

Introduction to Knowledge Graphs

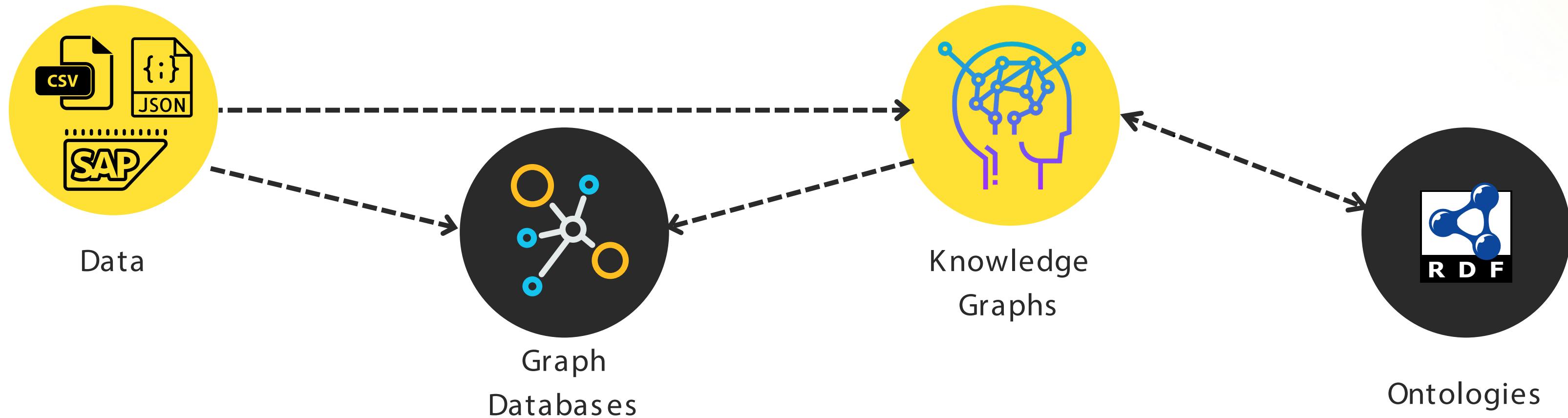
Associate Professor: Wei Liu
NTLP Research Group
UWA Data Institute
The University of Western Australia

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Data Science
Transforming
Maintenance

TEMINOLOGY OVERVIEW



Data Lakes
File Systems
Documents
Relational Databases

Data Storage
Data Query
Data Analytics

Data Enrichment
Data Categorisation
Data Integration

Formal Semantics
Unique Identifiers
Constraint Satisfaction

Reasoning
Triple Stores

Data Science
Transforming
Maintenance

Why Graph Databases?

Knowledge Graph as a Data Integration Tool



Relational Database Stores Data in Tabular Form

Books

Title	Author	Publisher	Year Published	Followed By
To Kill a Mockingbird	Harper Lee	J. B. Lippincott Company	1960	Go Set a Watchman
Go Set a Watchman	Harper Lee	HarperCollins, LLC; Heinemann	2015	
The Picture of Dorian Gray	Oscar Wilde	J. B. Lippincott & Co.	1890	
2001: A Space Odyssey	Arthur C. Clarke	New American Library, Hutchinson	1968	

Publishers

Name	City	Country
J. B. Lippincott & Company	Philadelphia	United States
HarperCollins, LLC	New York City	United States
Heinemann	Portsmouth	United States
New American Library	New York City	United States
Hutchinson	London	United Kingdom

Authors

Name	Country of Birth
Harper Lee	United States
Oscar Wilde	Ireland
Arthur C. Clarke	United Kingdom

How do
relational
databases
capture
relations?

Credit of Pictures: <https://enterprise-knowledge.com/whats-the-difference-between-an-ontology-and-a-knowledge-graph/>

How do relational databases capture relations?



What are the entities?

Briefly elaborate on what you want to discuss.

How are they related?

Briefly elaborate on what you want to discuss.



Relational Database Stores Data in Tabular Form

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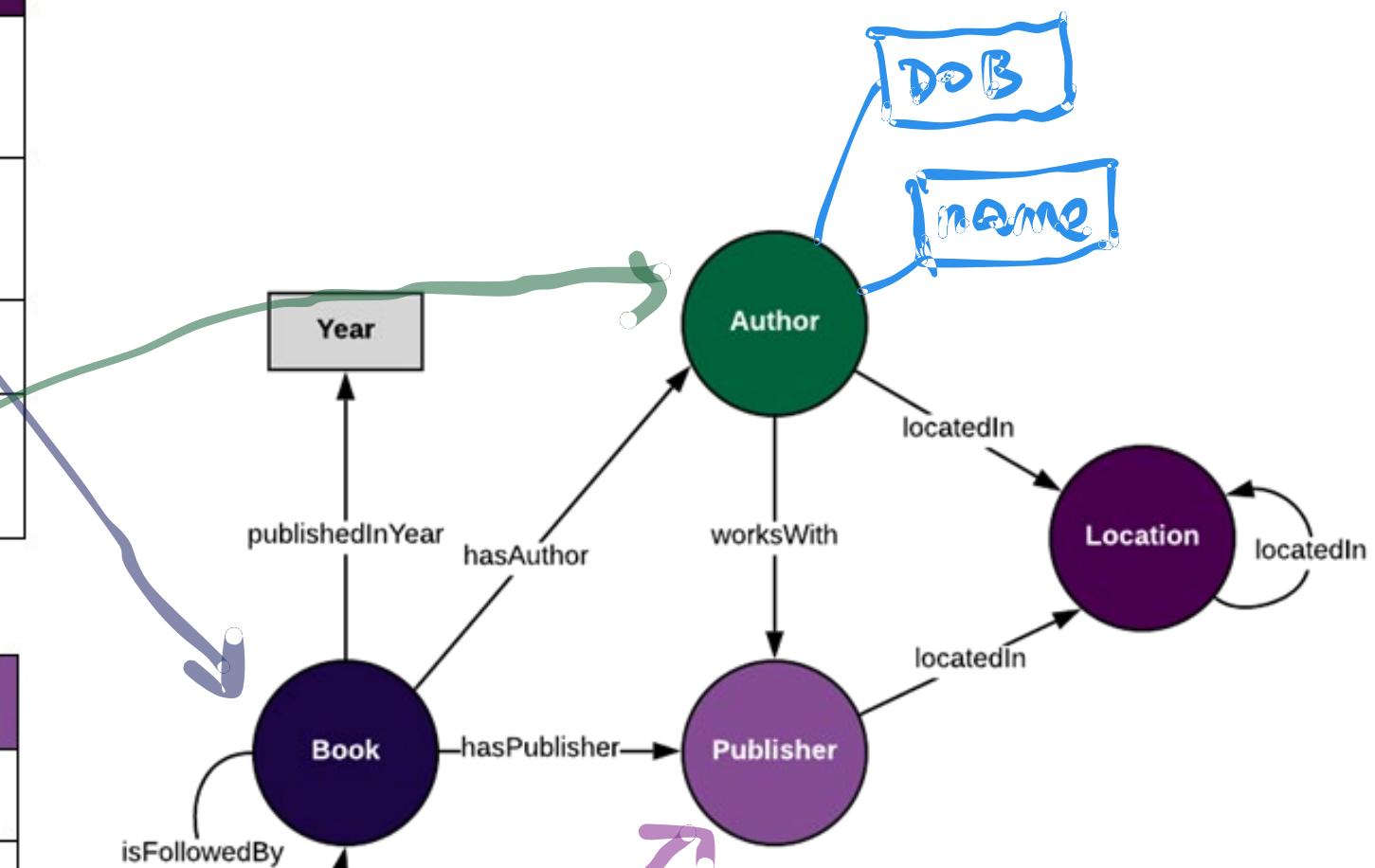
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Name	City	Country
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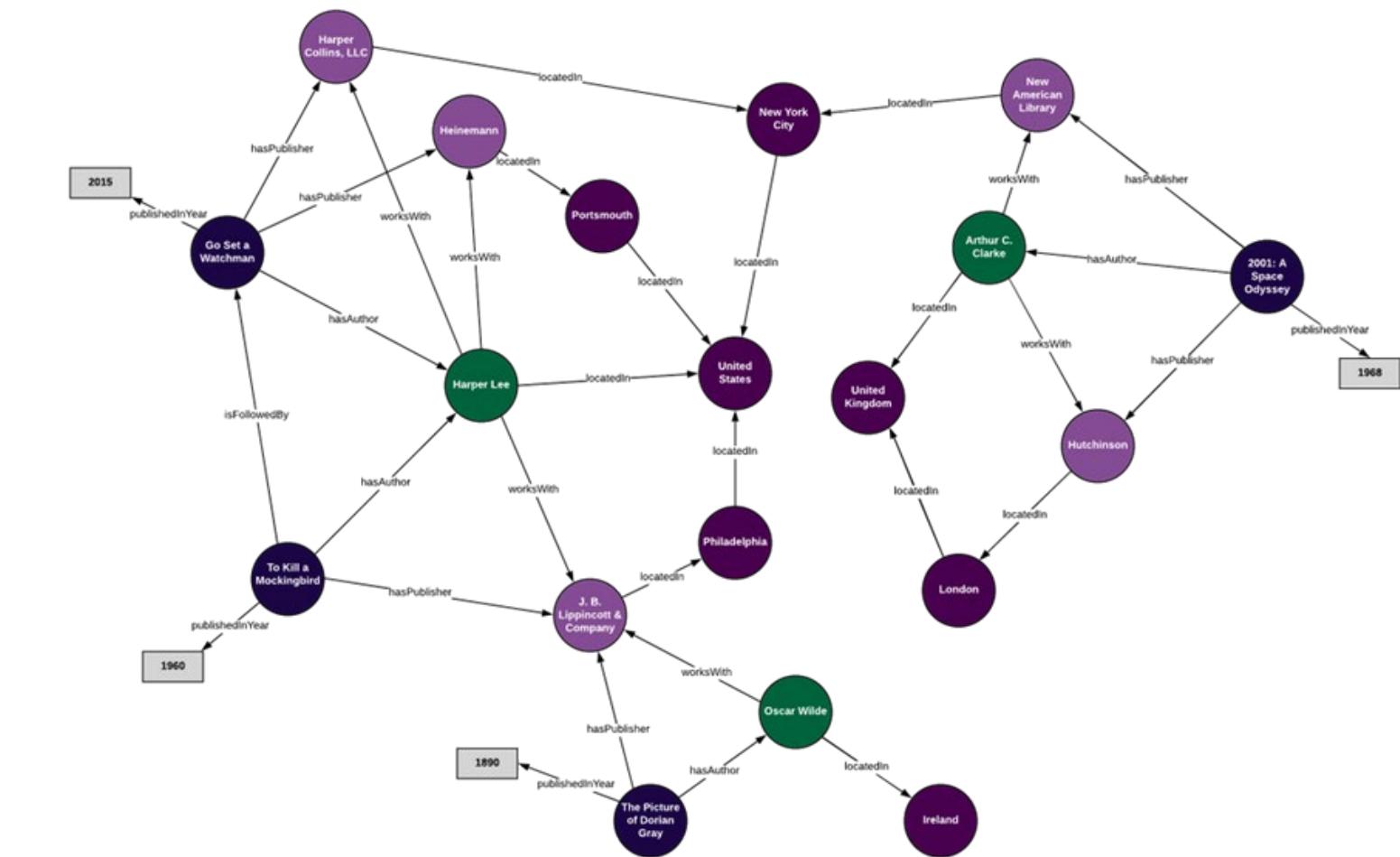
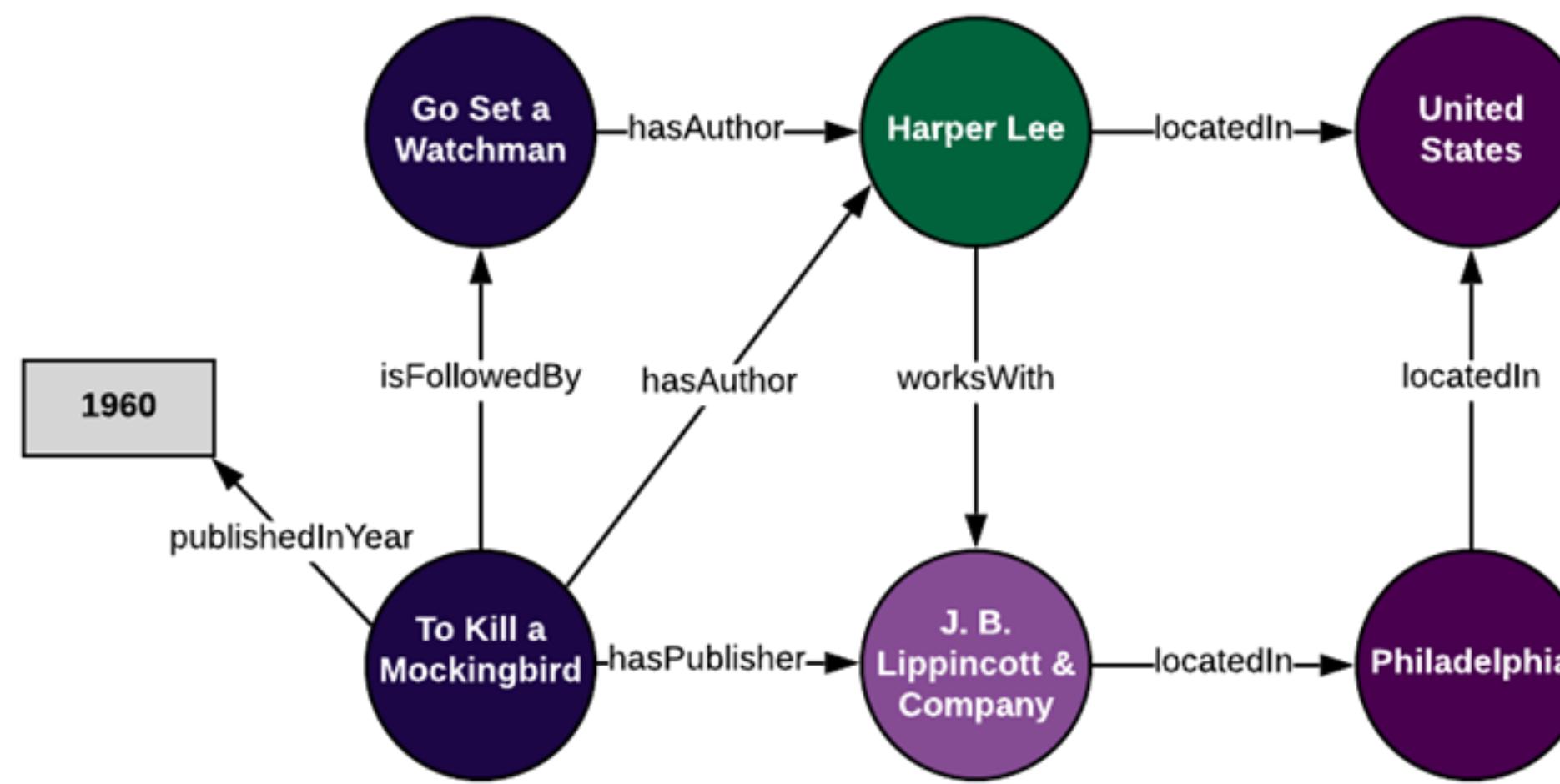
Name	Country of Birth
Harper Lee	United States
Oscar Wilde	Ireland
Arthur C. Clarke	United Kingdom

