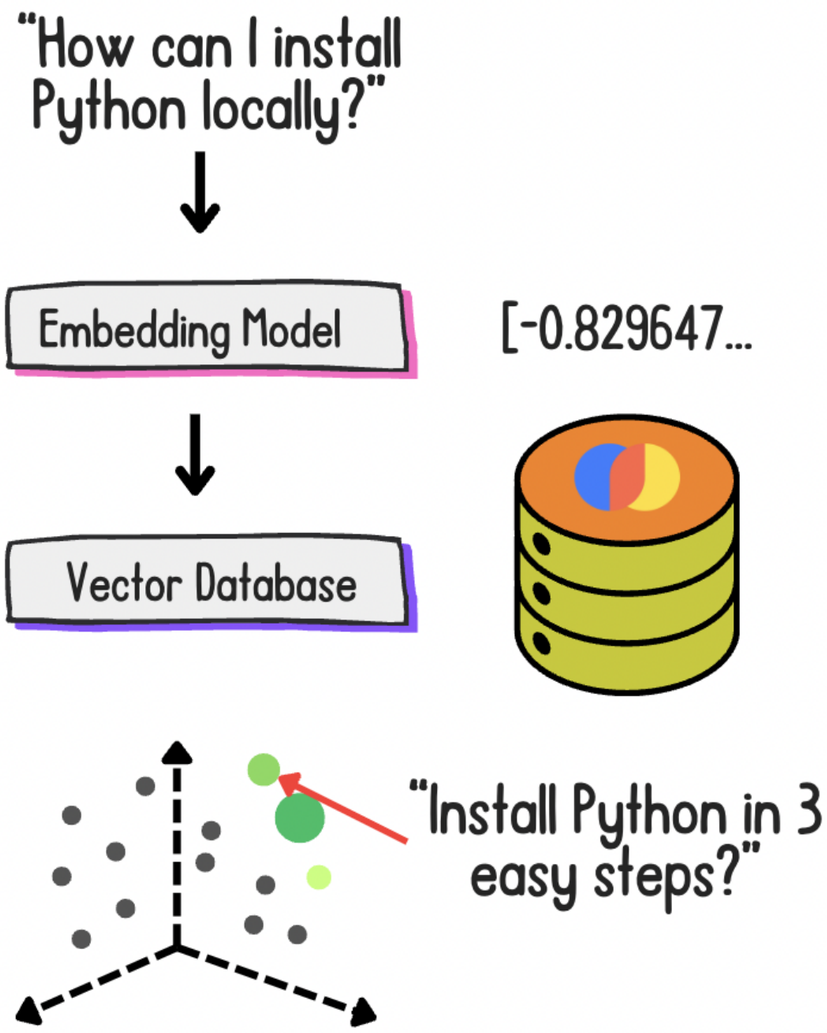
From vectors to graphs

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

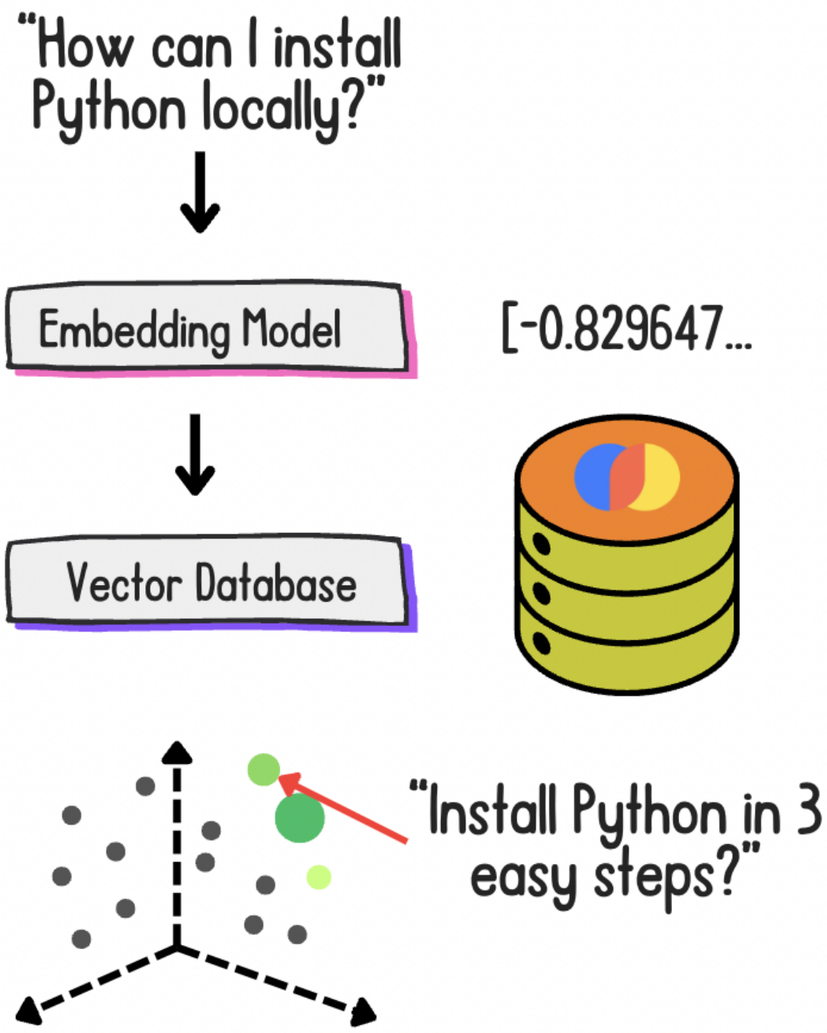
Meri Nova
Machine Learning Engineer

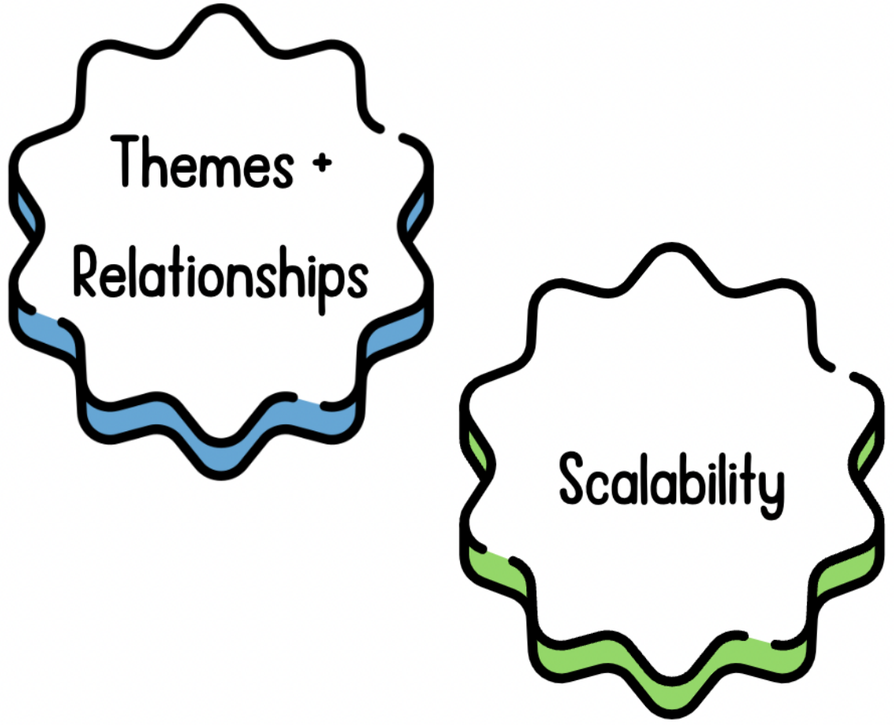
datacamp

Vector RAG limitations

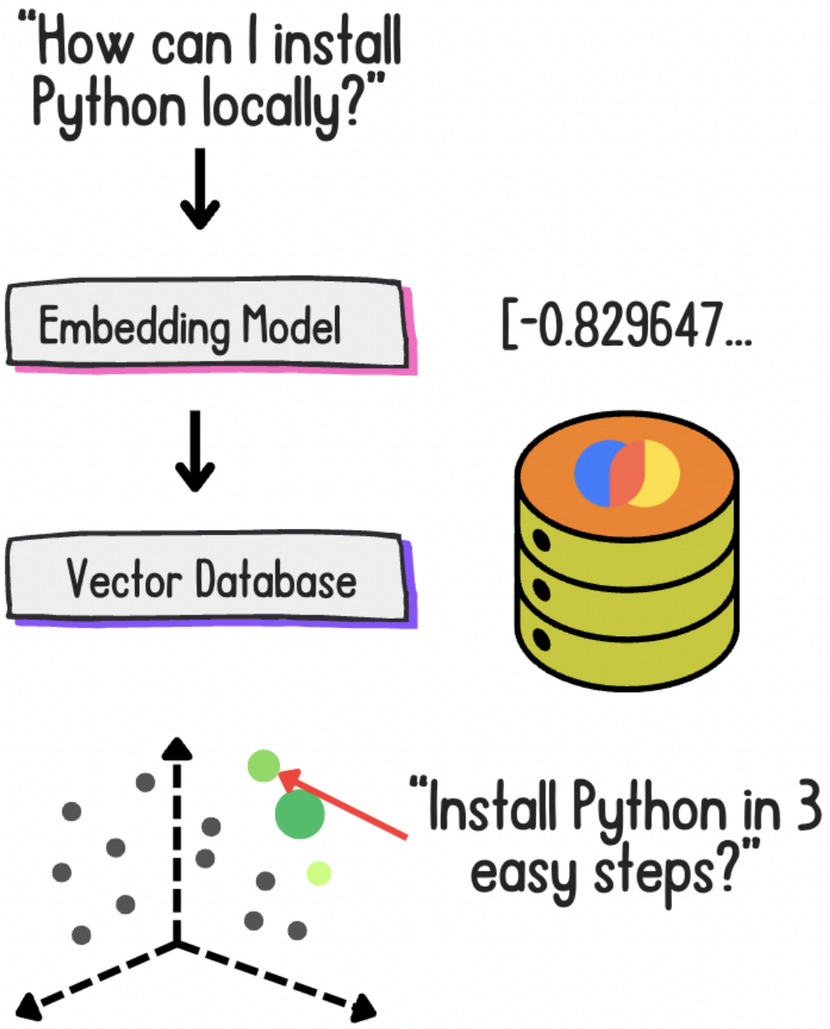


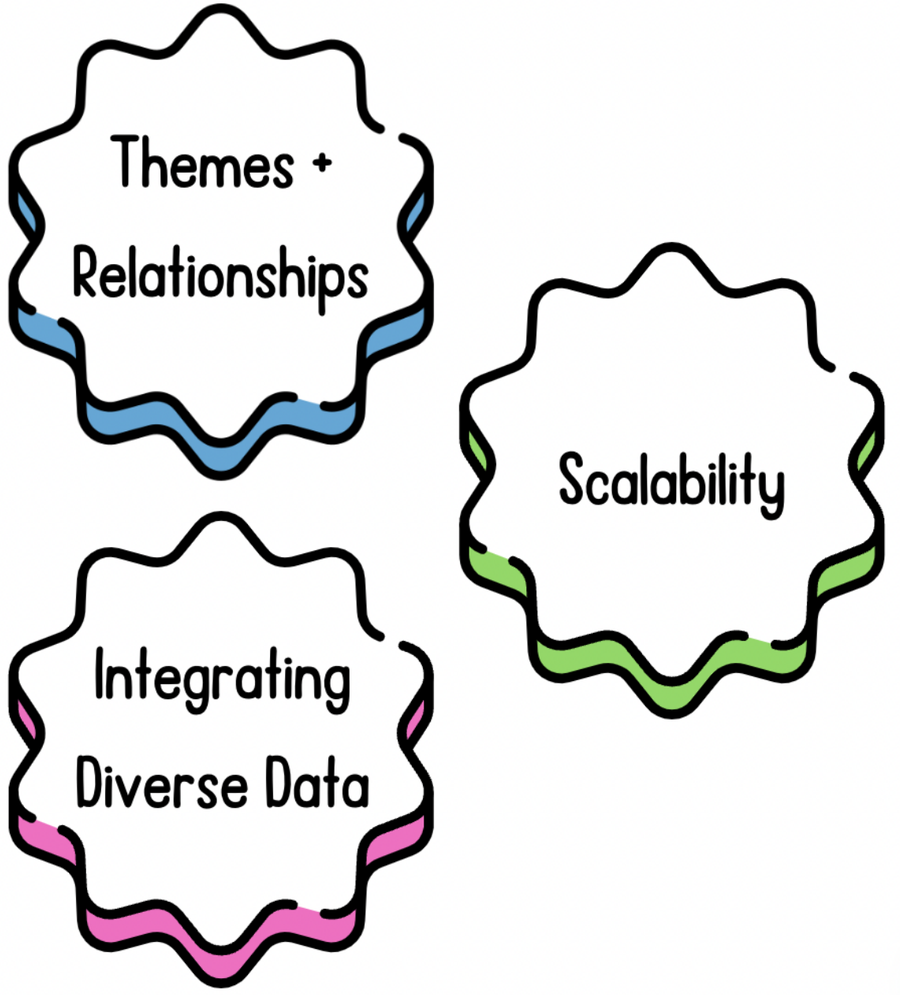
Vector RAG limitations



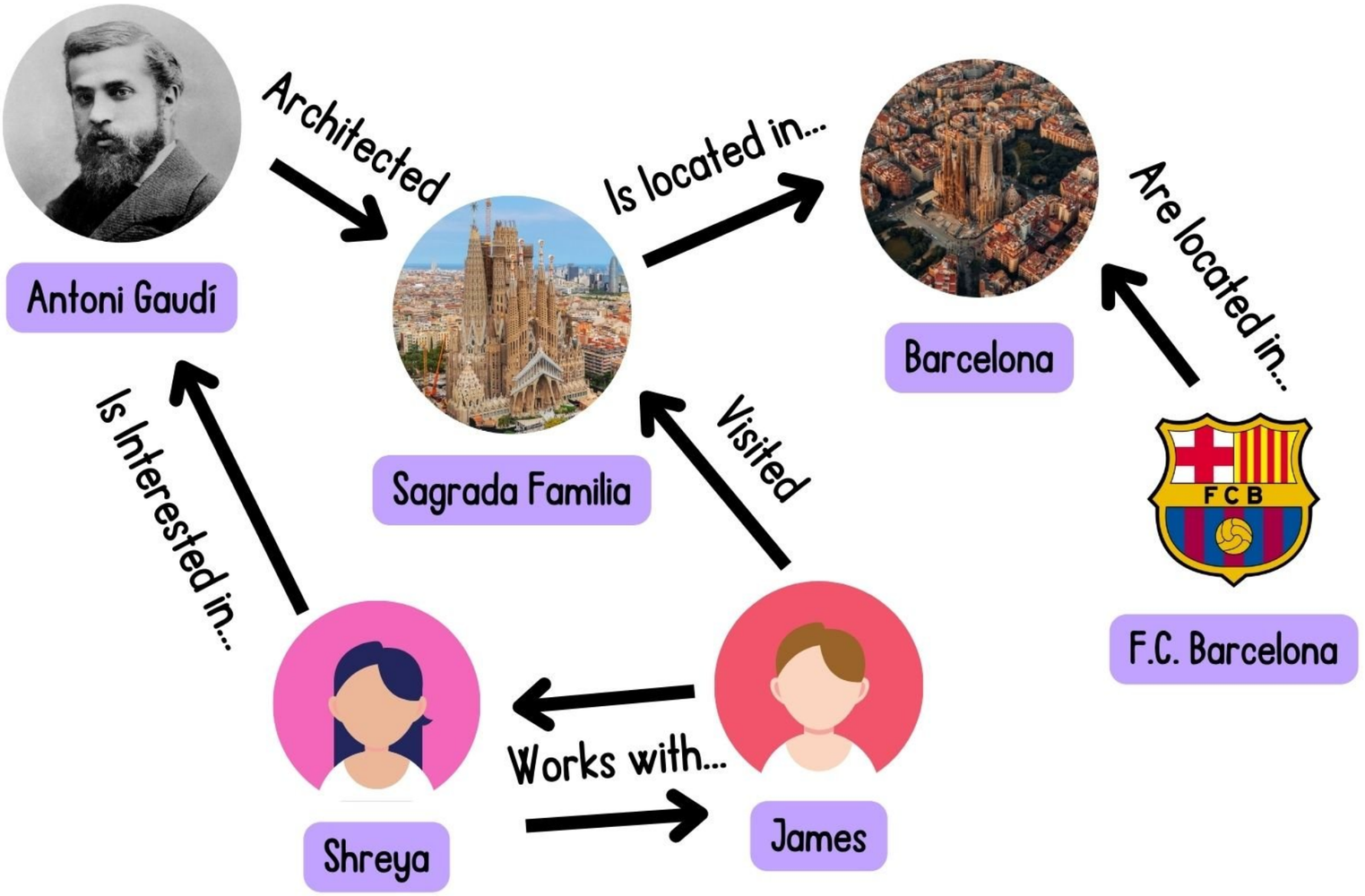


Vector RAG limitations

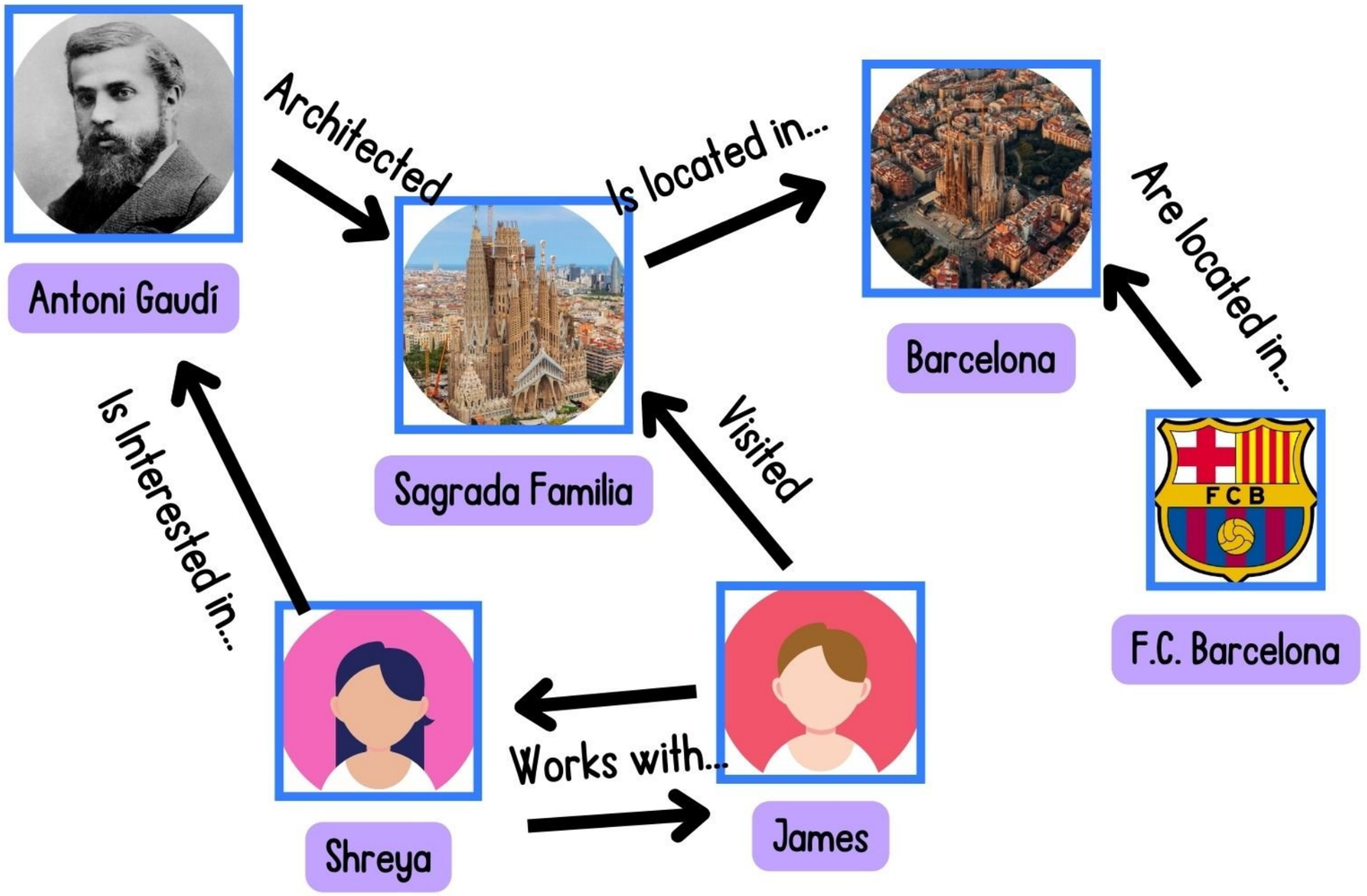




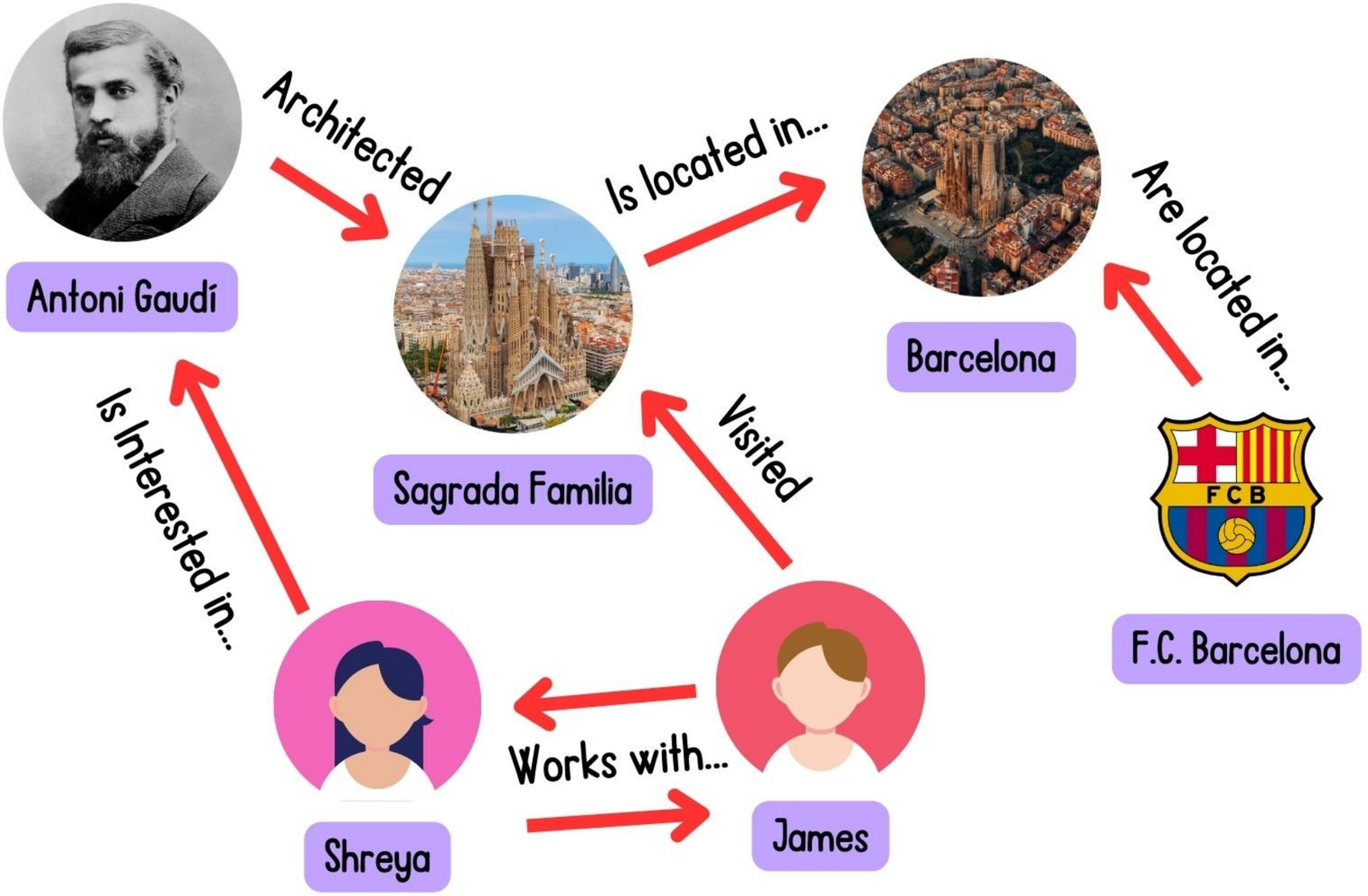
Graph databases



Graph databases - nodes



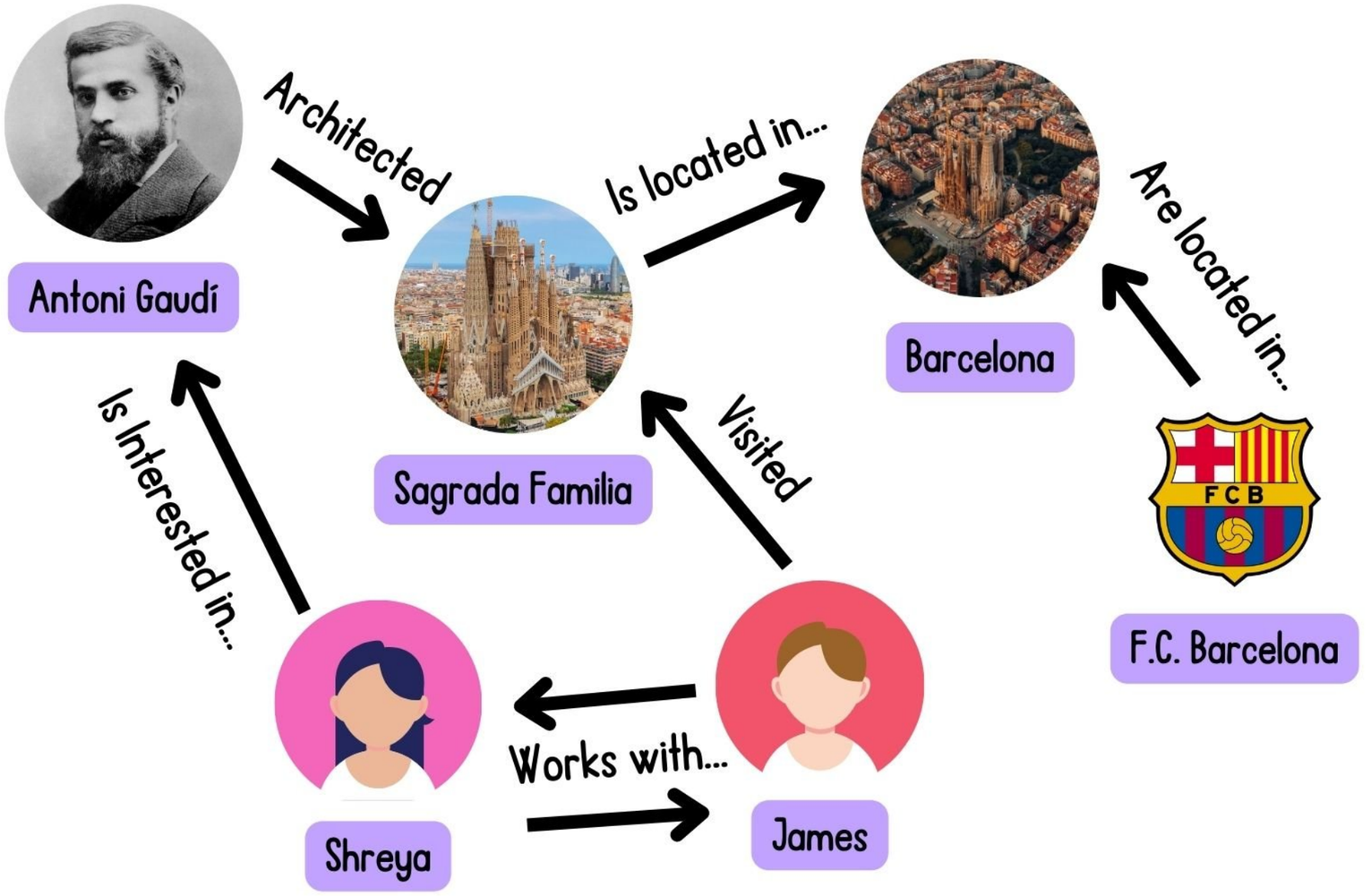
Graph databases - edges



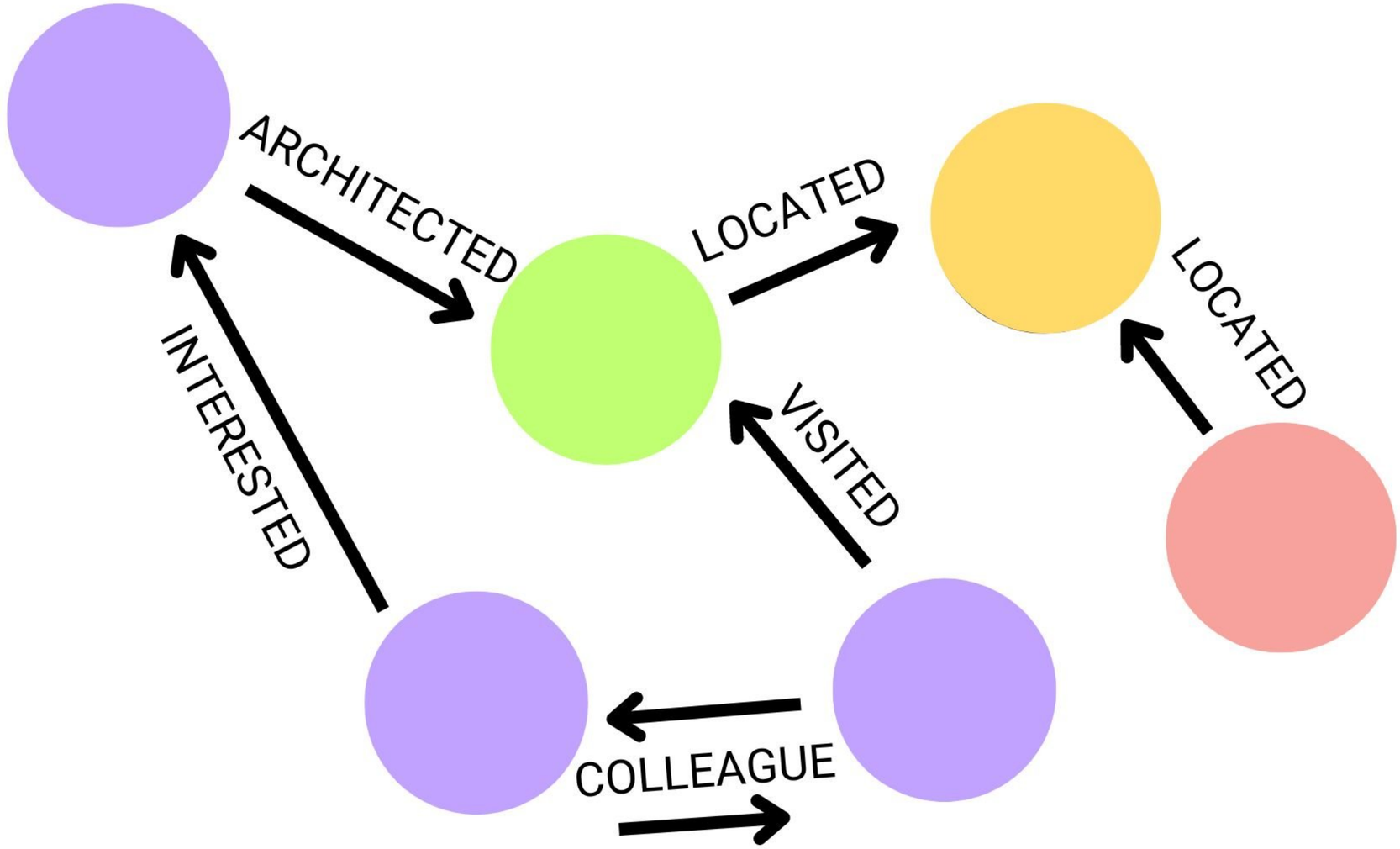
Neo4j graph databases

LangChain

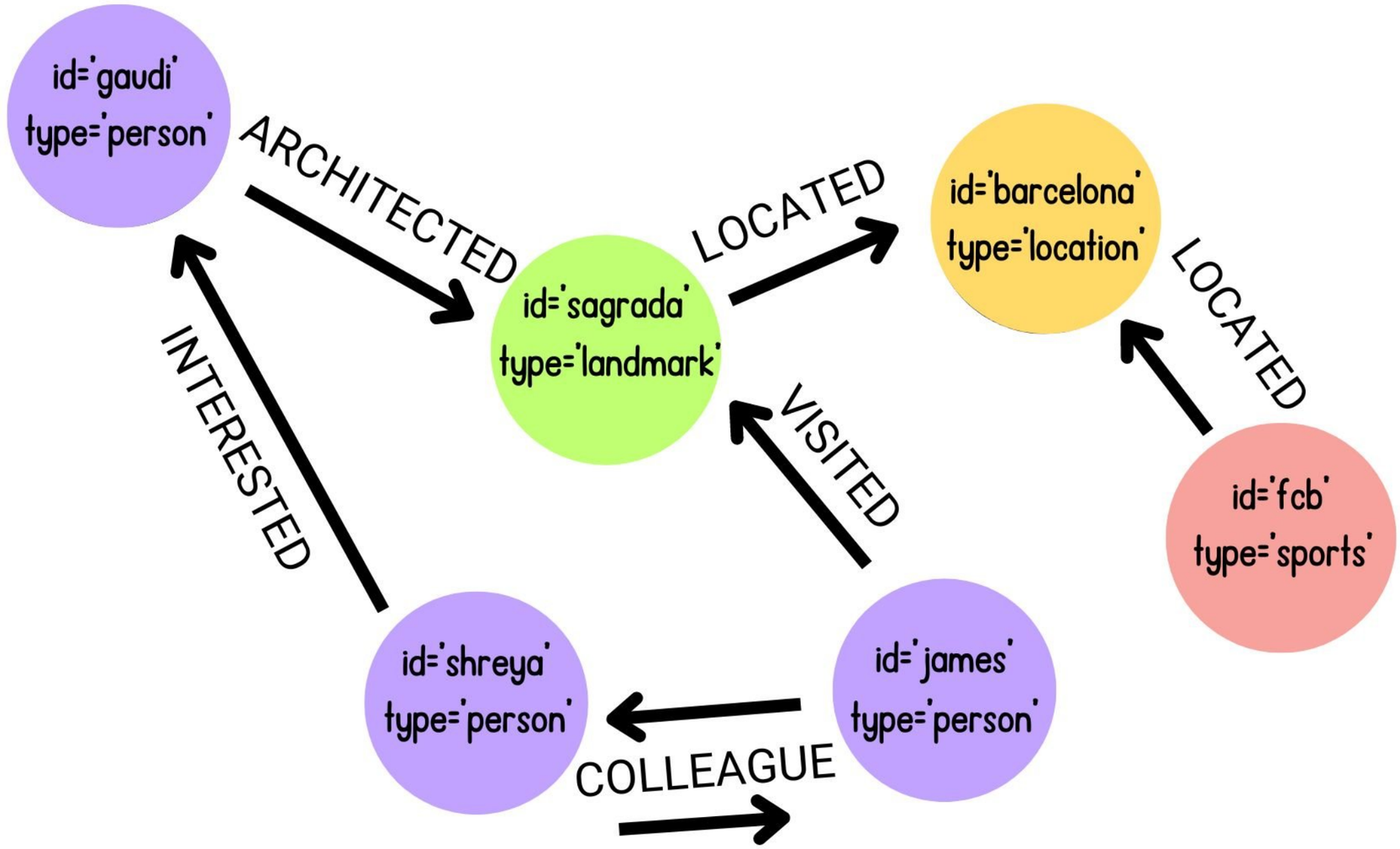
From graphics to graphs...



From graphics to graphs...



From graphics to graphs...



Loading and chunking Wikipedia pages

```
from langchain_community.document_loaders import WikipediaLoader
from langchain_text_splitters import TokenTextSplitter

raw_documents = WikipediaLoader(query="large language model").load()
text_splitter = TokenTextSplitter(chunk_size=100, chunk_overlap=20)
