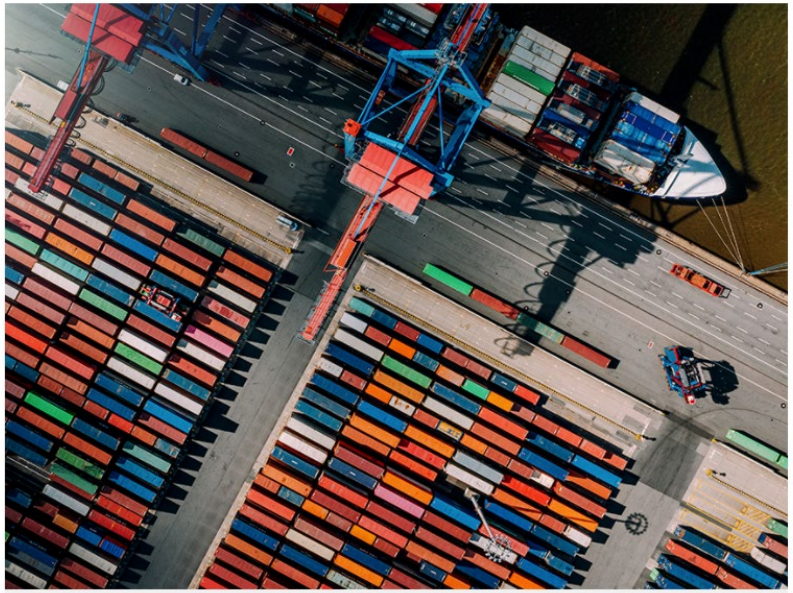
Using Neo4j to Mitigate Supply Chain Risk

Sammy Dagher
Enterprise Field Engineer

Agenda

- Supply Chain Risk
- Intro to Neo4j & Graph Databases
- How Graphs can Benefit your Supply Chain
- Demo

Global Supply Chains Near Make-or-Break Point for Easing in 2022



Rows of shipping containers at a cargo port. Photo: Getty Images.

January 25, 2022 *Bloomberg*

Vegetable oil prices hit all-time high over supply concerns: FAO

Published Feb. 15, 2022

Samantha Oller
Senior Editor

Chip shortage won't end in 2022, says AMD CEO Lisa Su

Brian Sozzi · **Anchor, Editor-at-Large**
Tue, February 15, 2022, 8:49 AM CST · 2 min read

In this article:

Lisa Su
American business executive and electrical engineer

The semiconductor shortage roiling industries from automakers Ford and General Motors to industrial products maker 3M is unlikely to end in 2022, hints one of the foremost minds in the space.

6:50 AM PST
Last Updated a month ago

Shipping group Maersk expects cargo delays to persist

Reuters

1 minute read

938
Fortune 1000
had a T1-2 supplier impacted by the pandemic

74% of supply chain companies are facing a shortage of critical parts/ materials

68% of supply chain companies have products being held up in ports or across borders

neo4j

Neo4j - The Graph Company

The industry's largest dedicated investment in Graph Database Ecosystem

neo4j

- Creator of the **Labeled Property Graph**
- **Thousands** of Customers World-Wide
- Graph Database Leader with more than **50%** of Market Share
- Innovation Leader with Highest concentration of Graph Innovators, Experts, Analysts, Developers and Publications
- HQ in **Silicon Valley,** offices include **Boston, London, Munich, Paris, Malmo, Sydney, Singapore, India, APAC**

Industry Leaders use Neo4j

20 of 20 Top Financial Institutions

9 of 10 Top High Tech Companies (Including those who have competitive products, use Neo4j internally for their mission critical applications)

7 of 10 Top Retailers

8 of 10 Top Insurance Companies

8 of 10 Top Automakers

3 of 5 Top Hotels

7 of 10 Top Telecoms

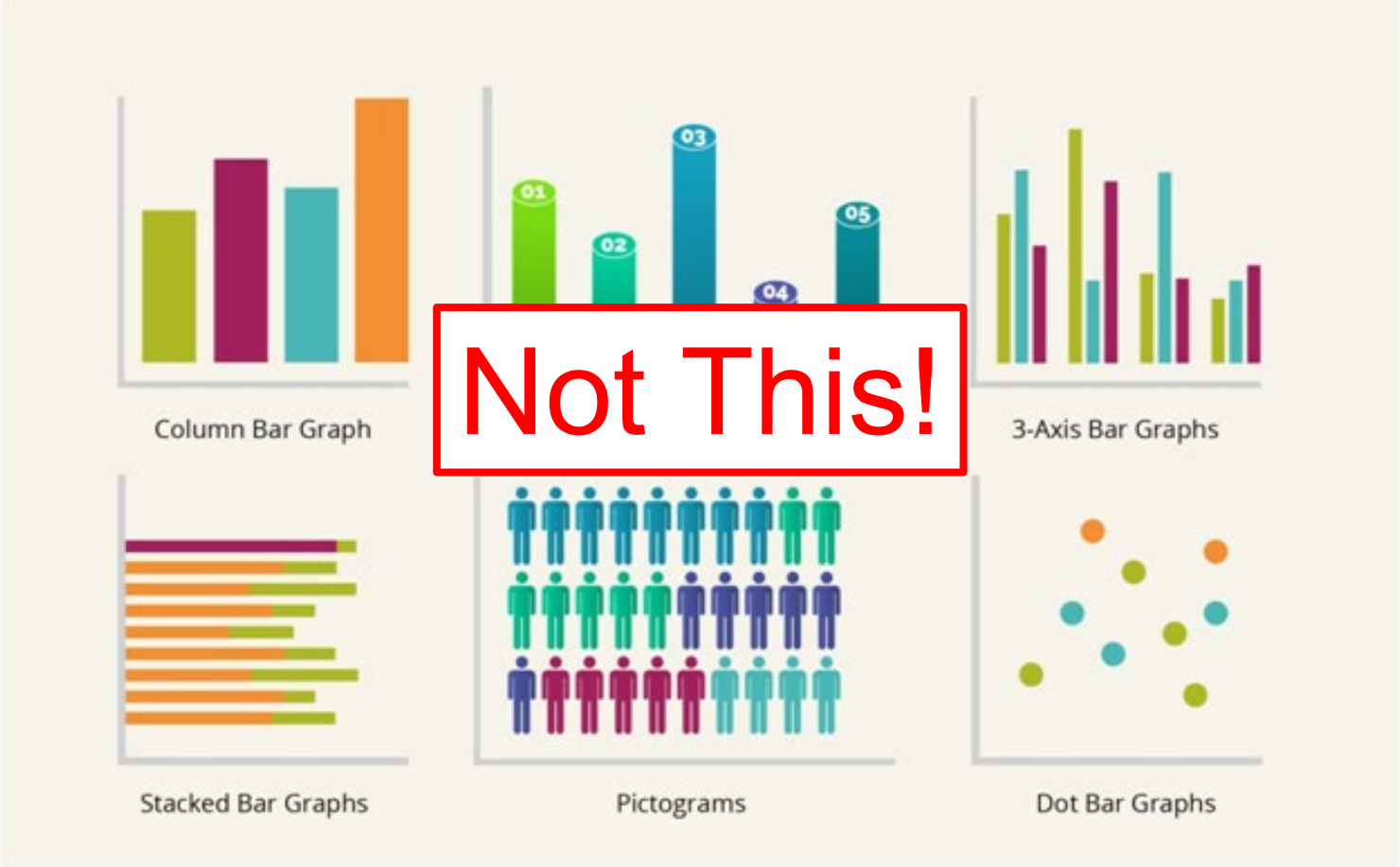
Global Governments - Civilian, Defense and Intelligence using Neo4j EE to Analyze, Optimize & Protect

ebay UBS MERCK Adobe

COMCAST cisco LinkedIn

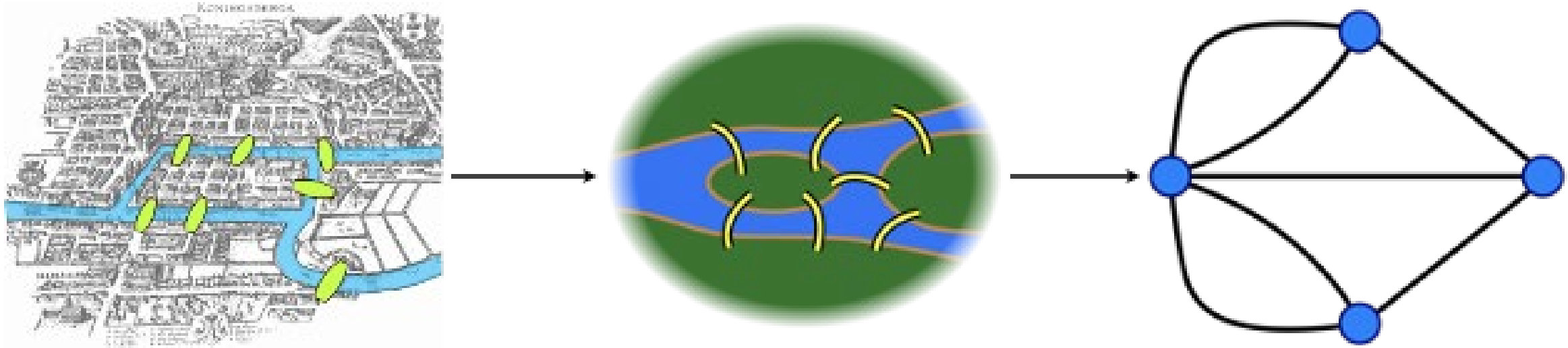
neo4j

What Do We Mean by Graphs?