Data + Ontology = Knowledge Graph



Credit of Pictures: <https://enterprise-knowledge.com/whats-the-difference-between-an-ontology-and-a-knowledge-graph/>

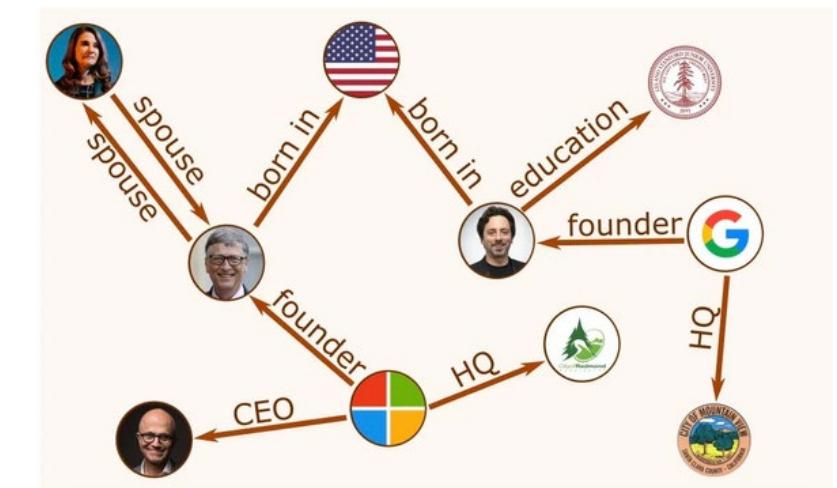
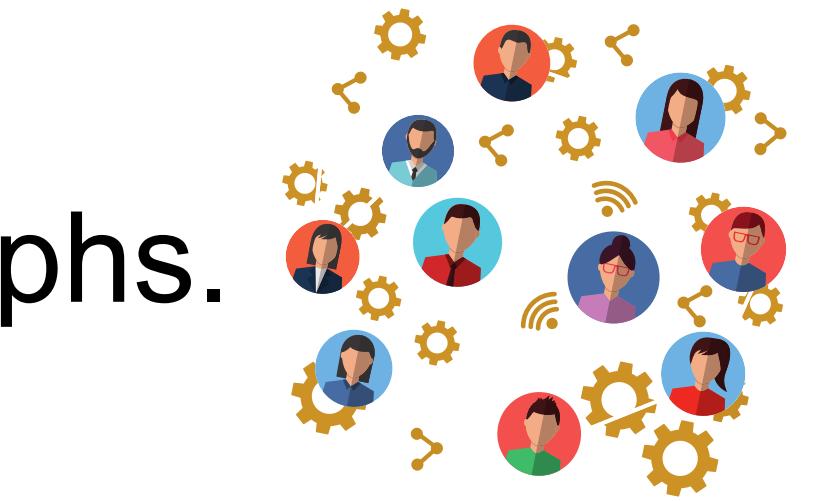
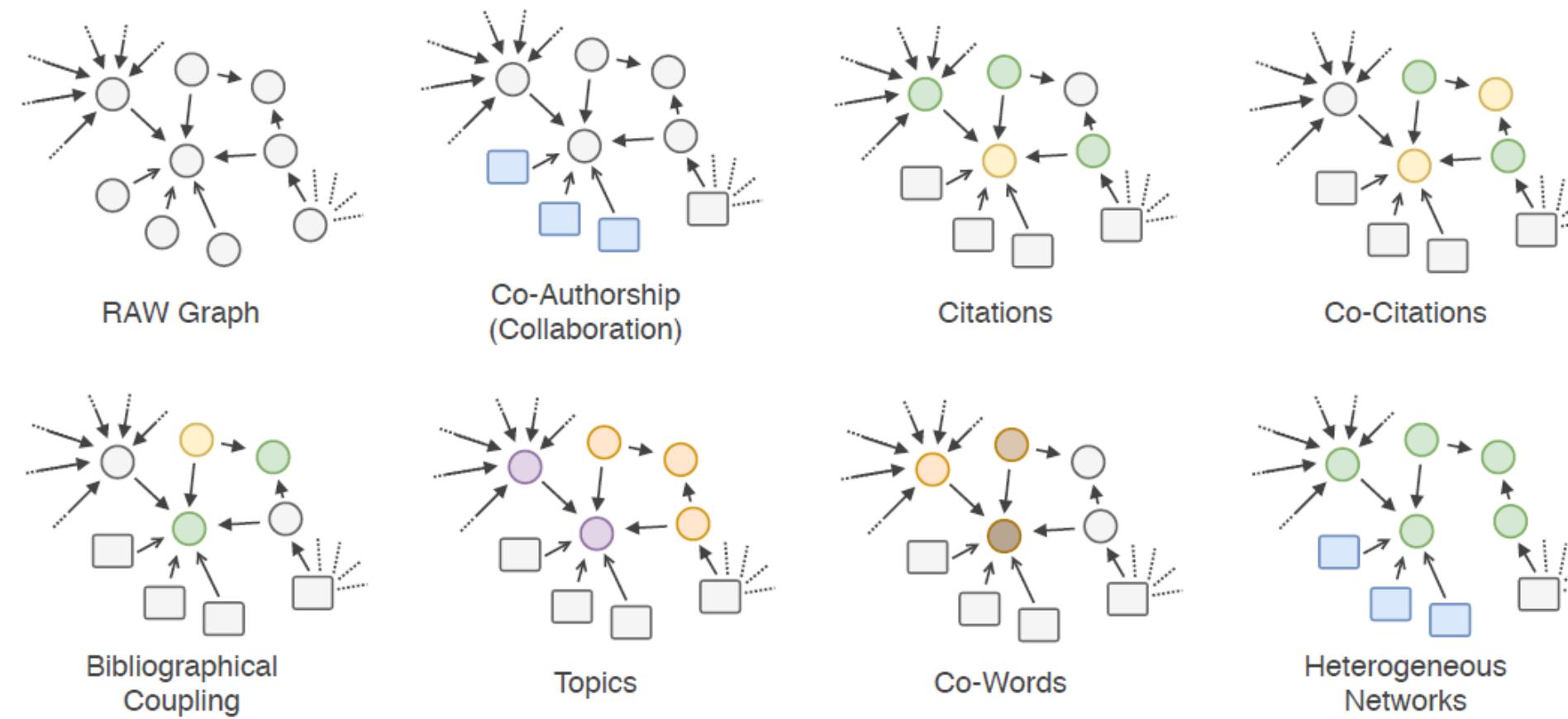
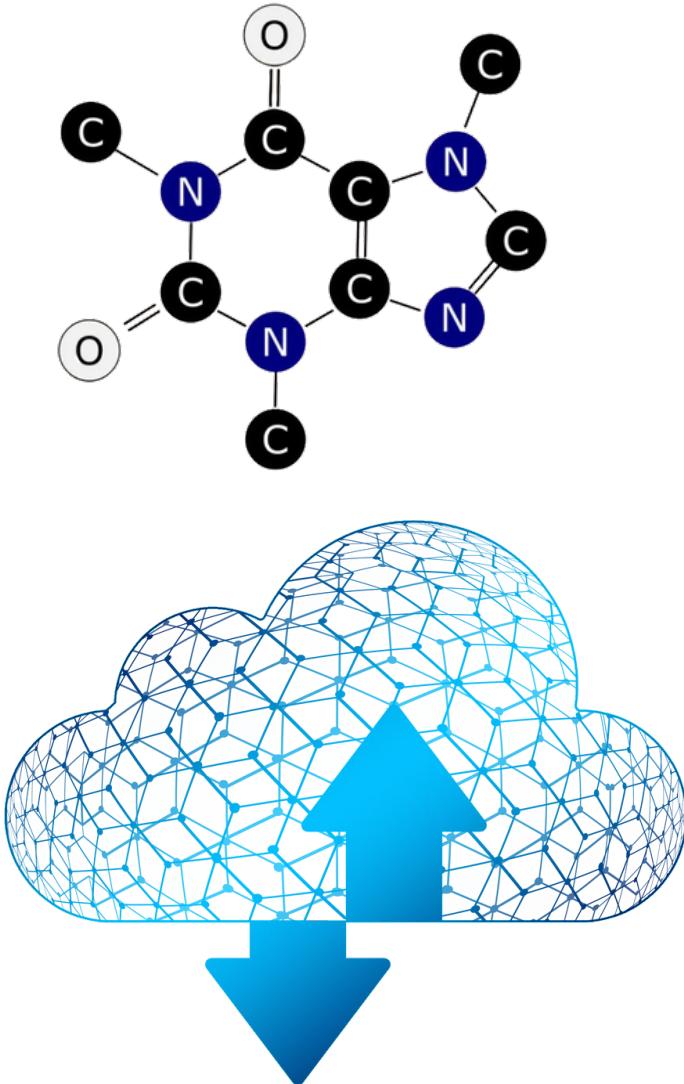
Graph Database Excels at Highly Connected Data



Credit of Pictures: <https://enterprise-knowledge.com/whats-the-difference-between-an-ontology-and-a-knowledge-graph/>

What is a graph

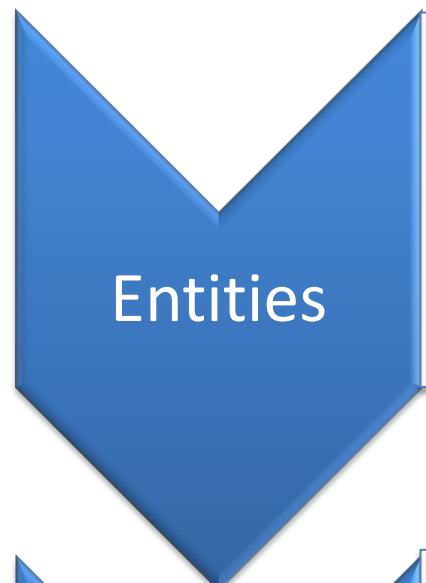
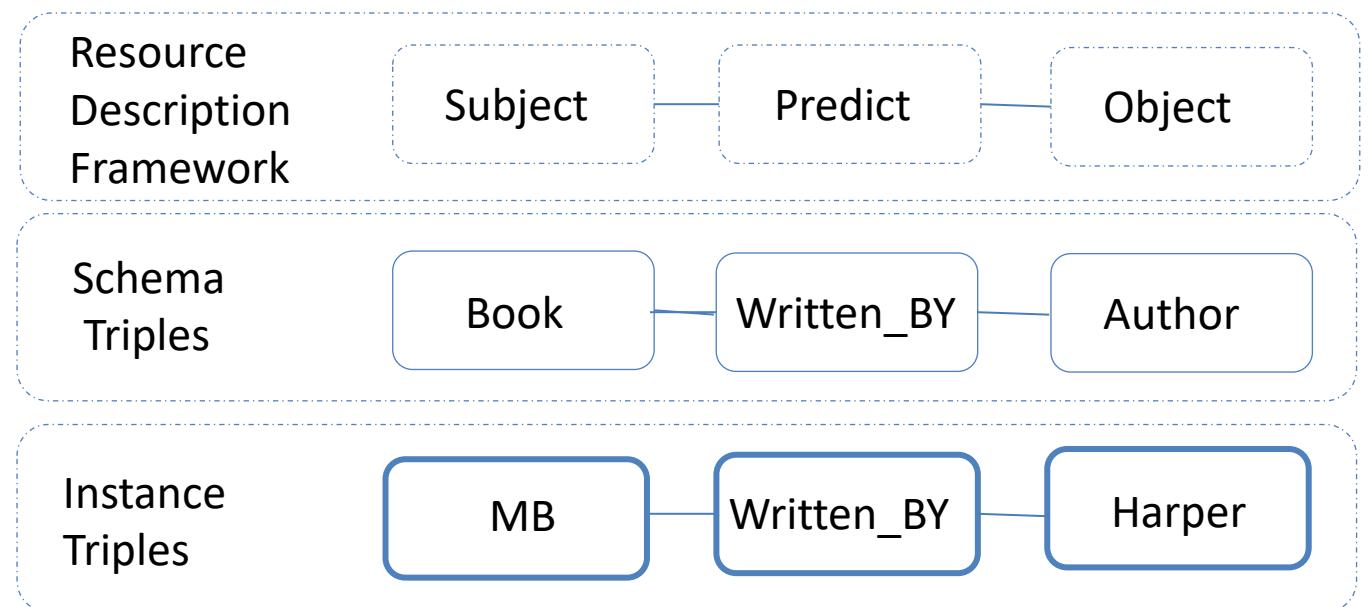
- A graph is a collection of vertices and edges, also known as nodes and relationships.
- We can model all sorts of scenarios using graphs.