documents = text_splitter.split_documents(raw_documents[:3])

print(documents[0])
```

```
page_content='A large language model (LLM) is a computational model capable of...'
metadata={'title': 'Large language model',
          'summary': "A large language model (LLM) is...",
          'source': 'https://en.wikipedia.org/wiki/Large_language_model'}
```

From text to graphs!

```
from langchain_openai import ChatOpenAI
from langchain_experimental.graph_transformers import LLMGraphTransformer

llm = ChatOpenAI(api_key="...", temperature=0, model_name="gpt-4o-mini")
llm_transformer = LLMGraphTransformer(llm=llm)

graph_documents = llm_transformer.convert_to_graph_documents(documents)
print(graph_documents)
```

From text to graphs!

```
[GraphDocument(
    nodes=[
        Node(id='Llm', type='Computational model'),
        Node(id='Language Generation', type='Concept'),
        Node(id='Natural Language Processing Tasks', type='Concept'),
        Node(id='Llama Family', type='Computational model'),
        Node(id='Ibm', type='Organization'),
        ..., Node(id='Bert', type='Computational model')],
    relationships=[
        Relationship(source=Node(id='Llm', type='Computational model'),
                     target=Node(id='Language Generation', type='Concept'),
                     type='CAPABLE_OF'),
        ...])]
```

Let's practice!

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

Storing and querying documents

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

Meri Nova
Machine Learning Engineer

datacamp

Instantiating the Neo4j database

```
from langchain_community.graphs import Neo4jGraph

graph = Neo4jGraph(url="bolt://localhost:7687", username="neo4j", password="...")
```

```
import os

url = os.environ["NEO4J_URI"]
user = os.environ["NEO4J_USERNAME"]
password = os.environ["NEO4J_PASSWORD"]

graph = Neo4jGraph(url=url, username=user, password=password)
```

[1] https://neo4j.com/download/

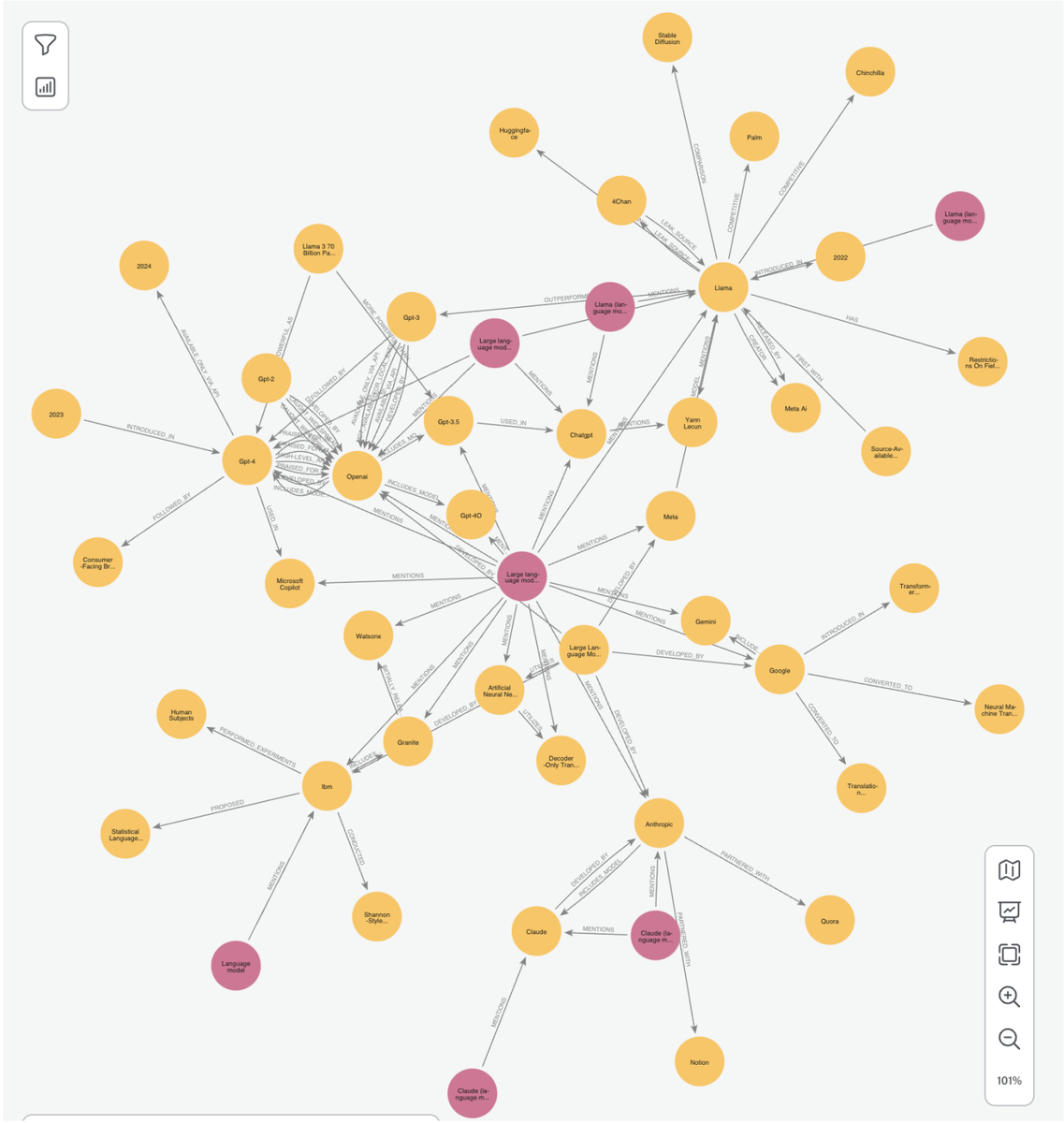
Storing graph documents

```
from langchain_experimental.graph_transformers import LLMGraphTransformer

llm = ChatOpenAI(api_key="...", temperature=0, model="gpt-4o-mini")
llm_transformer = LLMGraphTransformer(llm=llm)

graph_documents = llm_transformer.convert_to_graph_documents(documents)
```

