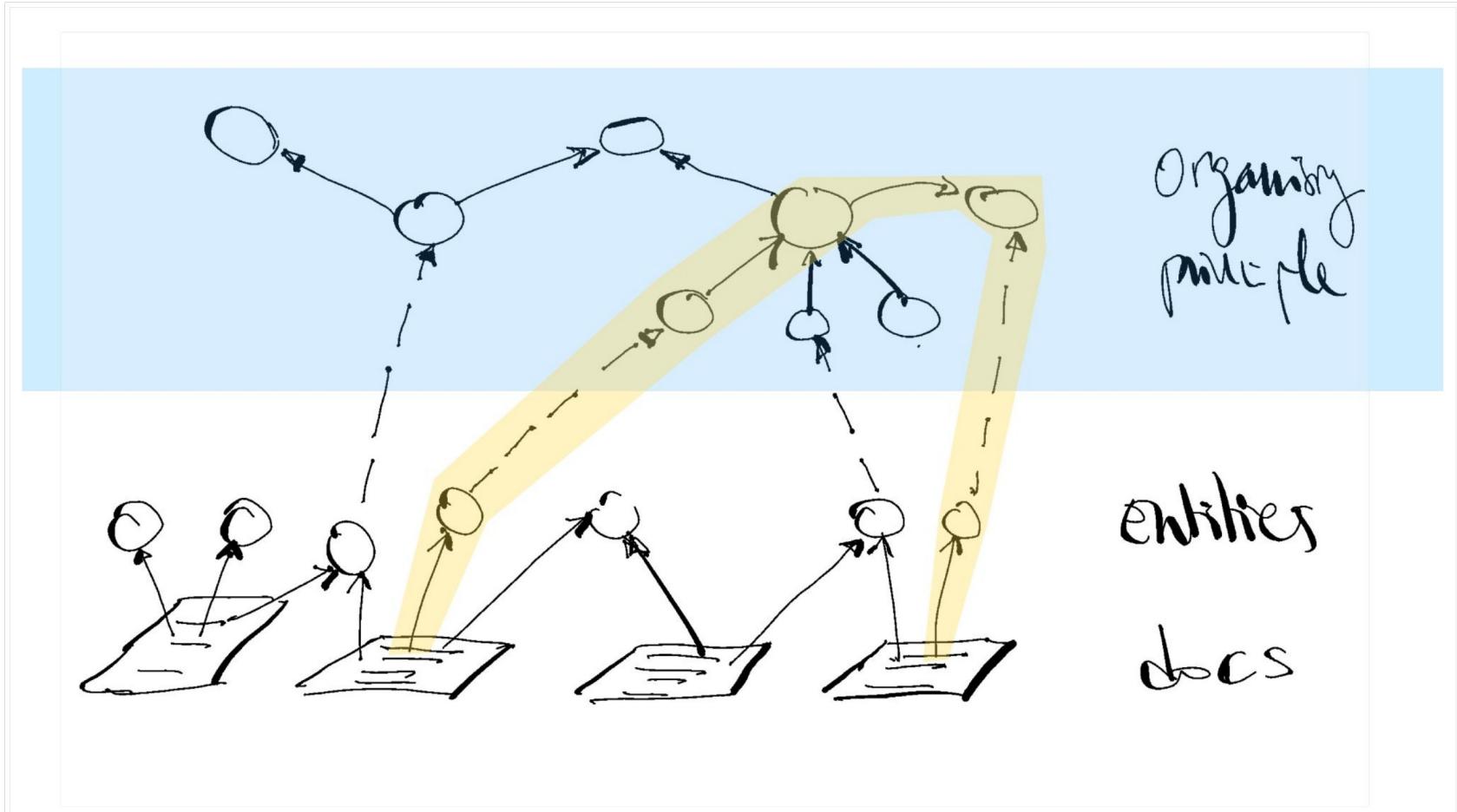
neo4j

- Organizing principle
 - documents split into Sections/Paragraphs
 - (Doc1 refers to Doc2 / Section 5 of Doc)