Credit of Picture on Scholarly Network Analysis: <https://towardsdatascience.com/scholarly-network-analysis-22cd352c0f86>
<https://towardsdatascience.com/graph-convolutional-networks-deep-99d7fee5706f>

What's a Knowledge Graph

- Structured representation of knowledge that captures **relationships** between **entities** and their **attributes**.
- Organises information in a way that is easily understandable by both humans and machines.
- Built upon the principles of graph theory, where entities are represented as nodes and relationships as edges.



- Real-world objects such as people, places, organisations, or concepts
- e.g. a book, a product, a person



- Capture semantic connections or associations between entities.
- e.g. "works for," "is a part of," "has a sibling," etc.



- Attributes represent properties or characteristics of entities.
- e.g. date, age, location, occupation, or any other relevant information.

Top FIVE Use Cases of Graph Databases

Graph Databases



Technologies used primarily for **transactional** online graph persistence, typically accessed directly in **realtime** from an application.

Graph Compute Engines



Technologies used primarily for **offline graph analytics**, performed as a series of batch steps.

Enterprise Knowledge Graph



EKG Platform



Consulting services



Top FIVE Use Cases of Graph Databases

- Handling massively connected data with speed and accuracy
- Bridging data silos
- Bringing Explainability
- Coupled with KG, ML and DL for Fraud Detection
- Supply Chain Management

UNITED HEALTH GROUP

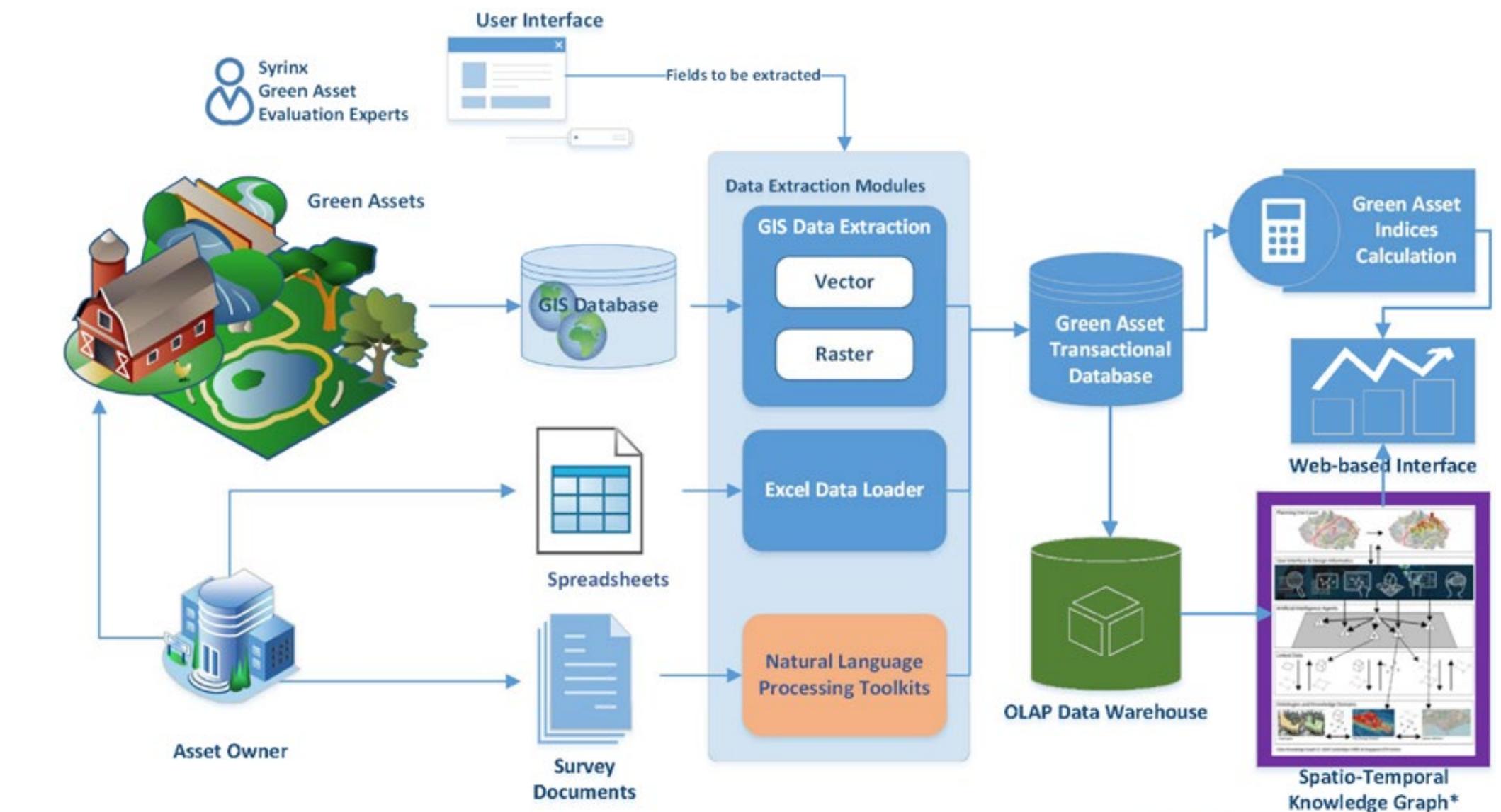
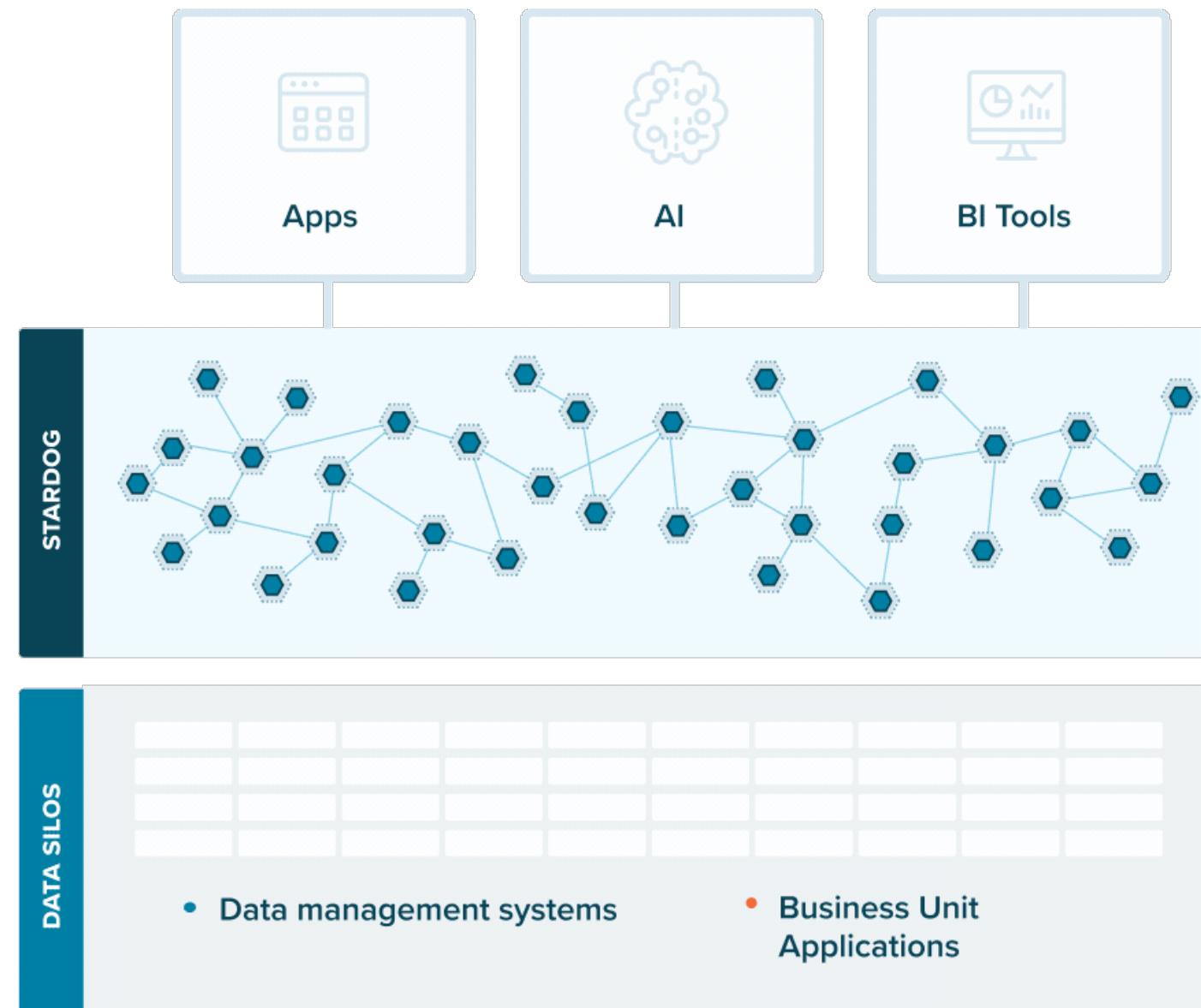
INTUIT

JPMORGAN CHASE & CO.

JLR



Knowledge Graph as a Data Integration Tool



A Client Server Cloud Ready Architecture

Picture Credit: <https://www.stardog.com/>

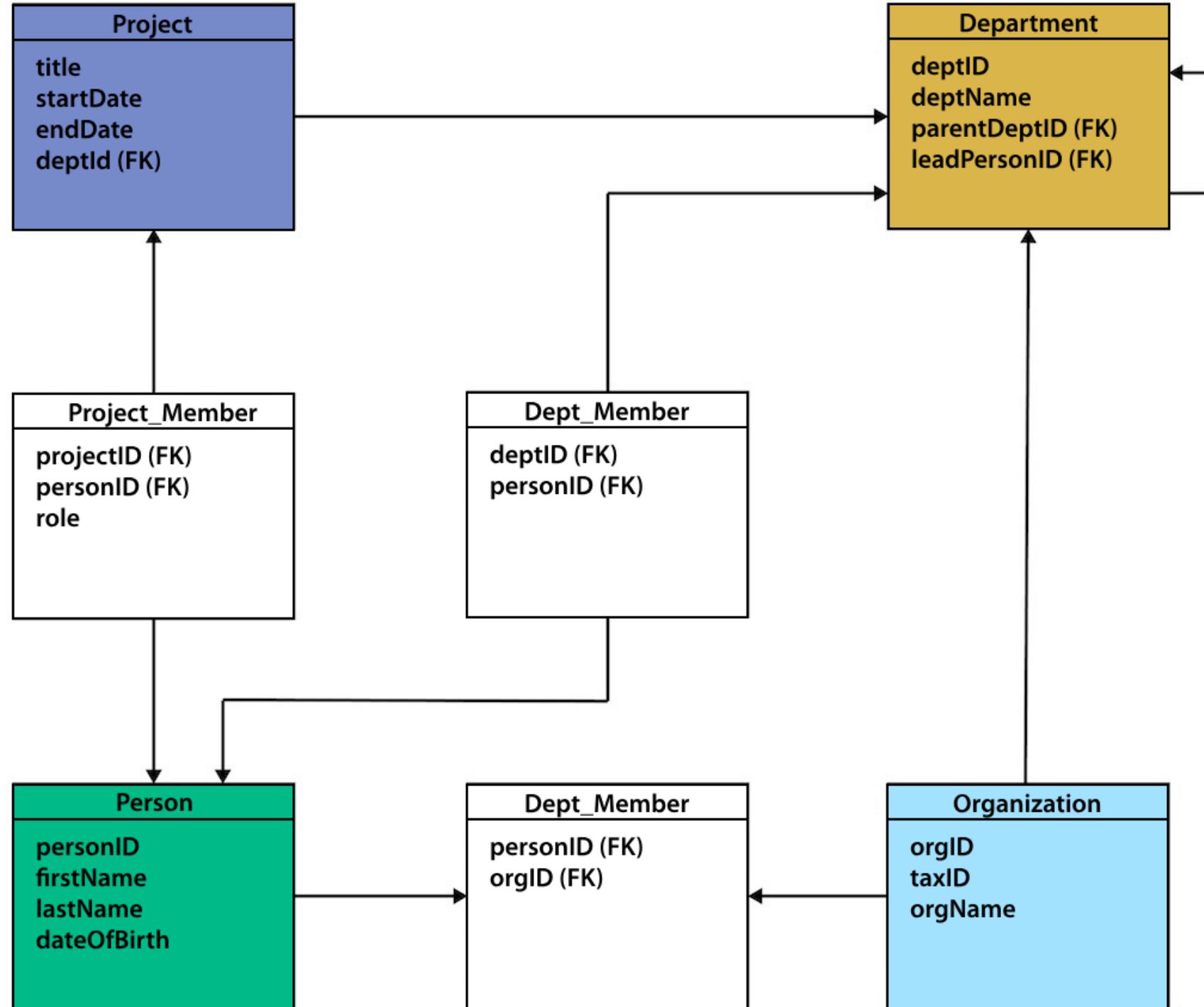
Picture Credit: A/Prof. Wei Liu

Relational to Graph Conversion

From RDBMS to Graph Databases



Relational to Graph Data Modelling



- Table to Node Label
- Row to Node
- Column to Node Property
- Foreign keys to Relationships
- No defaults
- Join tables to Relationships

YOUR TURN

How would
the graph
data model
looks like?



What are the entities?