Storing graph documents

```
graph.add_graph_documents(
  graph_documents,
  include_source=True,
  baseEntityLabel=True
)
```

- `include_source=True` : link nodes to source documents with `MENTIONS` edge
- `baseEntityLabel=True` : add `__Entity__` label to each node


Stable Diffusion
Chinchilla
Huggingfa-ce
Palm
4Chan
Llama (lan-guage mo...
2022
Llama
2024
Llama 3 70 Billion Pa...
Gpt-3
Large lang-uage mod...
Gpt-2
Plastricto-ns On Flat...
2023
Gpt-3.5
Chatgpt
Yann Lecun
Meta AI
Source-Av-ailable...
Gpt-4
Openai
Gpt-4O
Meta
Consumer -Facing Br...
Microsoft Copilot
Large lang-uage mod...
Transform-er...
Watsonx
Gemini
Large Lan-guage Mo...
Google
Artificial Neural Ne...
Neural Ma-chine Tran...
Human Subjects
Granite
Decoder -Only Tran...
Translatio-n...
Ibm
Anthropic
Statistical Language...
Shannon -Style...
Claude
Claude (la-nguage m...
Quora
Language model
Notion
INTRODUCED_IN
FOLLOWED_BY
USED_IN
MENTIONS
DEVELOPED_BY
INCLUDES_MODEL
OUTPERFORM
HAS
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FIRST_WITH
DEVELOPED_BY
INCLUDES
CONVERTED_TO
PERFORMED_EXPERIMENTS
PROPOSED
PARTNERED_WITH
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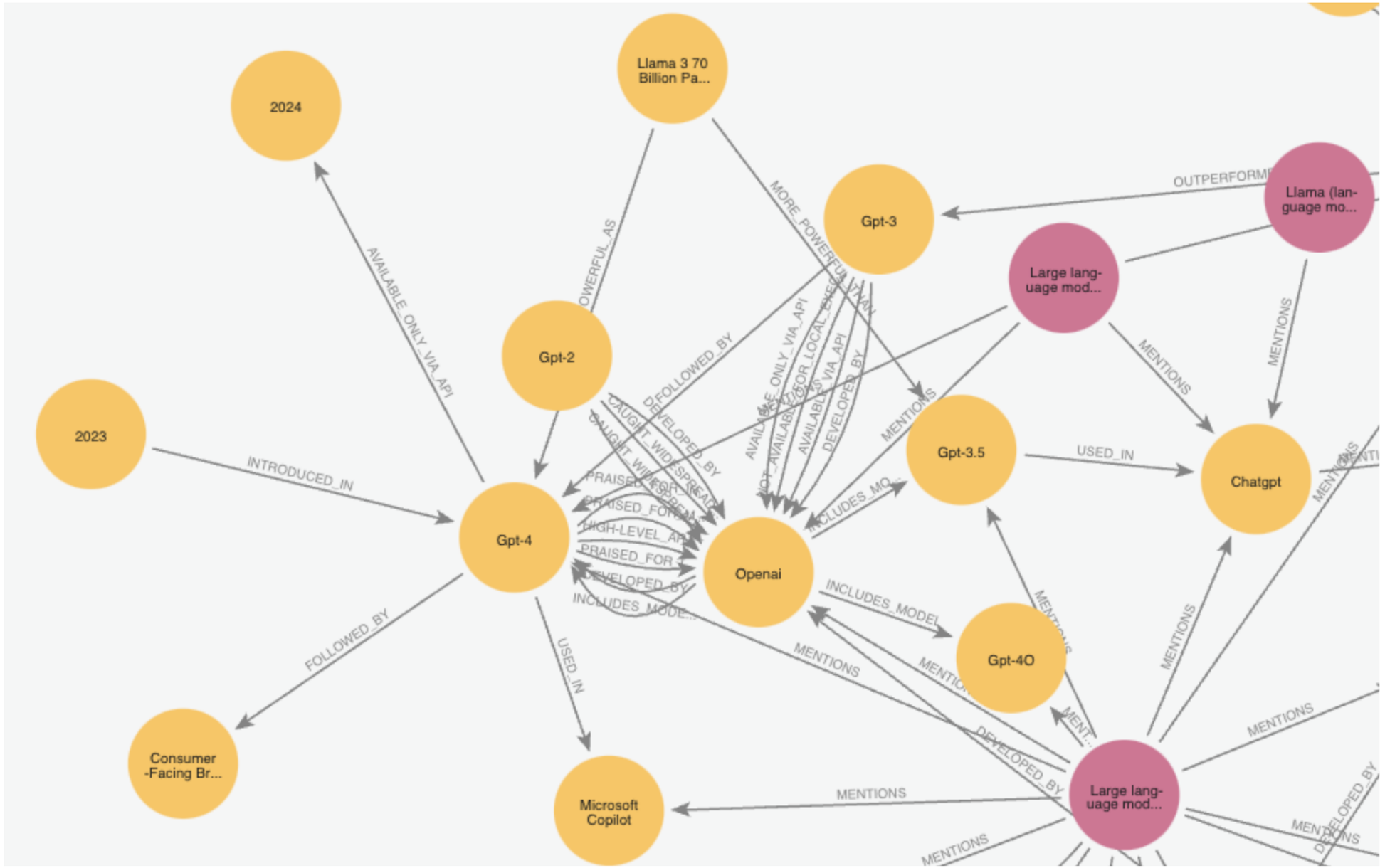

2024
Llama 3 70 Billion Pa...
Gpt-3
Llama (lan-guage mo...
Large lang-uage mod...
Gpt-2
2023
Gpt-3.5
Chatgpt
Gpt-4
Openai
Gpt-4O
Consumer -Facing Br...
Microsoft Copilot
Large lang-uage mod...
AVAILABLE_ONLY_VIA_API
MORE_POWERFUL_THAN
OUTPERFORMED_BY
MENTIONS
INTRODUCED_IN
FOLLOWED_BY
USED_IN
INCLUDES_MODEL
DEVELOPED_BY

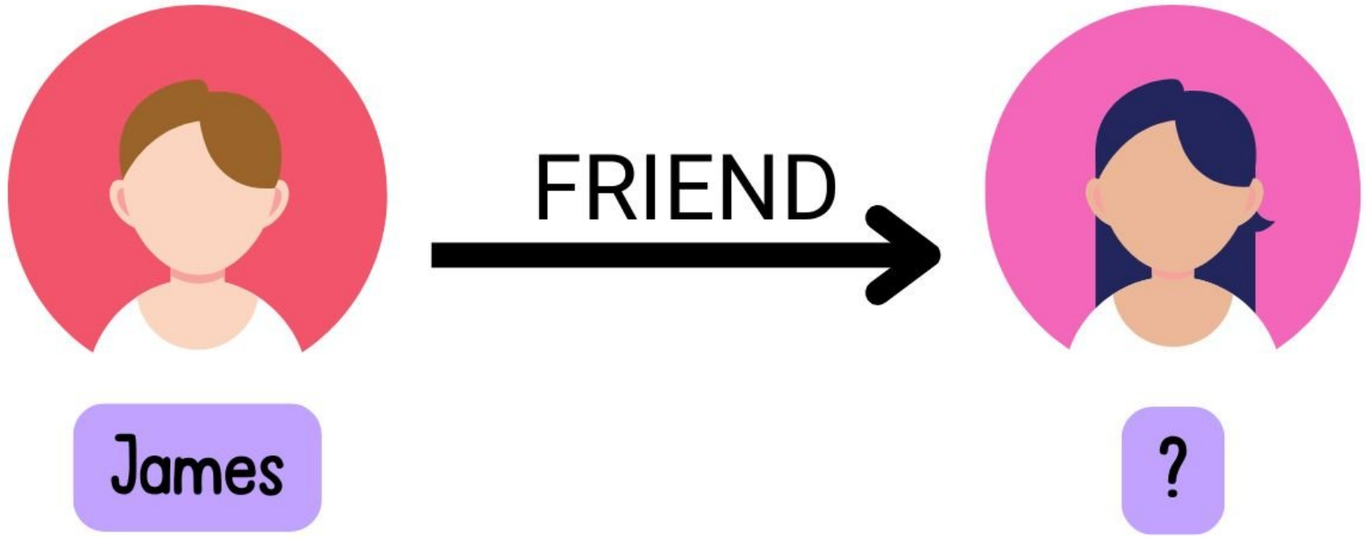
Database schema

```
print(graph.get_schema)
```

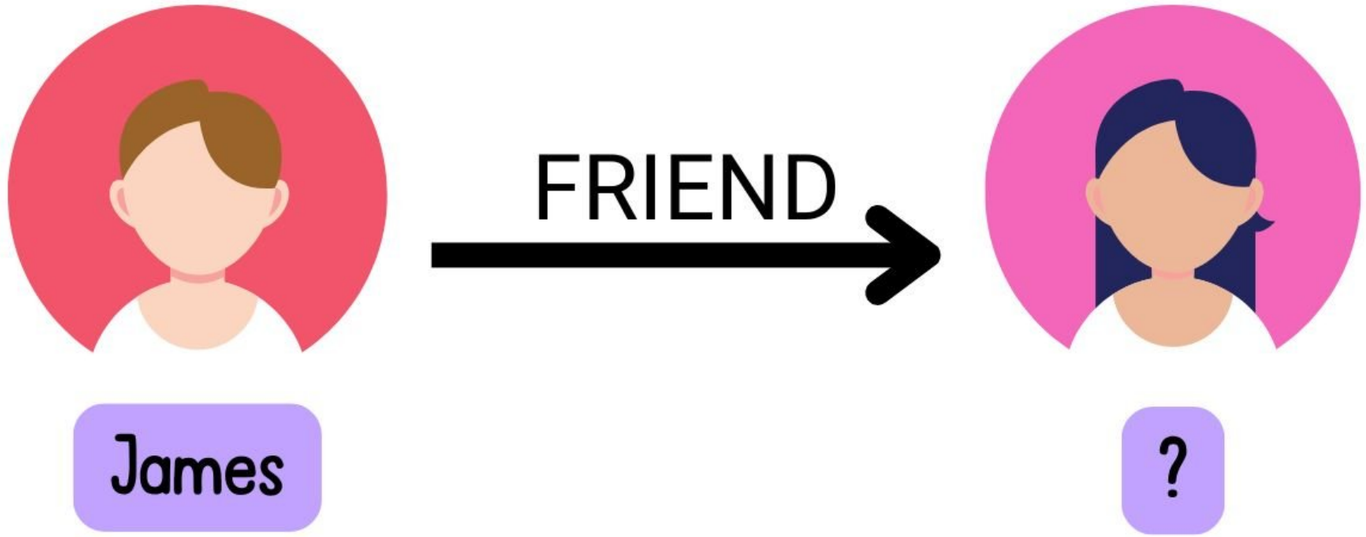
```
Node properties:
Concept {id: STRING}
Architecture {id: STRING}
Organization {id: STRING}
Event {id: STRING}
Paper {id: STRING}

The relationships:
(:Concept)-[:DEVELOPED_BY]->(:Person)
(:Architecture)-[:BASED_ON]->(:Concept)
(:Organization)-[:PROPOSED]->(:Concept)
(:Document)-[:MENTIONS]->(:Event)
(:Paper)-[:BASED_ON]->(:Concept)
```