Semantic Search / (Graph-based) Semantic Similarity

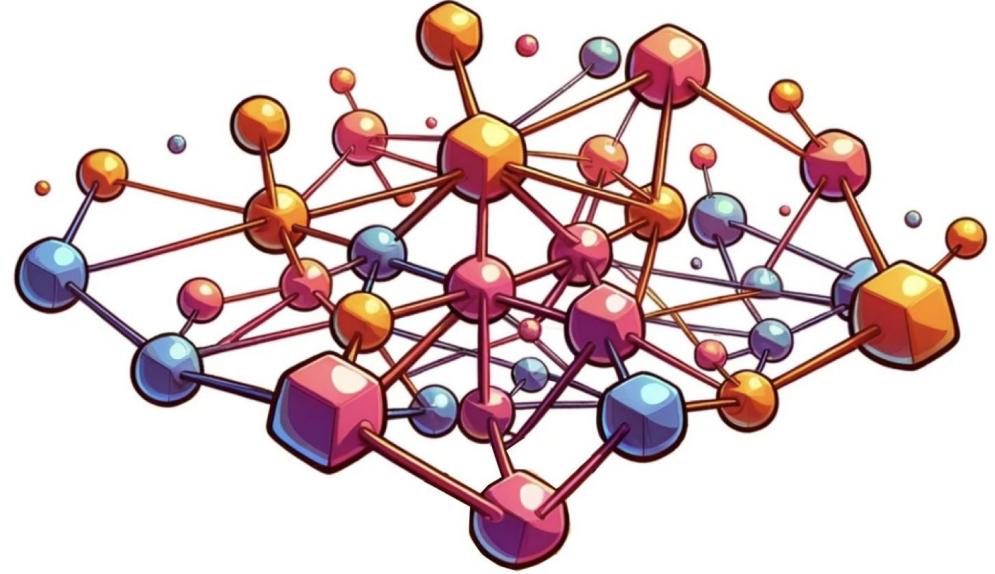


Semantic Search / (Graph-based) Semantic Similarity

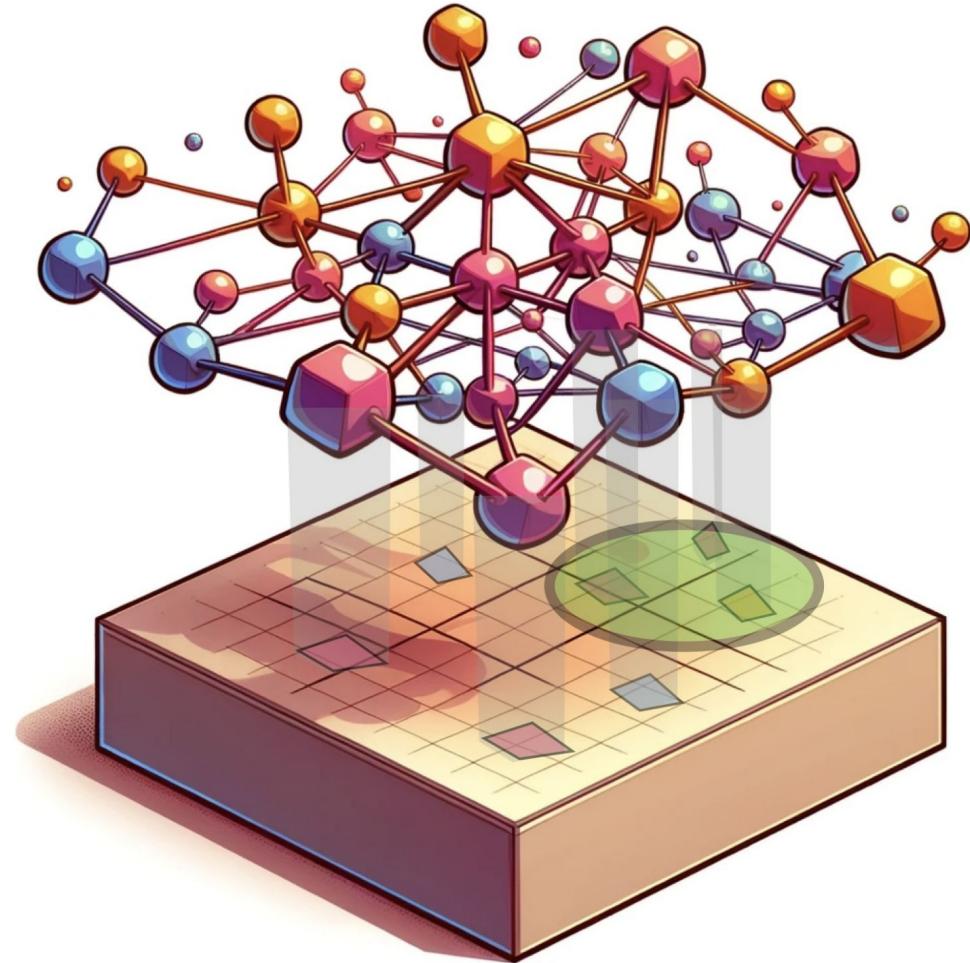


A **Knowledge Graph** captures key enterprise knowledge in the form of **entities and relationships between them**.