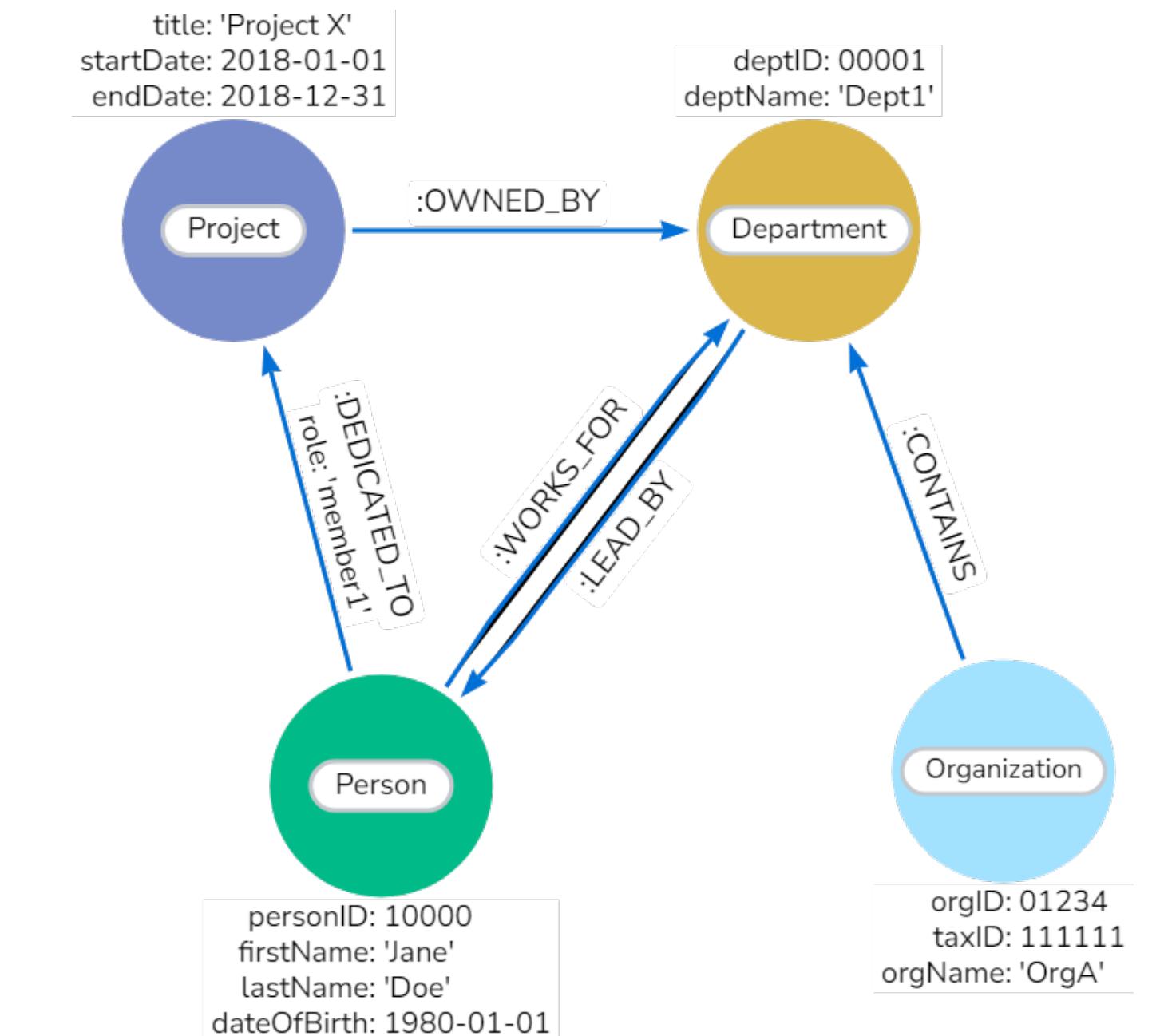
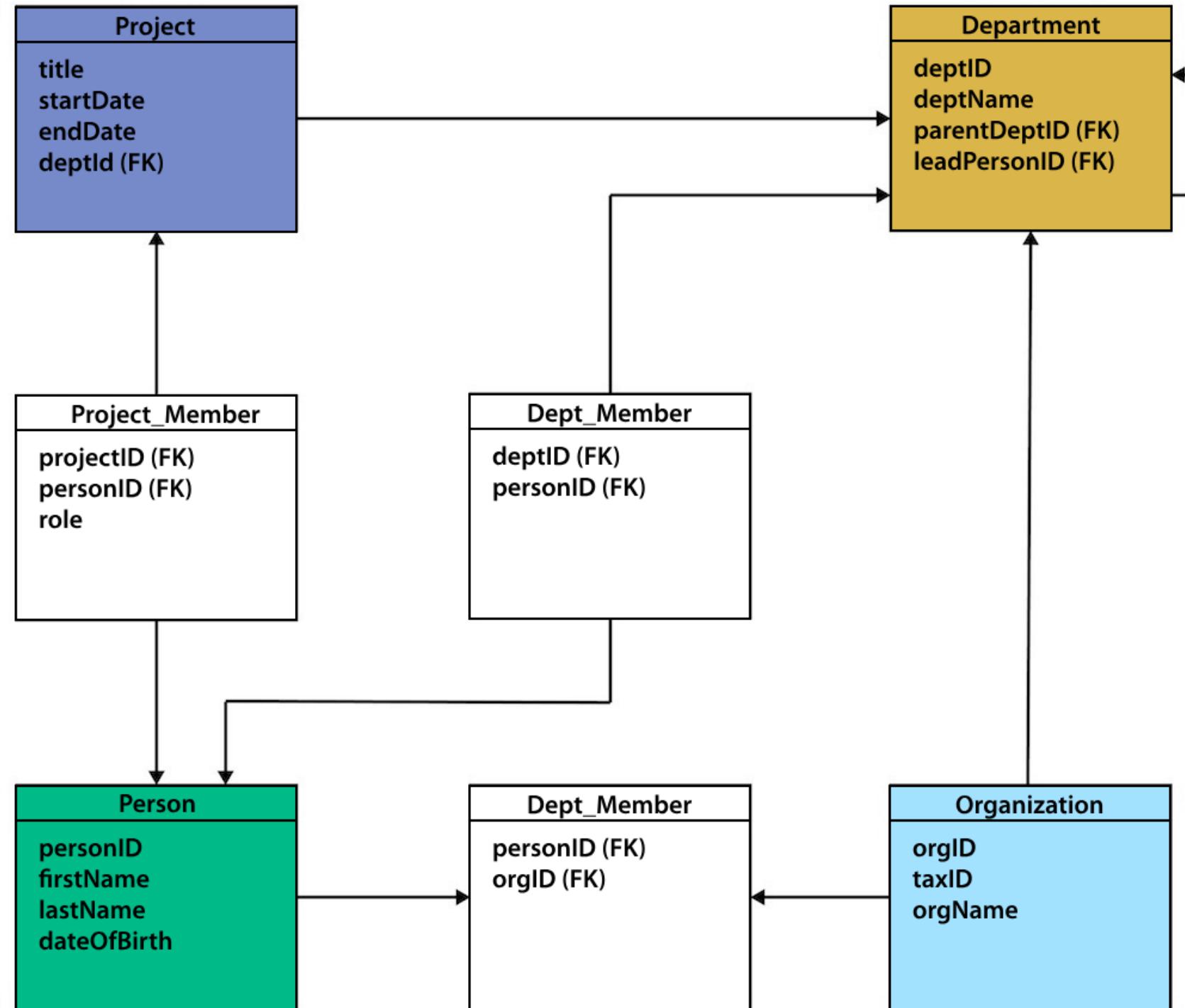
Does the mapping make sense? Should some properties be promoted to nodes? Why?

How are they related?

Are the relationships enough to answer your queries?

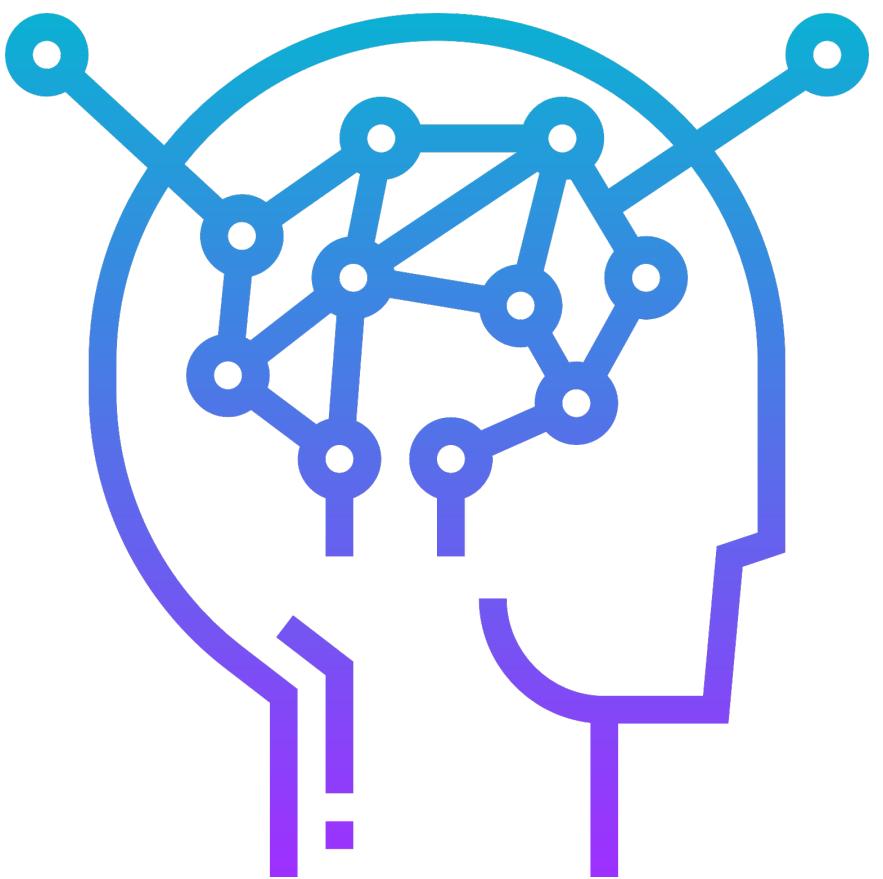


Relational to Graph Data Modelling

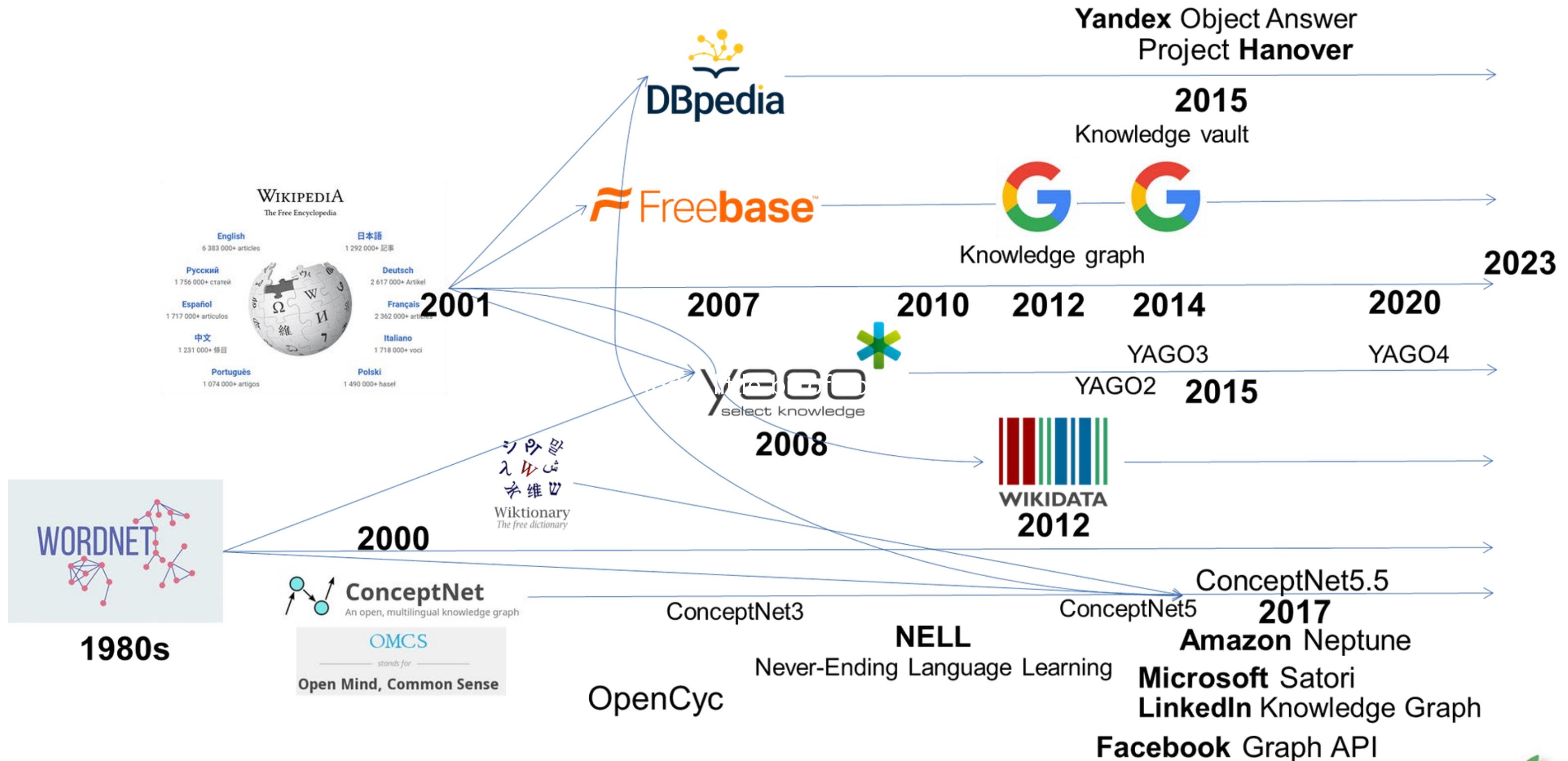


Semantic-Rich Knowledge Graph

knowledge graphs as data enriched with semantics



The Journey of Knowledge Graph



Using Google Enterprise Knowledge Graph API



Person Place Property Organization Product

Entity

Entities represent distinct, identifiable concepts



Every Entity has a MID

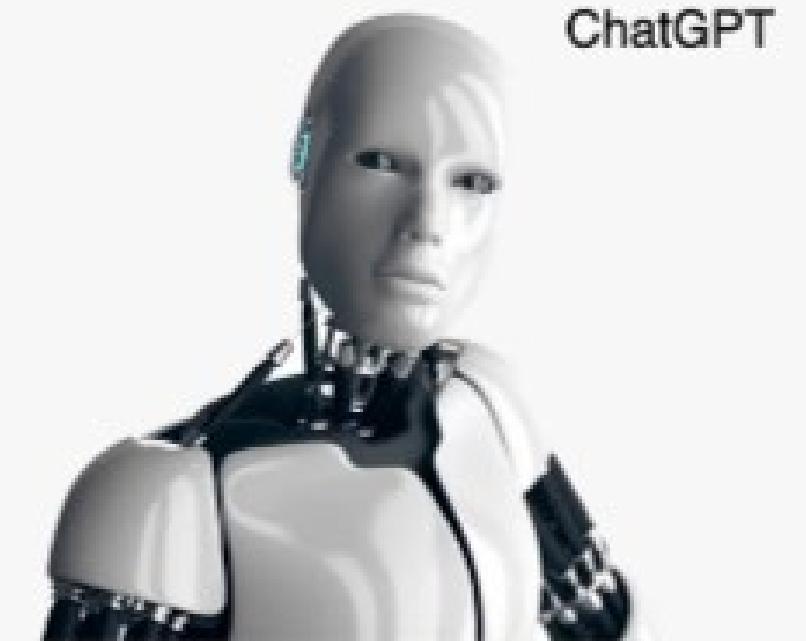
One entity aggregates all the information

In your CV you wrote that you can count quickly. What is 17 times 19

36 ...