What is a Graph?

A **graph** is set of discrete objects, each of which has some set of relationships with the other objects

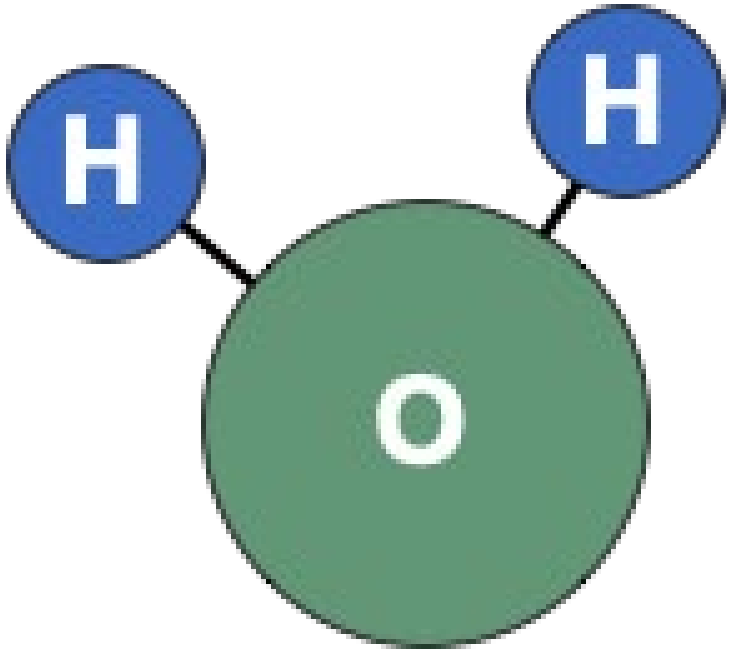


Seven Bridges of Konigsberg problem. Leonhard Euler, 1735

Anything can be a graph

The Internet

A water molecule



neo4j

Graph Model Components

Nodes

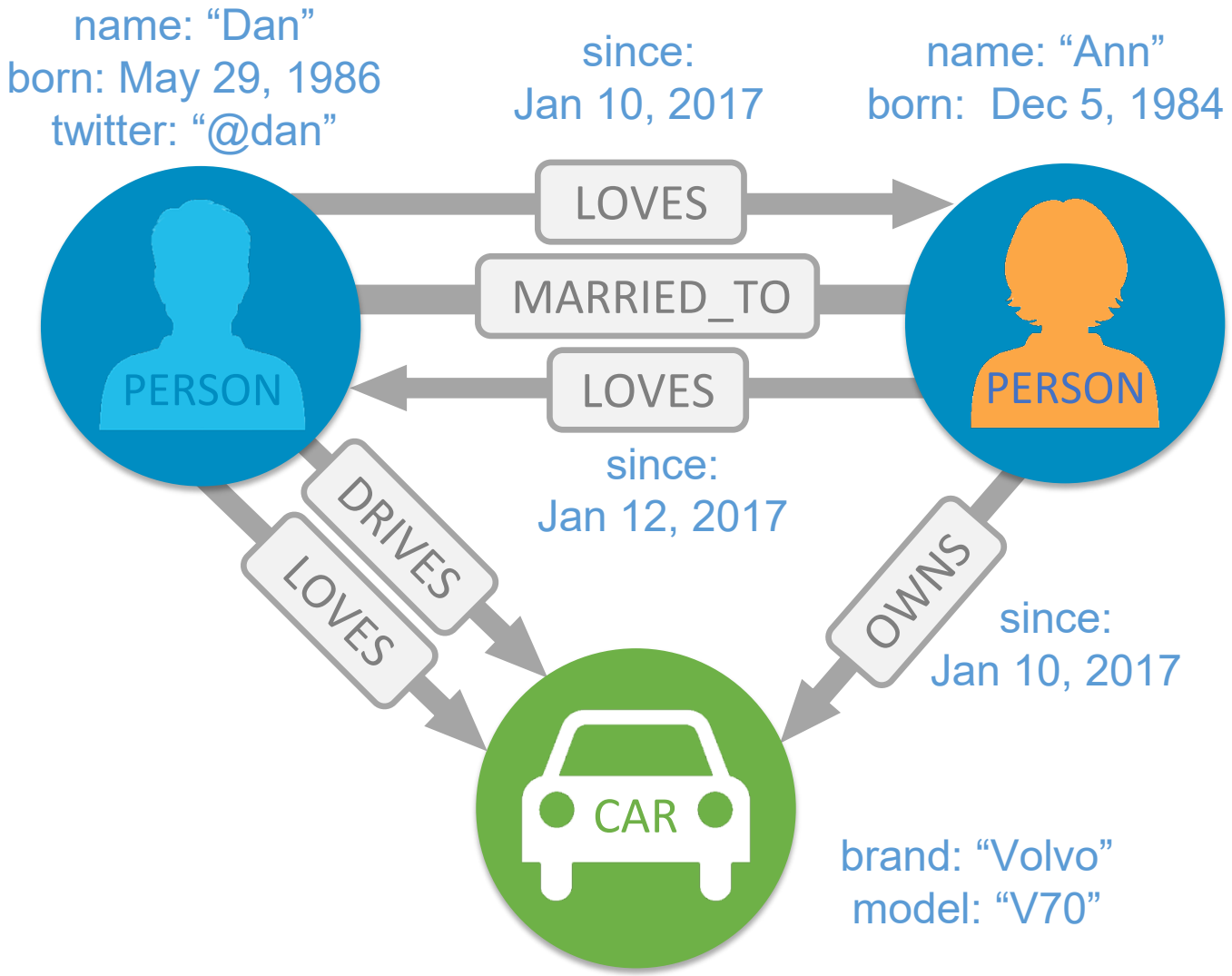
- Represent the objects in the graph
- Can have one or more ***labels*** *(noun)*