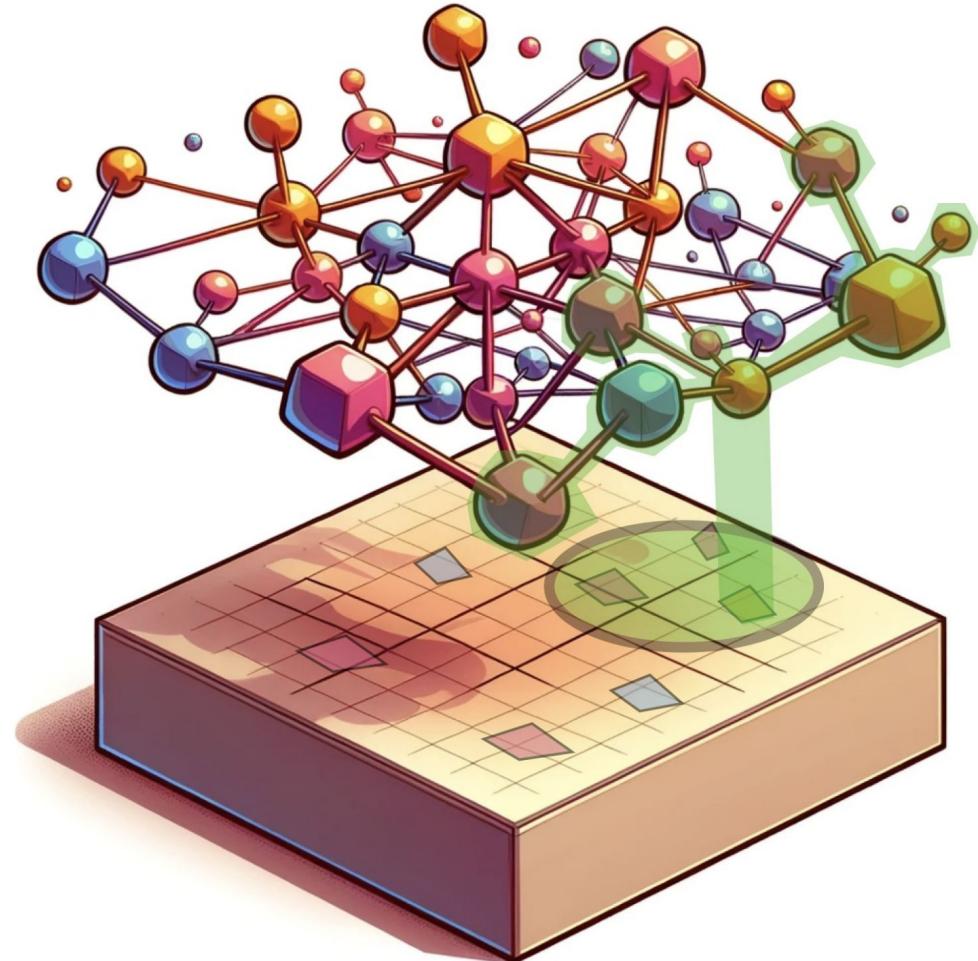
Some nodes in the graph have properties with NL text



A semantic search on the vector index returns the k **approximate nearest neighbours** to the search concept (word, question, image, etc)

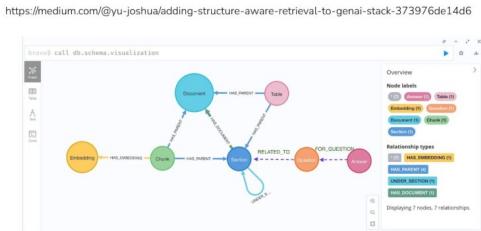
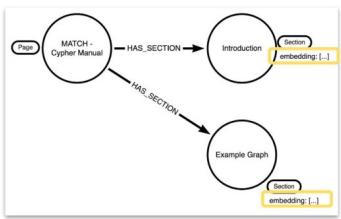


Each result from the vector search is “dereferenced” to get the corresponding node in the graph and a subsequent **graph exploration** finds **semantically related elements** that enrich and augment the final search result.



How do KG improve RAG?