That wasn't even close ...

But fast



ChatGPT

Book BookSeries
EducationalOrganization
Event GovernmentOrganization LocalBusiness
Movie MovieSeries
MusicAlbum MusicGroup MusicRecording
Organization Periodical Person Place SportsTeam
TEpisode TVSeries
VideoGame VideoGameSeries WebSite

Data augmentation with BigQuery and Google Knowledge Graph

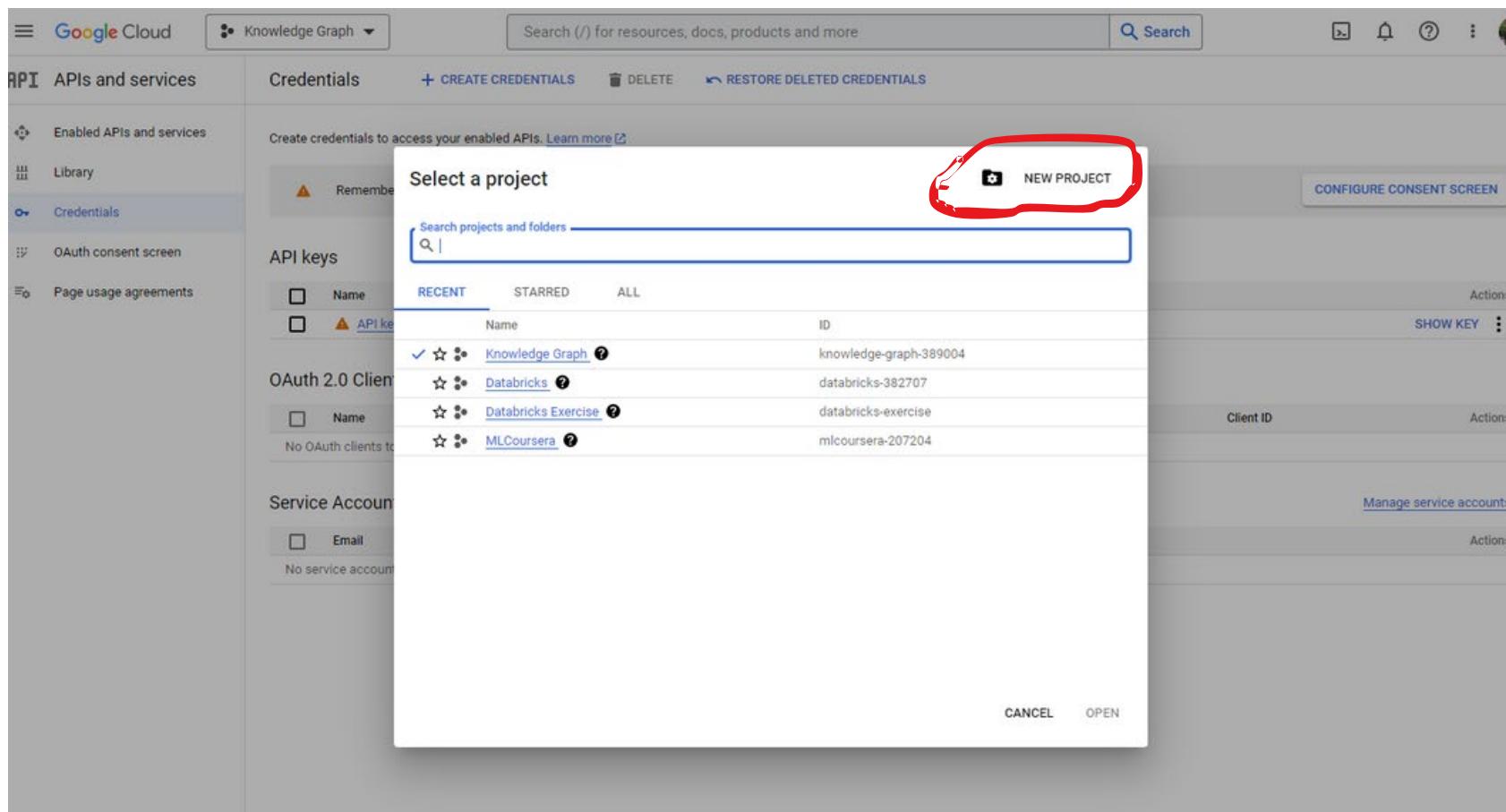
Seems like everybody is talking about Large Language Models these days and most people are impressed with how well they can use the words...

Medium / 21 Dec 2022

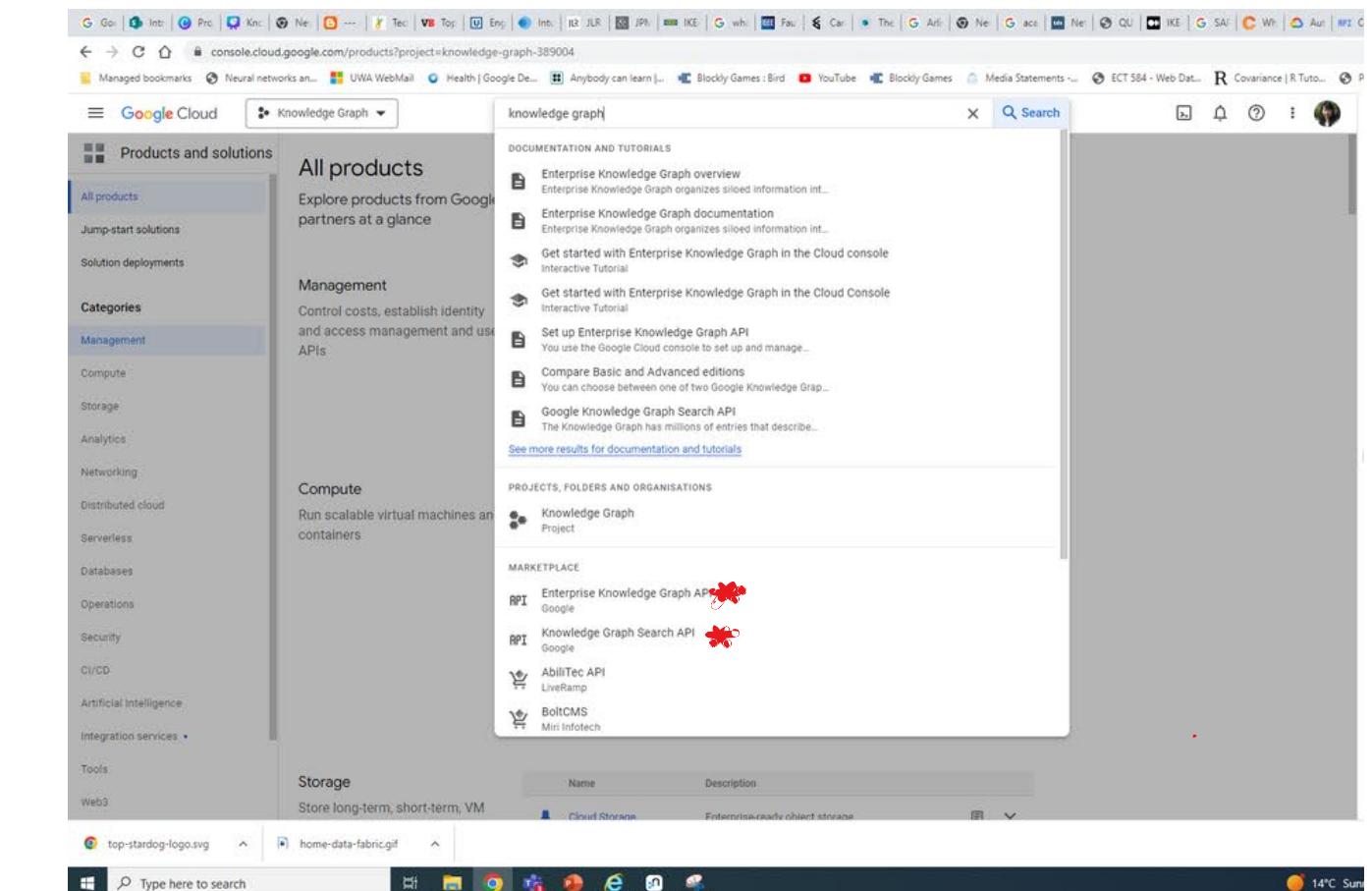


Let's First Take a Look at Google's Knowledge Graph API

Google Cloud Platform Credentials



Google Enterprise Knowledge Graph API Google Knowledge Graph API



Knowledge Graphs are the key technology supporting
semantically enriched search.
Beyond keyword matching!

<https://console.cloud.google.com/welcome?project=knowledge-graph-389004>

Google Knowledge Panel

Results for **Claremont** · Choose area · :

 Rio Tinto
<https://www.riotinto.com> · :

Rio Tinto | Global
Rio Tinto is a leading global mining group that focuses on finding, mining and processing the Earth's mineral resources. Discover more about **Rio Tinto's ...**

Careers
See another side to mining by investigating the type of career ...

Available Jobs
Email scam: recruitment support. Rio Tinto has recently become ...

Australia
Rio Tinto home. About. Back to main menu. About. Finding ...

About
Purpose & Values - Business Strategy - Board of Directors - ...
[More results from riotinto.com »](#)

People also ask · :

Which country owns Rio Tinto? ▾

Is Rio Tinto Australia's largest mining company? ▾

Does Rio Tinto pay well? ▾

Does China own Rio Tinto? ▾

Rio Tinto ←
Mining corporation


riotinto.com

Rio Tinto Group is an Anglo-Australian multinational company that is the world's second-largest metals and mining corporation. It was founded in 1873 when a group of investors purchased a mine complex on the Rio Tinto, in Huelva, Spain, from the Spanish government. [Wikipedia](#)

Stock price: RIO (ASX) \$113.13 -1.26 (-1.10%)
23 June, 4:10 pm AEST - [Disclaimer](#)

CEO: Jakob Stausholm (1 Jan 2021–)

Parent organization: Rio Tinto International Holdings Limited

Headquarters: London, United Kingdom

Subsidiaries: Rio Tinto Alcan, Rio Tinto Company Limited, MORE

Revenue: 55.55 billion USD (2022)

Founded: 1873

Number of employees: 45,000 (2022)

Disclaimer

Profiles

Google Knowledge Graph API

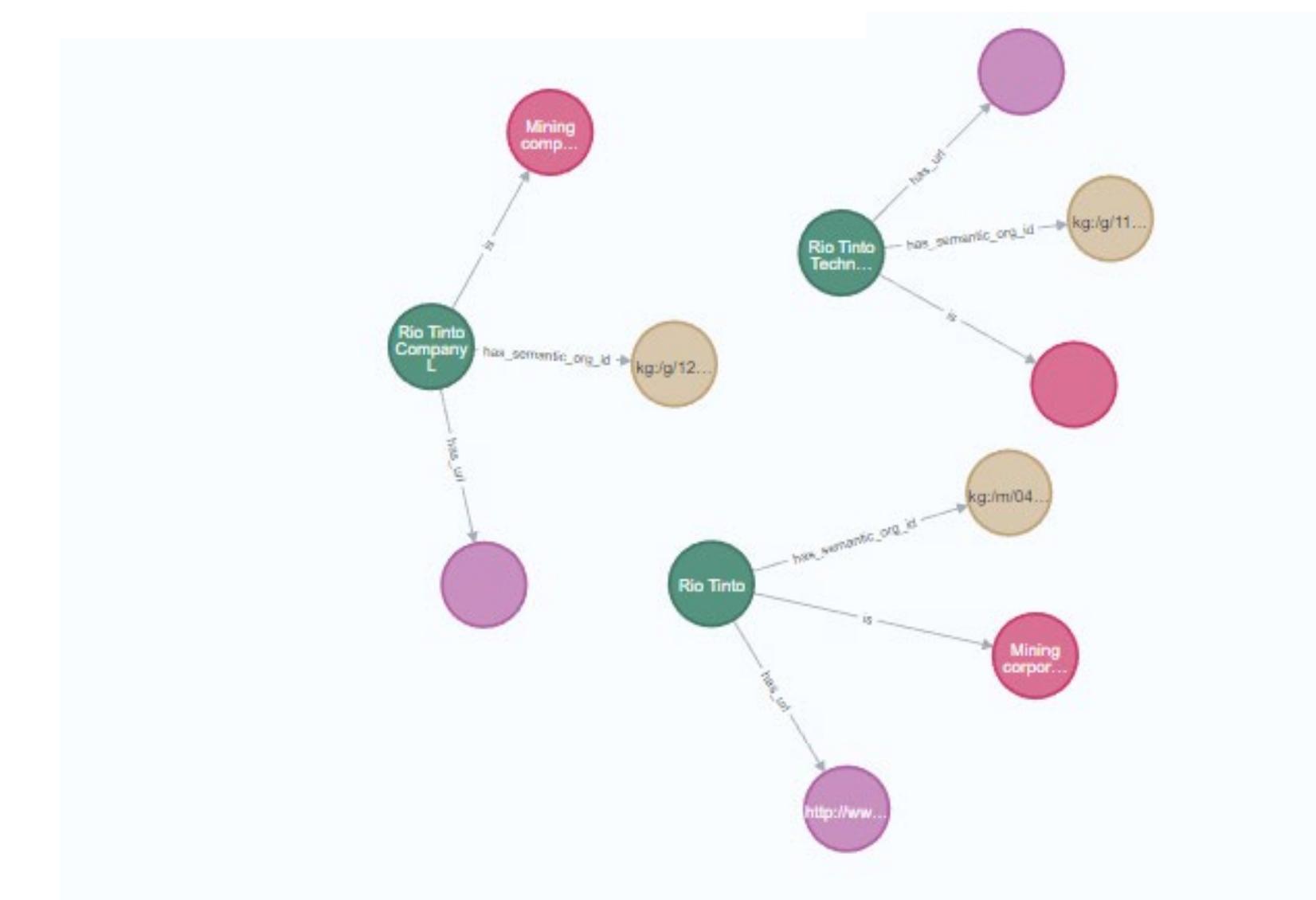
https://kgsearch.googleapis.com/v1/entities:search?query=rio+tinto+resources&types=Corporation&key=API_Key