Querying Neo4j - Cypher Query Language

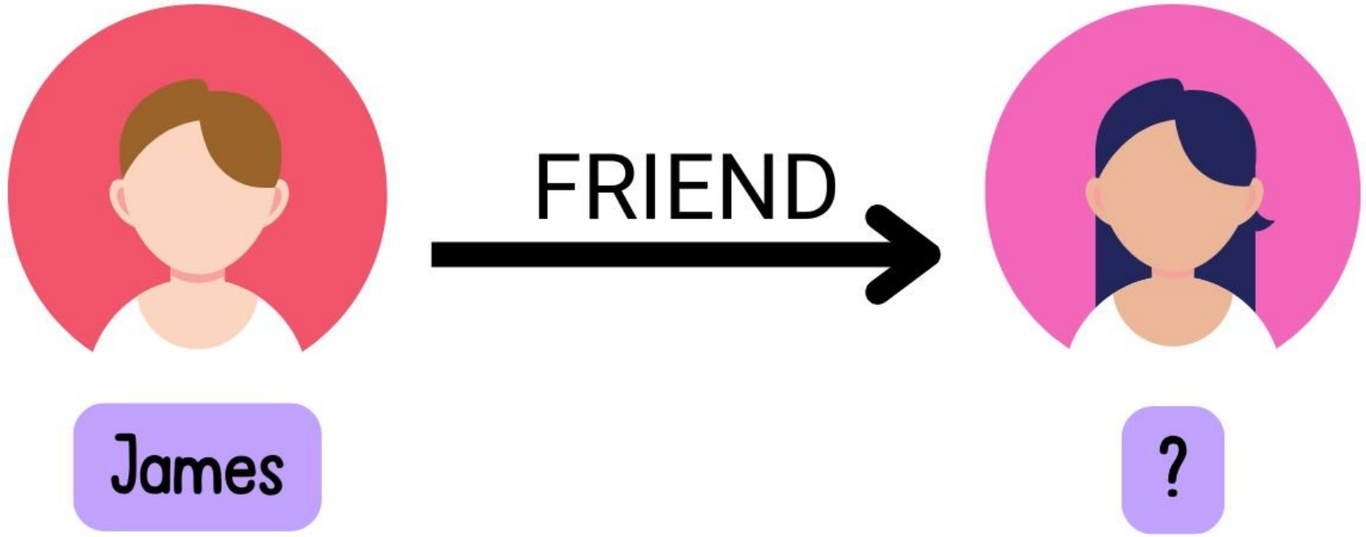


Querying Neo4j - Cypher Query Language




```
MATCH (james:Person {name: "James"})-[:FRIEND]->(friend) RETURN friend
```

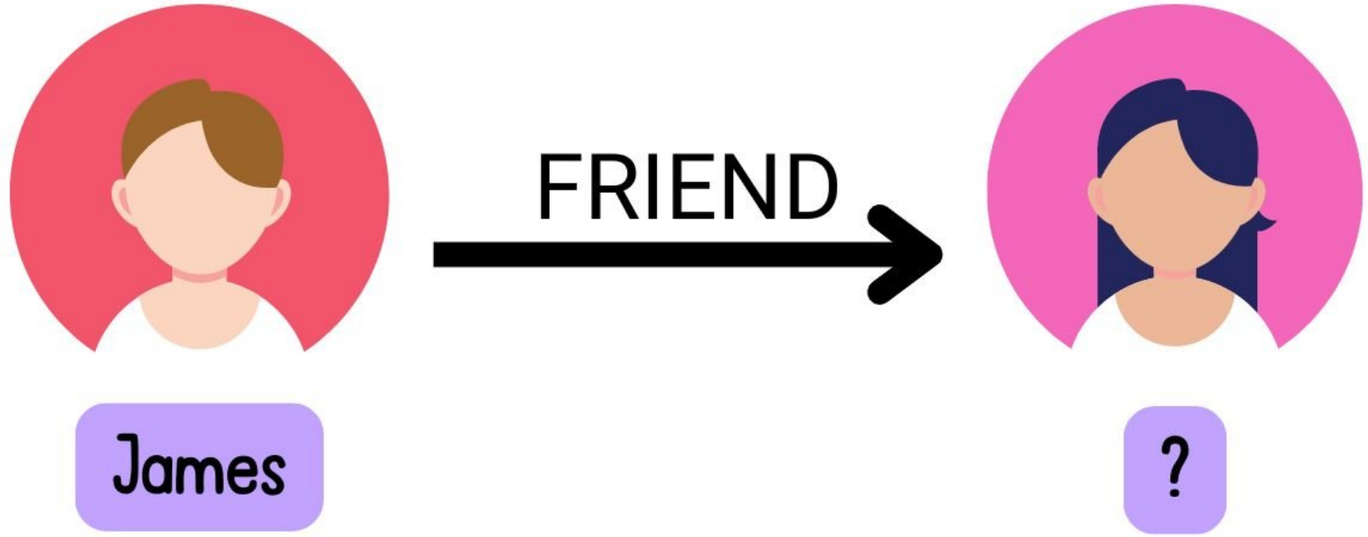
Querying Neo4j - Cypher Query Language



Node Relationship Node

```
MATCH (james:Person {name: "James"})-[:FRIEND]->(friend) RETURN friend
```

Querying Neo4j - Cypher Query Language

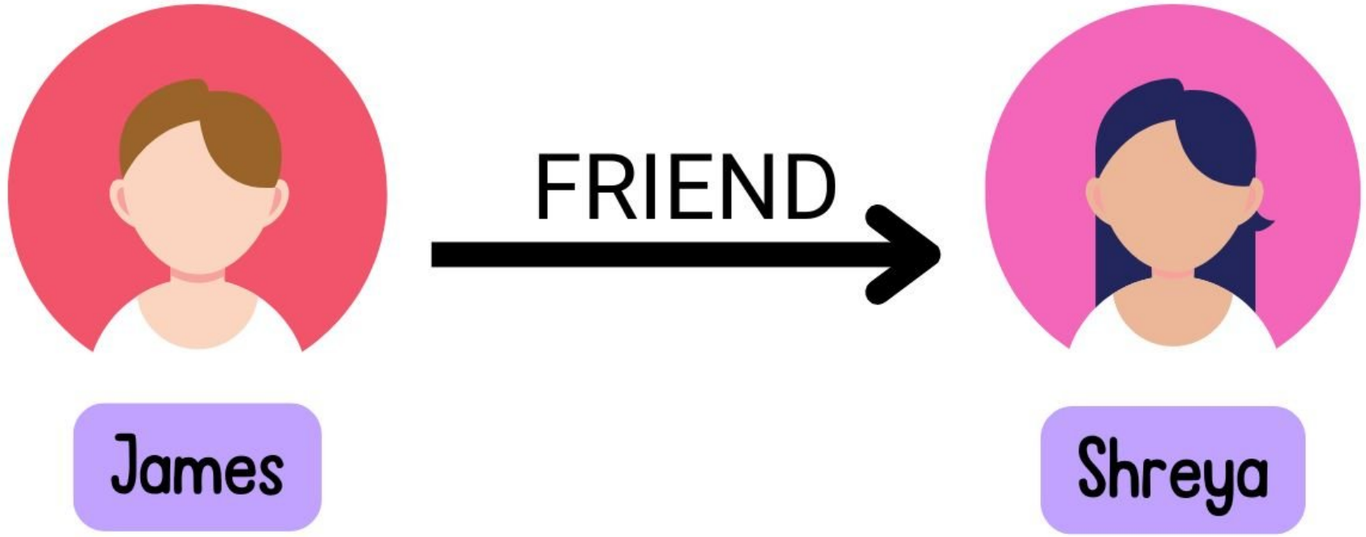


Node Relationship Node

```
MATCH (james:Person {name: "James"})-[:FRIEND]->(friend) RETURN friend
```

LABEL PROPERTY VARIABLE

Querying Neo4j - Cypher Query Language



Node Relationship Node

```
MATCH (james:Person {name: "James"})-[:FRIEND]->(friend) RETURN friend
```

LABEL PROPERTY VARIABLE

Querying the LLM graph

```
results = graph.query("""
MATCH (gpt4:Model {id: "Gpt-4"})-[:DEVELOPED_BY]->(org:Organization)
RETURN org
""")

print(results)
```

```
[{'org': {'id': 'Openai'}}]
```

Let's practice!

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

Creating the Graph RAG chain

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

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Machine Learning Engineer

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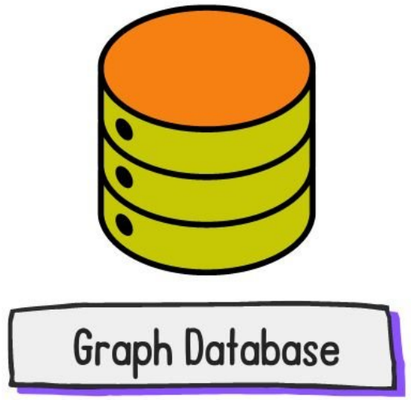
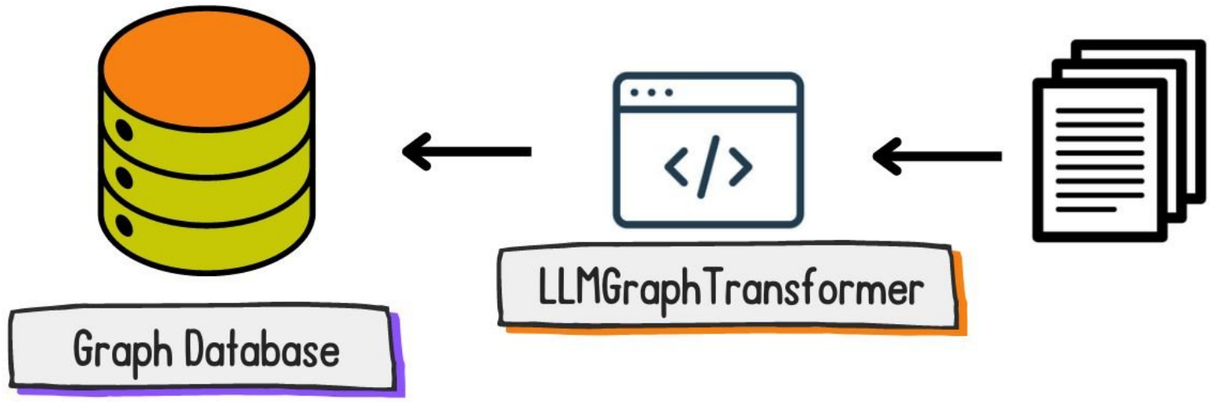
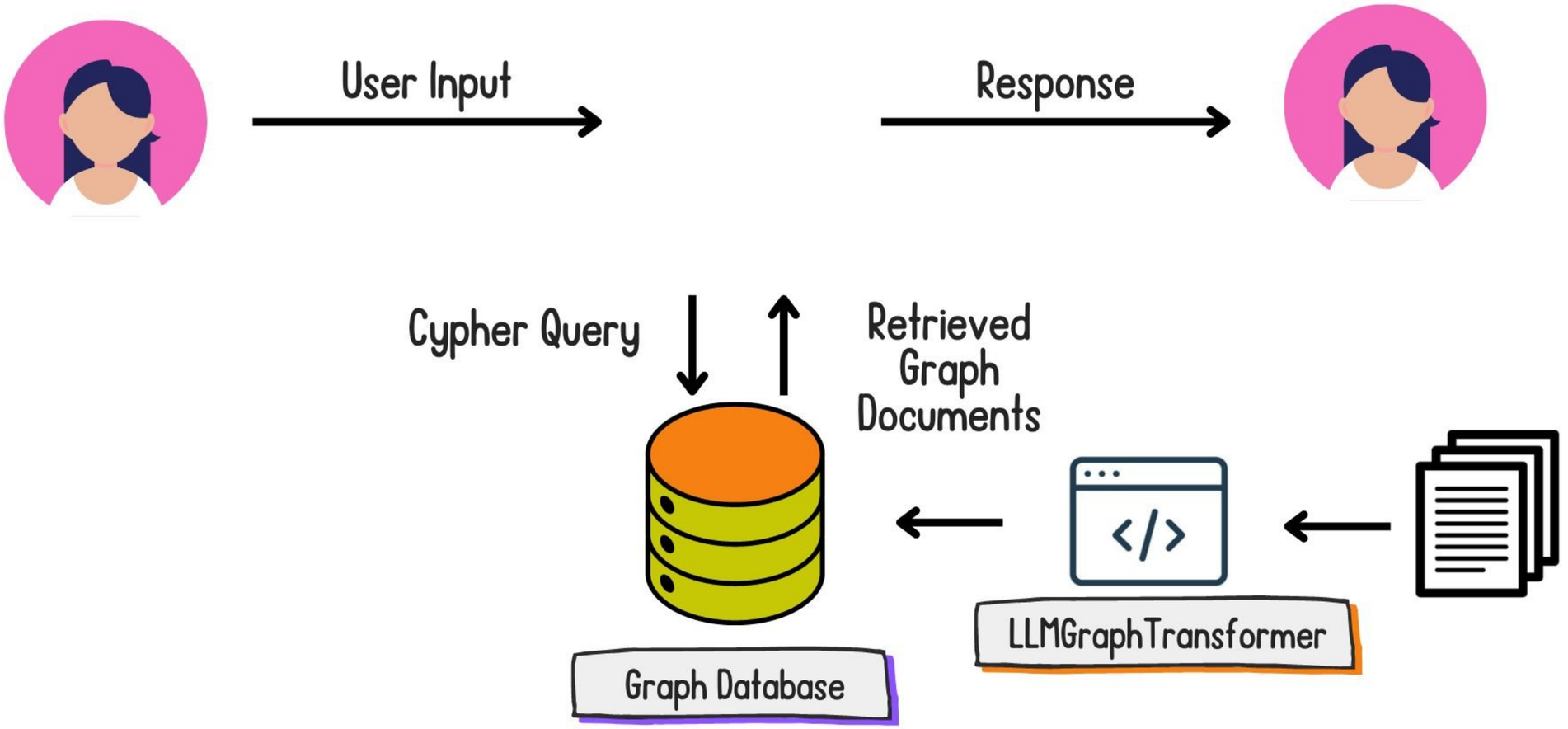
Building the Graph RAG architecture