Making retrieval **structure-aware**



https://medium.com/heo4j/building-an-educational-chatbot-for-graphacademy-with-neo4j-f707c4ce311b

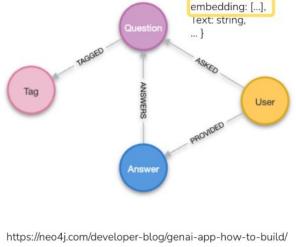
neo4j

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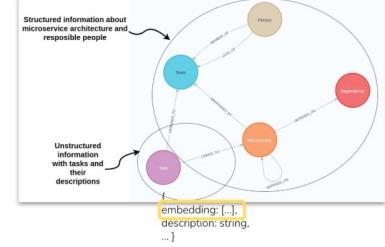
How do KG improve RAG?

Enabling **context augmentation**



https://neo4j.com/developer-blog/genai-app-how-to-build/

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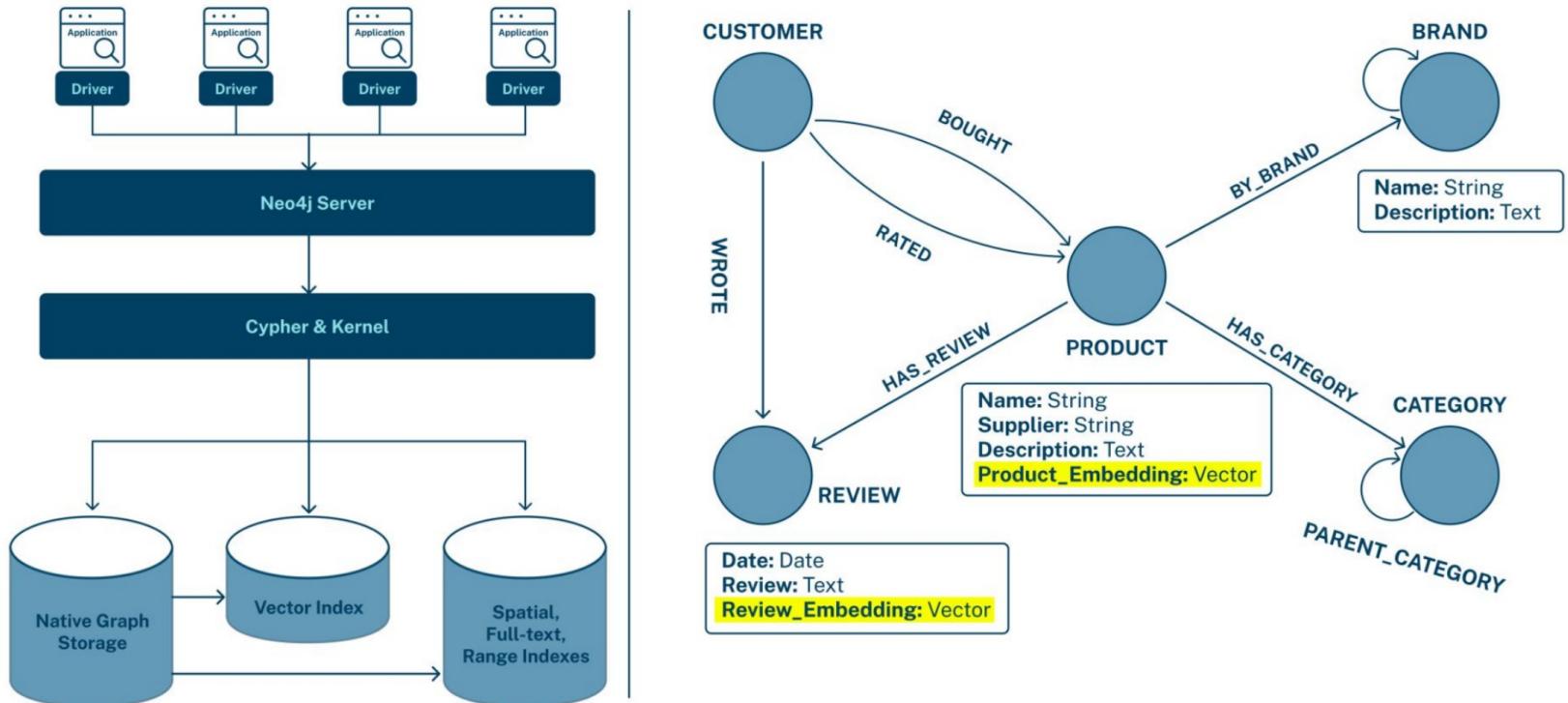


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neo4j

Neo4j's Vector Search



<https://neo4j.com/blog/vector-search-deeper-insights/>



<https://neo4j.com/docs/cypher-manual/current/indexes-for-vector-searc>

```
sudo neo4j-admin database load --from-path=/home/.../Documents/..../dump neo4j  
--overwrite-destination=true --verbose
```