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}
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<http://searchengineland.com/laymans-visual-guide-googles-knowledge-graph-search-api-241935>

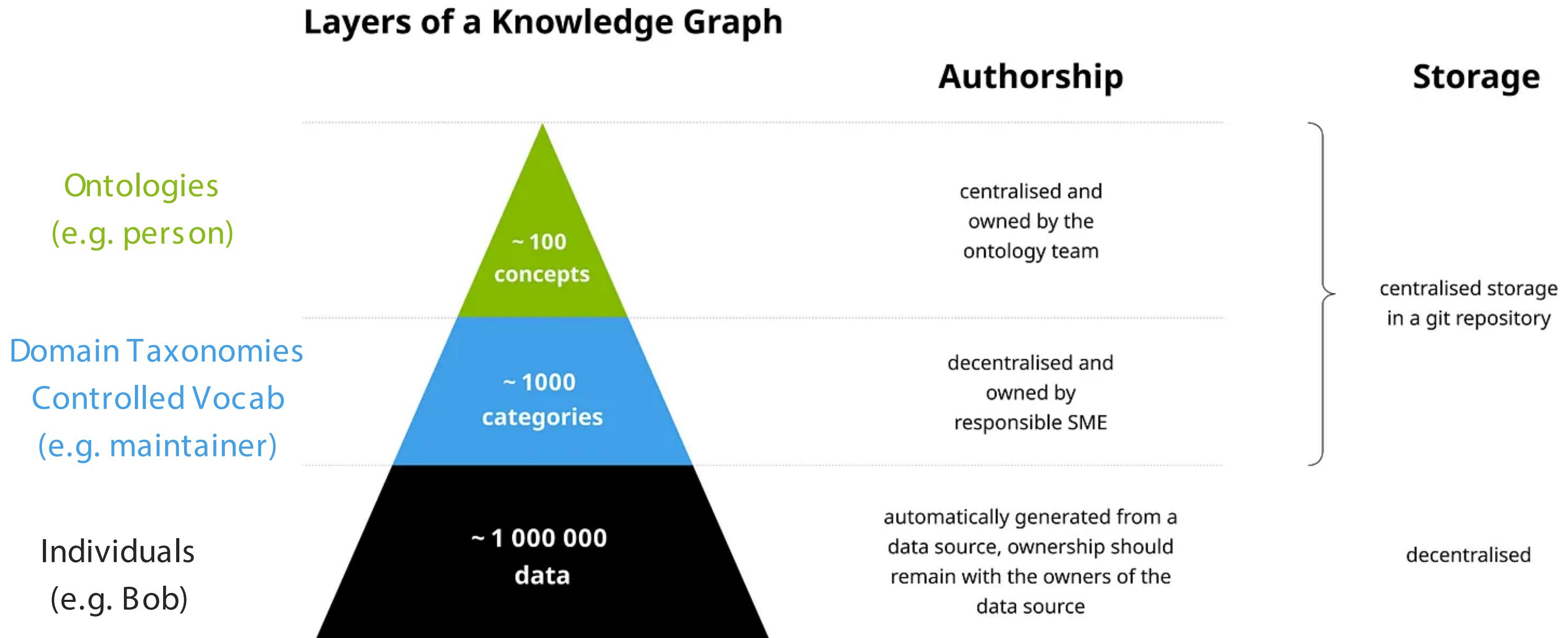
Neo4j Results

```
11
12 CALL apoc.create.node(record["@type"], {name:record["name"]}) yield node as p
13 CALL apoc.create.node(["Company"], {name:record["description"]}) yield node as pre
14 CALL apoc.create.node(["SemOrgID"], {sem_id:record["@id"]}) yield node as sem
15 CALL apoc.create.node(["URL"], {url:record["url"]}) yield node as u
16 CALL apoc.create.relationship(p, "is", null, pre) yield rel as isA
17 CALL apoc.create.relationship(p, "has_semantic_org_id", null, sem) yield rel as has_sem
18 CALL apoc.create.relationship(p, "has_url", null, u) yield rel as has_url
19 RETURN p, u, sem, pre, isA, has_sem, has_url
```

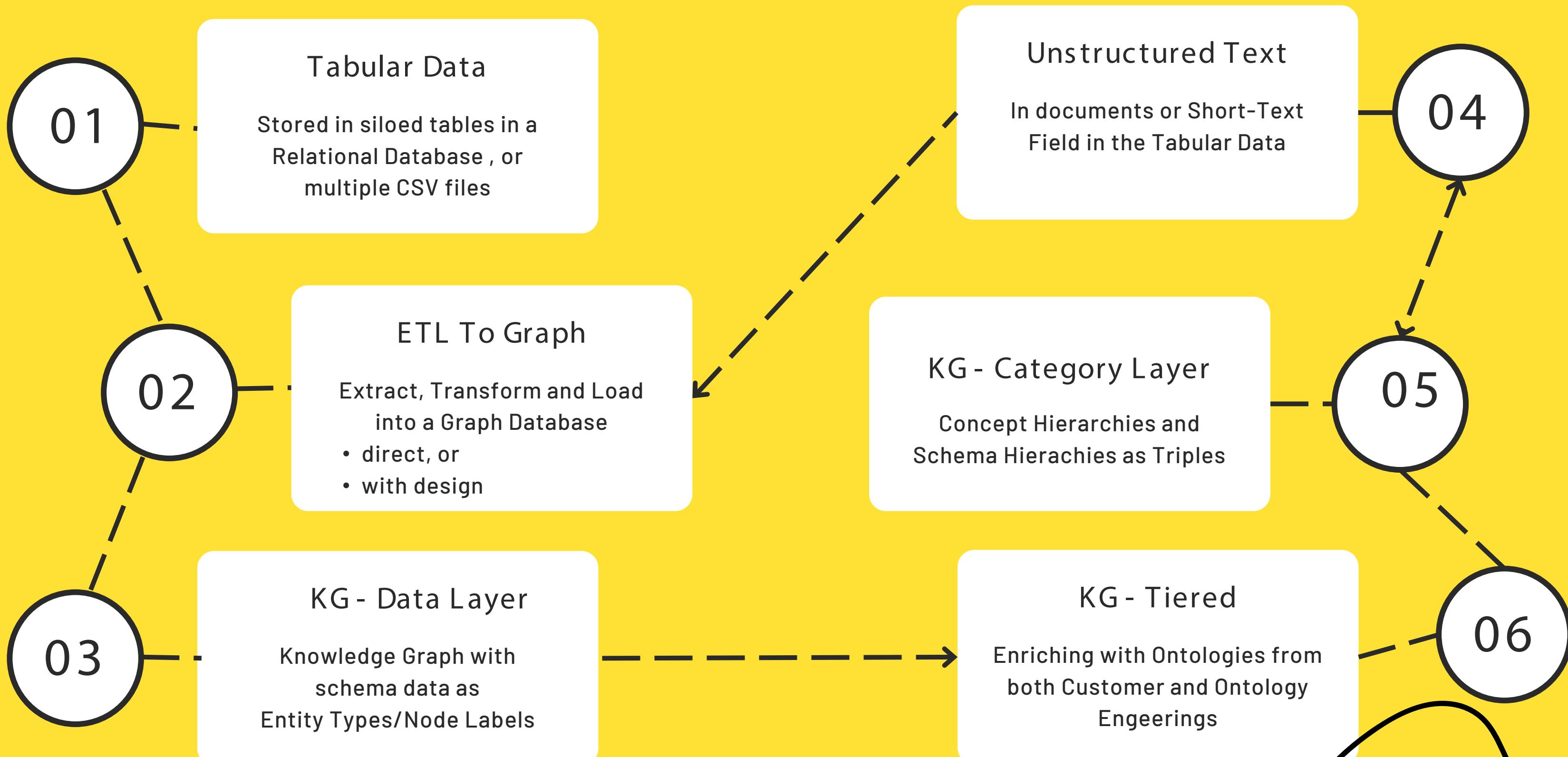


The Pyrmoid of Enterprise Knowledge Graph

IKEA's Knowledge Graph and Why it has Three Layers?



KNOWLEDGE GRAPH FOR DATA INTEGRATION AND ENRICHMENT



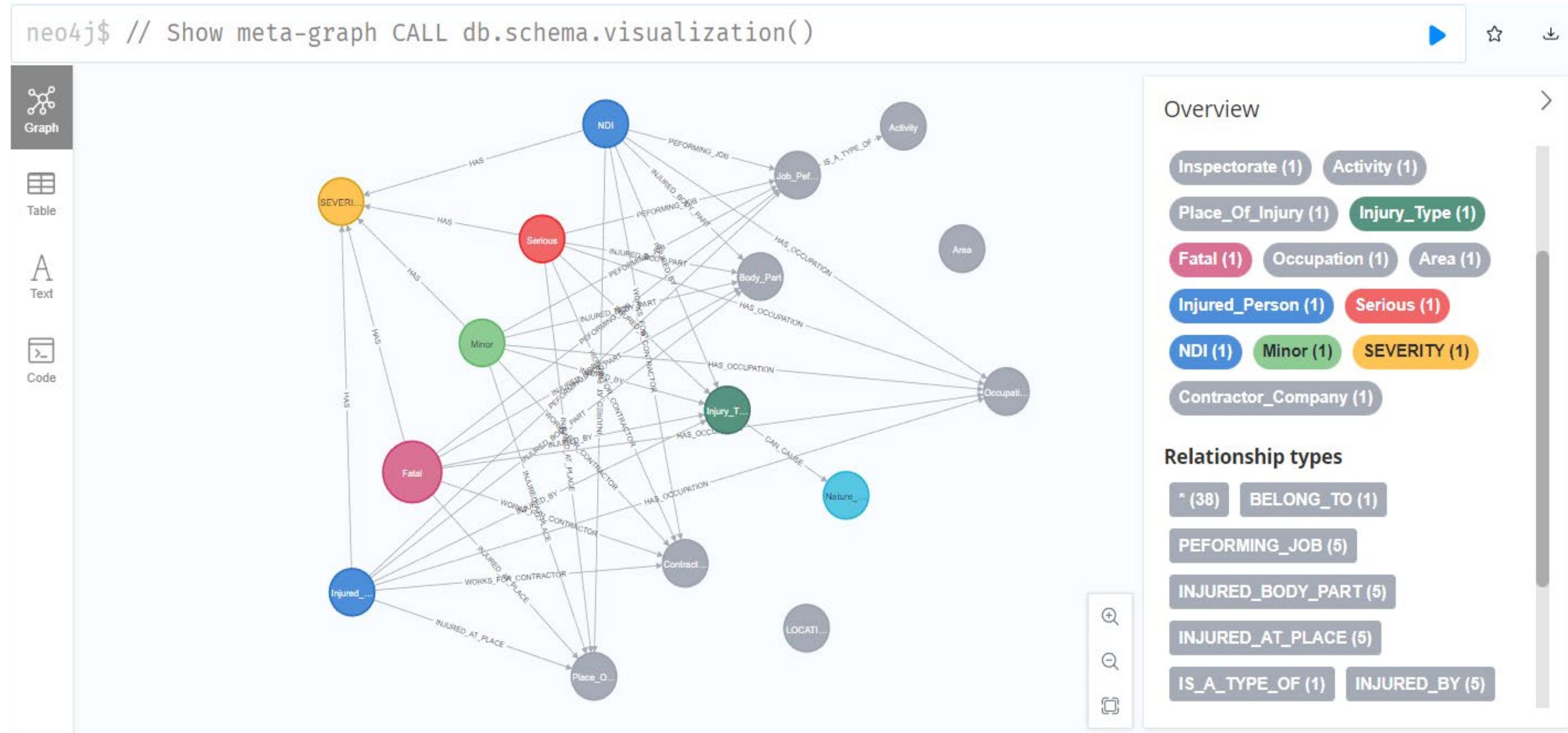
A Deeper Look at KG-Assisted Workplace Safety Analysis