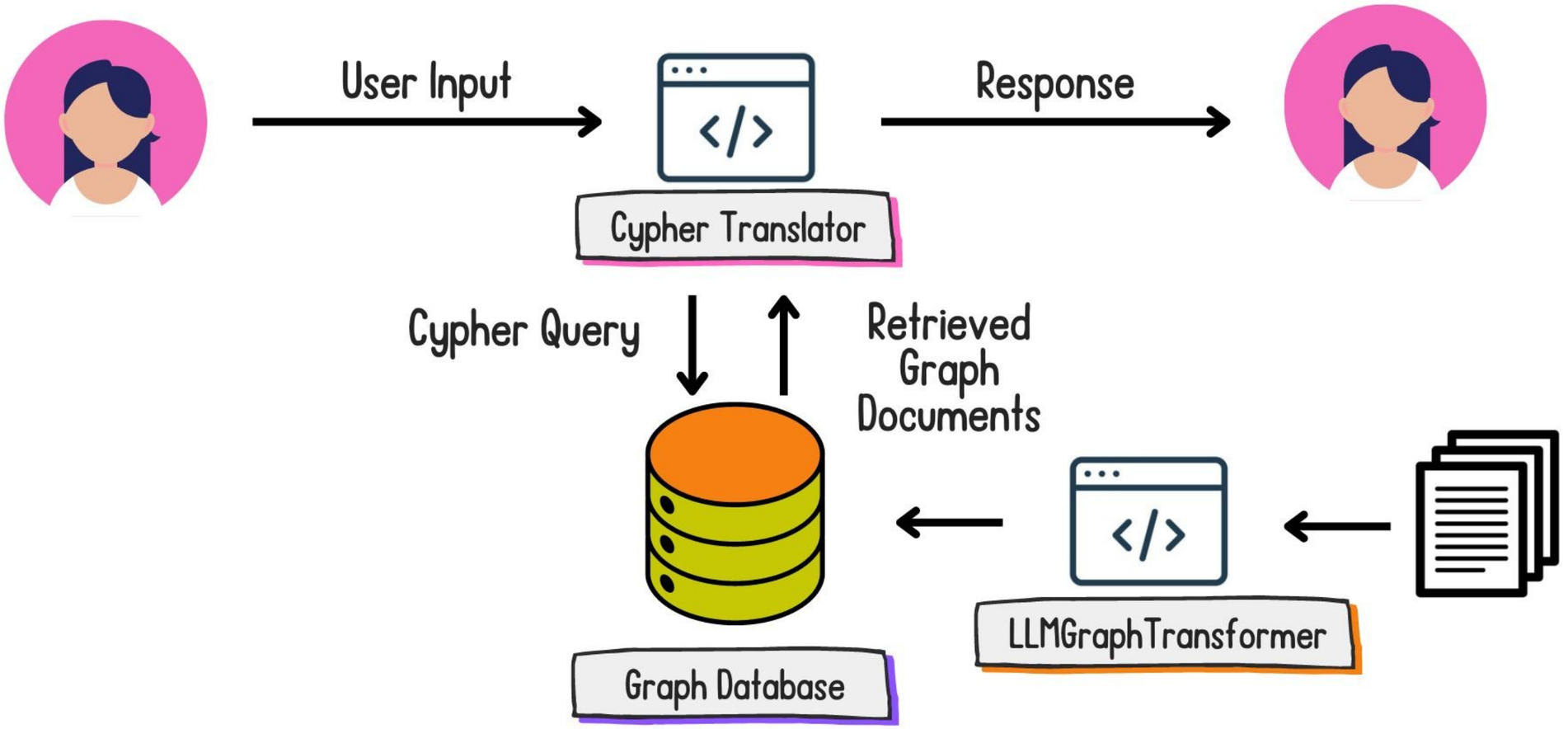
Building the Graph RAG architecture



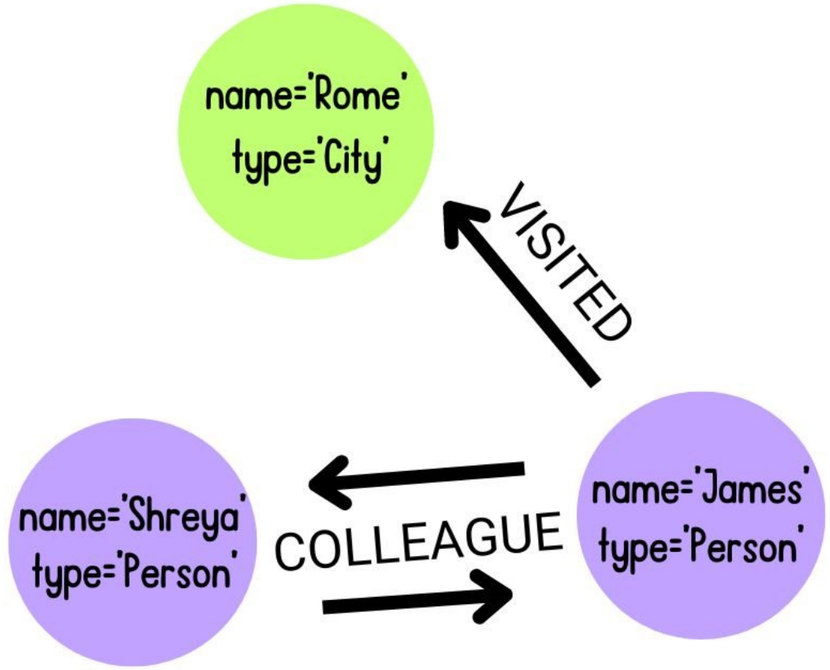
Building the Graph RAG architecture



Building the Graph RAG architecture



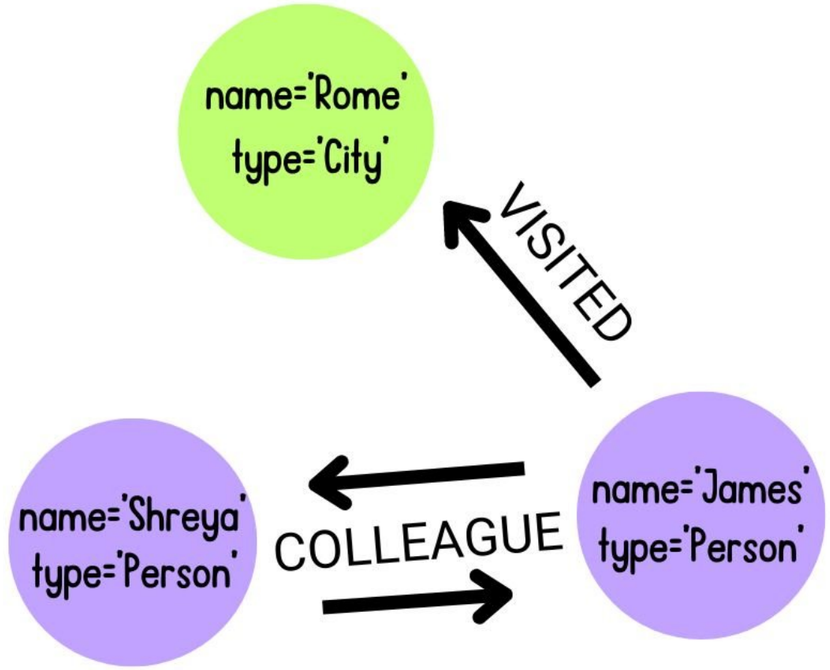
From user inputs to Cypher queries



From user inputs to Cypher queries

Where has James visited?

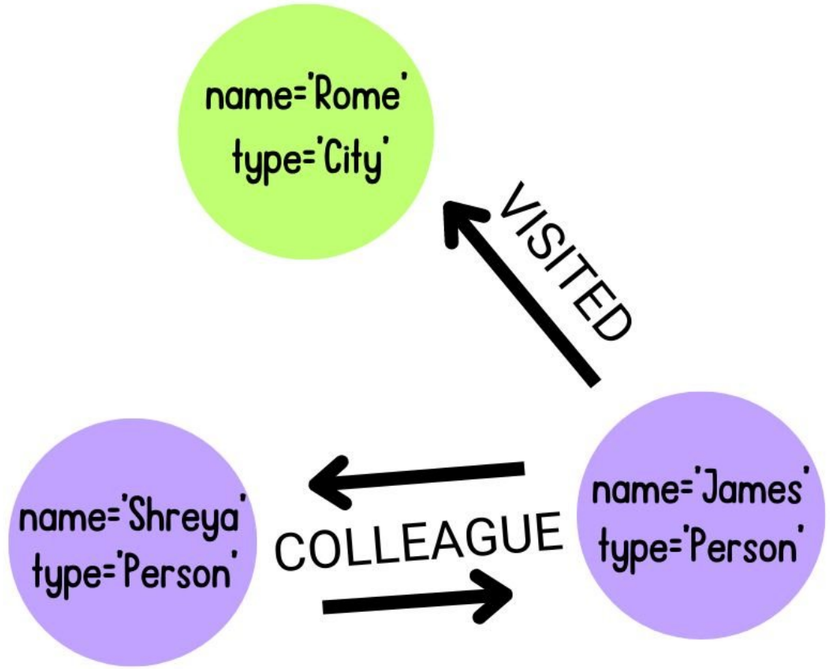
+



From user inputs to Cypher queries

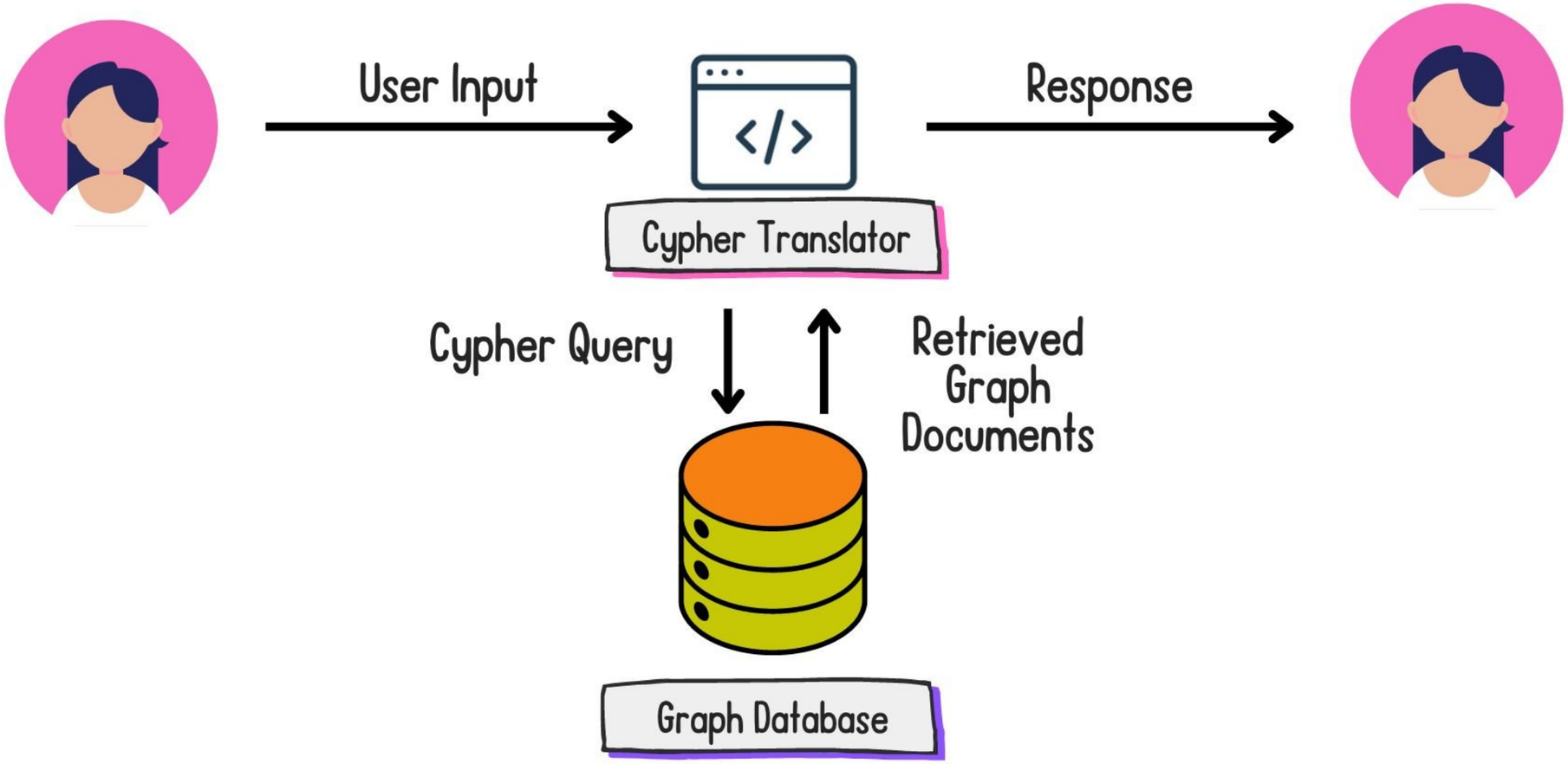
Where has James visited?