Relationships

- Relate nodes by ***type*** *(verb)* and ***direction***

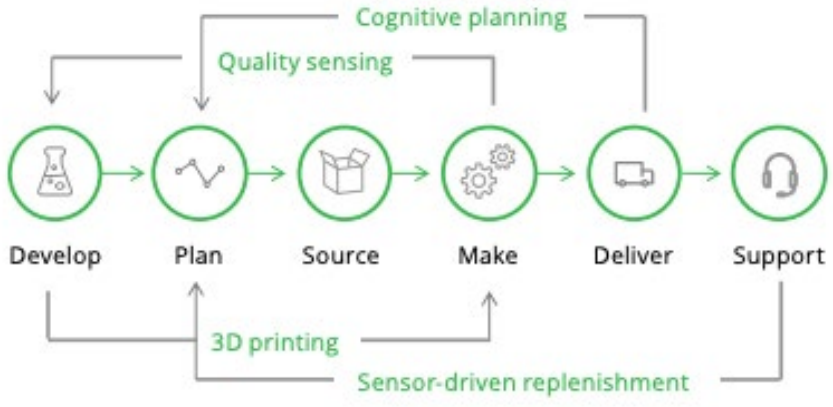
Properties

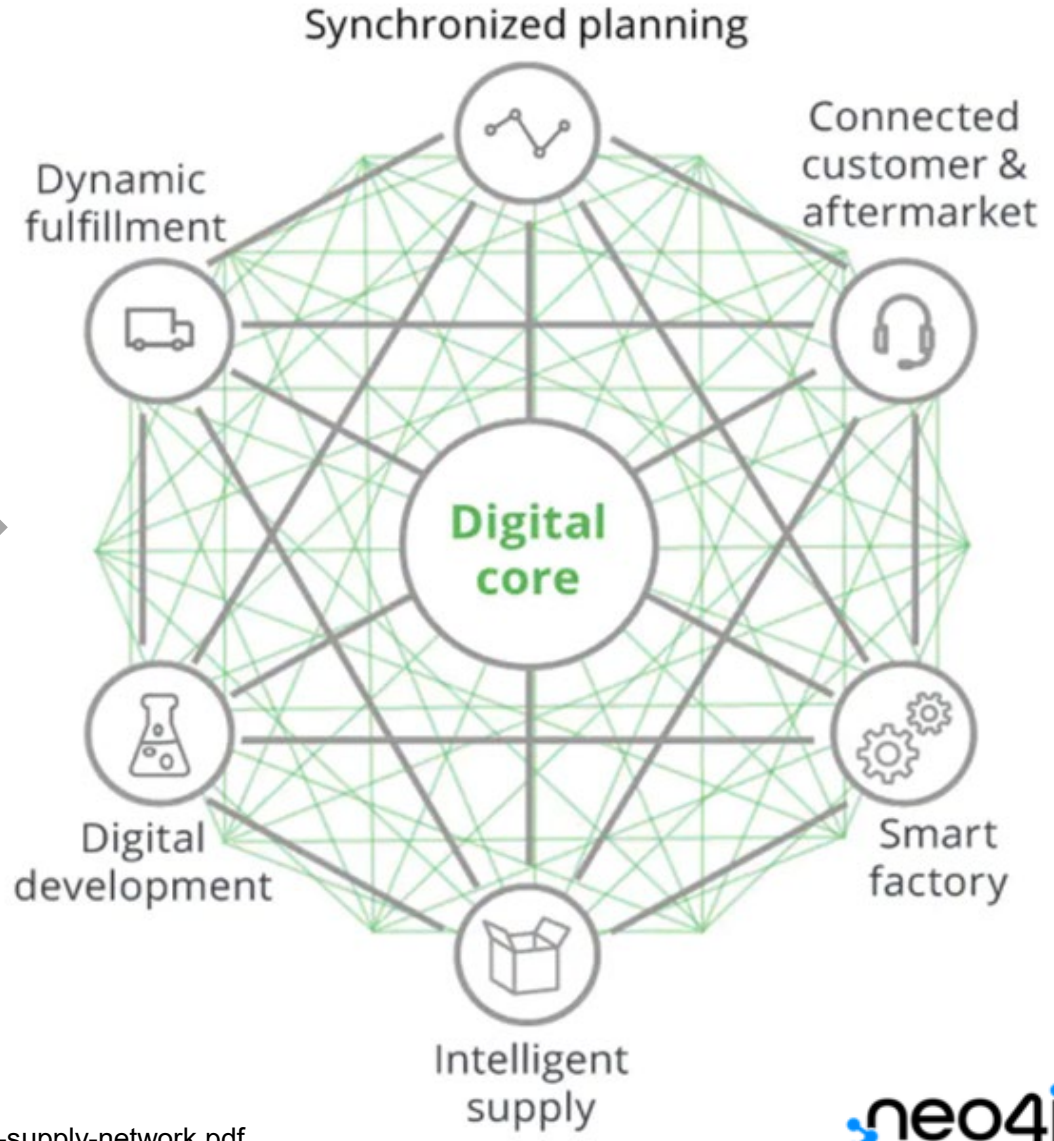
- Name-value pairs that can go on nodes *(adjective)* and relationships *(adverb)*



neo4j

The Modern Supply Chain is a Knowledge Graph

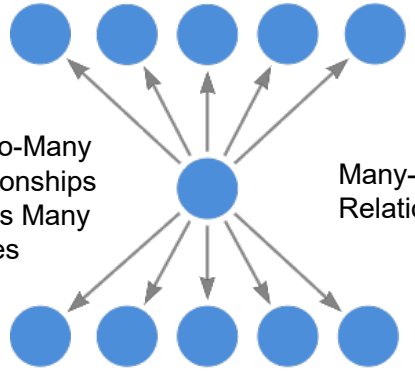




https://www2.deloitte.com/content/dam/insights/us/articles/3465_Digital-supply-network/DUP_Digital-supply-network.pdf

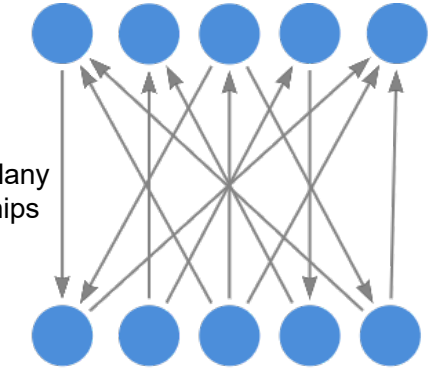
Data Comes in Many Shapes & Sizes

Small, Wide Data



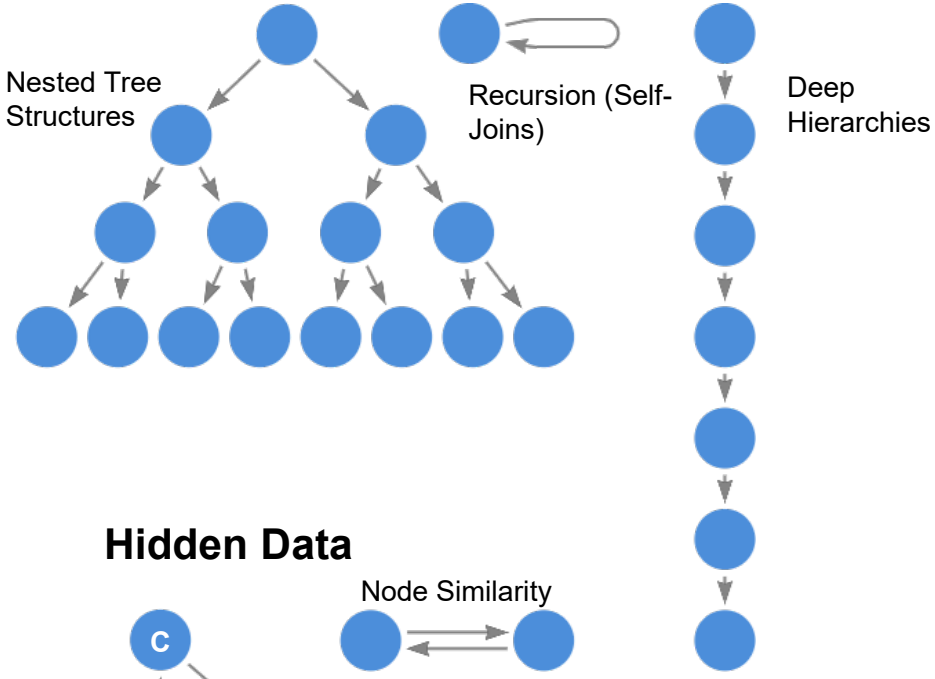
One-to-Many Relationships Across Many Entities