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1 Inspector	Date Of Ac	Area	Activity	Site Name	Site Active	Company	Location	Gender	DOB	Age At Acc	MTI	NDI	Recurrence	Total Days	Total Days	Total Alt D	Severity	Place Of Ir	Activity De	Injury Type	Body Part	Nature Of
2 North - Kir ##### MINING	Operations		Yes		SURFACE	Male	1987	26	No			No	0	0	0	Fatal	0471 - Pro	8230 - Rep	2510 - C/B	6300 - Hea	5600 - Cru	
3 North - Kir ##### MINING	Operation:	55	Yes	DD	SURFACE	Male	1983	30	Yes			No	108	602	300	Serious	0610 - W.S	8130 - Rep	2510 - C/B	6500 - Cor	5400 - Frac	
4 North - Kir ##### MINING	Construction		Yes		SURFACE	Male	1970	43	Yes			No	0	0	0	Fatal	0451 - Tail	7900 - Mis	2130 - S/B	6920 - Mul	5600 - Cru	
5 North - Kir ##### MINING	Operation:	55	Yes	DD	SURFACE	Male	1965	48	Yes			No	19	115	52	Serious	0610 - W.S	2110 - Wa	1210 - Fall	5300 - Kne	5200 - Stra	
6 West - Mic ##### MINING	Operation:	99	Yes	FFF	SURFACE	Male	1976	37	Yes			No	4	5	0	Minor	0370 - Sto	2450 - Mo	9100 - Bite	5400 - Lov	6310 - Bite	
7 West - Mic ##### MINING	Operation:	99	Yes	FFF	SURFACE	Male	1992	21	Yes			No	2	4	0	Minor	0471 - Pro	7900 - Mis	9100 - Bite	5200 - Upp	6310 - Bite	
8 West - Pla ##### MINING	Operation:	139	Yes	IIII	SURFACE	Male	1964	49	Yes			No	0	11	7	Minor	0464 - Rea	2450 - Mo	2510 - C/B	4630 - Fing	6100 - Lac	
9 West - Pla ##### MINING	Maintenar	139	Yes	IIII	SURFACE	Male	1984	29	No			No	0	6	5	Minor	0464 - Rea	2320 - Lift	4200 - O.X	3100 - Bac	5200 - Stra	
10 East - Nort ##### MINING	Operation:	15	Yes	G	UNDER	Male	1985	28	No			No	0	15	7	Serious	0128 - Lev	2410 - Pull	1120 - Fall	4620 - Har	5200 - Stra	
11 East - Nort ##### MINING	Operation:	15	Yes	G	UNDER	Male	1984	28	No			No	0	24	16	Serious	0128 - Lev	2180 - Get	3150 - Ste	5500 - Ank	5200 - Stra	
12 East - Nort ##### MINING	Operation:	15	Yes	G	SURFACE	Male	1969	44	No			No	0	23	13	Serious	0950 - Car	2110 - Wa	3120 - Ste	5500 - Ank	5200 - Stra	
13 East - Nort ##### MINING	Operation:	15	Yes	G	UNDER	Male	1975	38	Yes			No	0	26	8	Serious	0128 - Lev	2180 - Get	1420 - Fall	5300 - Kne	5200 - Stra	
14 East - Nort ##### MINING	Operation:	15	Yes	G	UNDER	Male	1965	48	Yes			No	0	18	11	Serious	0130 - Unc	2110 - Wa	1232 - Fall	3181 - Bac	6800 - Pair	
15 East - Nort ##### MINING	Maintenar	15	Yes	G	UNDER	Male	1965	48	No	Yes		No	0	0	0	NDI	0130 - Unc	2450 - Mo	4500 - O.E	4100 - Sho	5200 - Stra	
16 East - Nort ##### MINING	Operation:	18	Yes	J	UNDER	Male	1973	39	Yes			No	0	105	49	Serious	0128 - Lev	5700 - U.G	2510 - C/B	4630 - Fing	5600 - Cru	
17 East - Nort ##### MINING	Operation:	18	Yes	J	UNDER	Male	1980	32	Yes			No	7	421	258	Serious	0128 - Lev	2110 - Wa	3130 - Ste	5400 - Lov	5400 - Frac	
18 East - Nort ##### MINING	Operation:	145	Yes	0000	UNDER	Male	1984	29	Yes			No	0	8	8	Minor	0127 - Dec	5700 - U.G	1250 - Fall	3181 - Bac	5200 - Stra	
19 North - Kir ##### MINING	Constructi	3	Yes	A	SURFACE	Male	1993	20	Yes			No	0	31	30	Serious	0222 - Hea	2540 - Lub	4500 - O.E	4100 - Sho	5200 - Stra	
20 East - Nort ##### MINING	Operation:	44	Yes	U	SURFACE	Male	1990	23	Yes			No	0	111	70	Serious	0220 - Ben	2430 - Car	1250 - Fall	5500 - Ank	5100 - Spra	
21 East - Nort ##### MINING	Maintenar	44	Yes	U	SURFACE	Male	1982	31	Yes			No	0	7	0	Minor	0610 - W.S	4400 - Usin	6600 - Cor	6500 - Cor	6300 - Pun	
22 East - Nort ##### MINING	Operation:	44	Yes	U	SURFACE	Male	1950	63	No			No	0	550	339	Serious	0610 - W.S	2420 - Pus	4500 - O.E	5500 - Ank	5200 - Stra	
23 East - Nort ##### MINING	Operation:	44	Yes	U	SURFACE	Male	1983	30	Yes			No	4	53	28	Serious	0221 - Dril	6190 - Ope	2600 - C/B	4650 - Fing	5600 - Cru	
24 West - Pla ##### MINING	Operation:	36	Yes	P	SURFACE	Male	1972	41	Yes			No	0	17	11	Serious	0461 - Rea	2310 - Lift	4100 - O.X	4400 - Lov	5200 - Stra	
25 East - Nort ##### MINING	Exploratio	82	Yes	QQ	SURFACE	Male	1982	31	Yes			No	0	86	57	Serious	0221 - Dril	6110 - Ope	2600 - C/B	4500 - Wri	5400 - Frac	
26 Explorati ##### EXPLORAT	Operations			YYY	SURFACE	Male	1974	39	Yes			No	0	8	8	Minor	0040 - Exp	2310 - Lift	4100 - O.X	3181 - Bac	5200 - Stra	
27 West - Sou ##### MINING	Maintenar	103	Yes	III	SURFACE	Male	1962	50	Yes			No	0	125	70	Serious	0220 - Ben	2310 - Lift	4100 - O.X	4100 - Sho	6800 - Pair	
28 North - Kir ##### MINING	Construction	42	Yes	T	SURFACE	Male	1970	44	No			No	0	1	1	Minor	0270 - Sta	2110 - W	2120 - Sta	5200 - Kne	5200 - Stra	

The Original Safety Incident Dataset in a CSV file.

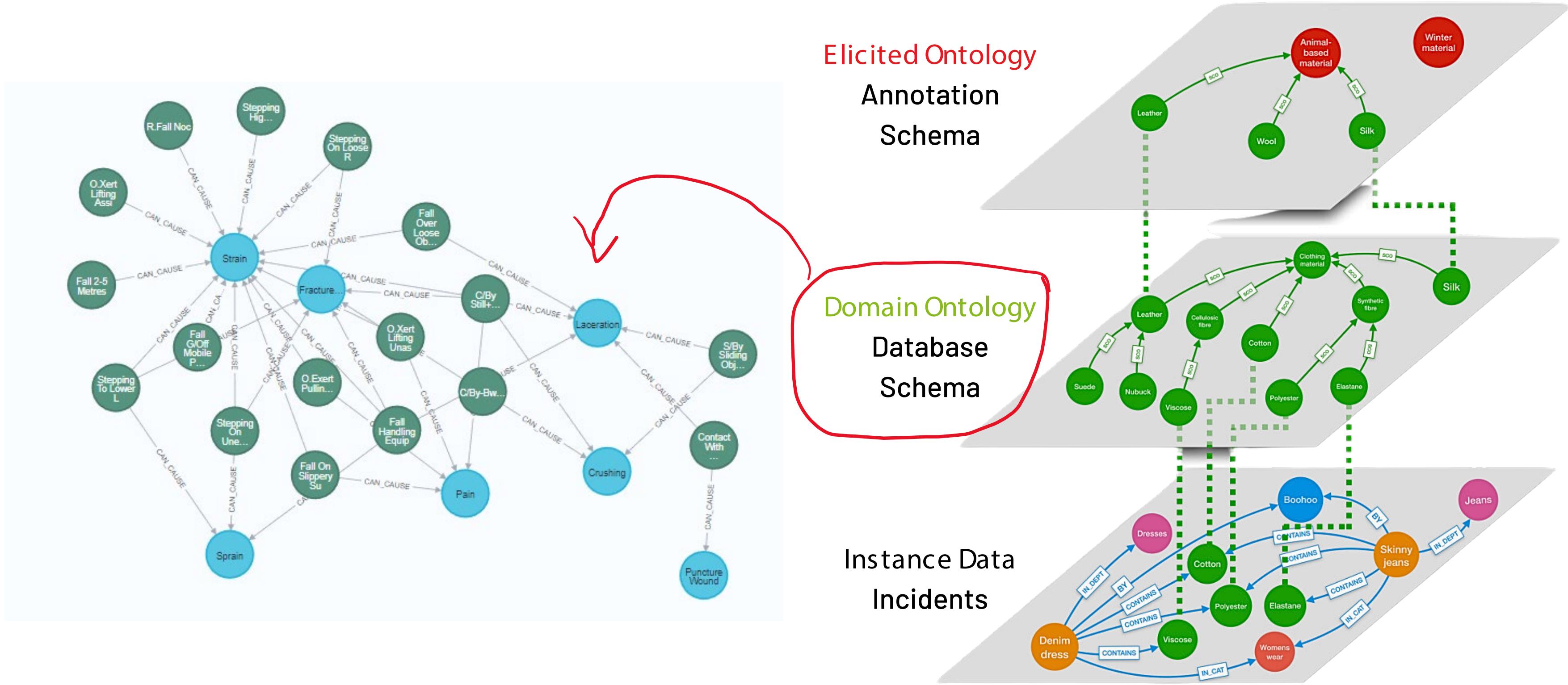


A Deeper Look at KG-Assisted Workplace Safety Analysis



Meta-graph (Schema Graph) Obtained From Data – A Bottom-UP Ontology Learning Process

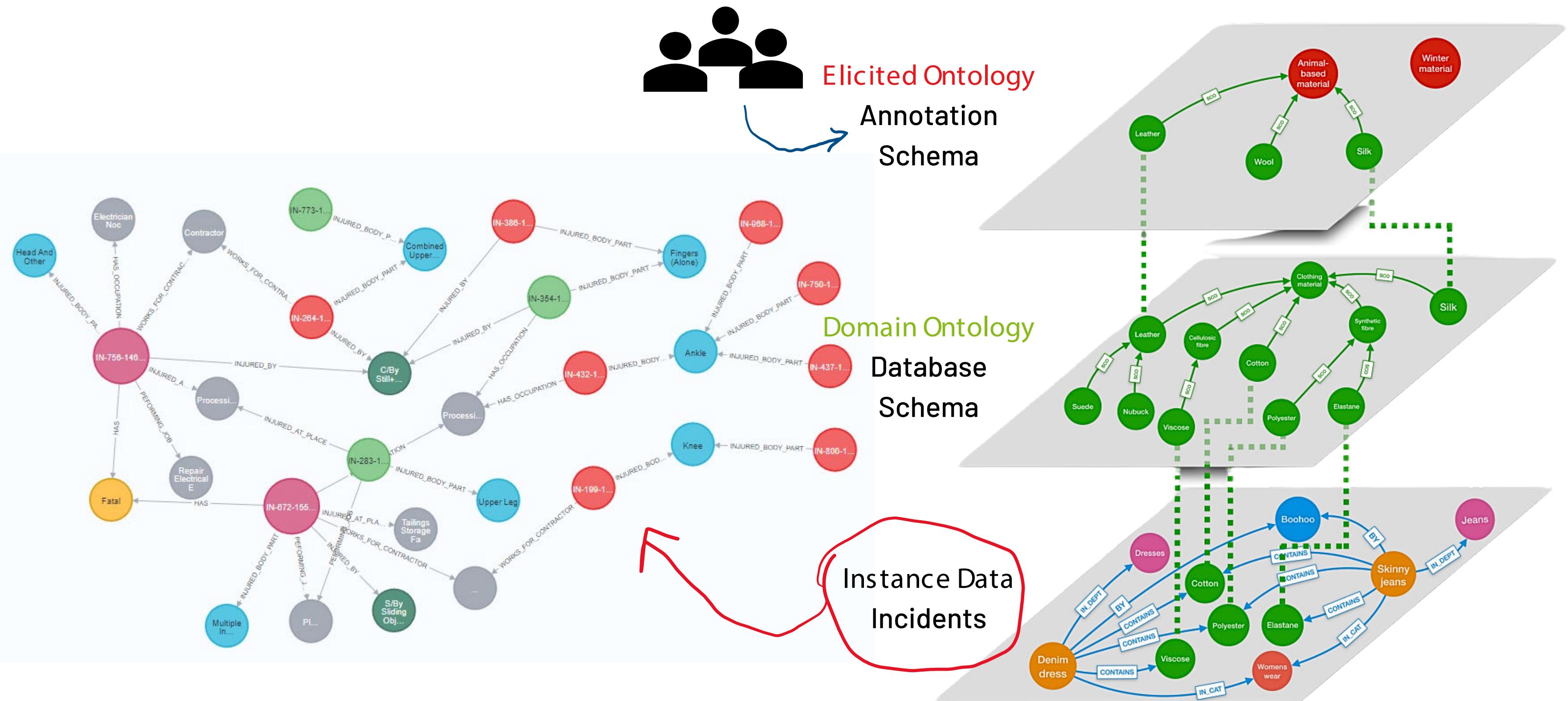
The Pyrmad of Enterprise Knowledge Graph



Picture Adapted From: <https://jbarrasa.com/2019/11/25/quickgraph9-the-fashion-knowledge-graph-inferencing-with-ontologies-in-neo4j>