+

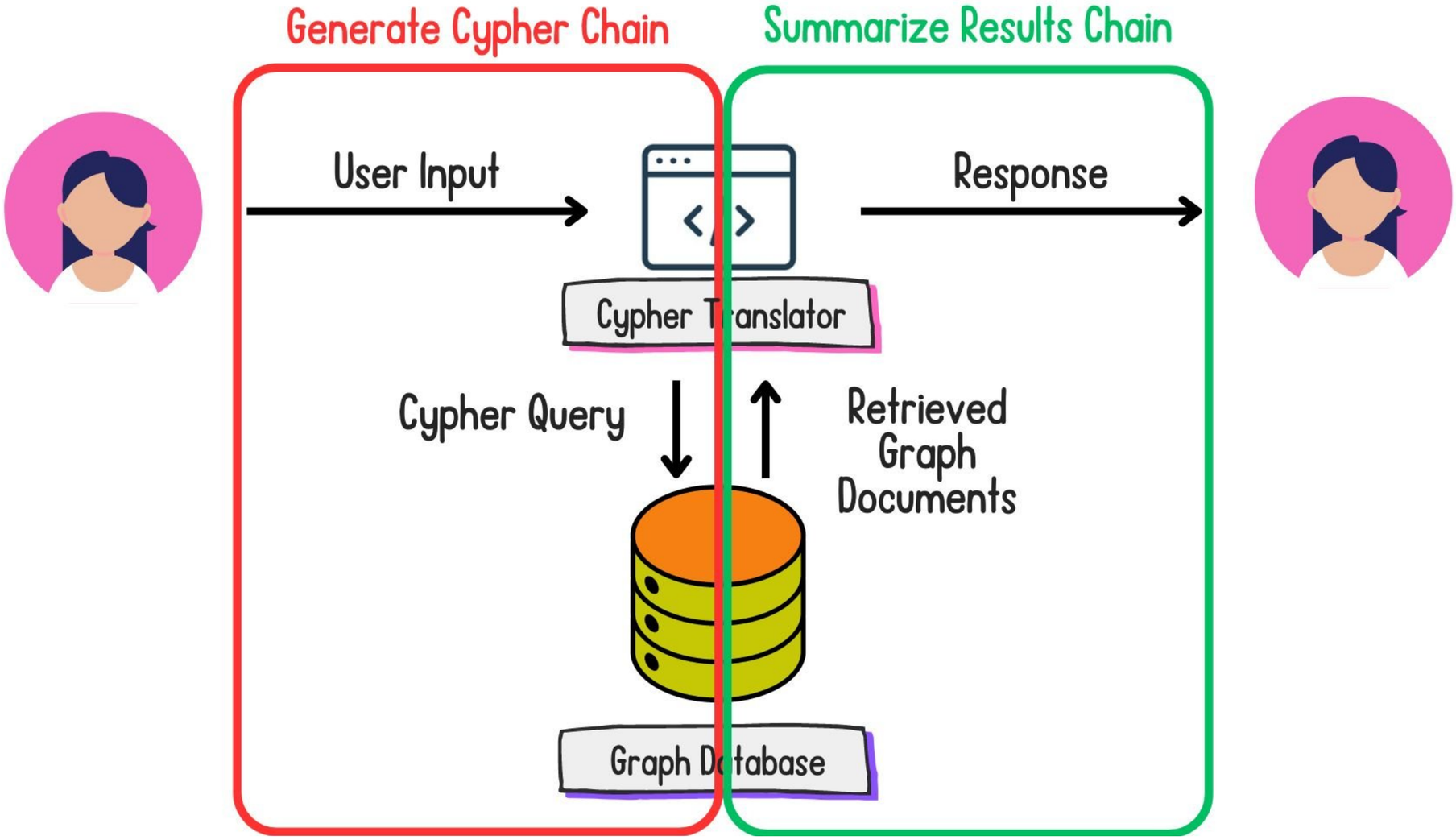



```
MATCH (james:Person{name:"James"}) -[:VISITED]> (location)
RETURN location
```

GraphCypherQAChain



GraphCypherQAChain



Refresh schema

```
graph.refresh_schema()
print(graph.get_schema)
```

```
Node properties:
Document {title: STRING, id: STRING, text: STRING, summary: STRING, source: STRING}
Concept {id: STRING}
Organization {id: STRING}
Relationship properties:

The relationships:
(:Document)-[:MENTIONS]->(:Organization)
(:Concept)-[:DEVELOPED_BY]->(:Person)
```

Querying the graph

```
from langchain_community.chains.graph_qa.cypher import GraphCypherQAChain

chain = GraphCypherQAChain.from_llm(
    llm=ChatOpenAI(api_key="...", temperature=0), graph=graph, verbose=True
)

result = chain.invoke({"query": "What is the most accurate model?"})
```

[1] https://api.python.langchain.com/en/latest/chains/langchain_community.chains.graph_qa.cypher.GraphCypherQAChain.html

Querying the graph

```
print(f"Final answer: {result['result']}")
```

```
> Entering new GraphCypherQAChain chain...
Generated Cypher:
MATCH (m:Model)
RETURN m
ORDER BY m.accuracy DESC
LIMIT 1;
Full Context:
[{'m': {'id': 'Artificial Neural Networks'}}]

> Finished chain.

Final answer: Artificial Neural Networks
```

Customization

```
chain = GraphCypherQAChain.from_llm(
    llm=ChatOpenAI(api_key="...", temperature=0), graph=graph, verbose=True
)
```

- `qa_prompt` : Prompt template for result generation
- `cypher_prompt` : Prompt template for Cypher generation
- `cypher_llm` : LLM for Cypher generation
- `qa_llm` : LLM for result generation

Let's practice!

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

Improving graph retrieval

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

Meri Nova
Machine Learning Engineer

datacamp

Techniques

Main limitation: reliability of user → Cypher translation

Strategies to improve graph retrieval system:

- Filtering Graph Schema
- Validating the Cypher Query
- Few-shot prompting

Filtering

```
from langchain_community.chains.graph_qa.cypher import GraphCypherQAChain

llm = ChatOpenAI(api_key="...", model="gpt-4o-mini", temperature=0)

chain = GraphCypherQAChain.from_llm(
    graph=graph, llm=llm, exclude_types=["Concept"], verbose=True
)
print(graph.get_schema)
```

```
Node properties:
Document {title: STRING, id: STRING, text: STRING, summary: STRING, source: STRING}
Organization {id: STRING}
```

Validating the Cypher query

- Difficulty in interpreting the *direction* of relationships

```
chain = GraphCypherQAChain.from_llm(
    graph=graph, llm=llm, verbose=True, validate_cypher=True
)
```

1. Detects nodes and relationships
2. Determines the directions of the relationship
3. Checks the graph schema
4. Update the direction of relationships

Few-shot prompting

```
examples = [
    {
        "question": "How many notable large language models are mentioned in the article?",
        "query": "MATCH (m:Concept {id: 'Large Language Model'}) RETURN count(DISTINCT m)",
    },
    {
        "question": "Which companies or organizations have developed the large language models mentioned?",
        "query": "MATCH (o:Organization)-[:DEVELOPS]->(m:Concept {id: 'Large Language Model'}) RETURN DISTINCT o.id",
    },
    {
        "question": "What is the largest model size mentioned in the article, in terms of number of parameters?",
        "query": "MATCH (m:Concept {id: 'Large Language Model'}) RETURN max(m.parameters) AS largest_model",
    },
]
```

Implementing few-shot prompting

```
from langchain_core.prompts import FewShotPromptTemplate, PromptTemplate

example_prompt = PromptTemplate.from_template(
    "User input: {question}\nCypher query: {query}"
)

cypher_prompt = FewShotPromptTemplate(
    examples=examples,
    example_prompt=example_prompt,
    prefix="You are a Neo4j expert. Given an input question, create a syntactically correct Cy
    suffix="User input: {question}\nCypher query: ",
    input_variables=["question"],
)
```

Complete prompt

```
You are a Neo4j expert. Given an input question, create a syntactically correct Cypher query to run.

Below are a number of examples of questions and their corresponding Cypher queries.

User input: How many notable large language models are mentioned in the article?
Cypher query: MATCH (p:Paper) RETURN count(DISTINCT p)

User input: Which companies or organizations have developed the large language models?
Cypher query: MATCH (o:Organization)-[:DEVELOPS]->(m:Concept {id: 'Large Language Model'}) RETURN DISTINCT o.id

User input: What is the largest model size mentioned in the article, in terms of number of parameters?
Cypher query: MATCH (m:Concept {id: 'Large Language Model'}) RETURN max(m.parameters) AS largest_model

User input: How many papers were published in 2016?
Cypher query:
```

Adding the few-shot examples

```
chain = GraphCypherQAChain.from_llm(
    graph=graph, llm=llm, cypher_prompt=cypher_prompt,
    verbose=True, validate_cypher=True
)
```

Let's practice!

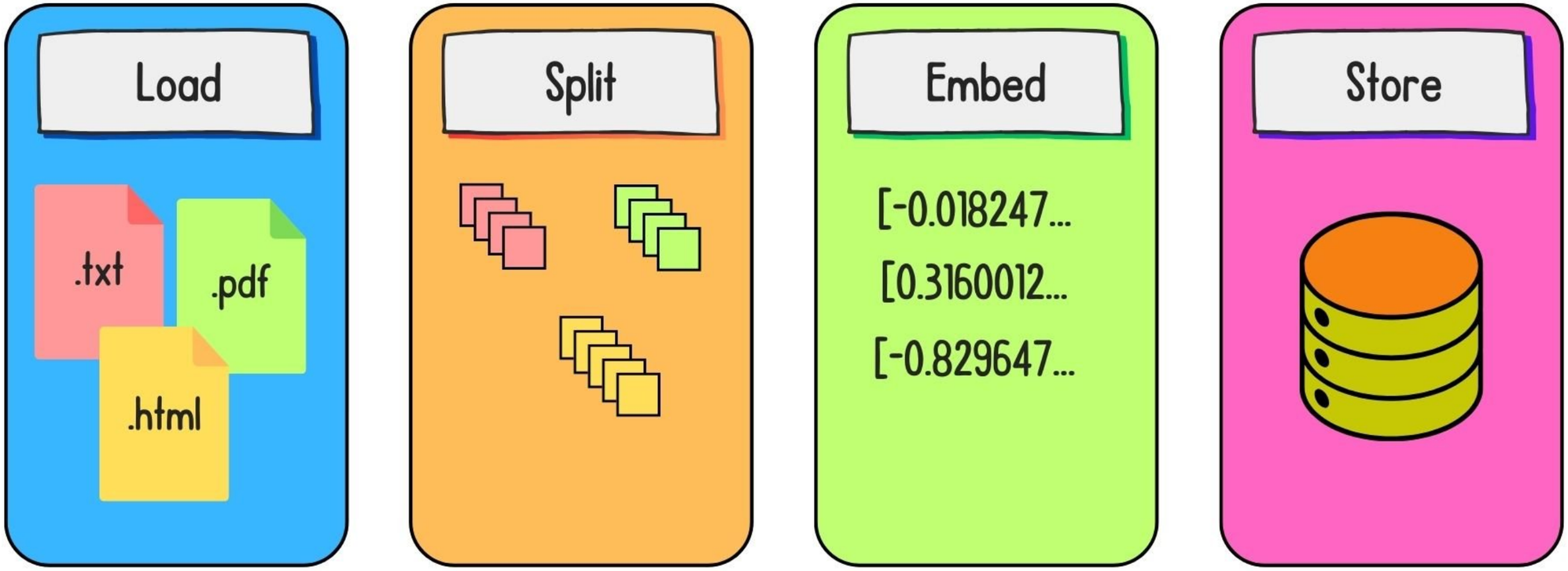
RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

Congratulations!

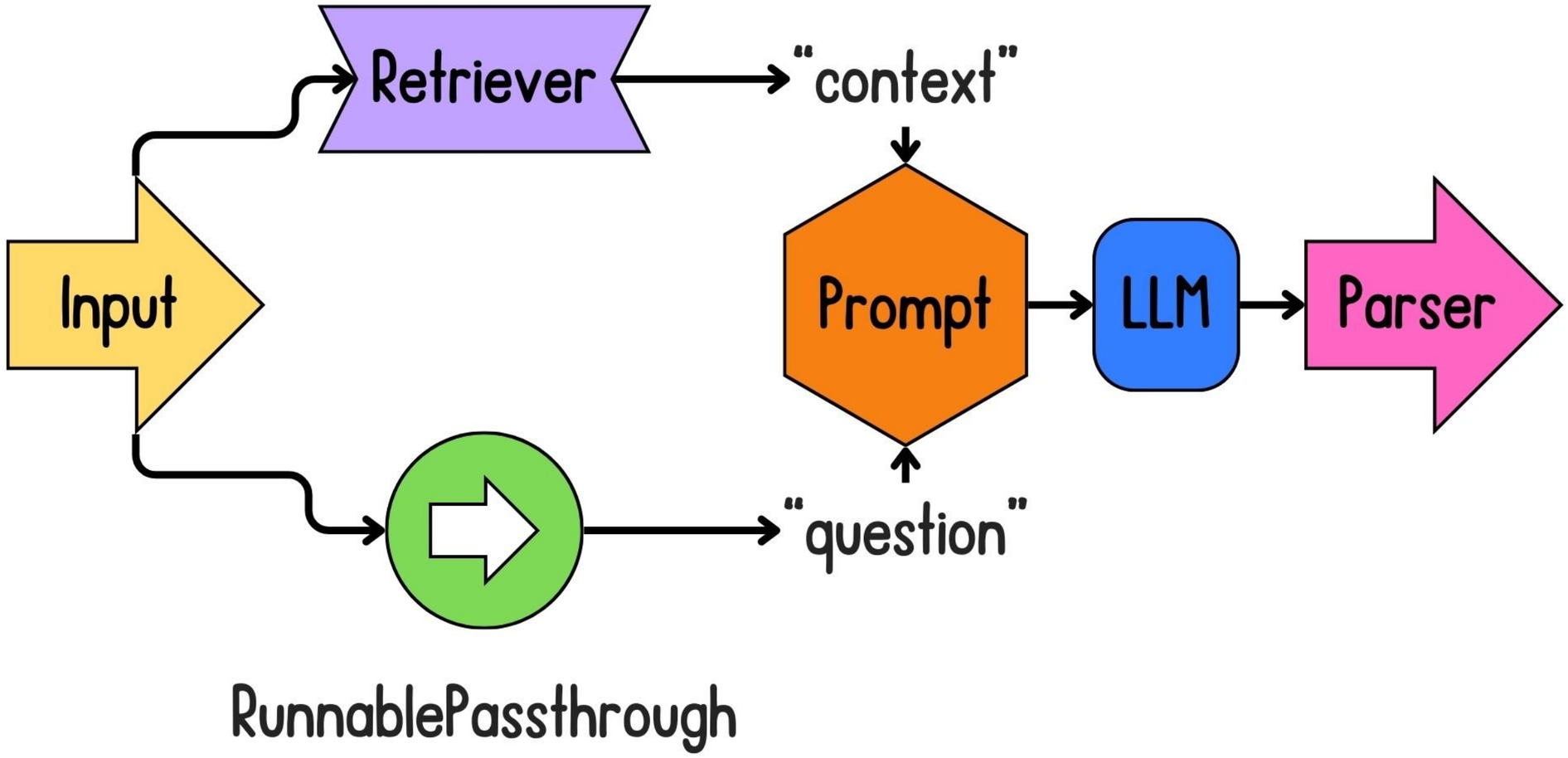
RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