Complex Data

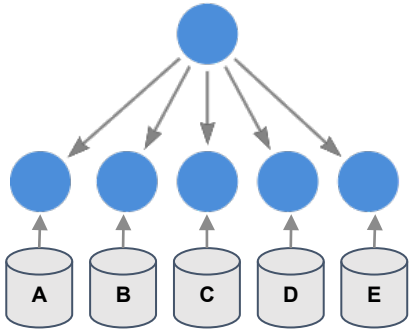


Many-to-Many Relationships

Hierarchical & Recursive Data

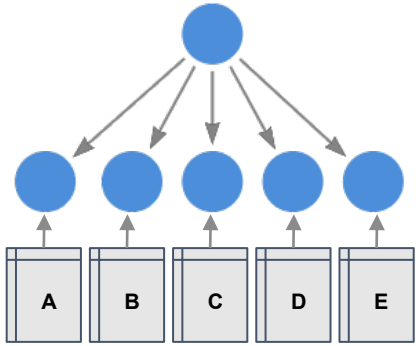


Legacy Data



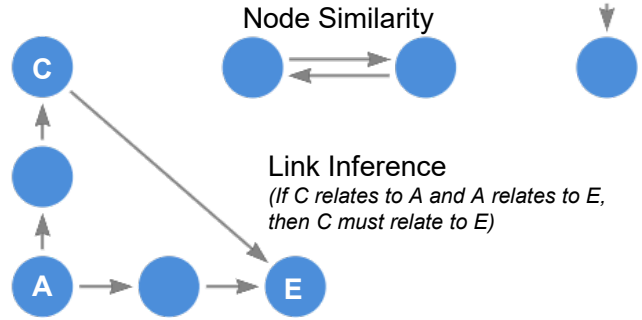
Legacy SQL Systems

Frozen Data



Data Lake Fact Tables

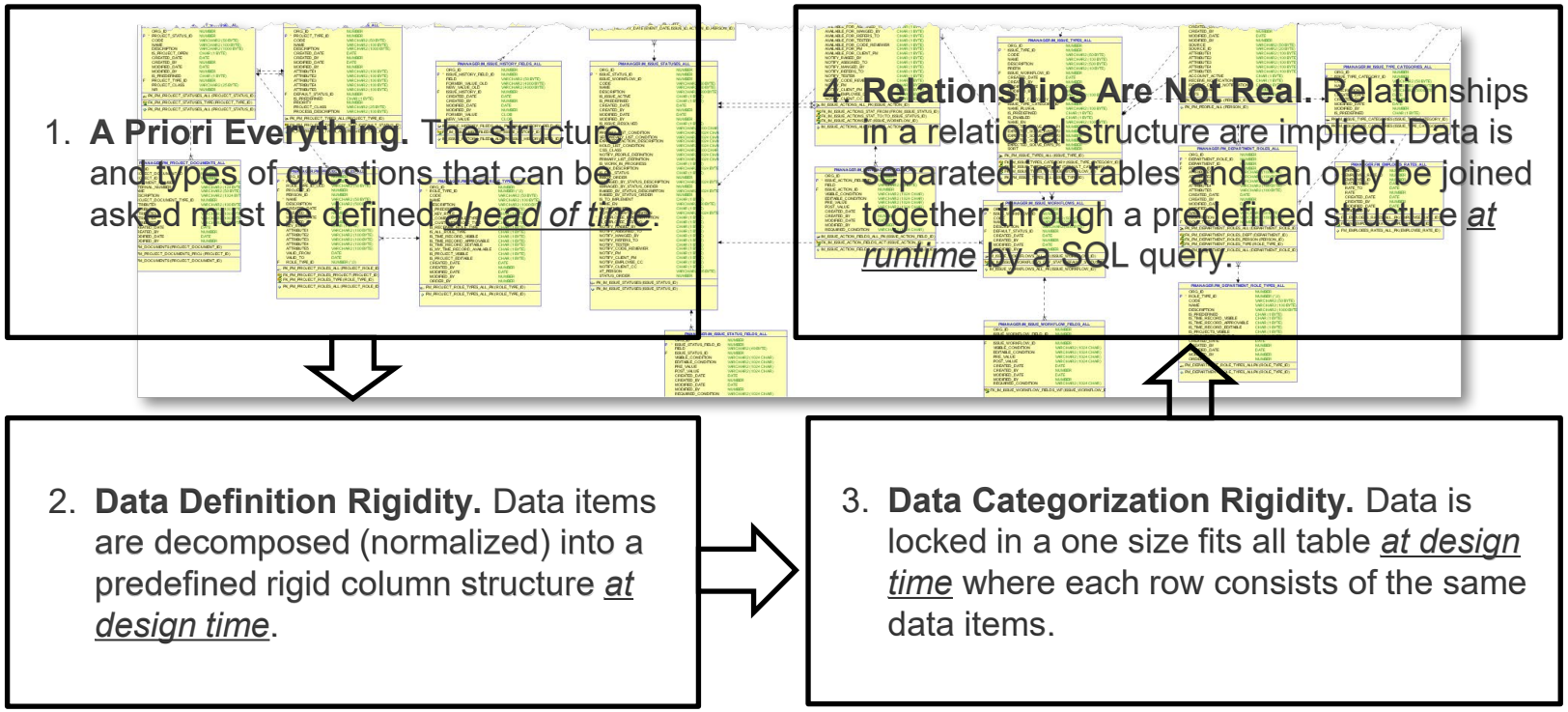
Hidden Data



Graph Data Science - Machine Reasoning

neo4j

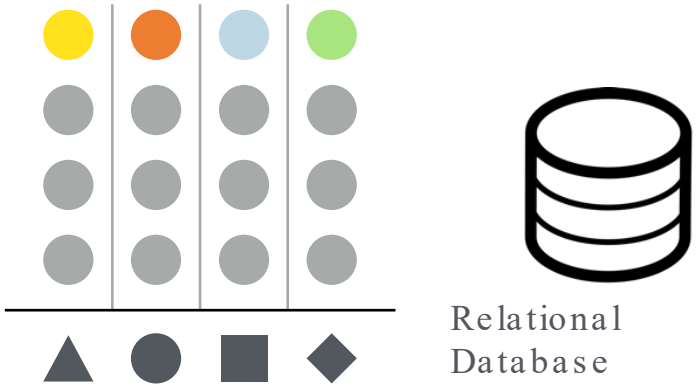
The Relational Model's Problem with Reality



1. **A Priori Everything.** The structure and types of questions that can be asked must be defined *ahead of time*.
2. **Data Definition Rigidity.** Data items are decomposed (normalized) into a predefined rigid column structure *at design time*.
3. **Data Categorization Rigidity.** Data is locked in a one size fits all table *at design time* where each row consists of the same data items.
4. **Relationships Are Not Real.** Relationships in a relational structure are implied. Data is separated into tables and can only be joined together through a predefined structure *at runtime* by a SQL query.

Relational vs Graph

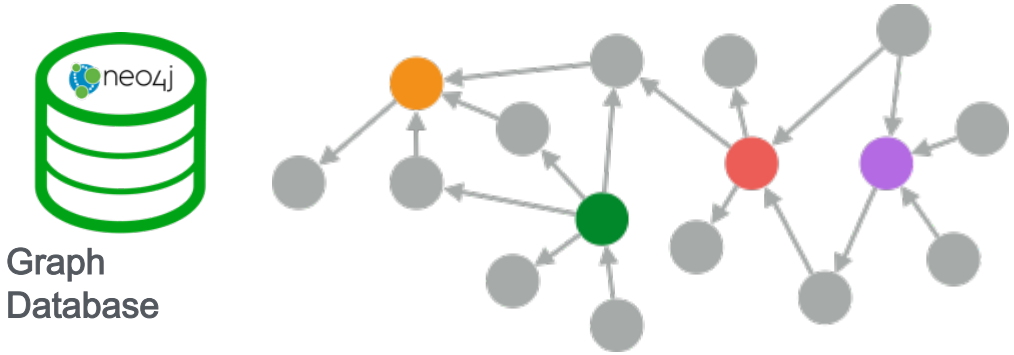
(It's not what you know)



Good for:

- Well-understood data structures that don’t change too frequently
- Known problems involving discrete parts of the data, or minimal connectivity levels in the data

(It's what you know and how it is connected)

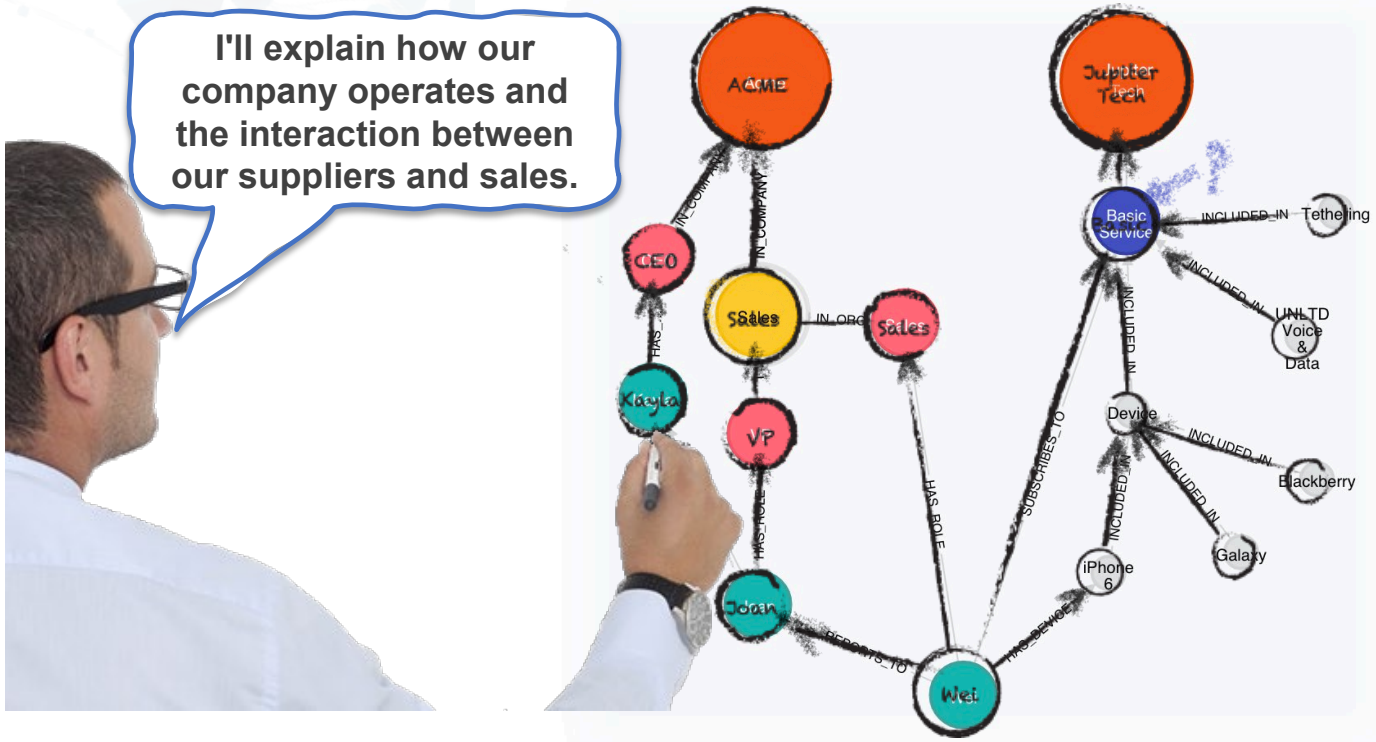


Good for:

- Dynamic systems: where the data topology is difficult to predict or unknown
- Value from ***fast traversals*** (no joins) at runtime
- Dynamic requirements that evolve with the business
- Problems where the relationships in data contribute meaning & value

Whiteboard to Graph Model

Process Tempo + neo4j

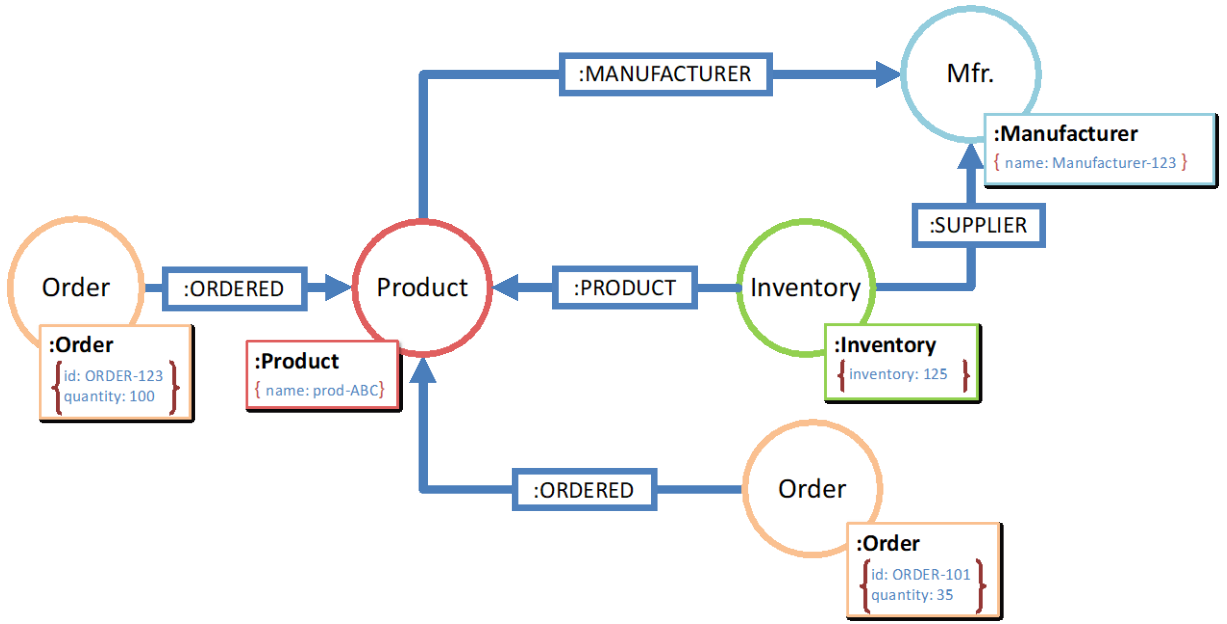


neo4j

Simple Graph Stored in Neo4j

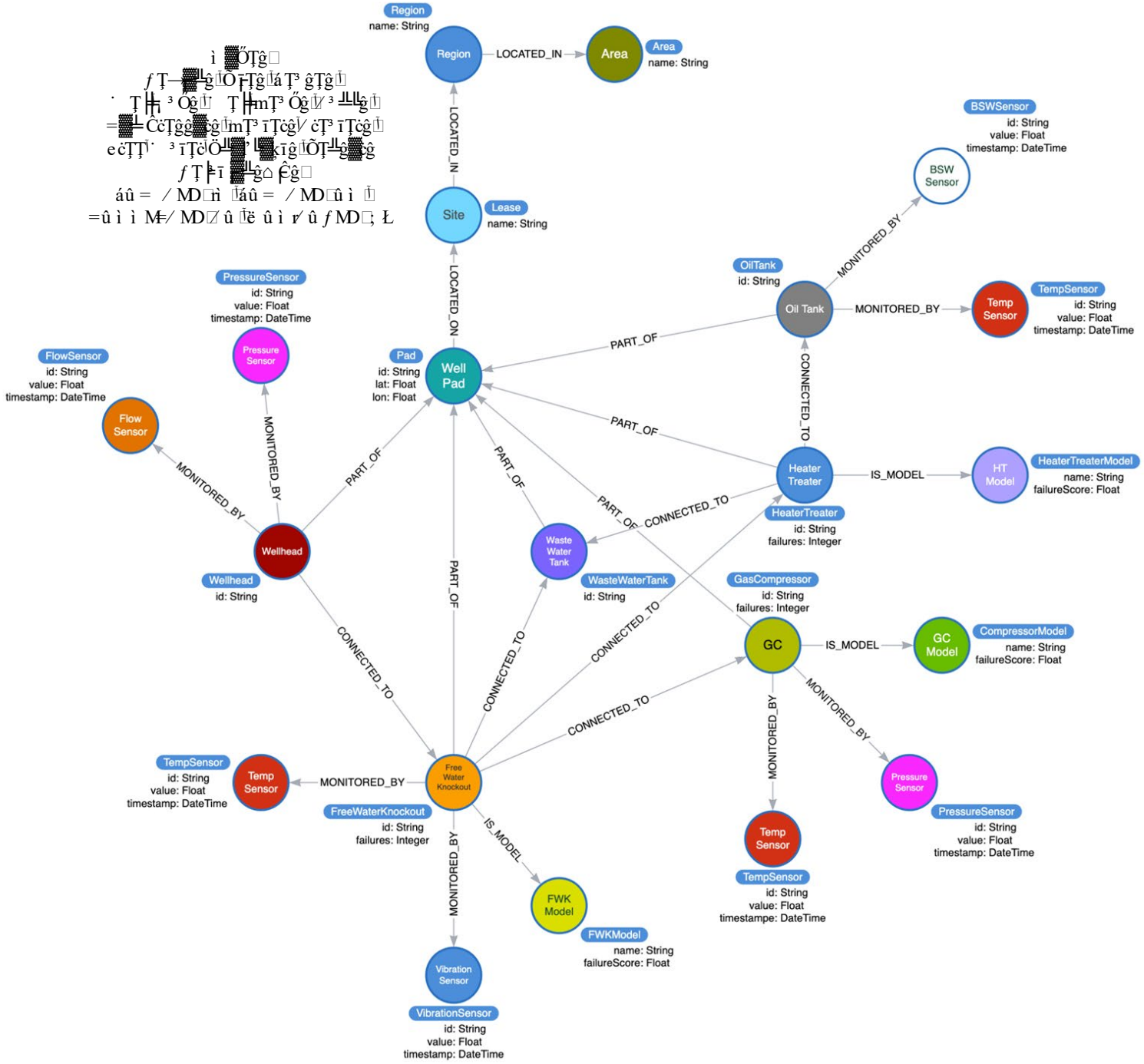
The Neo4j database is designed to store and query nodes and relationships via graph patterns (a.k.a. the Label Property Graph model).

- Considered "schema-less" or "schema-last".
- Data is traversed, not joined aka SQL.
- ACID compliant database.
- Expressive pattern-based Cypher query language (GQL).

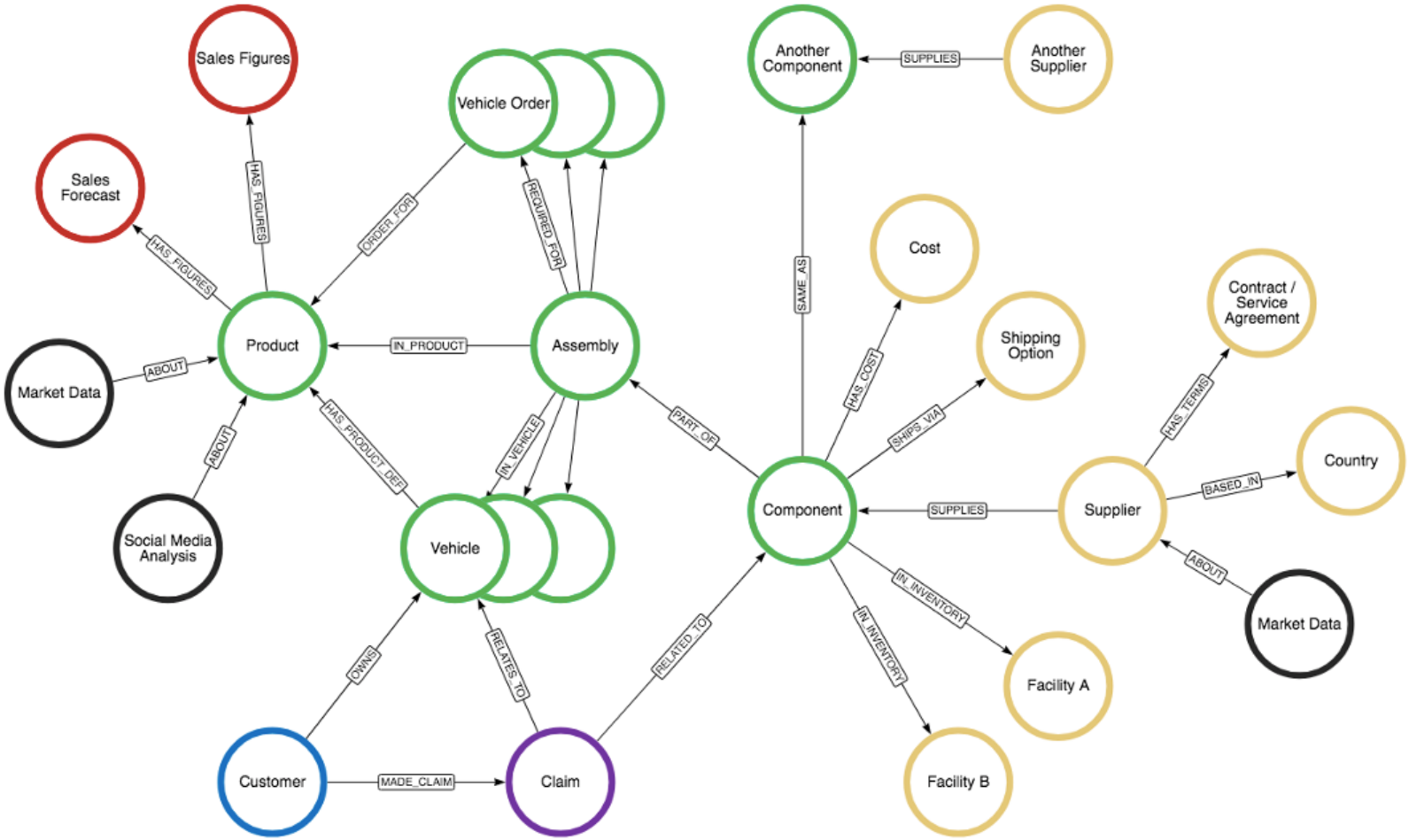


Graph Supply Chain

- Neo4j's flexible graph data model easily handles complex relationships and addition of new data sources
- Provides holistic "360°" view of assets, processes & related data with full spatial support
- Quickly traverse the network to understand dependencies, co-location, performance, history
- Scales to billions of nodes and relationships
- Powerful graph analytics to quickly identify bottlenecks, fragility and opportunities for optimization



Supply Chains in Graphs



- Organisational Data
- Customer Data
- Product Data
- Event Data
- 3rd Party Data
- Supply Chain Data

neo4j

Graph Data Science Algorithms and Workflows

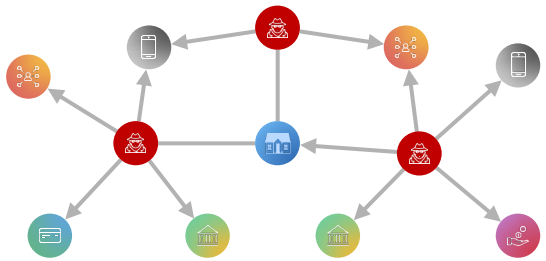
Query (e.g. Cypher/Python)

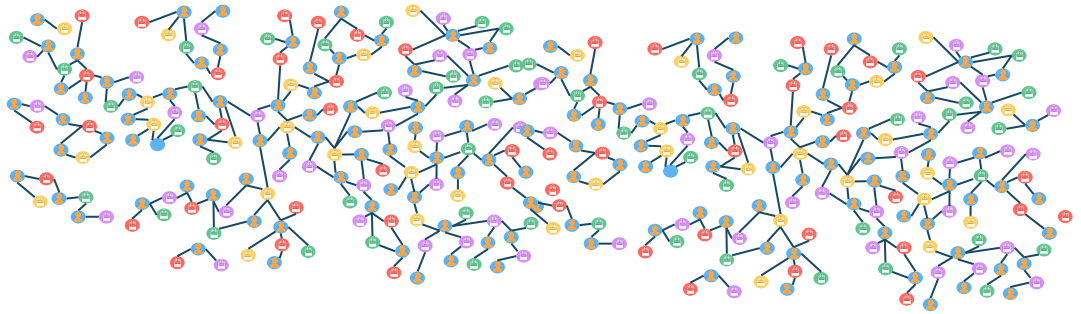
"Idea of what you're looking for based on known graph patterns.

Graph Algorithms

Global analysis and iterations

Local Patterns ⟷ **Global Computation**





You know what you're looking for and making a decision

You're learning the overall structure or from the overall structure of a graph

neo4j

More, Better, Faster Algorithms

Pathfinding & Search

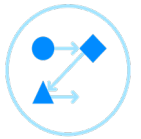
- Shortest Path
- Single-Source Shortest Path
- All Pairs Shortest Path
- A* Shortest Path
- Yen's K Shortest Path
- Minimum Weight Spanning Tree
- K-Spanning Tree (MST)
- Random Walk
- Breadth & Depth First Search

Centrality & Importance

- Degree Centrality
- Closeness Centrality
- Harmonic Centrality
- Betweenness Centrality & Approx.
- PageRank
- Personalized PageRank
- ArticleRank
- Eigenvector Centrality
- Hyperlink Induced Topic Search (HITS)
- Influence Maximization (Greedy, CELF)

Community Detection

- Triangle Count
- Local Clustering Coefficient
- Connected Components (Union Find)
- Strongly Connected Components
- Label Propagation
- Louvain Modularity
- K-1 Coloring
- Modularity Optimization
- Speaker Listener Label Propagation



Supervised Machine Learning

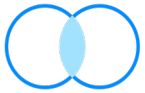
- Node Classification
- Link Prediction

… and more!

- Synthetic Graph Generation
- Scale Properties
- Collapse Paths
- One Hot Encoding
- Split Relationships
- Graph Export
- Pregel API (write your own algos)

Heuristic Link Prediction

- Adamic Adar
- Common Neighbors
- Preferential Attachment
- Resource Allocations
- Same Community
- Total Neighbors



Similarity

- Node Similarity
- K-Nearest Neighbors (KNN)
- Jaccard Similarity
- Cosine Similarity
- Pearson Similarity
- Euclidean Distance
- Approximate Nearest Neighbors (ANN)

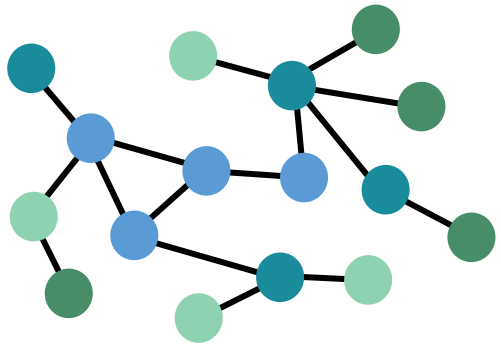
Graph Embeddings

- Node2Vec
- FastRP
- FastRPExtended
- GraphSAGE

neo4j

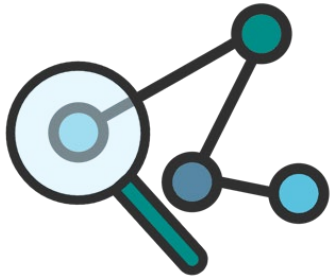
Graphs & Data Science

Knowledge Graphs



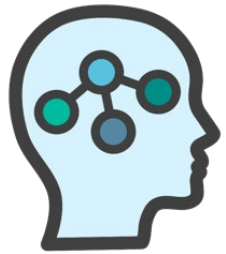
Find the patterns you're looking for in connected data

Graph Algorithms



Use unsupervised machine learning techniques to identify associations, anomalies, and trends.

Graph Native Machine Learning



Use embeddings to learn the features in your graph that you don't even know are important yet.

Train in-graph supervise ML models to predict links, labels, and missing data.

Force Readiness

5B
Nodes

14B
Relationships

7.5x
Faster

77%
Lower DB admin

Challenge

Slow, inflexible & expensive
PLM system for military equipment
Bill of Materials Management

Solution

Knowledge graph of components & costs
to determine lifespan of equipment for ordering, budgeting and what-if analyses

Why Neo4j

Flexible, Contextual Data Model

> *Neo4j enables analysts to save huge amounts of time. Answers are immediate. As a result, the parts delivery is more accurate and order turnaround is much faster.*

Preston Hendrickson
US Army Project, CALIBRE

Predictive Maintenance

27M
Documents analyzed

Reduced
downtime

Lower
Costs

Increased
Productivity

Challenge

Unplanned downtimes & failures of equipment causing costly post-failure remedial actions

Solution

A Neo4j knowledge graph built from 27 million warranty & service documents powering machine learning based predictive maintenance

Why Neo4j

Flexible, Contextual Data Model

Flexible Deployment Models

Database-as-a-Service

Fully-managed SaaS
Consumption-based pricing

Cloud-native

Self-service deployment

No access to underlying infrastructure and systems

Self-hosted

For private, hybrid or lift-and-shift cloud
Bring-your-own-license

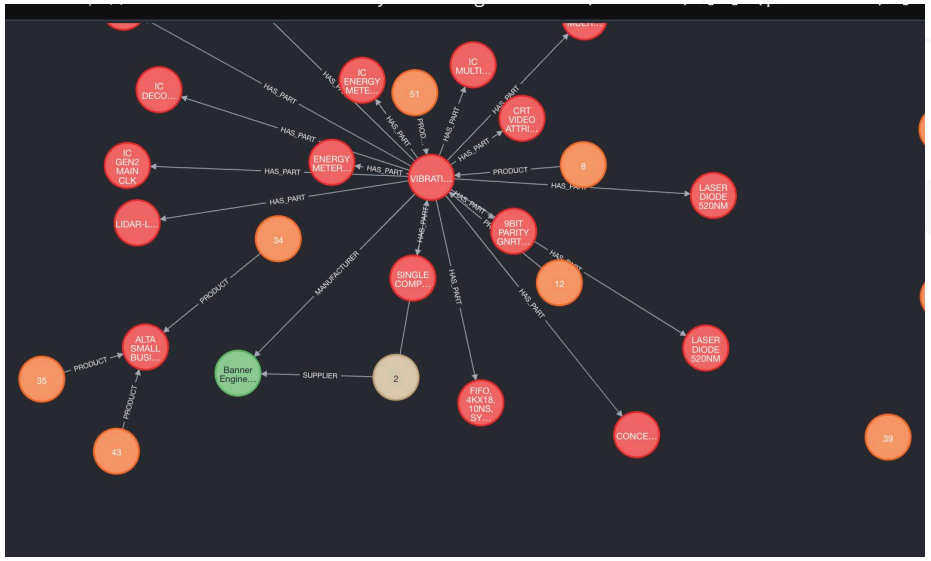
Full control of your environment

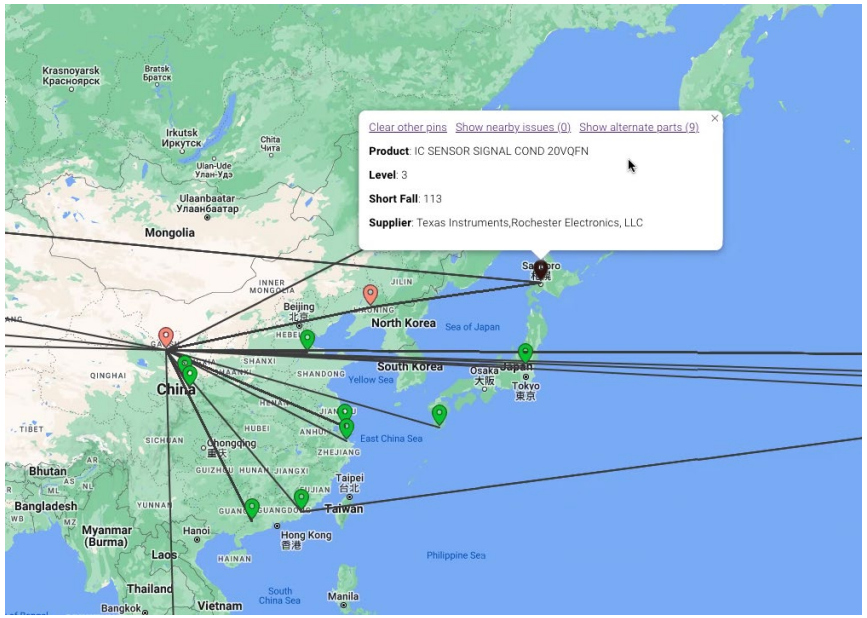
Run in any cloud, in your account

neo4j

Demo

- Data taken from SAP -> BigQuery and ported into Neo4j
- Using GKG Record – Google Knowledge Graph record for current events





neo4j

graphsummit

According to Gartner, *"by 2025, graph will be used in 80% of data and analytics innovations"*

Neo4j means Graph

Neo4j is coming to Detroit with GraphSummit on May 11, 2023

Learn from some of the top Neo4j experts

Network with other data leaders

See how graph databases can help transform your business

Register today - space is limited!

neo4j

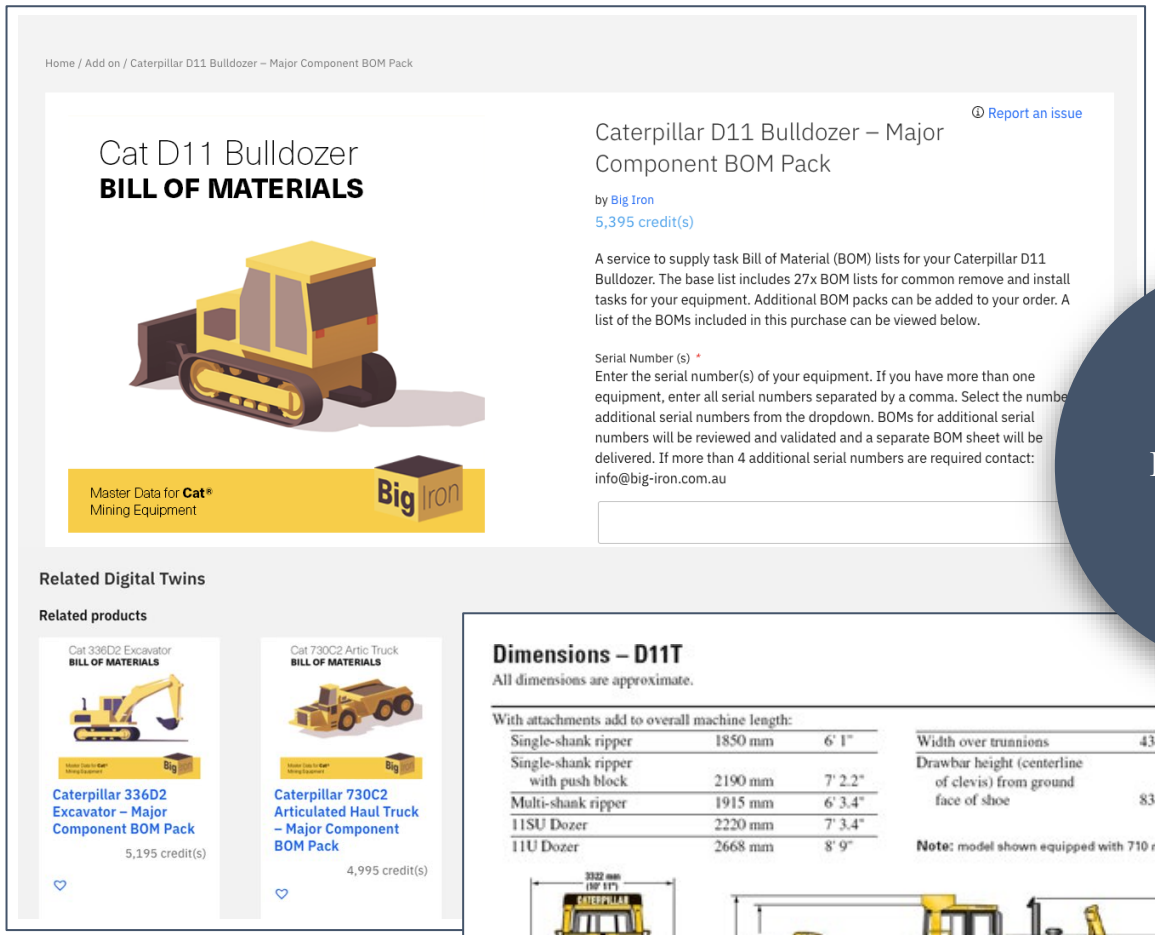
GREAT LAKES
DATA & ANALYTICS
SUMMIT

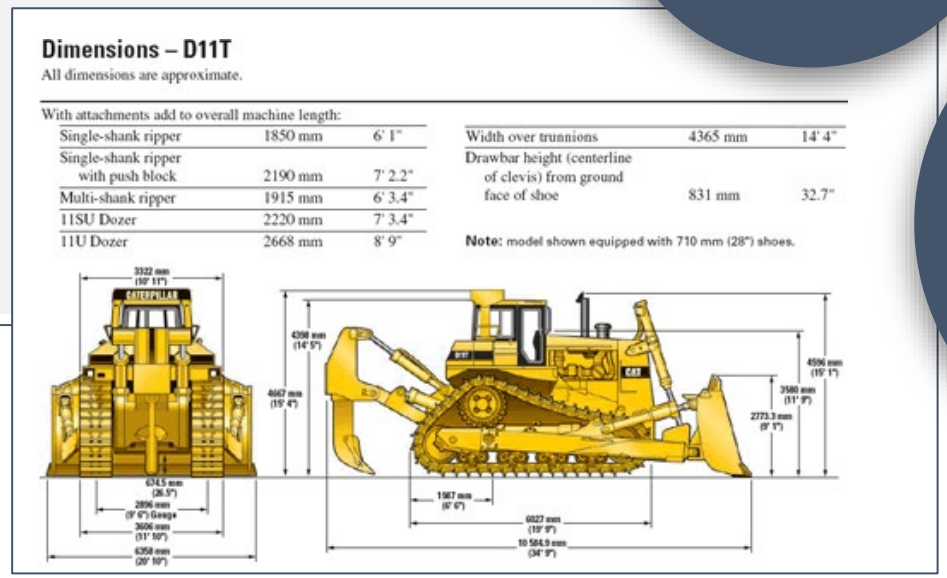
Thank you for attending!

Hosted by:

Appendix

Digital Twins in Graphs





DT Asset Nested BOM (Canonical Model)

DT Field Instance(s) Nested BOM (As Built)

DT Field Instance Metadata

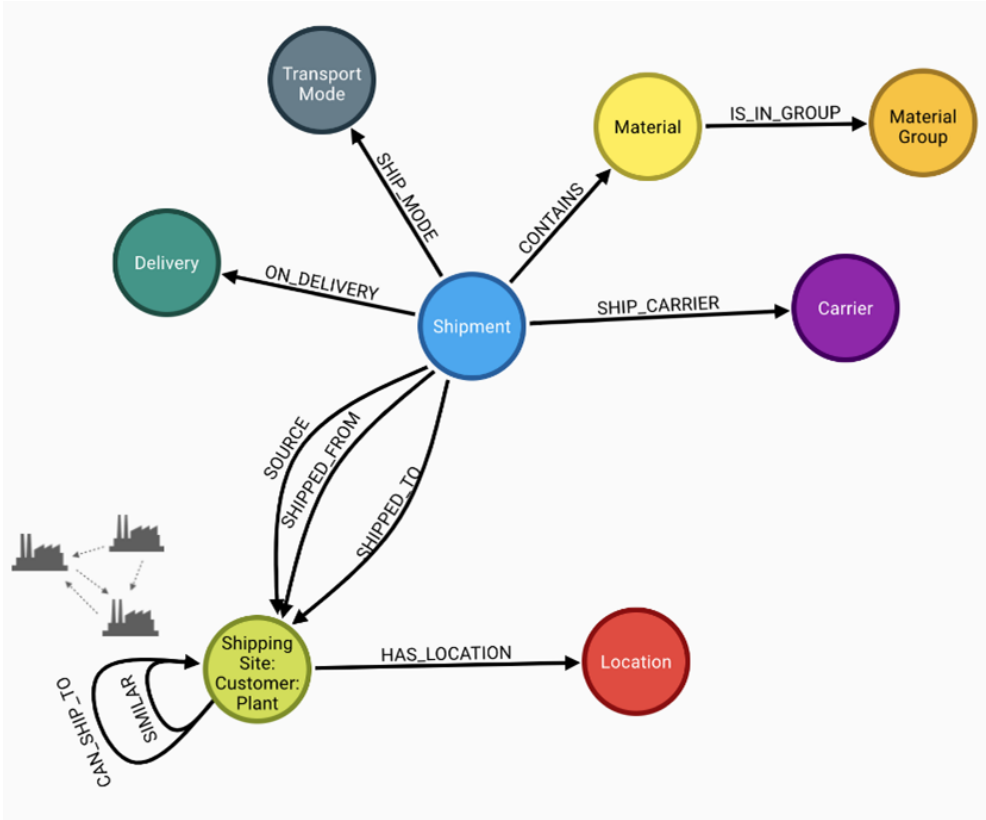
DT Field Instance Sensor Data

DT Field Instance Extended Data

neo4j

Why Knowledge Graphs for Supply Chains

Benefits	Features
Bridge data silos for end-to-end visibility	Provides a 360^0 view of assets, processes and related data with full spatial support
Identify bottlenecks, fragility and opportunities for optimization	Powerful graph queries and algorithms to ask “what-if” questions and analyze supply chain network
Minimize risk and costs	Quickly traverse the network to understand dependencies, co-location, performance, and history
Quicker time to value	Flexible graph data model that easily handles complex relationships and new data sources rapidly



FORRESTER

DB-ENGINES

#1 Most Popular Graph Database with Developers

☐ include secondary database models 36 systems in ranking, November 2021

Rank Nov 2021	Rank Oct 2021	Rank Nov 2020	DBMS	Database Model	Score Nov 2021	Score Oct 2021	Score Nov 2020
1.	1.	1.	Neo4j	Graph	57.98	+0.11	+4.45
2.	2.	2.	Microsoft Azure Cosmos DB	Multi-model	40.82	+0.54	+8.32
3.	↑ 4.	3.	ArangoDB	Multi-model	5.10	+0.65	-0.27
4.	↓ 3.	↑ 5.	Virtuoso	Multi-model	4.81	+0.12	+2.28
5.	5.	↓ 4.	OrientDB	Multi-model	4.64	+0.59	-0.66
6.	6.	↑ 8.	GraphDB	Multi-model	2.83	+0.18	+0.72
7.	↑ 8.	↓ 6.	Amazon Neptune	Multi-model	2.60	+0.21	+0.17
8.	↓ 7.	↓ 7.	JanusGraph	Graph	2.54	+0.02	+0.17
9.	9.	↑ 13.	TigerGraph	Graph	2.02	+0.04	+0.89
10.	10.	↑ 11.	Stardog	Multi-model	1.97	+0.04	+0.51

TOP 20 Database

200k+ Developers

72k+ Meetup Members Globally

50k+ Members with LinkedIn Skills

neo4j

Databases (graph or not) DO NOT Live In A

Development / Build [Dev's / Applications]
- Neo4j GraphQL Library / GRANDstack
- Spring Data Neo4j integration
- Language Drivers (Java, Javascript, GO, Python, .NET, Community provided)

Data Integration *[Data Source / Flow]*
- Kafka Connectors
- Spark Connector
- neoSemantics (RDF)
- DB Connectors
  (apoc - jdbc, C*, Mongo, CouchDB, LDAP…)

Deployment [Implement / Use]
- Cloud
  - Neo4j Aura
  - Marketplace
  - Manual GCE
- Docker / K8
- VM's / bare metal

Graph Queries *[User / Dev's]*
- Cypher Language / GQL
- APOC Library
- Kernel API / extensibility

Graph Tools *[User / Business Analyst / Dev's]*
- Neo4j Browser
- Neo4j Bloom
  - (end-user, no cypher needed large graph visualization tool)
- Neo4j Desktop / graphApps
- cypher-shell

Business Use / Analytics [User / Business Analyst / Dev's]
- Neo4j Graph Data Science Library
- Neo4j BI Connectors (SQL -> Cypher -> Data)
  - jdbc
  - ODBC (pre-release)