The Pyrmaid of Enterprise Knowledge Graph



Picture Adapted From: <https://jbarraza.com/2019/11/25/quickgraph9-the-fashion-knowledge-graph-inferencing-with-ontologies-in-neo4j>

The Pyrmad of Enterprise Knowledge Graph

jbarrasa/neosemantics-python-examples



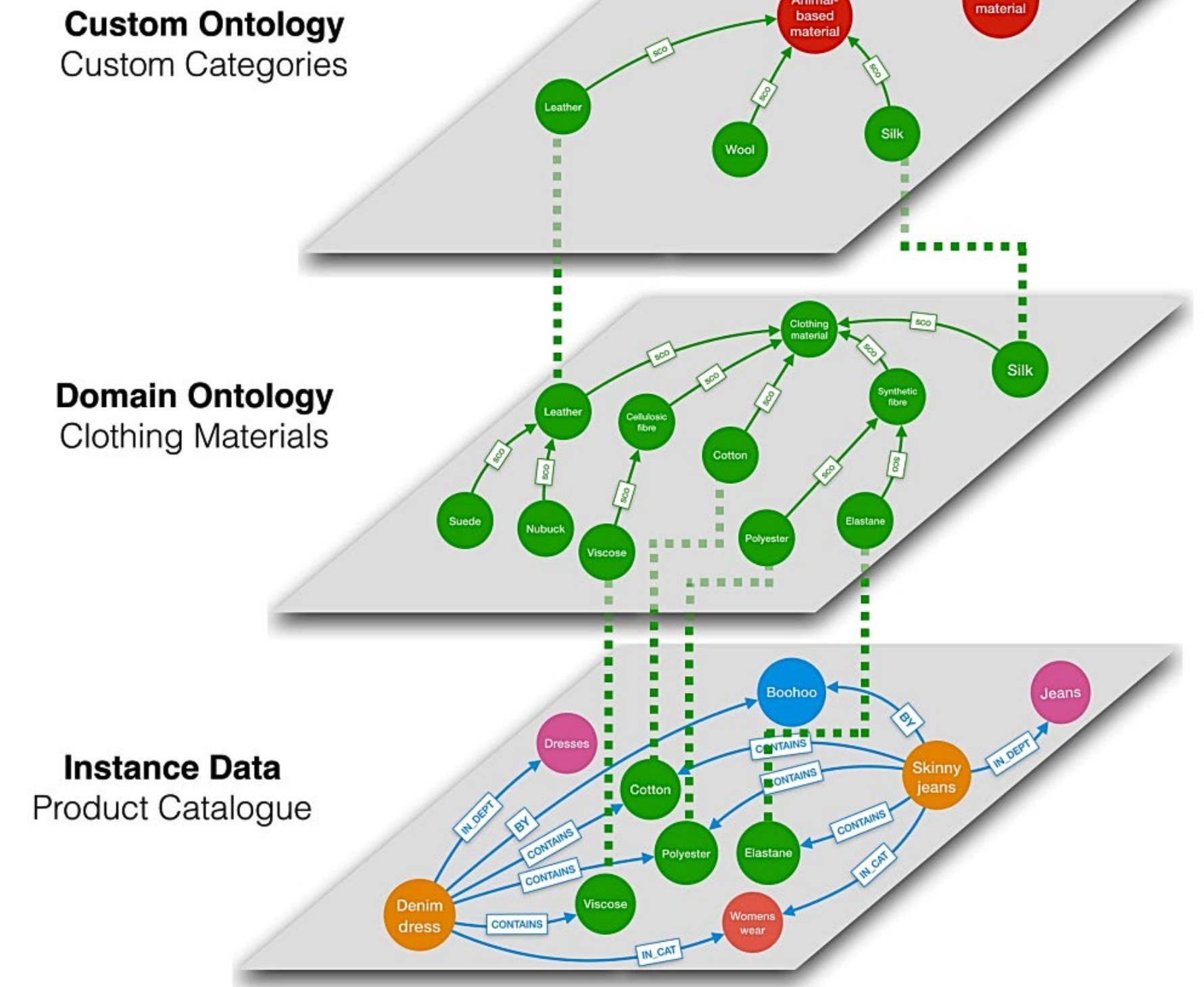
examples of use of the neosemantics plugin

At 1 Contributor 2 Issues ⭐ 32 Stars ⚡ 8 Forks

jbarrasa/neosemantics-python-examples: examples of use of the neosemantics plugin

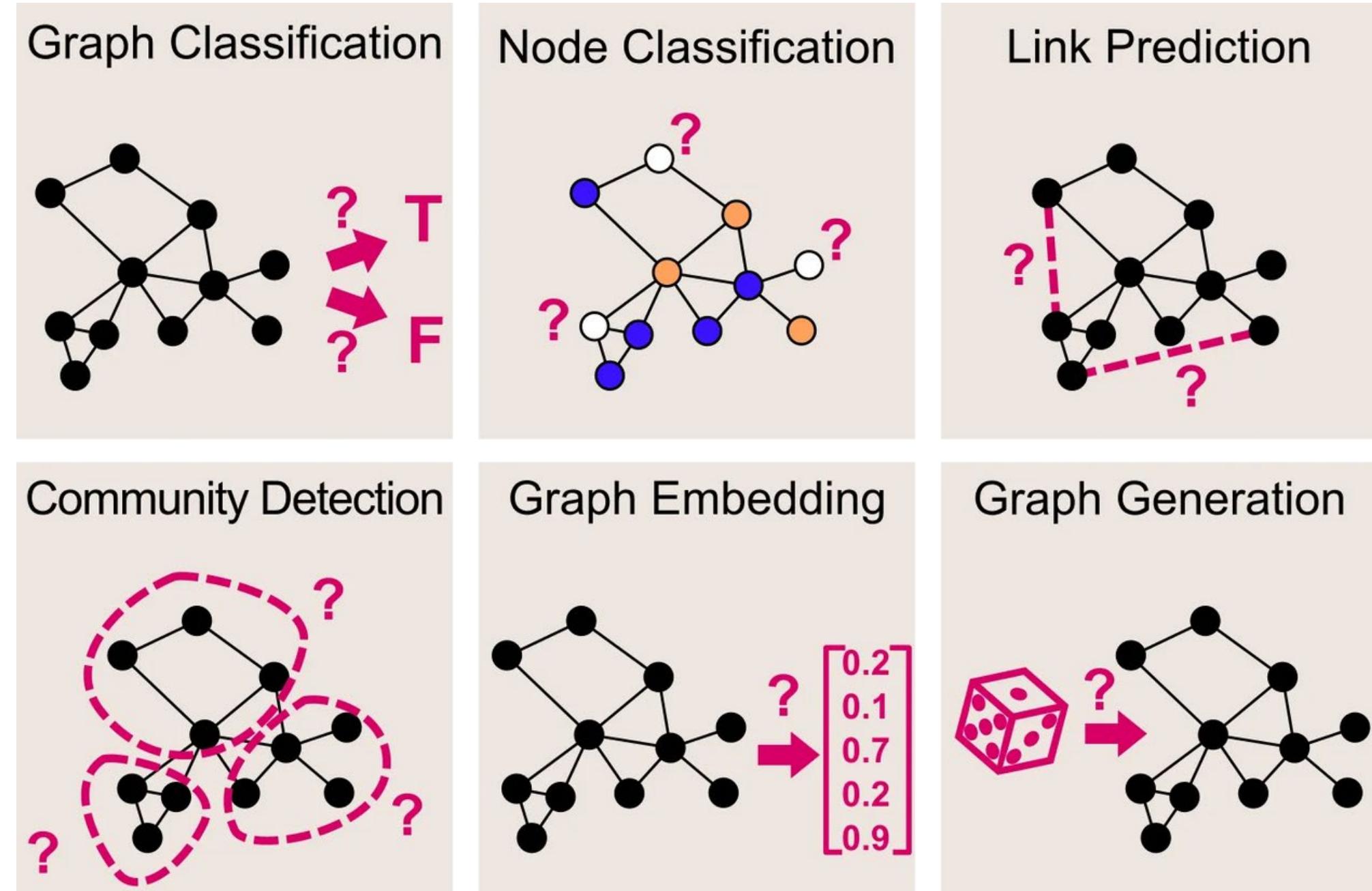
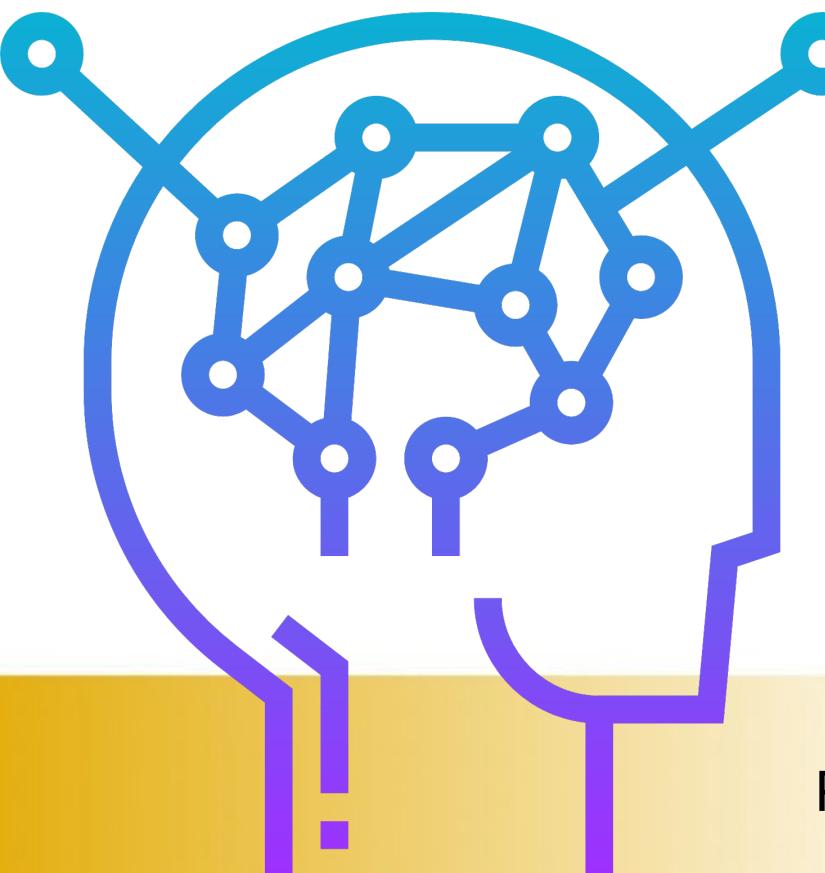
examples of use of the neosemantics plugin. Contribute to jbarrasa/neosemantics-python-examples development by creating an account on GitHub.

 GitHub

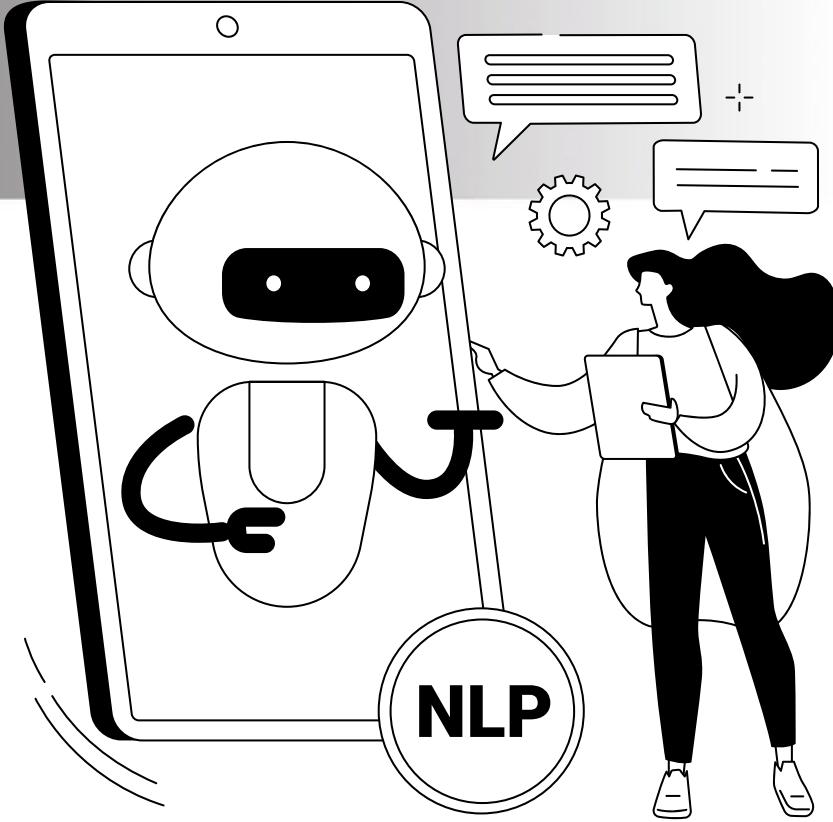


<https://jbarrasa.com/2019/11/25/quickgraph9-the-fashion-knowledge-graph-inferencing-with-ontologies-in-neo4j>

KGs are the key to future proof technologies!



Picture Credit: <https://towardsdatascience.com/graph-convolutional-networks-deep-99d7fee5706f>





Q&A

ARC Training Centre for Transforming Maintenance through Data Science

Email | wei.liu@uwa.edu.au

Web | <http://www.maintenance.org.au>



The Pyrmad of Enterprise Knowledge Graph

Structured representation of knowledge that captures relationships between entities and their attributes.

Organises information in a way that is easily understandable by both humans and machines.

Built upon the principles of graph theory, where entities are represented as nodes and relationships as edges.

- Entities

- Real-world objects such as people, place organisations, or concepts.

- Relationships

- Connections or associations between entities.
- Capture semantic connections between entities. These can be of different types, such as "works part of," "has a sibling," etc.

- Attributes

- Attributes represent properties or characteristics of entities.
- Examples of attributes could include age, gender, occupation, or any other relevant information.