Meri Nova
Machine Learning Engineer

Chapter 1


Load
.txt
.pdf
.html
Split
Embed
[-0.018247...
[0.3160012...
[-0.829647...
Store

Chapter 1


Retriever
"context"
Input
Prompt
LLM
Parser
"question"
RunnablePassthrough

Chapter 2

Markdown files

- `UnstructuredMarkdownLoader`

Python files

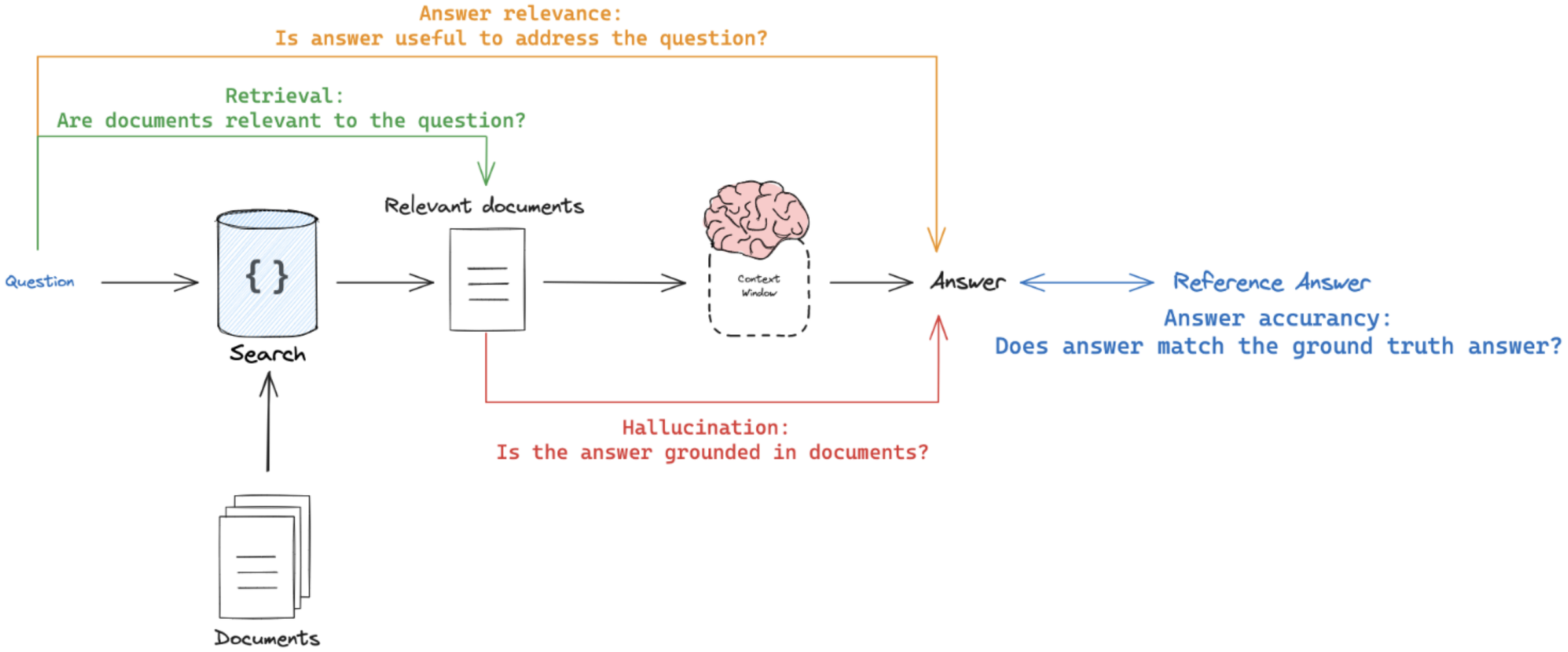
- `PythonLoader`
- `language=Language.PYTHON`

Token splitting → `TokenTextSplitter`

Semantic splitting → `SemanticChunker`

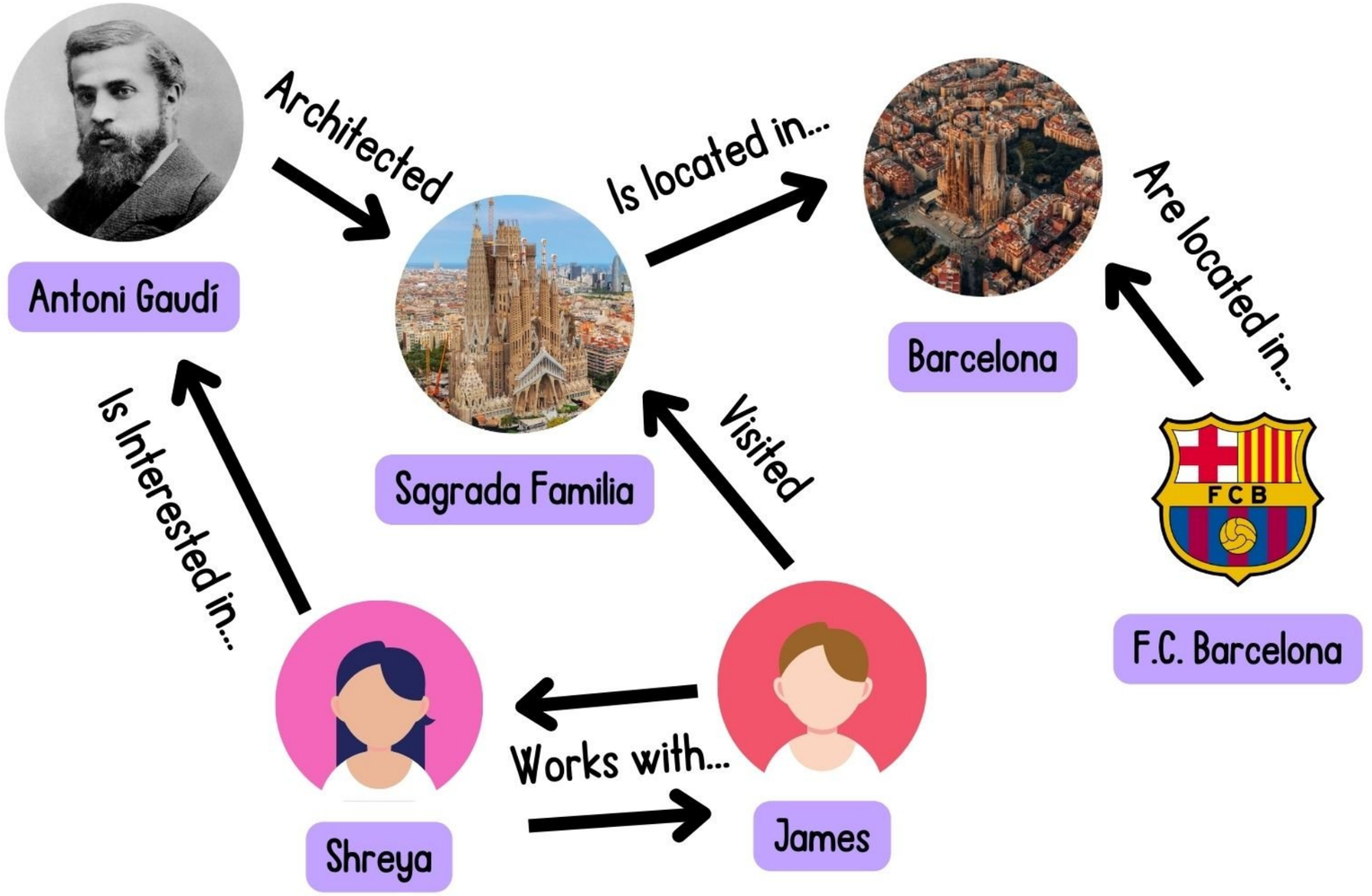
RAG applications has numerous use cases, but are most frequently deployed in chatbots. Domestic dogs are descendants from an extinct population of Pleistocene wolves over 14,000 years ago.

Chapter 2

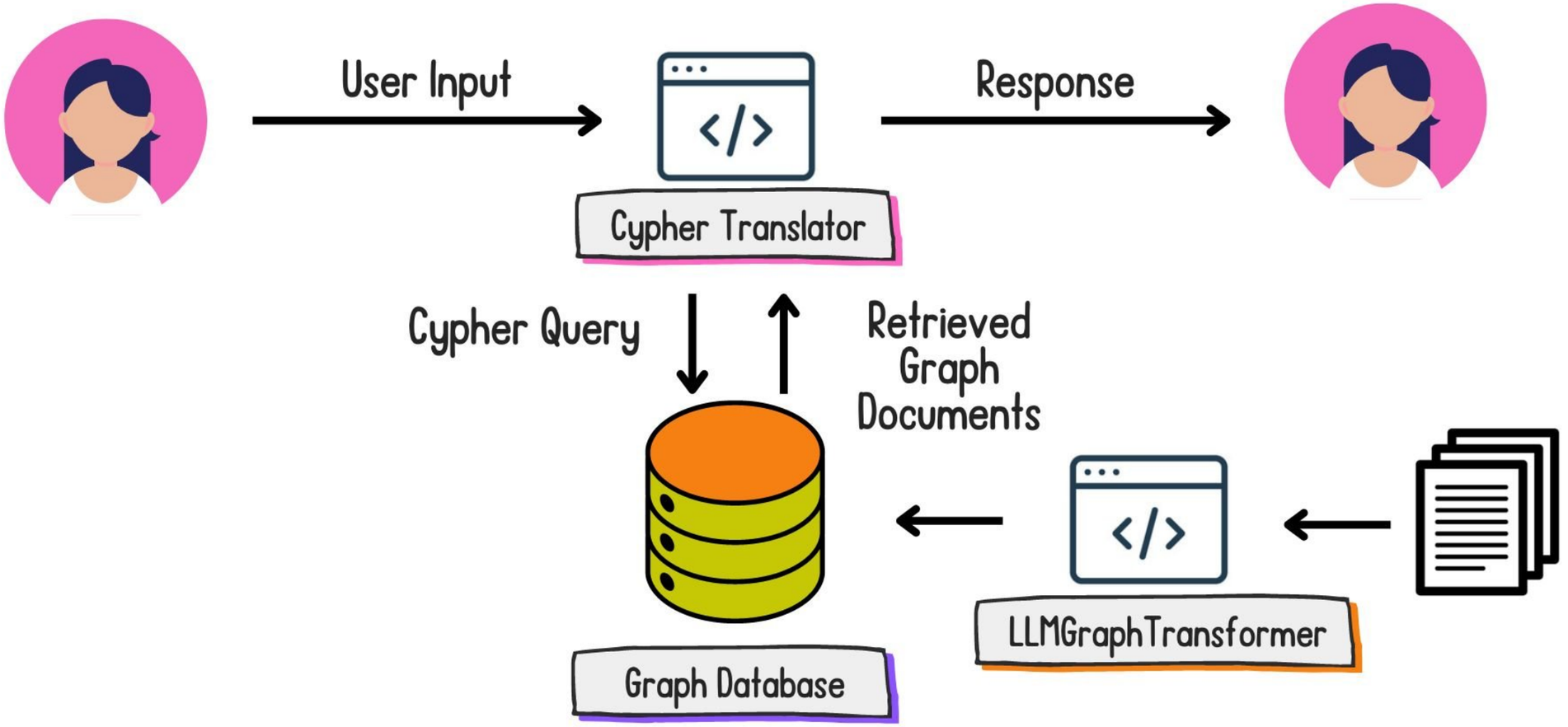


[1] Image Credit: LangSmith

Chapter 3


Antoni Gaudí
Architected
Sagrada Familia
Is located in...
Barcelona
Are located in...
F.C. Barcelona
Is Interested in...
Shreya
Visited
Works with...
James

Chapter 3


User Input
Response
Cypher Translator
Cypher Query
Retrieved Graph Documents
Graph Database
LLMGraphTransformer

Let's practice!

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN